DORMANCY OF THE POTATO TUBER AS IT AFFECTS A SEED CERTIFICATION AND BREEDING PROGRAM

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C. R. Magee

Major professor

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by

Charles Richard Ode

A THESIS

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The writer wishes to express his appreciation to Professor H. C. Moore, and Mr. E. J. Wheeler for their valuable suggestions and criticisms during the course of the experiment and also to Dr. S. T. Dexter and others whose aid was invaluable throughout the course of this investigation.

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1. INTRODUCTION

Each year the Michigan Crop Improvement Association, in conducting a program of seed potato certification, requires a field and bin inspection to determine vigor and freedom of disease. To additionally insure high quality of the seed, a trial planting has been made in Florida of a two hundred tuber sample from each lot of certified seed passing field inspection. This seed when harvested in September and planted in late November, frequently gives poor stands and uncertain disease readings due to the dormancy of the tubers. Seed treatment with dormancy-breaking chemicals appear to offer some hope of solution of this problem. Since several varieties are certified, variations in their length of rest period must be considered. The Russet Rural for instance has a relatively long rest period while the Chippewa, Katahdin, Pontiac and some others have a much shorter rest period.

In conducting a potato breeding program, seed from potato seed balls has been planted in flats in the greenhouse during the month of September, transplanted to small flower pots in October, and the seedling tubers harvested the last two weeks of December. The tubers have then been placed in cold storage for 5 months which has provided sufficient time for the tubers to complete their dormant period. However, some years a second crop of seed is planted late in the winter and harvested late in the spring. This latter procedure has been unsatisfactory as the storage period between harvest and planting of the tubers in the field has been too short to permit normal sprouting. This has caused poor stands and difficulty in the selection of promising seedlings.

The irregularities encountered in the winter testing of certified seed samples, and the testing of spring grown potato seedlings warrants further investigation in methods of treatment with the ethylene chlorhydrin. The methods used and the results obtained are here given.

2. REVIEW OF LITERATURE

Most potatoes have a dormant period lasting for several weeks. Stuart (9) states that the dormant period includes a rest period in which the eyes of the tuber do not respond to normal growth stimuli (i.e. heat and light).

The length of the rest period in the potato tuber has been found to vary with different varieties. Rosa (7,8) states that in the case of the McCormick, Cobbler, and Bodegan varieties the rest period is considerably longer than that of the Early Rose, whereas a variety from Peru has no rest period.

Rosa (8), Appleman (1), and Werner (11) noted that the tubers harvested immature had a much longer dormant period than matured tubers. Loomis (6) states that in a lot of seed, the larger the tuber the more rapidly sprouting occurred.

As early as 1900-1909 several anaesthetical compounds were used to induce early sprouting. Appleman (1) found that by removing the skin of the tuber, especially near the eyes, at any stage of the rest period sprouting can be produced within 10 days. The earliest sprouting, in his work, occurred when the skins were removed from the tubers and the tubers cut lengthwise. He concluded that the abbreviation or elimination of the rest period, under the conditions used, correlated with increased oxygen adsorption. Appleman (1) also had marked results with the use of ethyl bromide.

Denny (2) tested 224 various chemicals for their effects on the sprouting of dormant tubers. The thiocyanates of sodium and potassium, and ethylene chlorhydrin gave the best and most consistent results.

Ethylene chlorhydrin was used in three ways; (1) soaking the tubers for 1½ - 2 hours in 38 - 40% solution, rinsing with tap water and planting, (2) dipping the tubers in a solution of 38 - 40% solution, diluted at the rate of 970cc to 30cc ethylene chlorhydrin and placing them in an air tight container for 16 - 24 hours at a temperature of 68 - 75° F., and (3) gas or vapor method by adding 38 - 40% solution to cloth, placing it in an airtight container with tubers for 2 days at 85°F., 4 days at 75°F., or 5 days at 65°F. Denny found the vapor method to be remarkably effective in causing prompt germination.

Denny (5) and Rosa (7) reported that if the temperature of the treatment was allowed to exceed 91° to 96° F. the seed pieces were killed.

