

THE BREAKING OF THE REST PERIOD  
IN THE MATURE IRISH POTATO AS  
RELATED TO VARIETIES AND TIME  
OF TREATMENT

THESIS FOR THE DEGREE OF M. S.

Cloyd G. Swem

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Potatoes







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THESIS

Submitted to the faculty of Michigan State College  
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*P. J. Hebbard*

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The Breaking of the Rest Period in the Mature  
Irish Potato as Related to Varieties and Time  
Of Treatment.

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Introduction

The potato is a member of the Solanaceae family and is known botanically as *Solanum tuberosum*. Morphologically it is a thickened stem with the eyes representing buds from which shoots will arise. As the tubers are stems and the eyes, buds, it is natural to believe that they will develop like stems and buds of other plants.

Johannsen (7) concluded as a result of studies on a few woody plants that dormancy was divided into three periods; a preliminary rest, a deep rest and a forced rest. The middle period required stringent methods to return buds to active growth. Our object of this study was to determine what period in the dormancy of the potato tuber was the most difficult to shorten.

Potato varieties are classified into early, late and very late maturing groups. Are the varieties that mature at different times responsive to chemical treatment for breaking dormancy, in the same degree or not? Can one standard treatment be used on all varieties tested, or must certain varieties be dipped in one concentration and others in a different concentration to obtain the same results? Are there definite periods of time of exposure to the vapor that will give the best results, or may other periods of time be as effective?

## Historical Resume

Jost (§) says that developmental processes in organisms are not always carried out with the same degree of activity nor at an equal rate. Thus periodicity variations arise. These are due sometimes to more or less recognizable external factors, and again sometimes to purely internal conditions. Among these various activities the resting period is of special interest.

Winter buds exhibit the rudiments of an entire shoot which develops when a proper length of time has passed and conditions are favorable for growth. The winter buds begin to form in May or June, but they unfold only in the following spring. It is impossible to believe that the time between June and September does not provide suitable external conditions for immediate growth. This would indicate that internal conditions are affecting the development of the shoot the following spring.

Eyes, or buds, on potatoes are formed in June, go through the resting period and develop shoots the following February. This resting period is easily lengthened by external conditions, but is with difficulty shortened. Much study has been given to the problem of why plant organs pass into a period of rest, and how the rest period may be shortened.

It is believed by some that growth inhibiting substances lead to the rest period and that a breaking of the rest period depends on a method of removing the inhibiting agencies.

Jost (§) in quoting Johannesen, writes that, "the action of ether is that of an anaesthetic, i.e. that certain functions which tend to retard growth in the plant are inhibited by the ether." "It is more likely, "Jost writes further, "that we have to deal

not with a specific action of ether, but that other poisons may produce a similar effect. What we have to think of is the stimulatory action which we have seen poisons to possess when below that degree of concentration which is fatal. We have every right to assume that active metabolic processes go on in the plant during the resting period."

Maximov (11) writes that in general all vital activities manifest themselves during dormancy with the exception of growth, which does not take place though external conditions may be favorable.

Askenasy (1) also found that a complete rest, where growth is at an absolute standstill, does not occur in buds.

Potatoes matured in September and October, can not be made to sprout immediately after harvesting even if favorable external conditions are supplied. In the early spring the same potatoes will sprout in a cold, dry room.

This appears quite similar to the conditions in the buds of certain woody stems. In this case the first period of dormancy is the summer stage and buds are readily returned to active life. In the fall, after the leaves have fallen, dormancy of buds is deepest and it is difficult to bring the buds into active life. Forced rest comes in the early spring when the external conditions are unfavorable for growth. Since the absence of growth in this period is not due to internal factors the usual stimulants will not hasten the unfolding buds.

Many experiments in past years have been conducted and tubers can now be made to sprout when stimulated by chemicals and supplied



with favorable external conditions for growth. Chemical treatments for breaking the dormant period in plants have been known for some time.

Loomis and Evans (10) reported that any vegetative organ containing stored starch will respond to treatments of ethylene, ethylene chlorhydrin, ether and similar volatile compounds.

W. E. Loomis (9) says that possibly dormancy may be related to cytoplasmic structure and that the rest period may be broken by changes in the permeability of the cytoplasm. A temperature of  $30^{\circ}\text{C}$  to  $33^{\circ}\text{C}$  for a period of four weeks induced earlier sprouting.

Earlier workers such as Müller-Thurgau and others subjected dormant potatoes to low temperatures with varying results. Müller-Thurgau found that the rest period could be shortened by one month, with a treatment of one month's duration at  $0^{\circ}\text{C}$ . More recent work has shown that temperature is not a primary factor.

C. O. Appleman<sup>11</sup> found that growth could be stimulated by cutting or peeling the tubers. In removing the skin he believed that oxygen had a freer access to the cells and thus released certain agents that promoted growth.

R. N. Salaman (17) reported favorable results by removing cylinders of potato tissue with a cork borer, thus exposing the cells to a more active absorption of oxygen.

McCallum (12) using ethyl bromide, chloroform, ammonia and gasoline found these chemicals had some effect on shortening the rest period. Ethyl bromide was more effective than the other chemicals.

C. O. Appleman (2) has shown that hydrogen peroxide could





stimulate dormant potatoes to early growth.

J. T. Rosa (14) working with Russett Burbank reports a marked response when dormant seed pieces were planted in soil to which nitrate of soda had been added. Potassium permanganate and ferric chloride all shortened the dormant period. During these experiments it was found that the middle and terminal periods of dormancy were most reactive to treatments. The first period seemed to resist treatment.

J. T. Rosa 1929 (15) treated the varieties White Rose, Idaho Rural and Irish Cobbler with the vapor of ethylene chlorhydrin. White Rose and Idaho Rural made good responses when treated immediately after harvest. The results were not favorable when treatment was made in the middle or terminal periods.

This conclusion is diametrically opposed to his previous work done in 1923. Further J. T. Rosa found that ammonium thiocyanate was more effective than ethylene chlorhydrin when used to stimulate Irish Cobbler. Ethyl bromide was not suitable for cut tubers as it caused excessive rotting. Sodium nitrate was moderately effective, but caused excessive decay when the seed pieces were planted in hot weather. Ethylene dichloride showed good results on cut sets when used either in the liquid or vapor.

F. E. Denny 1926 (3) in his first report was successful in breaking the rest period of Bliss Triumph with ethylene chlorhydrin.

In his second report (4) he showed that out of several hundred chemicals ethylene chlorhydrin and sodium thiocyanate were the most effective. Three methods were used. Seed pieces were dipped into the solution and then exposed to the vapor which arose from the wet

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surface of the potatoes which were placed in air tight containers after immersion. The second method was to expose the potatoes to the vapors in an air tight container without first dipping them. The third method was to soak whole tubers in the solutions over a period of one or two hours, depending on conditions. Later they were cut and then planted. Denny designates these methods as dip, vapor and soak.

L. P. Miller (13) in experimenting with sulphur compounds, found that ammonium dithiocarbamate was effective. The method of treatment was to soak the seed pieces for one hour and then to plant immediately.

This method and this chemical seem from our meagre experiments to warrant further study but for lack of space too few tests were made to obtain more than general ideas.

This experiment was conducted in the Botany Greenhouse at Michigan State College, East Lansing, Michigan. The work should be repeated on a larger scale.

#### Methods and Treatments

The treatments for all varieties were the dip and soak as outlined by Denny. The dip method was more satisfactory with ethylene chlorhydrin while sodium thiocyanate and ammonium dithiocarbamate were more conveniently handled by the soak method. Ethylene chlorhydrin was the forty percent commercial grade. The sodium thiocyanate was of the regular laboratory grade. The ammonium dithiocarbamate was prepared according to the method suggested by Freund and Bachrach (6).

Ethylene chlorhydrin was made up with distilled water into five



concentrations; twenty, twenty-five, thirty, thirty-five and forty c.c. per liter of water.

Sodium thiocyanate was made up into one, two, three, four and five percent solutions. Ammonium dithiocarbamate was made into the concentrations of one fourth, one, one and one fourth percent solutions with distilled water.

The solutions for dipping or soaking were put into two gallon crocks, each crock representing one of the concentrations. The ten varieties of potatoes used were Brown Beauty, Early Rose, Early Ohio, Spaulding Rose, Irish Cobbler, Russett Rural, Russett Burbank, Kathadin, Peachblow and Green Mountain. The seed pieces were of the usual block, shape and weight recommended. Two or more eyes were left to a seed piece. To keep the seed pieces of each variety together when dipping and exposing to vapor, they were placed in cloth bags. The stock supply of potatoes was kept in the basement at a low temperature between periods of treatment.

To test the oft repeated statement that dormancy can be shortened more easily just after harvest or at the end of the regular dormant period and can only with difficulty be broken in the middle, seed pieces were treated chemically about every ten days from October 22, 1932, seven days after harvesting to December 5, 1932, when the planting program was ended. Of necessity, this work had to be done in the greenhouse, in steam-heated cold frames and under the greenhouse benches. Plants were not grown to maturity, but sufficiently long enough to show how effective the chemical treatments had been, and what type or kind of growth had been produced. Sufficient control cultures were set up to run under the same



environmental conditions to which the test plants were exposed. From October 22 to December 5 there were four periods in which chemical treatments were made. The routing of treatment was the same for each period. The potatoes were cut into seed pieces which were placed in bags, dipped into the solutions of varying concentrations. These were then exposed to the vapors arising from the wet surfaces in a tightly covered container for varying periods of time arbitrarily determined. On removal they were placed on a table to aerate for varying periods of time (2-7 days). It was found, as shown by Denny (4), that this prevented rotting. It was determined also that two days exposure at room temperature was just as effective as seven days, the only essential condition being to allow time for the surfaces to dry thoroughly. Each variety of potato was treated like the other.

