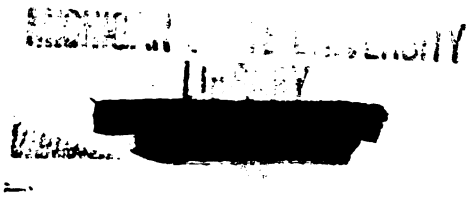
THE EFFECT OF STORAGE CONDITIONS ON THE VIABILITY OF MATURE AND IMMATURE POTATOES

THESIS FOR DEGREE OF M. S.

EARNEST JOSEPH WHEELER

1928



THE EFFECT OF STORAGE CONDITIONS ON THE VIABILITY OF MATURE AND IMMATURE POTATOES

A Thesis Prepared by

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in partial fulfillment

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1928.

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ACKNOWLEDGMENT

The writer wishes to acknowledge the hearty co-operation that he has received from those who have assisted with this thesis; Professor E. E. Down for the assistance in the interpretation of the data, also Professor J. F. Cox and H. C. Moore for the help in the procedure and cultural methods used in the experiment.

He also wishes to thank the ones that had charge of the storage where the lots of potatoes were stored.

CONTENTS

REVIEW OF LITERATURE.

H. P. Hutchinson, Jour. Bd. Agr. (London) No. 6, pp 529-539 concludes that immature seed is superior because, (1) In using immature tubers for seed the largest tubers of the most productive plants will naturally be selected, thus resulting in increased yields, or, at least in maintaining previous yields. (2) The cortex of immature tubers is thinner than that of mature tubers thus lessening the check or imbibition of water from without, which is necessary during the early stages of growth. (3) The amount and available ability of the reserve plant food material may be greater in immature tubers than in the mature ones. (4) The length of time of storage may materially affect the amount and form of plant food material which would favor immature tubers due to the longer period of storage which they are subjected to.

The use of immature tubers for seed promotes earliness, vigor and an ability to form tubers under an adverse seasonal condition.

W. T. Macoun reports in Bulletin No. 90 that the Department of Agriculture for Ireland makes this recommendation: "Immature seed--It is recognized that seed from crops lifted before they fully mature will

produce more vigorous plants, and consequently, heavier yields than seed from crops which have been allowed to become fully ripe. In Ireland, this applies more particularly, perhaps, to early varieties, but it is a point worthy of notice by growers of seed potatoes.

In 1906, Stewart, University Leeds and Yorkshire Council Agr. Ed. (pamphlet) 63, p 14-16, reports results from a study of the relative merits of immature and mature seed potatoes. The vines of those harvested as immature were green and those for mature were ripe and the skin of the tuber was tough indicating maturity. In 1905 the average of five varieties showed less than 6 per cent increase in yield of immature over mature whole seed.

Ramsay, Department of Agriculture, Victoria 13: 340-348 in 1914-15 compared whole and cut seed of both immature and mature tubers. Immature whole sets yielded at the rate of 207 bushels per acre and mature sets only 100 bushels. In the case of the cut sets there was a much greater difference in favor of immature sets - 178.5 to 65.6. The whole immature sets showed an increase of 38 per cent and the cut sets more than 172 per cent. 1921-22 test showed a difference of 41 per cent; 1923 test showed 65 per cent, and in 1925 nearly 26 per cent.

All these differences in favor of immature seed are sufficiently large to be significant.

Dunlop, Midland Agricultural and Dairy College Report 1914: 21-22, and 1915: 42, reported that immature and mature seed of the Factor Variety were compared, the immature seed stock yielded at the rate of 486.7 bushels per acre and the ripe seed produced 456.7 bushels. In 1915 a similar comparison was made of the King Edward variety. The immature seed was dug September 9, 1914 and the ripe seed October 15, 1914. The immature seed produced 108 per cent larger yield than the mature seed.

The experience of Helmer, Canada Experimental Farm Station, Summerland, B. C., Report September 1926: 60-61 with immature and mature seed was distinctly in favor of mature seed.

Davidson, Jour. Department of Lands and Agriculture Ireland 24: 374-423 suggests that experiments have proved that there is nothing to the idea that immature seed is superior to mature seed stock.

In their reports of field crops Appleman, N. J. Agricultural Experiment Station Annual Report 1920, 41: 251-256 and Cox, N. Y. Agricultural Experiment Station Annual Report 1920, 41: 207-210

state that the immature seed had better germination and the vigor throughout the growing season was better than northern grown seed. The immature tubers set more tubers per plant, but they averaged smaller and more rot was present.

William Stuart in "Source, Character and Treatment of Potato Sets", U. S. D. A., Washington, D. C., Technical Bulletin No. 5, p 23-24, summarizes the work of immature and mature seed as affecting the yield of potatoes. A review of experimental data disclosed very little difference between mature and immature seed potatoes, but there is sufficient evidence to support that immature seed is slightly better than mature seed.

The experimental results from Norfolk, Va., studies show that in the tests of only two seasons of the five were larger yields of primes obtained from immature seed.

The Caribou, Maine data showed a slight gain in primes from mature seed and a trifle larger increase in total yield. Based on three year averages, both medium mature and immature seed stock gave larger yields than mature stock at Presque Isle, Maine.