Denny (3) also reported the danger of overtreating the tubers with the gas method. He recommended a storage of one week for greensprouting of the tubers after treatment to avoid the toxicity of the chemical. Tubers treated with certain concentrations of ethylene chlorhydrin when planted at once often rotted, but samples of the same lot held in air a few days after treatment did not rot but showed early, healthy, sprouting.

Denny (3) concluded that an ethylene chlorhydrin dip treatment was impractical until a storage period of 36 days after digging had been maintained, whereas a storage of 22 days was necessary in the use of the vapor or gas method.

3. THE TREATMENT OF RUSSET RURAL AND CHIPPEWA TUBERS WITH ETHYLENE CHLORHYDRIN

Experiment A.

A Comparison of Methods of Treatment with Ethylene Chlorhydrin

This experiment was set up to compare the gas, dip, and soak method for breaking the rest period of the potato tuber. Tubers 1½ - 2 inches in size were selected from one lot of certified Russet Rurals. These tubers were dug in October 1942 and treatment started December 15. Five concentrations of ethylene chlorhydrin (see table 1) were used in each of the three methods of treatment.

In the gas treatment, 5 lots of six tubers each were weighed and placed in metal boxes (14 x 9 x 7"). To these boxes were added small pieces of burlap soaked with the ethylene chlorhydrin solution at the rate of 1cc per pound of tubers. The boxes were then placed in an enclosed chamber (512 cu. ft.) for 96 hours at a temperature of 72 - 75°F.

In the dip treatment, 5 lots of 6 tubers each were placed in the various concentrations of solution (solutions diluted at the rate of 30cc ethylene chlorhydrin to 970cc water) from 10 - 20 seconds or enough time to permit the surface of the potato to become thoroughly covered with the solution. The tubers were than placed in boxes, in the enclosed chamber for 16 hours at a temperature of 72 - 75°F.

In the soak treatment, 5 lots of 6 tubers each were treated in open pans containing the various concentrations of solution, for 1½ hours at a temperature of 77°F. The tubers were then rinsed in tap water and set out to greensprout.

These three treatments were essentially those as outlined by Denny (2).

All results in table 1 were based on observations and counts of greensprouted tubers.

TABLE 1.

The treatment of Russet Rural tubers with ethylene chlorhydrin using 3 methods of treatment. All calculations in the table are based on the number of sprouts per tuber.

Method of Treatment	Concentration of Ethylene Chlorhydrin						Average number of Sprouts per Tuber of 30 Tubers
	30%	40%	50%	60%	70%	ck	
Gas	6.5	8.2	5.2	3.8	3.2	.8	5.2
Dip	0.0	0.0	0.0	1.2	11.2*	2.2	2.5
Soak	4.8	4.7	5.2	4.7	1.8	---	4.2

*Only treatment producing weak sprouts.

Results of table 1 show that the tubers treated in the lower concentrations (30% - 40% - 50%) of ethylene chlorhydrin produced the most vigorous sprouting. The 40% concentration using the gas method of treatment gave the best results. Plates 1 and 2, pages 24 and 25, show the difference between treated and untreated tubers and weak and vigorous sprouting.

The tubers in this experiment were actually treated about one month later than would be necessary for planting in Florida. However, this experiment provided a suitable comparison of methods of treatment for dormant tubers.

Experiment B.

Results of the Ethylene Chlorhydrin Treatment on the Michigan Grown Certified Seed Samples Planted in Florida for Disease Readings

In 1942 and 1943, two hundred tuber samples of each lot of certified seed that passed the field inspection requirements of the Michigan Crop Improvement Association, were collected during the month of October. These tubers were treated by the 40% gas method.* The tubers were planted in Florida the first week of December, and were ready for the disease reading test the first of February. At that time, H. C. Moore of the Farm Crops department at Michigan State College made the disease readings and the observations regarding the effectiveness of the treatment.