The procedure followed in gathering data was as follows: the planted areas were inspected every day for shoots appearing above ground. As the shoots appeared the dates were noted, and when all had appeared an average was calculated for every feature of the treatment and for each variety. The dry weights of the plants were determined as this could, with certain reservations, serve as an indication of the response to the different tests made. While a great many factors enter into the calculations it was thought that the dry weights of the foliage would show a definite relationship between the percentage of germination and the time of appearance above ground for all varieties in a period. Dry weight yield can not, however, be used for comparison between periods. The variety

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making the earliest appearance and showing the strongest germination would naturally give the greatest weight.

### Experimental Results

The following table is given to show the days aerated and dates of planting in accordance with the treatments. The other necessary data as percentage of germination, dry weight yield, and time of appearance of shoots above ground, for the different periods and treatments will be given in tabular form when treatments of the individual periods are discussed. Ethylene chlorhydrin is the chemical which has been used in all of the following periods of experimentation.



| Concentrations | Hours<br>Exposed to<br>Vapor | Days Aerated<br>Periods |          |         |          | Date Planted<br>Periods |    |     |      |
|----------------|------------------------------|-------------------------|----------|---------|----------|-------------------------|----|-----|------|
|                |                              | I                       | II       | III     | IV       | I                       | II | III | IV   |
| 20             | 16                           | Two                     | 10/24/32 | 11/1/32 | 11/14/32 | 12/1/32                 |    |     |      |
|                | 24                           | Four                    | 26/32    | 11/3/32 | 16/32    |                         |    |     |      |
|                | 32                           | Six                     | 28/32    | 5/32    | 18/32    |                         |    |     |      |
|                | 48                           | Seven                   | 29/32    | 6/32    | 19/32    |                         |    |     |      |
|                | 16                           | Three                   | 25/32    | 2/32    | 15/32    |                         |    |     |      |
| 25             | 24                           | Two                     | 27/32    | 4/32    | 17/32    |                         |    |     |      |
|                | 32                           | Seven                   | 29/32    | 6/32    | 19/32    |                         |    |     |      |
|                | 48                           | Seven                   | 29/32    | 6/32    | 19/32    |                         |    |     |      |
|                | 16                           | Four                    | 26/32    | 3/32    | 16/32    |                         |    |     |      |
|                | 24                           | Six                     | 28/32    | 5/32    | 18/32    |                         |    |     |      |
| 30             | 32                           | Seven                   | 29/32    | 6/32    | 19/32    |                         |    |     |      |
|                | 48                           | Seven                   | 29/32    | 6/32    | 19/32    |                         |    |     | 6/32 |
|                | 16                           | Five                    | 27/32    | 4/32    | 17/32    |                         |    |     |      |
|                | 24                           | Seven                   | 29/32    | 6/32    | 19/32    |                         |    |     |      |
|                | 32                           | Seven                   | 29/32    | 6/32    | 19/32    |                         |    |     | 6/32 |
| 35             | 48                           | Two                     | 24/32    | 1/32    | 14/32    |                         |    |     |      |
|                | 16                           | Four                    | 26/32    | 3/32    | 16/32    |                         |    |     |      |
|                | 24                           | Six                     | 28/32    | 5/32    | 18/32    |                         |    |     |      |
|                | 32                           | Seven                   | 29/32    | 6/32    | 19/32    |                         |    |     |      |
|                | 48                           | Seven                   | 29/32    | 6/32    | 19/32    |                         |    |     |      |
| 40             | 16                           | Two                     | 24/32    | 1/32    | 14/32    |                         |    |     |      |
|                | 24                           | Four                    | 26/32    | 3/32    | 16/32    |                         |    |     |      |
|                | 32                           | Six                     | 28/32    | 5/32    | 18/32    |                         |    |     |      |
|                | 48                           | Seven                   | 29/32    | 6/32    | 19/32    |                         |    |     |      |



### First Period

Table one, graph one shows that Russett Rural, Kathadin, Irish Cobbler, Peachblow and Green Mountain gave the lowest dry weight yields. It was also found that, with the exception of Irish Cobbler, the same varieties gave the poorest percentages of germination and made later appearances, than the other varieties. (See tables 3 and graphs 4). Exposures of sixteen to twenty-four hours for all the above varieties, except Irish Cobbler, were just as effective as the longer exposures. This shows that the effective exposures could vary between sixteen and twenty four hours.

Table two and graph two show the dry weight yields as affected by the different concentrations. These weights indicate that Brown Beauty, Early Rose, Spaulding Rose and Irish Cobbler made the best response to treatment. The lower concentrations are effective and the most favorable periods of exposure to the vapor appear to be the shorter ones. This all goes to show that ~~the~~ these early maturing varieties, with the exception Brown Beauty, will be more responsive to the lower concentrations, and shorter periods of exposure. Early Ohio, Russett Burbank, Russett Rural, Kathadin, Peachblow and Green Mountain, all late maturing varieties, except Early Ohio, respond to the higher concentrations and longer periods of exposure.

Table three and graph three show the percentage of germination for each variety under the conditions of the experiment. Brown Beauty, Early Rose, Early Ohio, Spaulding Rose and Russett Burbank responded with high germination and indicated that the lower

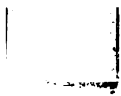


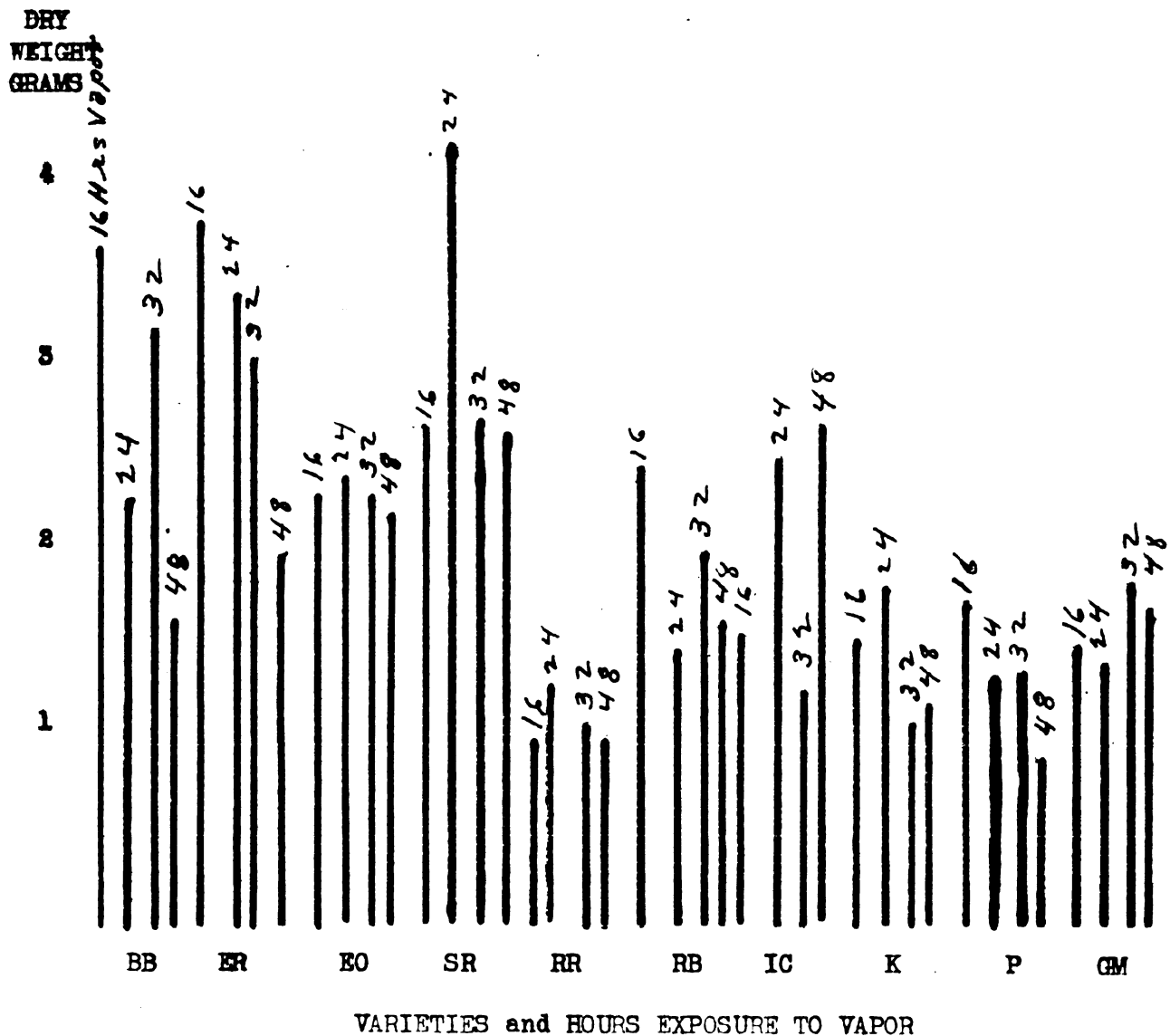
TABLE 1

Dry Weight Data for All Varieties at Varying  
Hours of Exposure to the Vapor of Ethylene  
Chlorhydrin. First Period Average of Fifteen  
Plants.

| Hours Exposed to Vapor |       |       |       |                 |
|------------------------|-------|-------|-------|-----------------|
| 16.                    | 24.   | 32.   | 48.   | Varieties       |
| Grams                  | Grams | Grams | Grams |                 |
| 3.75                   | 2.40  | 3.30  | 1.70  | Brown Beauty    |
| 3.90                   | 3.50  | 3.20  | 2.00  | Early Rose      |
| 2.40                   | 2.45  | 2.40  | 2.25  | Early Ohio      |
| 2.75                   | 4.30  | 3.80  | 3.20  | Spaulding Rose  |
| 1.05                   | 1.40  | 1.10  | 1.05  | Russett Rural   |
| 2.50                   | 1.50  | 2.10  | 1.65  | Russett Burbank |
| 1.65                   | 2.60  | 1.40  | 2.80  | Irish Cobbler   |
| 1.60                   | 1.80  | 1.15  | 1.20  | Kathadin        |
| 1.80                   | 1.50  | 1.50  | 1.00  | Peachblew       |
| 1.60                   | 1.50  | 1.80  | 1.70  | Green Mountain  |

GRAPH 1

DRY WEIGHT DATA FOR ALL VARIETIES AT VARYING HOURS  
OF EXPOSURE TO THE VAPORS OF ETHYLENE CHLORHYDRIN.  
FIRST PERIOD AVERAGE OF FIFTEEN PLANTS.