The 1943 planting in Florida was better in respect to stand and uniformity of plant size than was the 1942 planting. It was observed that in the Chippewa, Katahdin, Pontiac and Green Mountain varieties the chlorhydrin treatment was unnecessary as these varieties sent to Florida without treatment produced as good a stand and as much uniformity of plant development as the treated lots. None of the untreated Russet Rural lots, however, produced plants and many of the treated Russet Rural samples gave poor stands. Some of the Russet Rural lots gave stands comparable to the best lots of other varieties. A comparison of the various lots is best shown by giving them ratings of good, fair and poor. Of the 119 Russet Rural lots compared, 55 were classified as good, 50 as fair, and 14 as poor. In the lots classed as good the plants ranged from 16 - 18" in height with a 75 - 93% stand. Those classed as fair produced a stand of 30 - 75% and the plants ranged from 2 - 12" in height. The poor lots

*See Experiment 1.

ranged from 0 - 30% of a stand and the plants were 2" or less in height.*

To determine what factors might be responsible for causing the differences of stand and vigor of growth of the various lots in Florida, a study was made of the 1943 Michigan field records of each lot, to see if such factors as the length of growing season, the planting date, or the length of time between harvest and the time of the ethylene chlorhydrin treatment (graphs 1-2-3 pages 21, 22, 23) could have had any effect on the sprouting of the seed. The results of the test showed that generally the longer the growing season (shortest 92 days, longest 151 days) and the earlier the date of planting (earliest date May 10, latest date July 7), the better the stand of large vigorous plants (see graphs 1 - 3). The stand and plant growth apparently was not affected by the length of time between harvesting and treatment (shortest time 6 days, longest time 51 days, see graph 2).

Experiment C.

The Treatment of Florida Grown Tubers with Ethylene Chlorhydrin

The Chippewa and Russet Rural tubers for this experiment were harvested from two lots of certified seed grown in Florida. These lots were planted in Florida December 1, and harvested February 20, having a growing period of 84 days. Upon arrival at East Lansing the tubers were divided into lots of large (av. 4.5 oz.) and small (av. 2 oz.) tubers. Half of each lot was stored for 7 days at 50° to 55° F., and the other half at 34° to 36° F.

Forty tubers, of each variety, were used as checks. They were kept at room temperature during the time of treatment and greensprouting of

*It is to be noted that variations exist in the uniformity of plant development after most treatments for breaking the potato rest period. This is best illustrated by photographs of treated tubers resulting from experiments conducted by Denny (2).

the treated tubers, and then planted in the greenhouse. The remaining 70 tubers, of each variety, were treated whole, using a 40% ethylene chlorhydrin solution at the rate of 1cc. per pound (gas method). They were treated in air tight 4 gallon crocks for 72 hours at a temperature of 72° to 75°F. Immediately after treatment 5 large treated and 5 large untreated tubers, of each variety, were cut lengthwise making 40 seed pieces. In another lot of 10 large and 10 small treated and untreated tubers, the stem ends were cut off from each tuber. All tubers were then greensprouted 14 days after which the cutting procedure was repeated with the treated tubers. Twenty four hours later all cut and whole treated and untreated tubers were planted in the greenhouse.

Of the treated Russet Rural tubers, 69% rotted within two weeks after planting, whereas but 3% of the Chippewa tubers rotted. No comparisons could be made between the Russet Rural treatments due to the tuber rot, and they are not included in the results of table 1. There is a possibility that the immaturity of the Russet Rural was responsible for the high percentage of rot. This opinion is supported by the fact that the more matured Chippewa, under the same treatment conditions, was quite satisfactory. The Chippewa variety grew 84 of the 90 to 100 days necessary for its maturity, whereas the Russet Rural grew only 84 of the 120 to 130 days necessary for the maturity of this variety.

TABLE 1.

The effect of time and method of cutting seed, and size of tuber in the treatment of the Chippewa variety.

Comparison of time and method of cutting seed, and comparison of whole and cut seed	Average Height of Plants	
	Large tubers (4.5 ounces)	Small tubers (2 ounces
Tubers cut lengthwise immediately after treatment (10 seed pieces.)	8.5"	No treatment
Tubers cut lengthwise 14 days after treatment (10 seed pieces)	4.6"	No treatment
Tubers with stem end cut off immediately after treatment (10 tubers.)	7.0"	1.8"
Tubers with stem end cut off 14 days after treatment (10 tubers)	6.5"	3.5"
Tubers treated whole (10 tubers)	8.0"	4.0"
Whole tubers check (10 tubers no treatment.)	.6"	.1"
Tubers cut lengthwise check (10 seed pieces no treatment.)	.5"	.1"

The comparisons of table 1 of the average height of the plants in inches, were based on all tubers used for each treatment. The results indicate that the larger tubers, whether cut or whole, were better than the smaller tubers. In the large tuber treatments, those cut immediately after treatment were somewhat better than those cut 14 days later. The whole tubers produced approximately the same plant development as the best cut tubers.

4. SEEDLING PROGENY TREATMENTS WITH ETHYLENE CHLORHYDRIN

Experiment A.

A Comparison of Methods, Length of Treatment, and Concentration of Solution using Ethylene Chlorhydrin.

During the spring of 1943, about 500 seedlings were grown to maturity in the greenhouse and were harvested May 26. From these tubers 45 samples of 40 tubers each were selected. These 45 samples were divided into three groups of 15 lots each and were treated on June 8. The three treatments included in this study were the gas, dip, and soak. The lengths of time for the gas treatment were 12 - 24 - 48 hours, for the dip treatment 6 - 12 - 24 hours, and for the soak treatment 1 - 2 - 4 hours. The five concentrations of solution used for each method of treatment were 30% - 40% - 50% - 60% and 70%. All tubers were planted in the field June 12. On August 1 no plants had emerged from the ground and no sprouting was observed. A few plants appeared later, but were too late in emerging to be of value in the potato breeding program.

Experiment B.

The Effect of Length of Storage Period on Seedling Tubers Treated with Ethylene Chlorhydrin.

In experiment A, just discussed, the seedling tubers were harvested in the greenhouse May 26, treated June 8, and planted June 12. None of the plants emerged on August 1. It was suspected that the length of time in storage was too short between harvest and treatment with ethylene chlorhydrin.

In experiment B, the tubers were harvested in the greenhouse January 7 and stored at a temperature of about 55° F., until the first lot of 30 tubers was treated on January 20. At three day intervals, thereafter, 11 lots of 30 tubers each were treated. This provided for storage periods ranging from 13 to 46 days (see table 1).

Ethylene chlorhydrin was used in the dip method at concentrations of 30% - 40% and 50%. All samples were dug and examined on March 21, 75 days after harvest.

TABLE 1.

A comparison of 3 concentrations of ethylene chlorohydrin solution using the dip method of treatment at various intervals after harvest.

Number of days from harvest to treatment	Concentration of Ethylene Chlorhydrin											
	30%			40%			50%			Check		
	A*	B*	C*	A	B	C	A	B	C	A	B	C
13 - 19 days	40	13	47	33	27	40	30	43	27	20	80	0
22 - 28 days	33	57	10	20	60	20	23	54	23	20	80	0
31 - 37 days	27	73	0	27	67	6	47	50	3	45	55	0
40 - 46 days	33	63	4	10	83	7	7	80	13	20	80	0

A* = average per cent tubers sprouted.
B* = average per cent tubers not sprouted.
C* = average per cent tubers rotted.

Although an interval of 75 days had elapsed from the harvest of the tubers in January until the experiment was discontinued, table 1 shows that no treatment gave satisfactory germination percentages. From the standpoint of a plant breeding program the dip treatment of the tubers with ethylene chlorhydrin was not as effective as the 4 - 6 months

storage used on the fall grown seedling tubers. However, table 1 indicates that a storage period of about 35 days produced the lowest per cent rot, and from daily observations of the treated tubers, those treated and planted after a 35 days storage, produced more plants than did the tubers stored for shorter or longer periods.

Experiment C.

The Effect of the Ethylene Chlorhydrin Gas Treatment on Breaking the Dormancy of Seedling Tubers.

As a storage period of 35 - 40 days before treatment appeared to give the best results in Experiment B, the tubers, in this experiment, of nine seedling progenies were harvested in the greenhouse January 7, stored 39 days and treated February 15. For each sample, 10 tubers (6.3 gms. per sample) were placed in 3/4 by 5" test tubes.