**TABLE 2**

Dry Weight Data of Ten Varieties of Potatoes  
Previously Treated with Varying Concentrations  
of Ethylene Chlorhydrin. First Period Average  
of Twelve Plants.

| 20 c c<br>Grams | 25 c c<br>Grams | 30 c c<br>Grams | 35 c c<br>Grams | 40 c c<br>Grams | Varieties       |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| 2.90            | 4.80            | 4.85            | 2.50            | 1.80            | Brown Beauty    |
| 3.40            | 2.90            | 4.70            | 2.40            | 3.50            | Early Rose      |
| 2.40            | 1.20            | 1.40            | 2.50            | 3.90            | Early Ohio      |
| 1.30            | 3.40            | 2.90            | 2.40            | 2.50            | Irish Cobbler   |
| 1.              | .70             | 2.              | 2.2             | 1.70            | Russett Rural   |
| 1.50            | 1.90            | 2.10            | 1.40            | 2.90            | Russett Burbank |
| 3.60            | 3.30            | 3.70            | 3.              | 2.80            | Spaulding Rose  |
| 1.80            | .90             | 1.20            | .80             | 2.60            | Kathadin        |
| 3.10            | 1.80            | 1.70            | 1.30            | 2.8             | Peachblow       |
| 1.80            | 1.30            | 1.              | 1.20            | 1.90            | Green Mountain  |

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## GRAPH 2

Dry Weight Data of Ten Varieties of  
Potatoes Previously Treated with  
Varying Concentrations of Ethylene  
Chlorhydrin. First Period Average  
of Twelve Plants

Dry Weight

Grams

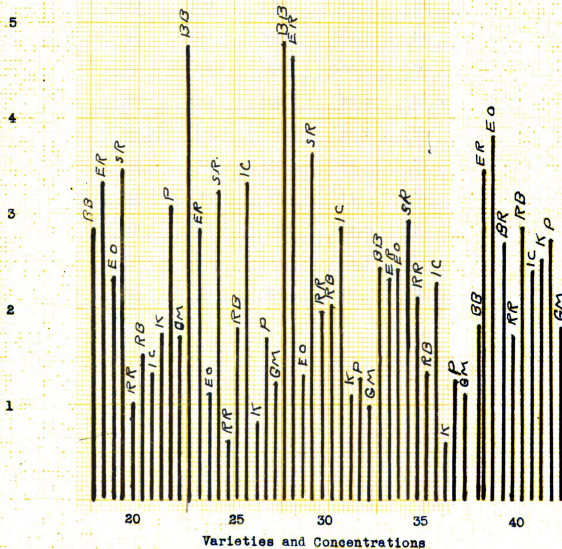


TABLE 3

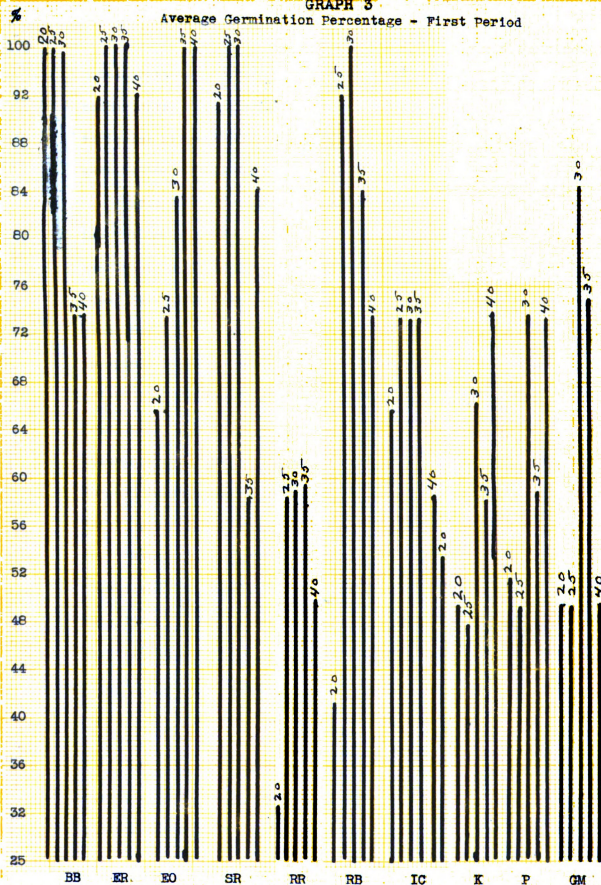
Germination Percentages of Tubers of Ten Varieties  
 In Varying Concentrations of Ethylene Chlorhydrin.  
 First Period Average of Twelve Plants.

| 20 c c<br>% | 25 c c<br>% | 30 c c<br>% | 35 c c<br>% | 40 c c<br>% | Varieties       |
|-------------|-------------|-------------|-------------|-------------|-----------------|
| 100         | 100         | 100         | 74          | 74          | Brown Beauty    |
| 92          | 100         | 100         | 100         | 92          | Early Rose      |
| 66          | 74          | 84          | 100         | 100         | Early Ohio      |
| 92          | 100         | 100         | 58.5        | 83.5        | Spaulding Rose  |
| 33.33       | 58.5        | 58.5        | 58.5        | 50          | Russett Rural   |
| 42          | 92          | 100         | 84          | 74          | Russett Burbank |
| 66          | 74          | 74          | 74          | 59          | Irish Cobbler   |
| 52          | 50          | 66          | 58.5        | 74          | Kathadin        |
| 52          | 50          | 74          | 58.5        | 74          | Peachblow       |
| 50          | 50          | 84          | 74          | 50          | Green Mountain  |



GRAPH 3.

Average Germination Percentage - First Period



Varieties and Concentrations



concentrations of ethylene chlorhydrin were just as effective as the higher ones, with the exception of Early Ohio. The other five varieties responded better to higher concentrations, but here the germination percentages were lower.

Table four and graph four show the average number of days elapsing after planting, before the shoots appeared above ground. As was to be expected the early maturing varieties came up first. Early Rose, Spaulding Rose and Irish Cobbler made the earliest appearance. Brown Beauty, a late variety, also appeared early. The time taken to appear above ground for these varieties, with the exception of Irish Cobbler, which came later, was between twenty one and twenty four days. The concentration giving the best results with the early maturing varieties was thirty or thirty-five c.c. per liter of water. Russett Burbank, Kathadin, Peachblow, Green Mountain and Russett Rural appear later and need higher concentrations.

These results would seem to indicate that the varieties group themselves, as regards their response to the different treatments, into three groups, and possibly two. The response seems related to the earliness or lateness of maturity in the different varieties.

#### Second Period

The second period results were very similar to those of the first. Potato seed pieces from each variety were treated and planted in the same way as in the first period. These potatoes had been in storage sixteen days from the date of harvesting and it is supposed that they were more dormant than those in the first period.





TABLE 4

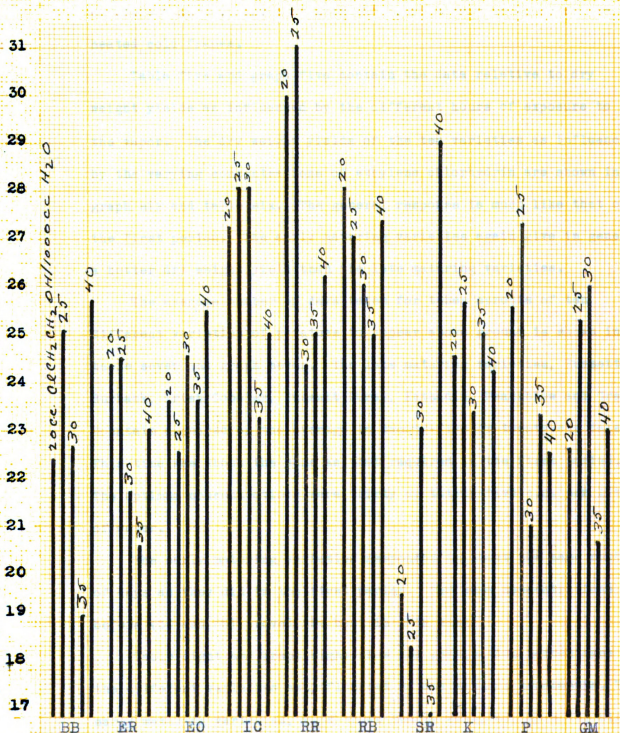
Average Number of Days Taken for the Appearance  
of Tuber Sprouts Above Ground at Varying Concentrations of Ethylene Chlorhydrin. First Period.

| 20 c c<br>Days | 25 c c<br>Days | 30 c c<br>Days | 35 c c<br>Days | 40 c c<br>Days | Varieties       |
|----------------|----------------|----------------|----------------|----------------|-----------------|
| 22.3           | 25             | 22.6           | 19             | 25.6           | Brown Beauty    |
| 24.3           | 23.2           | 23             | 24.5           | 21.7           | Early Rose      |
| 23.5           | 22.5           | 24.5           | 23.7           | 25.5           | Early Ohio      |
| 27.2           | 28             | 28             | 23.3           | 25             | Irish Cobbler   |
| 30.4           | 31             | 24.3           | 25             | 26.7           | Russett Rural   |
| 28             | 27             | 26             | 25             | 27.2           | Russett Burbank |
| 19.5           | 18.5           | 23             | 17             | 29             | Spaulding Rose  |
| 24.4           | 26.6           | 23.2           | 25             | 24.2           | Kathadin        |
| 25.5           | 27.4           | 21             | 23             | 22.5           | Peachblow       |
| 22.7           | 25.2           | 26             | 20.5           | 23             | Green Mountain  |

GRAPH 4

Average Number of Days Taken for the Appearance  
of Tuber Sprouts Above Ground at Varying Concentrations  
of Ethylene Chlorhydrin. First Period

Days



Varieties and Concentrations

The dry weight yields were not quite up to those of the first period, although the plants had grown 15 or 20 days longer. This is probably due to slightly less favorable growing conditions, especially light. The plants in this period were grown in steam-heated cold frames.