Ethylene chlorhydrin solutions of various concentrations were added at the rate of 1cc., 2cc., or 4cc. of solution per pound of tubers. The proper quantity of solution was placed on a strip of filter paper and inserted in the test tubes, which were then stoppered. A total of 75 different treatments with 5 concentrations of solution (30% - 40% - 50% - 60% - 70%) for 5 treatment periods (4 - 8 - 16 - 24 - 48 hours) at the above mentioned rates were compared. The checks were placed in test tubes without the ethylene chlorhydrin solution. Five checks were used representing each length of time of treatment, and were stoppered for the required time. All lots were planted in the greenhouse on February 20.

The first plants emerged 10 days after planting which was similar to the emergence time for potatoes grown under field conditions. The photographs in plate 3, page 26 shows a comparison of growth of the var-

ious treated and untreated samples. The plate illustrates the fact that short periods of treatment with high rates of solution added (row 1), were more or less equivalent to long periods of treatment at lower rates (row 2), while the intermediate treatment lengths (row 3) were better than either. The photographs in plate 4, page 27 show that the short treatment periods at low rates of solution (row 1) and the long treatment periods at high rates of solution (row 2) were distinctly inferior to the intermediate treatment (row 3). It is evident that in both plates the ethylene chlorhydrin gas treatment was effective in inducing early sprouting. At no time, from planting to harvest of the experiment, did the tubers in the check equal the treated tubers in rate of plant emergence or in plant development (see table 1.).

TABLE 1.

Emergence of Plants as Affected by Three Rates of Ethylene Chlorhydrin

10 day intervals from planting of experiment.	Number of Plants Emerged, at Ten Day Intervals, Using Three Rates of Ethylene Chlorhydrin Solution			
	1cc./pound	2cc./pound	4cc./pound	check
10 days	41	65	22	0
20 days	93	116	77	50
30 days	112	131	100	65

At the completion of the experiment, (30 days after planting) the best results were produced from tubers treated for 8 to 16 hours with a 50% or 60% ethylene chlorhydrin solution at the rate of 2cc. per pound. Rotting of the tubers appeared to be quite low in the check as in the tubers treated for shorter treatment periods, lower rates and

with lower concentrations of solution. The per cent of rotting of the tubers increased as the rate, concentration, and time of treatment increased.

Previous work on seedling tubers indicated that sunburned or greened tubers were generally more dormant than ungreened or normal tubers. The observations of this experiment show that of 194 treated greened tubers, 27% germinated and the plants emerged, 16% only sprouted and 54% of the greened tubers remained dormant. Of the 300 ungreened tubers, 82% germinated and produced plants, 11% only sprouted, and 7% remained dormant.

5. THE TREATMENT OF SEEDLING PROGENIES WITH VARIOUS CONCENTRATIONS OF OXYGEN

Experiment A.

A Comparison of Concentration of Oxygen under Dry and Moist Conditions using Two Tuber Sizes.

This experiment was set up similar to an experiment on varietal tubers by Thornton (10). He obtained sprouts on tubers within 7 - 10 days after harvest with the use of 5% and 2% oxygen gas. In his work, the oxygen was lowered at the time of harvest by placing the tubers in containers and adding the various concentrations of the gas. He found that by subjecting the tubers to these low concentrations of oxygen the periderm thickened much sooner and became impermeable to oxygen and external gases, and that it was the lack of the gaseous material passing through the skin of the tuber that induced the early sprouting. He concluded that when a treatment developed an impermeable condition to external gases, it resulted in a much shorter rest period of the tuber.

It was an experiment that shortened the storage period from harvest to treatment which was found necessary by Denny (3) in the use of ethylene chlorhydrin for breaking the rest period of potato tubers.

In this experiment, the two gases (5% - 2% oxygen) were prepared by the dilution of air with pure nitrogen. Four lots of 90 tubers each were selected from the same seedling progeny (I.C. - 528-118). These four lots were made up of 2 lots of "large" (1.03 gms. per tuber) and 2 lots of "small" (.26 gms. per tuber). Previous observations had indicated that the small tubers were more subject to rotting and were somewhat less dormant than the larger tubers. Therefore, one lot of large and one lot of small tubers were exposed to the 5% oxygen gas, and one lot of each was exposed to the 2% oxygen gas. The 5% oxygen tubers were treated under moist conditions by placing wet sphagnum moss in the flask. The 2% oxygen tubers were treated under dry conditions. The treatment began immediately after the harvest of the tubers. Concentrated sodium hydroxide was placed in each flask of treated tubers to adsorb the CO_2 liberated and eliminate it as a possible factor in breaking the dormancy. At 24 hour intervals, the 300 ml. flasks containing the tubers were flushed out with 500 cc. of the 2% and 5% oxygen gases (by water displacement method). The small flasks containing the tubers were stored in a dark closet at room temperature (75 - 77°F.), and exposed to light only for length of time necessary to change the air. The tubers were treated for 7 days after which ten tubers were removed from each flask and planted. Every third day, thereafter, for a period of 31 days, 10 tubers were removed from each flask and planted.