Table five and graph five contain the data relative to dry weight yields as influenced by the different hours of exposure to the vapor. The dry weight yields of the ten varieties as influenced by the varying concentrations of ethylene chlorhydrin are shown in graph six and table six. The general response is much like that of the first period. The early maturing varieties again give in general a better dry weight yield than the late maturing varieties.

The average number of days taken for tuber sprouts of ten different varieties of potatoes to appear above ground is shown in table seven and graph seven. The late maturing varieties, Russett Burbank, Irish Cobbler, Russett Rural, Kathadin, Peachblow and Green Mountain appeared on the average in twenty-five or twenty-six days. This time was about the same as that required in the first period. The optimum concentrations were thirty or thirty-five c.c. per liter of water.

The early maturing varieties responded in about the same number of days as they did in the first period. The same concentrations as before (30 and 35) proved the best in this case.

Table eight and graph eight show the germination percentages of the different varieties as influenced by the various treatments. The early maturing varieties, with Brown Beauty excepted, gave the highest germination results. The late maturing varieties do not germinate as



TABLE 5

Dry Weight Data for All Varieties at Varying  
Hours of Exposure to the Vapor of Ethylene  
Chlorhydrin. Second Period Average of Fifteen  
Plants.

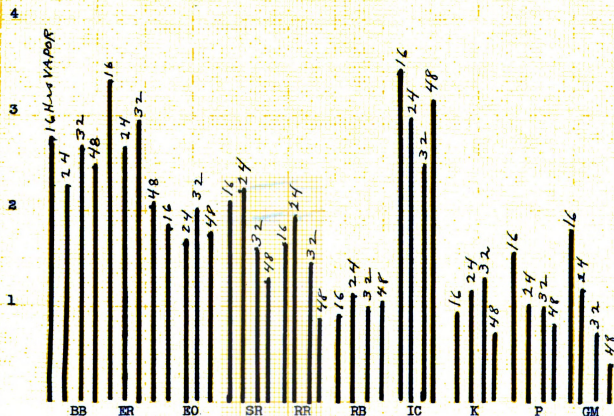
| Hours Exposed to Vapor |              |              |              | Varieties       |
|------------------------|--------------|--------------|--------------|-----------------|
| 16.<br>Grams           | 24.<br>Grams | 32.<br>Grams | 48.<br>Grams |                 |
| 2.74                   | 2.18         | 2.63         | 2.45         | Brown Beauty    |
| 3.32                   | 2.63         | 2.93         | 2.03         | Early Rose      |
| 1.80                   | 1.65         | 2.03         | 1.73         | Early Ohio      |
| 3.40                   | 2.90         | 2.50         | 3.07         | Spaulding Rose  |
| 1.65                   | 1.96         | 1.45         | .90          | Russett Rural   |
| .90                    | 1.10         | .95          | 1.           | Russett Burbank |
| 2.10                   | 2.20         | 1.60         | 1.25         | Irish Cobbler   |
| 1.                     | 1.60         | 1.30         | .70          | Kathadin        |
| 1.20                   | .95          | .87          | .80          | Peachblow       |
| 1.80                   | 1.10         | .68          | .40          | Green Mountain  |



## GRAPH 5

DRY WEIGHT DATA FOR ALL VARIETIES AT VARYING  
HOURS OF EXPOSURE TO THE VAPORS OF ETHYLENE  
CHLORHYDRIN. SECOND PERIOD AVERAGE OF FIFTEEN  
PLANTS.

DRY  
WEIGHTS  
GRAMS



VARIETIES and HOURS EXPOSURE to VAPOR



TABLE 6

Dry Weight Data of Ten Varieties of Potatoes  
Previously Treated with Varying Concentrations  
of Ethylene Chlorhydrin. Second Period Average  
of Twelve Plants.

| 20 c c<br>Grams | 25 c c<br>Grams | 30 c c<br>Grams | 35 c c<br>Grams | 40 c c<br>Grams | Varieties       |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| 2.              | 3.              | 1.90            | 3.70            | 1.70            | Brown Beauty    |
| 2.25            | 2.55            | 2.70            | 2.40            | 3.50            | Early Rose      |
| 2.25            | 1.90            | 3.35            | 1.25            | 1.55            | Early Ohio      |
| 1.50            | 1.70            | 2.              | 2.80            | 2.35            | Irish Cobbler   |
| 1.50            | 1.55            | 1.90            | 1.40            | 1.50            | Russett Rural   |
| 1.15            | 1.              | 1.75            | .70             | 2.              | Russett Burbank |
| 2.30            | 3.20            | 2.80            | 1.25            | 3.70            | Spaulding Rose  |
| .95             | 1.05            | 1.50            | .55             | .80             | Peachblow       |
| .75             | 1.50            | .70             | 1.10            | 1.50            | Green Mountain  |
| 1.25            | 1.              | 1.20            | .80             | .85             | Kathadin        |

## GRAPH 6

Dry Weight Data of Ten Varieties of  
Potatoes Previously Treated with  
Varying Concentrations of Ethylene  
Chlorhydrin. Second Period Average  
of Twelve Plants

Dry Weight

Grams

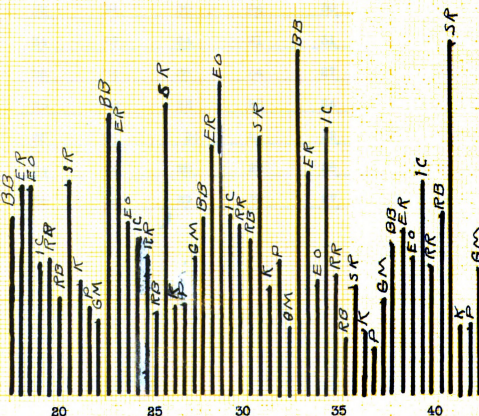
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Varieties and Concentrations



TABLE 7

Average Number of Days Taken for the Appearance  
of Tuber Sprouts Above Ground at Varying Concentrations  
of Ethylene Chlorhydrin. Second Period

| 20 c c<br>Days | 25 c c<br>Days | 30 c c<br>Days | 35 c c<br>Days | 40 c c<br>Days | Varieties       |
|----------------|----------------|----------------|----------------|----------------|-----------------|
| 24             | 24             | 22             | 20             | 22             | Brown Beauty    |
| 24             | 22             | 21             | 21             | 25             | Early Rose      |
| 26             | 26             | 23             | 23             | 27             | Early Ohio      |
| 32             | 24             | 30             | 24             | 30             | Irish Cobbler   |
| 34             | 27             | 24             | 21             | 31             | Russett Rural   |
| 26             | 24             | 28             | 24             | 27             | Russett Burbank |
| 23             | 22             | 22             | 22             | 24             | Spaulding Rose  |
| 28             | 24             | 24             | 26             | 32             | Kathadin        |
| 24             | 26             | 28             | 25             | 28             | Peachblow       |
| 26             | 28             | 29             | 28             | 27             | Green Mountain  |

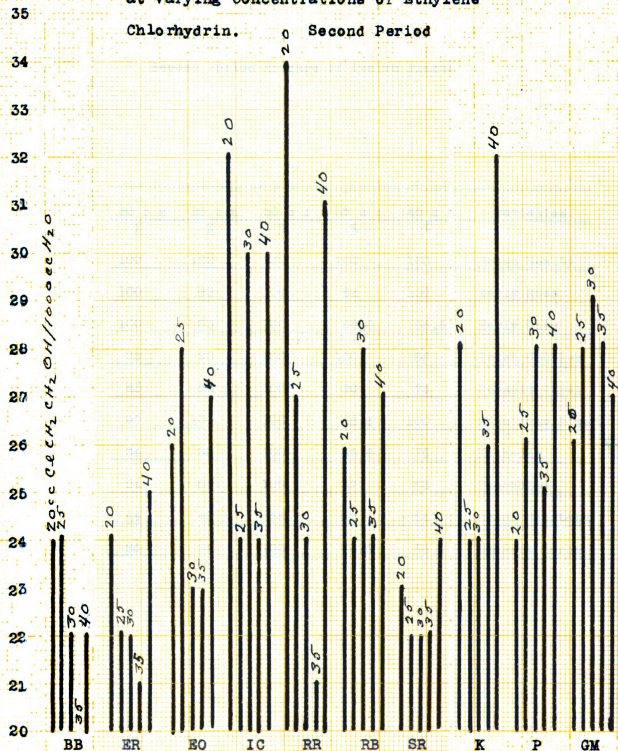


GRAPH 7

Average Number of Days taken for the  
appearance of Tuber Sprouts above Ground  
at varying Concentrations of Ethylene  
Chlorhydrin.