The large and small check tubers for this experiment, were kept in a 300 ml. flask. The flasks were kept air tight by rubber stoppers, which were removed each 24 hours permitting a change of air. The first check was planted the day the experiment began; the second after a 7 day storage in the flask; and the other three at regular intervals throughout the experiment.

TABLE 1.

The reaction of large and small seedling tubers treated for various lengths of time in 5% and 2% oxygen.

Treatments	Days Treated in 2% and 5% Oxygen before Planting																				
	7			10			13			16			19			22			25			28			31		
	A*	B*	C*	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
5% O_2 Large	2	3	5	4	3	3	5	-	5	6	-	4	7	1	2	-	-	10	-	-	10	-	-	10	-	-	10
2% O_2 Large	3	5	2	5	3	2	2	6	2	6	2	2	3	-	7	5	-	5	4	2	4	4	-	6	3	-	7
5% O_2 Small	3	6	1	2	1	7	2	6	2	-	-	10	-	-	10	-	-	10	-	-	10	-	-	10	-	-	10
2% O_2 Small	3	6	1	2	6	2	1	5	4	1	5	4	2	-	8	2	3	5	1	-	9	-	1	9	2	-	8
Ck. Small	4	4	2	-	-	-	3	5	2	6	-	-	-	-	-	4	2	4	-	-	-	-	-	-	5	2	3
Ck. Large	5	4	1	-	-	-	5	4	1	-	-	-	-	-	-	3	4	3	-	-	-	-	-	-	9	-	1

A* = number of tubers sprouted.
B* = number of dormant tubers.
C* = number of tubers rotted.

From table 1, it is evident that none of the treatments were much better than the check, and that in the 5% moist treatments a high percentage of rot occurred in both the large and small tubers. In the 2% dry oxygen treatment less rotting occurred. This is in accord with the findings of Thornton (10).

It was observed, from the growing plants, that the check tubers planted immediately after harvest produced no plants, while the other check tubers produced as good a per cent stand and plant development as the treated tubers. The longer the check tubers were kept in the air tight flasks the more plants and sprouting they produced. This condition indicated that the CO_2 evolved in the respiratory reactions of the tubers had some influence in shortening the rest period.

6. SUMMARY

Dormancy of the potato tuber has been directly responsible for the failure to obtain accurate disease readings on certified seed samples tested in Florida, and to obtain satisfactory stands from spring grown seedling tubers used for breeding purposes. Several methods were tested to determine an efficient procedure for the handling of tubers before, during, and after treatment with ethylene chlorhydrin.

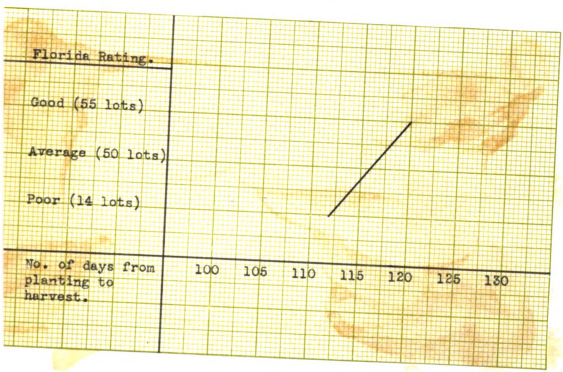
The results, of this study, indicated that the Russet Rural variety was the only variety (Chippewa, Katahdin, Pontiac, Green Mountain, and Sebago) in which an ethylene chlorhydrin treatment was necessary to obtain prompt emergence. The response of the Russet Rural tubers to the chemical treatment varied within and between lots. From experiments in the greenhouse it appeared that larger tubers should be treated and cut immediately after treatment. The best results with ethylene chlorhydrin were obtained by the use of the gas method of treatment with a 40% concentration of solution, at the rate of 1cc. per pound of tubers, for a period of either 72 or 96 hours at a temperature of 72° to 75° F.