Days

Second Period



J

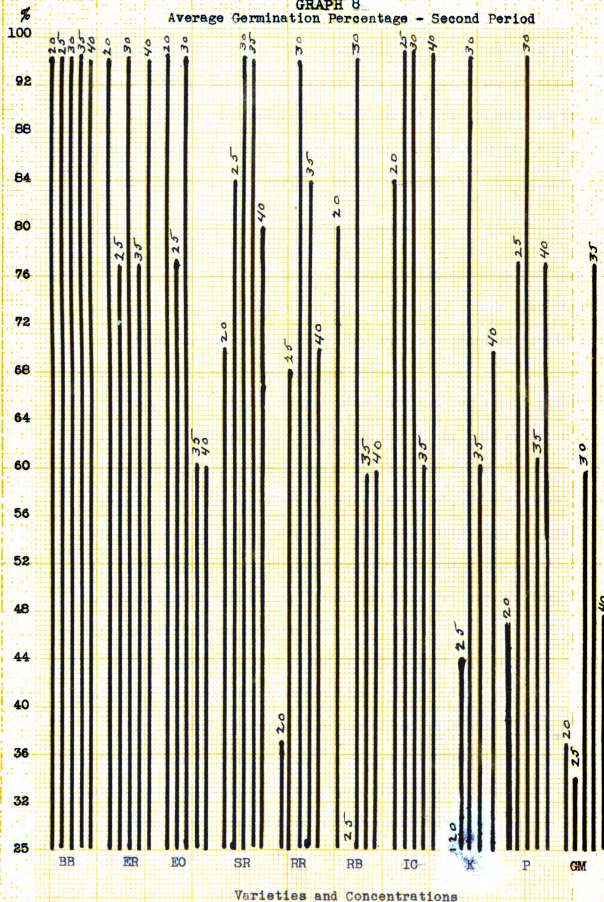
TABLE 8

Germination Percentages of Tubers of Ten Varieties  
 in Varying Concentrations of Ethylene Chlorhydrin.  
 Second Period Average of Twelve Plants.

| 20 c c<br>% | 25 c c<br>% | 30 c c<br>% | 35 c c<br>% | 40 c c<br>% | Varieties       |
|-------------|-------------|-------------|-------------|-------------|-----------------|
| 100         | 100         | 100         | 100         | 100         | Brown Beauty    |
| 100         | 83          | 100         | 83          | 100         | Early Rose      |
| 100         | 83          | 100         | 66.6        | 66.6        | Early Ohio      |
| 76          | 90          | 100         | 100         | 86          | Irish Cobbler   |
| 43          | 74          | 100         | 90          | 76          | Russett Rural   |
| 90          | 100         | 100         | 66.6        | 100         | Spaulding Rose  |
| 34          | 50          | 100         | 66.6        | 76          | Kathadin        |
| 54          | 84          | 100         | 67          | 83          | Peachblow       |
| 44          | 40          | 66.6        | 83          | 54          | Green Mountain  |
| 86          | 34          | 100         | 66.6        | 66.6        | Russett Burbank |



GRAPH 8  
Average Germination Percentage - Second Period



Varieties and Concentrations



early or as strongly. The concentrations giving the best response varies between thirty and thirty-five c.c. per liter of water.

In general the results in this period are the same as in the first period. If in this period potato seed pieces are supposed to be more dormant, our experiments do not show it.

### Third Period

For this test in the third period potatoes which had been in storage thirty days after digging, were used. These seed pieces were grown in the greenhouse. The same procedure of treatment was followed as in the other two periods.

Graph nine and table nine show that the dry weight yields made by the early maturing varieties are nearly the same as those of the first period, but being slightly higher than those of the second period. The late maturing varieties as usual, make a slightly less vigorous response than the early maturing varieties. The response in this period is becoming more nearly the same for the late and early maturing varieties. In the previous two periods there was a decided difference between them.

The response to the hours of exposure to the vapor is still slightly in favor of short periods.

Graph ten, table ten show the effect of the different concentrations on the dry weight yield. Here the varieties respond so nearly alike that it is difficult to separate them. Possibly Spaulding Rose and Early Rose stand out as reacting more favorably to the treatment. The rest appear to be on a par.



TABLE 9

Dry Weight Data for All Varieties at Varying  
Hours of Exposure to the Vapor of Ethylene  
Chlorhydrin. Third Period Average of Fifteen  
Plants.

| Hours Exposed to Vapor |              |              |              |                 |
|------------------------|--------------|--------------|--------------|-----------------|
| 16.<br>Grams           | 24.<br>Grams | 32.<br>Grams | 48.<br>Grams | Varieties       |
| 2.26                   | 1.92         | 1.56         | 1.90         | Brown Beauty    |
| 3.10                   | 1.85         | 3.05         | 3.           | Early Rose      |
| 2.10                   | 1.70         | 1.70         | 1.90         | Early Ohio      |
| 1.35                   | 2.           | 1.60         | 1.75         | Irish Cobbler   |
| .85                    | 1.12         | 1.30         | 1.85         | Russett Rural   |
| 1.30                   | 1.82         | 1.40         | 1.40         | Russett Burbank |
| 2.60                   | 2.15         | 2.80         | 2.80         | Spaulding Rose  |
| 1.85                   | 1.80         | 1.40         | 1.70         | Kathadin        |
| 1.05                   | 1.40         | 1.50         | 1.40         | Peachblow       |
| 1.50                   | 2.04         | 1.85         | 1.90         | Green Mountain  |



## GRAPH 9

DRY WEIGHT DATA FOR ALL VARIETIES AT VARYING  
HOURS OF EXPOSURE TO THE VAPORS OF ETHYLENE  
CHLORHYDRIN. THIRD PERIOD AVERAGE OF FIFTEEN  
PLANTS.

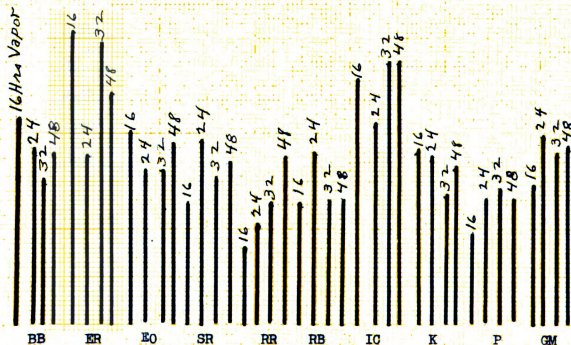
DRY  
WEIGHTS  
GRAMS

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VARIETIES and HOURS EXPOSURE to VAPOR

TABLE 10

Dry Weight Data of Ten Varieties of Potatoes  
Previously Treated with Varying Concentrations  
of Ethylene Chlorhydrin. Third Period Average  
of Twelve Plants.

| 20 c c<br>Grams | 25 c c<br>Grams | 30 c c<br>Grams | 35 c c<br>Grams | 40 c c<br>Grams | Varieties       |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| 1.90            | 2.10            | 1.90            | 2.10            | 1.30            | Brown Beauty    |
| 2.20            | 2.60            | 2.70            | 2.20            | 2.75            | Early Rose      |
| 2.              | 1.85            | 2.20            | 1.60            | 1.60            | Early Ohio      |
| 1.30            | 1.70            | 1.20            | 2.35            | 1.70            | Irish Cobbler   |
| 2.              | 1.              | .50             | 1.50            | .35             | Russett Rural   |
| 1.30            | 1.60            | 1.60            | 2.05            | .90             | Russett Burbank |
| 2.              | 3.              | 2.50            | 2.70            | 3.05            | Spaulding Rose  |
| 2.35            | 1.80            | .70             | 1.50            | 1.80            | Kathadin        |
| 1.20            | .50             | 1.50            | 1.40            | 1.15            | Peachblow       |
| 2.05            | 2.15            | 1.80            | 1.70            | 1.95            | Green Mountain  |



1. 2. 3. 4. 5.  
6. 7. 8. 9. 10.  
11. 12. 13. 14. 15.  
16. 17. 18. 19. 20.  
21. 22. 23. 24. 25.  
26. 27. 28. 29. 30.  
31. 32. 33. 34. 35.  
36. 37. 38. 39. 40.  
41. 42. 43. 44. 45.  
46. 47. 48. 49. 50.

GRAPH 10

Dry Weight Data of Ten Varieties of  
Potatoes Previously Treated with  
Varying Concentrations of Ethylene  
Chlorhydrin. Third Period Average  
of Twelve Plants

Dry Weight

Grams

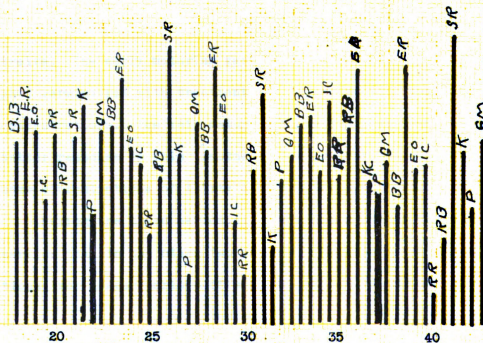
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Varieties and Concentrations

The average number of days taken for tuber sprouts of ten varieties to appear above ground is shown in graph eleven, table eleven. The different varieties did not appear above ground at the same time. In this respect there was quite a little difference between varieties. The early maturing varieties, including Brown Beauty which is supposed however to be a late maturing variety, appeared in approximately eleven days after planting. In the previous two periods these varieties, Brown Beauty, Early Rose, Early Ohio, Spaulding Rose and Irish Cobbler required from twenty-one to twenty-three days. Irish Cobbler is an exception in that it always requires three or four more days to appear. The varieties Russett Rural, Russett Burbank, Kathadin, Peachblow and Green Mountain required twenty or twenty-one days to appear in this period, while in the two previous periods they appeared in about twenty-six or twenty-seven days.

The germination percentages for the different varieties under the conditions of the experiment are shown in graph twelve, table twelve. The early maturing varieties as indicated by our work make good germination with treatments of thirty or thirty-five c.c. concentrations. The late maturing varieties have made in general a better response to this treatment than in previous periods at the same concentrations of thirty c.c. and thirty-five c.c.