Tubers from seedling plants were treated with ethylene chlorhydrin. The results of this study indicated that in general no method of treatment produced sprouting equal to tubers untreated and stored for 4 - 6 months between harvest and field planting, where a range in germination of 80% or better is usually secured. Since the majority of treatments in this paper have not approached that range in germination, potato seedlings should be grown in the fall of the year. If, however, it would be necessary to grow seedlings in the spring of the year, the seedling plants should be planted early enough to provide for a 35 to 40 days storage period between harvest and treatment of the tubers. The tubers should

then be treated with ethylene chlorhydrin using the gas method, with a 50% or 60% solution for 8 or 16 hours at the rate of 2cc. per pound of tubers. The temperature should range from 72° to 77° F.

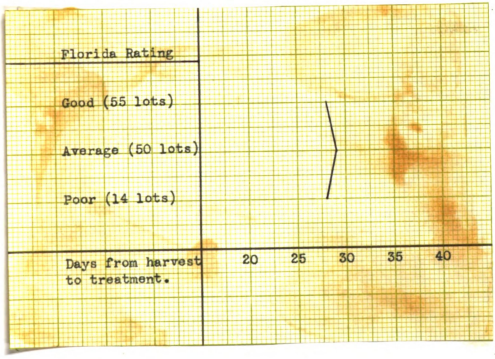
7. GRAPHS AND PLATES

GRAPH 1.



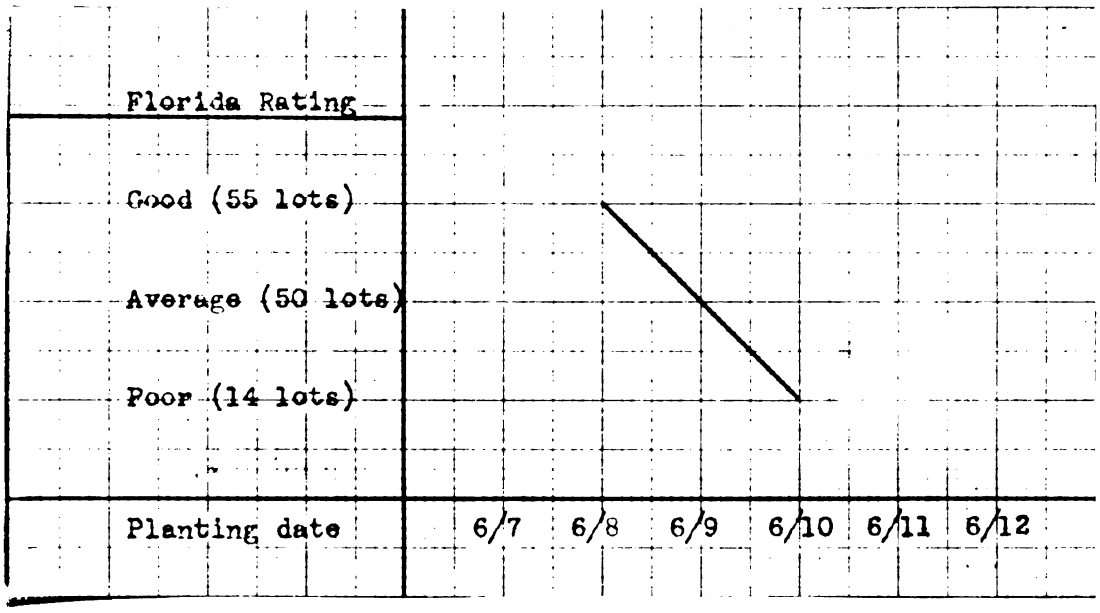
Length of growing season in days.

GRAPH 2.



Time in days between harvest and treatment.

GRAPH 3.



Planting Dates.

PLATE 1.

Photographs showing differences between treated and untreated Russet Rural and Chippewa tubers.

Row 1.

Row 2.