During the third period all varieties appeared above ground earlier than in the other two periods. In general no higher concentrations, nor longer periods of exposure to the vapor were required.

#### Fourth Period

Potato tubers forty-five days old, counting from the day they

TABLE 11

Average Number of Days Taken for the Appearance  
of Tuber Sprouts Above Ground at Varying Concentrations of Ethylene Chlorhydrin. Third Period.

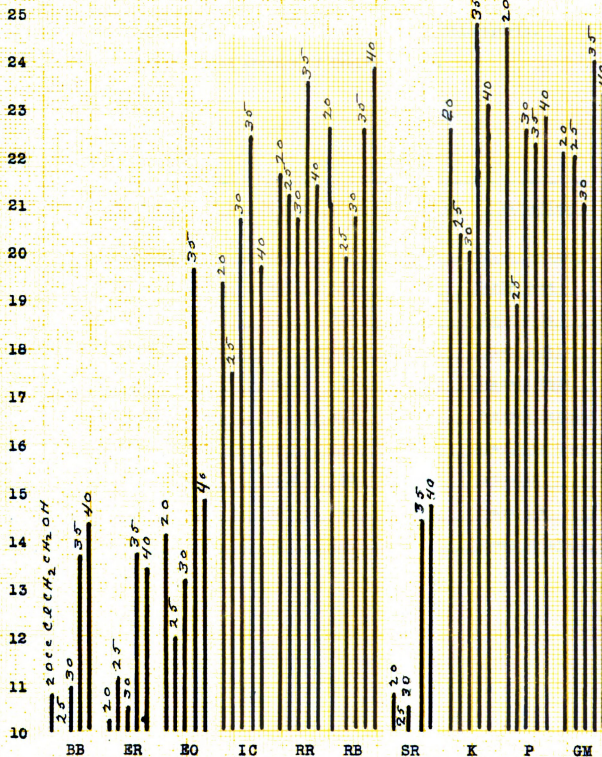
| 20 c c<br>Days | 25 c c<br>Days | 30 c c<br>Days | 35 c c<br>Days | 40 c c<br>Days | Varieties       |
|----------------|----------------|----------------|----------------|----------------|-----------------|
| 10.8           | 10             | 11             | 13.8           | 14.5           | Brown Beauty    |
| 10.3           | 11.2           | 10.6           | 13.8           | 13.5           | Early Rose      |
| 14.2           | 12.            | 13.2           | 19.8           | 15             | Early Ohio      |
| 19.5           | 17.7           | 20.8           | 22.5           | 19.8           | Irish Cobbler   |
| 21.7           | 21.3           | 20.9           | 23.7           | 21.5           | Russett Rural   |
| 22.8           | 20             | 20.8           | 22.8           | 24.            | Russett Burbank |
| 10.8           | 10             | 10.4           | 14.5           | 14.8           | Spaulding Rose  |
| 22.7           | 20.5           | 20.2           | 24.8           | 23.2           | Kathadin        |
| 24.8           | 19             | 22.7           | 22.5           | 23             | Peachblow       |
| 22.2           | 22.2           | 21.2           | 24.2           | 23.5           | Green Mountain  |



GRAPH 11

Average Number of Days Taken for the Appearance  
of Tuber Sprouts Above Ground at Varying Concen-  
trations of Ethylene Chlorhydrin. Third Period

Days



Varieties and Concentrations



TABLE 12

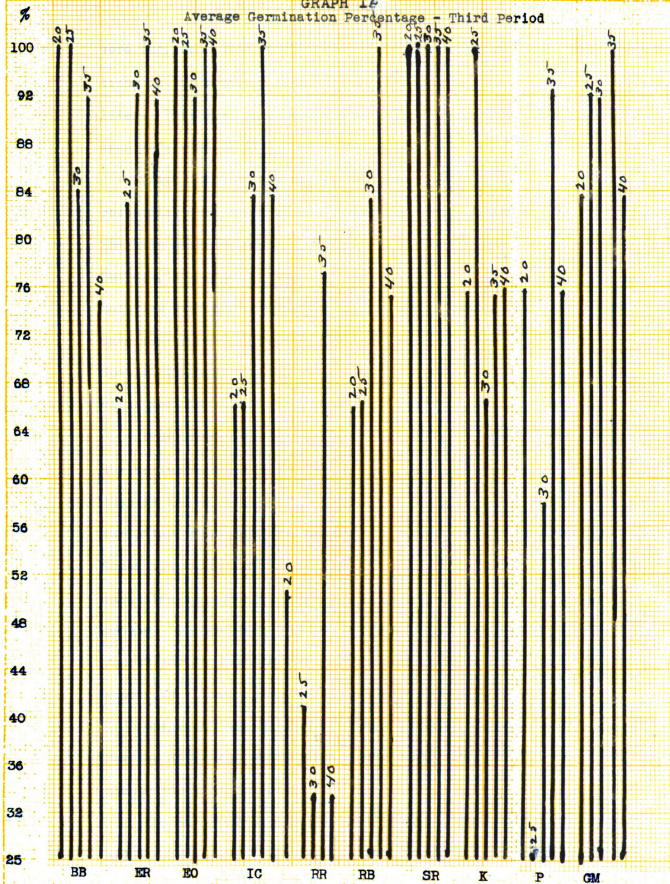
Germination Percentages of Tubers of Ten Varieties  
 In Varying Concentrations of Ethylene Chlorhydrin.  
 Third Period Average of Twelve Plants.

| 20 c c<br>% | 25 c c<br>% | 30 c c<br>% | 35 c c<br>% | 40 c c<br>% | Varieties       |
|-------------|-------------|-------------|-------------|-------------|-----------------|
| 100         | 100         | 83          | 92          | 75          | Brown Beauty    |
| 66.6        | 83          | 92          | 100         | 92          | Early Rose      |
| 100         | 100         | 92          | 100         | 100         | Early Ohio      |
| 66.6        | 66.6        | 83          | 100         | 83          | Irish Cobbler   |
| 50          | 41          | 33.3        | 77          | 33.3        | Russett Rural   |
| 66.6        | 66.6        | 84          | 100         | 75          | Russett Burbank |
| 100         | 100         | 100         | 100         | 100         | Spaulding Rose  |
| 75          | 100         | 66.6        | 75          | 75          | Kathadin        |
| 75          | 25          | 53          | 92          | 75          | Peachblow       |
| 83          | 92          | 92          | 100         | 83          | Green Mountain  |

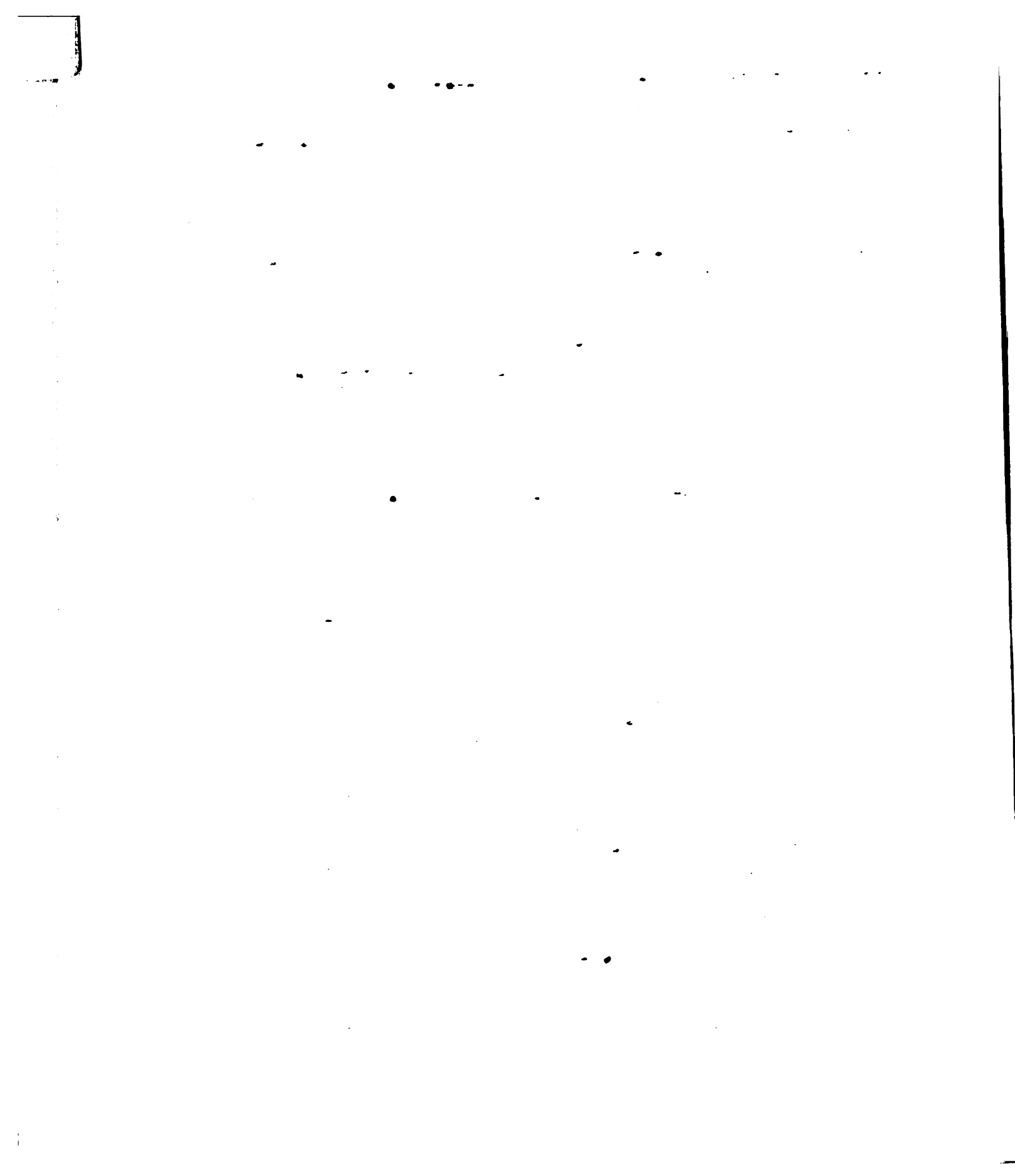




## Average Germination Percentage Third Period



Varieties and Concentrations



were dug, were used in this fourth period. The favorable concentrations in the previous tests were thirty and thirty-five c.c. to the liter. This last treatment included only these concentrations and twenty-four hours of exposure to the vapors.