Row 1. - Russet Rural tubers - Left - 5 tubers untreated.
Right - 5 tubers treated.

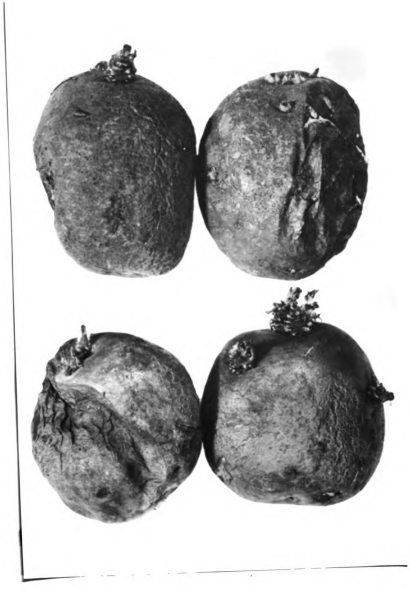
Row 2. - Chippewa tubers - Left - 5 tubers untreated.
Right - 5 tubers treated.

PLATE 2.

Photograph of Russet Rural and Chippewa tubers showing differences between vigorous and weak greensprouting.

Row 1.

Row 2.

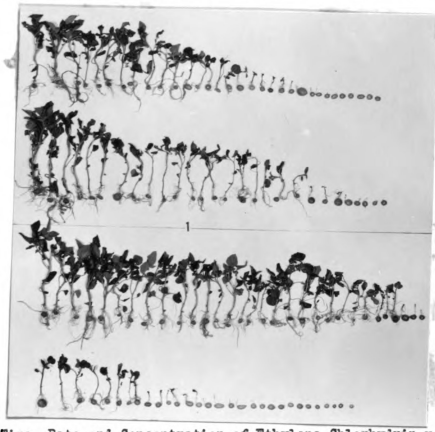


Row 1. - Russet Rural tubers - Left tuber - vigorous greensprouting.
Right tuber - weak grensprouting.

Row 2. - Chippewa tubers - Left tuber - weak greensprouting.
Right tuber- vigorous greensprouting.

PLATE 3.

Photograph showing the effect of various lengths and rates of ethylene chlorhydrin treatment on plant development.



Time, Rate and Concentration of Ethylene Chlorhydrin used.

(1). 5 treatment periods (4 - 8 - 16 - 24 - 48 hours).
(2). 3 rates of solution (1 - 2 - 4 cc. per pound of tubers).
(3). 5 contrations of solution (30 - 40 - 50 - 60 - 70%).

Row 1. Short treatment periods at high rates of solution (tubers treated for 4 - 8 hours at rate of 4 cc. per pound, with 50%, 60%, and 70% concentrations of solution).
Row 2. Long treatment periods at low rates of solution (tubers treated for 24 - 48 hours at rate of 1 cc. per pound, with 50%, 60%, and 70% concentrations of solution).
Row 3. Intermediate treatment periods at intermediate rates of solution (tubers treated for 8 - 16 hours at rate of 2 cc. per pound, with 40%, 50%, and 60% concentrations of solution).
Row 4. No treatment (checks).

PLATE 4.

Photograph showing the effect of various lengths and rates of ethylene chlorhydrin treatment on plant development.

Row 1.

Row 2.

Row 3.

Row 4.

Time, Rate and Concentrations of Ehtylene Chlorhydrin used.

(1). 5 lengths of treatment (4 - 8 - 16 - 24 - 48 hours).
(2). Rates of solution (1 - 2 - 4 cc. per pound of tubers).
(3). 5 concentrations of solution (30 - 40 - 50 - 60 - 70%).

Row 1. Short treatment periods at low rates of solution (tubers treated at rate of 1 cc. per pound for 4 - 8 hours, with 50%, 60%, 70% concentrations of solution.
Row 2. Long treatment periods at high rates of solution (tubers treated at rate of 4 cc. per pound for 24 - 48 hours, with 30%, 40% and 50% concentrations of solution.
Row 3. Intermediate treatment periods at intermediate rates of solution (tubers treated at rate of 2 cc. per pound for 8 - 16 hours, with 40%, 50% and 60% concentrations of solution.
Row 4. 5 lots untreated (check).

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