Graph thirteen and table thirteen show that all varieties are responding very unusually as far as indicated by dry weight yields. The late maturing varieties, Green Mountain, Kathadin, and Russett Burbank, have made unusually high weight yields, while the early maturing varieties, Brown Beauty, Early Ohio and Irish Cobbler, have made poor responses. The early maturing Early Rose and Spaulding Rose continue to make good response as they have in previous periods.

From graph fourteen and table fourteen one can see that all the varieties make an earlier appearance above ground in this period than in any of the previous ones. This is particularly true of the varieties Irish Cobbler, Russett Rural, Russett Burbank, Kathadin and Green Mountain. In the first and second periods these late maturing varieties required twenty-six or twenty-seven days to appear above ground. In the third period twenty days were necessary. Now in the fourth period some six weeks after digging, these same varieties appear in fifteen or sixteen days after treatment.

Graph fifteen and table fifteen show the germination percentages for the different varieties. The general response is higher than in the previous periods.

The data for this period substantiate those of the third period and lend support to the results and conclusions arrived at for that period. It seems clear that during a period of a month after

TABLE 13

Dry Weight Data for All Varieties at Varying  
Hours of Exposure to the Vapor of Ethylene  
Chlorhydrin. Fourth Period Average of Fifteen  
Plants.

| Hours Exposed to Vapor |        |                 |
|------------------------|--------|-----------------|
| 30 c c                 | 35 c c | Varieties       |
| 1.532                  | 2.238  | Brown Beauty    |
| 3.245                  | 1.756  | Early Rose      |
| .330                   | .619   | Early Ohio      |
| 2.550                  | .738   | Irish Cobbler   |
| 1.113                  | 6.249  | Spaulding Rose  |
| 3.254                  | 3.213  | Russett Burbank |
| 0.                     | 0.     | Russett Rural   |
| 2.731                  | 4.736  | Kathadin        |
| .950                   | 0.     | Peachblow       |
| 4.718                  | 1.928  | Green Mountain  |

GRAPH 13

DRY WEIGHT DATA FOR ALL VARIETIES AT VARYING  
HOURS OF EXPOSURE TO THE VAPORS OF ETHYLENE  
CHLORHYDRIN. FOURTH PERIOD AVERAGE OF FIFTEEN  
PLANTS.

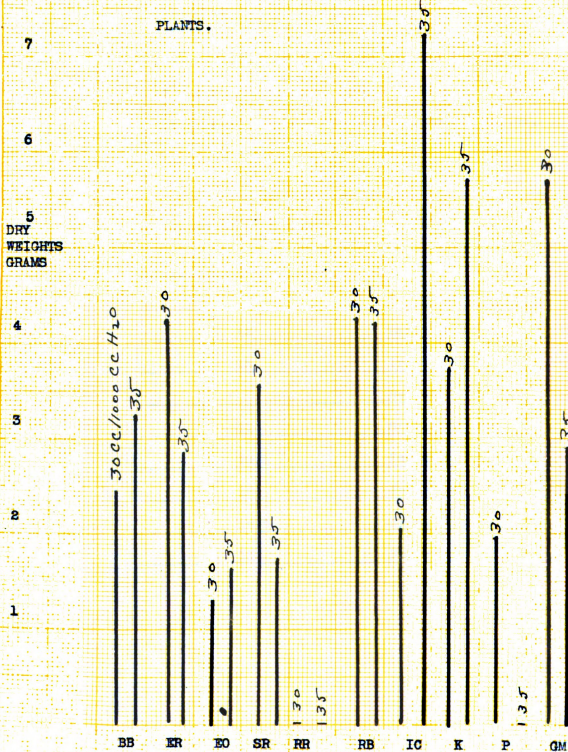




TABLE 14

Average Number of Days Taken for the Appearance  
of Tuber Sprouts Above Ground at Varying Concentrations of Ethylene Chlorhydrin. Fourth Period.

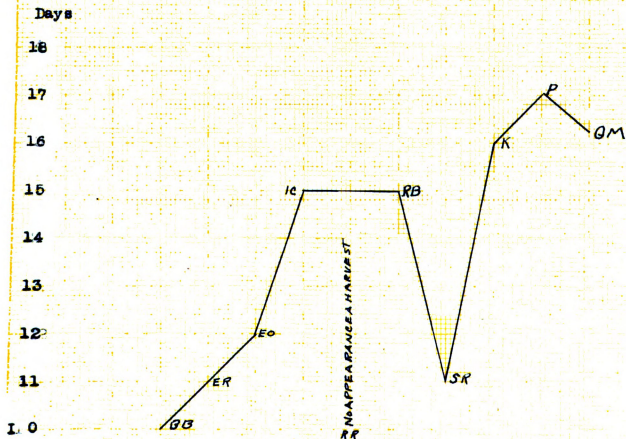
| 30-35 c c<br>Days | Varieties       |
|-------------------|-----------------|
| 10                | Brown Beauty    |
| 11                | Early Rose      |
| 12                | Early Ohio      |
| 15                | Irish Cobbler   |
|                   | Russett Rural   |
| 11                | Spaulding Rose  |
| 16.5              | Kathadin        |
| 17                | Peachblow       |
| 16.5              | Green Mountain  |
| 15                | Russett Burbank |





## GRAPH 14

Average Number of Days Taken for  
the Appearance of Tuber Sprouts  
Above Ground at Varying Concentra-  
tions of Ethylene Chlorhydrin.  
Fourth Period.





**TABLE 15.**

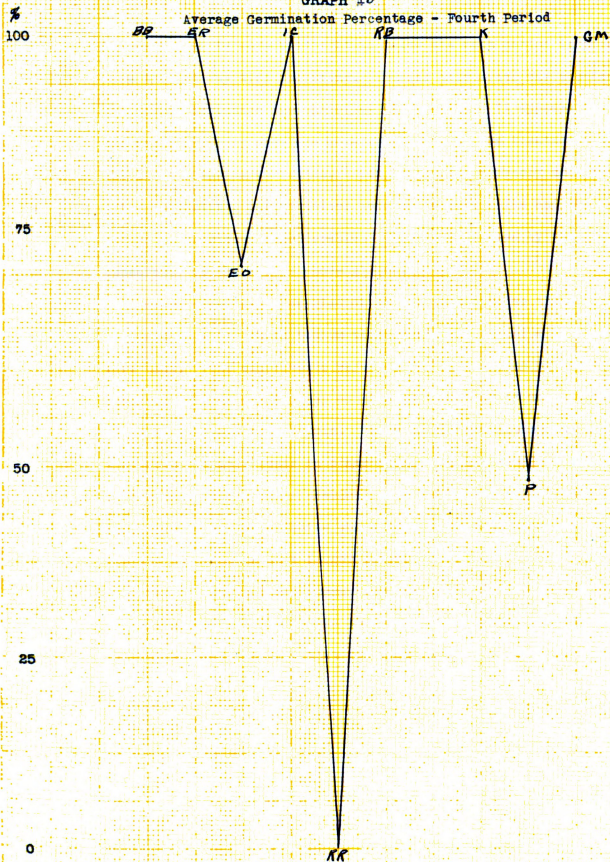
**Germination Percentages of Tubers of Ten Varieties  
In Varying Concentrations of Ethylene Chlorhydrin.  
Fourth Period Average of Twelve Plants.**

| 30-35 c c<br>% | Varieties       |
|----------------|-----------------|
| 100            | Brown Beauty    |
| 100            | Early Rose      |
| 75             | Early Ohio      |
| 100            | Irish Cobbler   |
| 0              | Russett Rural   |
| 100            | Russett Burbank |
| 100            | Spaulding Rose  |
| 100            | Kathadin        |
| 50             | Peachblow       |
| 100            | Green Mountain  |



GRAPH 15

Average Germination Percentage - Fourth Period



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harvesting it is more difficult to break the rest period in potatoes than at any time following. During this month the chemical treatments influence the varieties differently. It appears that the early maturing ones are more responsive to the treatments than the later maturing varieties. Six, eight, and probably more weeks after harvesting, all varieties tend to respond alike and the rest period is shortened considerably. This is indicated by the quicker appearance of the shoots above ground.

Other experiments carried on at the same time as those discussed included some in which Sodium thiocyanate and Ammonium dithiocarbamate were used. The experiments were too few in the case of the former chemical to draw any further conclusion than that it was not as effective as ethylene chlorhydrin. Space in the greenhouse was not available for many tests on other chemicals than ethylene chlorhydrin. In the case of the other chemical only sufficient experiments were performed to arouse a desire and a hope to be able sometime to continue the experiments on a larger scale.

The following table summarizes the data relative to the number of days needed for the shoots to appear above ground and the most favorable concentrations that resulted in the responses obtained.





TABLE II A

| Varieties       | Periods               |            |                       |            |           |            |                       |            |                       |            |
|-----------------|-----------------------|------------|-----------------------|------------|-----------|------------|-----------------------|------------|-----------------------|------------|
|                 | First                 |            | Second                |            | Third     |            | Fourth                |            |                       |            |
|                 | Days                  | Best Conc. | Ave. Days             | Best Conc. | Ave. Days | Best Conc. | Ave. Days             | Best Conc. | Ave. Days             | Best Conc. |
| Brown Beauty    | 20                    | 35 c.c.    | 20                    | 35 c.c.    | 11        | 30 c.c.    | 10                    | 30 c.c.    | 10                    | 30-35 c.c. |
| Controls        | 30                    |            | 45                    |            |           |            | 25                    |            | 25                    |            |
| Spaulding Rose  | 17                    | 35 c.c.    | 22                    | 35 c.c.    | 10.5      | 30 c.c.    | 11                    | 30 c.c.    | 11                    | 30-35 c.c. |
| Controls        | 40                    |            | 47                    |            |           |            | 28                    |            | 28                    |            |
| Early Rose      | 20                    | 35 c.c.    | 21                    | 35 c.c.    | 10.5      | 30 c.c.    | 11                    | 30 c.c.    | 11                    | 30-35 c.c. |
| Controls        | 35                    |            | 43                    |            |           |            | 22                    |            | 22                    |            |
| Early Ohio      | 23                    | 35 c.c.    | 23                    | 35 c.c.    | 13        | 30 c.c.    | 12                    | 30 c.c.    | 12                    | 30-35 c.c. |
| Controls        | No appear. at 50 Days |            | No Appear. at 65 Days |            |           |            | 30                    |            | 30                    |            |
| Irish Cobbler   | 23                    | 35 c.c.    | 23                    | 35 c.c.    | 17        | 25 c.c.    | 15                    | 25 c.c.    | 15                    | 30-35 c.c. |
| Controls        | No appear. at 50 Days |            | No appear. at 65 Days |            |           |            | 32                    |            | 32                    |            |
| Green Mountain  | 21                    | 35 c.c.    | 26                    | 20 c.c.    | 21        | 30 c.c.    | 16.5                  | 30 c.c.    | 16.5                  | 30-35 c.c. |
| Controls        | No appear. at 50 Days |            | No appear. at 65 Days |            |           |            | No appear. at 50 Days |            | No appear. at 50 Days |            |
| Peachblow       | 21                    | 30 c.c.    | 24                    | 20 c.c.    | 19        | 25 c.c.    | 17                    | 25 c.c.    | 17                    | 30-35 c.c. |
| Controls        | 32                    |            | 52                    |            |           |            | 20                    |            | 20                    |            |
| Russett Burbank | 25                    | 35 c.c.    | 24                    | 35 c.c.    | 20        | 25 c.c.    | 15                    | 25 c.c.    | 15                    | 30-35 c.c. |
| Controls        | No appear. at 50 Days |            | No appear. at 65 Days |            |           |            | No appear. at 50 Days |            | No appear. at 50 Days |            |
| Kathadin        | 23                    | 30 c.c.    | 24                    | 30 c.c.    | 20        | 30 c.c.    | 16.5                  | 30 c.c.    | 16.5                  | 30-35 c.c. |
| Controls        | No appear. at 50 Days |            | No appear. at 65 Days |            |           |            | No appear. at 50 Days |            | No appear. at 50 Days |            |
| Russett Rural   | 25                    | 35 c.c.    | 24                    | 30 c.c.    | 21        | 30 c.c.    | No appear. at 50 Days |            | No appear. at 50 Days |            |
| Controls        | No appear. at 50 Days |            | No appear. at 65 Days |            |           |            | No appear. at 50 Days |            | No appear. at 50 Days |            |



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In Gilbert's (6) and Stuart's (19) books it is found that Brown Beauty is a late maturing variety, yet in these experiments it has consistently acted as though it were an early maturing variety, and shows similar responses to Early Rose, Spaulding Rose and Early Ohio. A question might be asked at this point. Is it possible to determine early and late maturing varieties by some such chemical treatment as has been given these potatoes? Early maturing varieties react quicker to chemical stimuli and the period of dormancy is more easily broken six weeks after harvest than at any previous time. This may only mean that part of its rest period was completed while still in the ground as the top had yellowed and become functionless. (All these varieties had been planted the same day but in the fall unless freezes occur they would mature at slightly different periods.) Green Mountain, Peachblow, Russett Burbank, Kathadin and Russett Rural are late maturing varieties, but they also make a better response in the third and fourth periods, six weeks after harvest than at any previous time.

#### Conclusions

1. The varieties Brown Beauty, Early Rose, Spaulding Rose, Early Ohio, Irish Cobbler, Kathadin, Peachblow, Green Mountain, Russett Burbank and Russett Rural responded to treatment with ethylene chlorhydrin, but in different ways, especially in the earlier periods.
2. According to Gilbert (6) and Stuart (19), the above varieties are listed as very late, late and early, as shown below -

| <u>Early Maturing</u> | <u>Late Maturing</u> | <u>Very Late</u> |
|-----------------------|----------------------|------------------|
| Early Rose            | Peachblow            | Kathadin         |
| Spaulding Rose        | Brown Beauty         | Green Mountain   |



Early Ohio

Russett Burbank

Irish Cobbler

Russett Bural

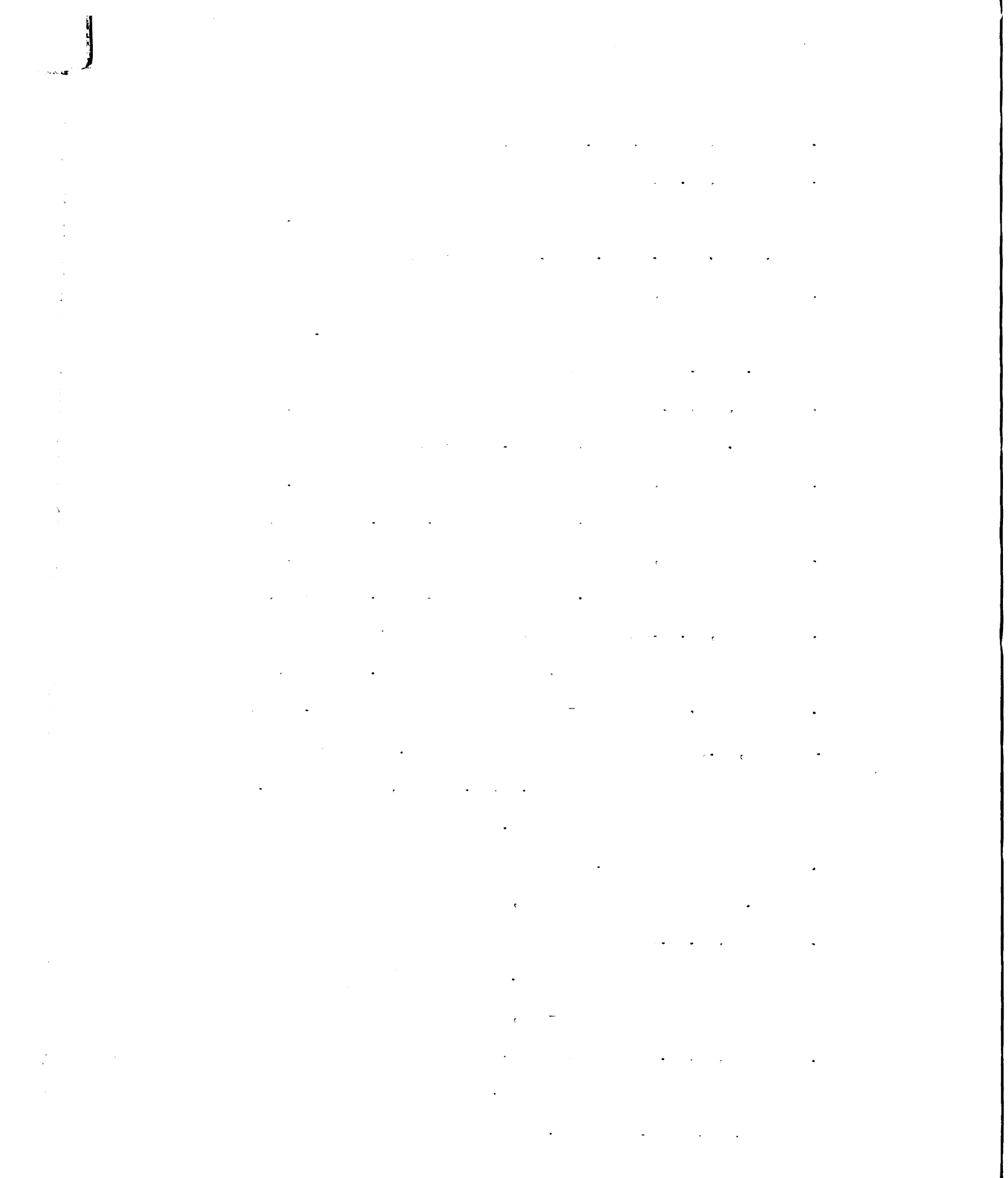
3. Twenty-five, thirty and thirty-five cubic centimeters of ethylene chlorhydrin to a liter of water gave the concentrations that were favorable for shortening the rest period. Twenty and forty c.c. per liter were respectively too weak and too strong. A definite concentration is not mandatory. For general use in the field this feature is of practical value.
4. It appears that for all varieties the late period of dormancy is more easily broken than the earlier period. The apparent quicker response of the earlier maturing varieties is explained through the fact that very likely they have passed through a portion of the period of dormancy while still in the ground. In this end period, the dormant period for the late varieties is almost as easily broken as that of the early maturing varieties.
5. Tubers treated after forty-five days in storage sprouted earlier and had a higher germination percentage than those selected any time previous up to the day they were dug.
6. In these experiments, chemical treatments shorten the rest period, depending on the depth of dormancy of the variety. Each variety seems to have a dormant period peculiar to that variety.



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