The percentage of disease was larger in immature seed when immaturity was obtained from late plantings, and the reverse was found to be true when immaturity was the results of early harvesting.

In the Greeley, Colorado experiments where immaturity was the result of early harvesting, larger yields were obtained in three out of five seasons from immature seed. The difference, however, was not sufficiently great to be convincing, as the average increase for the five year period for primes was only 3.7 bushels and for total yield only 3.1 bushel.

At Jerome, Idaho, the average gains in acre yields of primes were so strikingly large as to preclude the possibility of its being due to accidental variation.

Appleman and Miller, Journal of Agricultural Research 33: 569-577 report results that the ripening and maturity processes may continue during storage. No chemical or physiological basis has revealed any superiority of immature seed over mature potatoes for seed. The authors express their belief that where immature tubers have outyielded mature may be accounted for by the mature having greater amounts of degeneration diseases.

INTRODUCTION:

Michigan farmers on the average harvest 303,100 acres of potatoes each season yielding 101 bushels per acre making a total production of 30,383,000 bushels. The average price for a period of 9 years, 1918-1927, has been hinety cents (90¢) a bushel making the potato crop worth Twenty-five million seven hundred sixty-nine thousand dollars ($25,769,000) each year.

The state is divided into two parts as far as the production of seed potatoes and table stock is concerned. The northern part of the state produces a greater part of the 300,000 bushels of certified seed, while the southern half of the Lower Peninsula produces the greater part of the table stock potatoes.

Certified seed is stored by the grower and delivery is made in early spring. The potatoes are in many cases stored under poor conditions in house cellars, with and without furnaces, in storages above ground made of wooden frame structures where the temperature and humidity varies with weather conditions, in pit storages and storages that are built in the side of a hill.

Better potato production demands that the growers plant good seed that is free from disease and in such condition that it will produce good vigorous plants. Immature seed harvested when the plants are still green and the skin feathers up is claimed by Sutton and Sons of Reading, England and I. T. Ramsey of the Department of Agriculture of Victoria, to be better for seed as it gives increased yields. In the United States a few experiments have shown immature seed to be better, but most of the Experiment Station Workers report negative results as to immature seed yielding any better than mature seed.

EXPERIMENTAL METHODS.

This thesis is based on an experiment conducted to show if there is a difference between mature and immature potatoes stored under various conditions. Storage conditions varied in this experiment as they vary in the different potato seed storages of the state. The data here given were secured from observations made of plats grown at the Michigan Experiment Station.

Storage space was obtained where the desired conditions could be located. It was necessary to utilize some space in a house cellar also some space in a cold storage where the different temperatures desired could be maintained.

Russet Rural potatoes that had been planted at the College one year were used. The seed was certified in 1926 and was of the same strain and practically free from any noticeable disease. The first lot of seed was planted June 8, 1926 and and the second lot of seed was planted July 2, 1926. Both lots of seed were harvested after frost had killed the vines, September 22, 1926. The early planting showed maturity in the vine growth whereas the later planting had vines that were still green at the time of frost. The potatoes from the later planting were much smaller than the potatoes from the earlier planting. The seed from the early planting was designated as mature seed. The seed from the later planting was designated as immature seed. Both the mature and immature seed were stored under conditions described in the following paragraphs.

The seed potatoes were divided into lots of fifty and one hundred pounds and placed in sacks. Some of the sacks were placed in tight containers while others were stored in the center of the bin and in special bins.

The following are the different ways in which the seed potatoes were stored:

1. Root cellar storage at the College Storage cellar. Tubers were stored in the open, also stored in closed containers.

2. Cold storage at Michigan Butter and Egg Cold Storage, Lansing. 36° F. open storage also storage in closed containers.

3. Cold Storage at Michigan Butter and Egg, Lansing 32° F. open storage also storage in closed containers.

4. High temperature storage (40-70°F.) Storage was in a room next to a furnace in a house cellar.

5. Pit storage in a sand hill near the College root cellar.

As many storage conditions were selected as the writer has observed being used by growers. The chief object was to test the viability of mature and immature seed when stored under different conditions.

In all cases the lots of potatoes were stored in burlap sacks for convenience in handling.

Figure I. This Photograph shows the type of closed container used in the experiment.

Immature and mature seed was stored under all the conditions named. Records were taken including notes on temperature and moisture conditions. Photographs were made May 10, 1927 of the different lots when removed from storage to show the comparative dormancy of the seed.

The seed was treated with corrosive sublimate, four ounces to thirty gallons of water for thirty minutes, and left for two weeks before planting for the potatoes to green sprout. The seed stored at low temperature would be more likely to have the rest period broken by the green sprouting and would start to growing immediately providing the potatoes had not been injured by the storage treatment.

GREENHOUSE TEST.

An extra supply of potatoes was stored at the Michigan State College root cellar for greenhouse planting. Each month beginning with November and ending with April, plantings of mature and immature seed were made in eight inch pots buried in soil on the greenhouse bench.

The weight of each tuber was taken and the date that the first sprout appeared in each pot was recorded. The general vigor of the sprouts was recorded by means of photographs.

FIELD PLAT TECHNIQUE.

The lots of seed were planted in plats at the College Experiment Station. Each lot was planted in two replications, that is, three plats, the original and two other plantings. It is advisable to plant at least four replications, but owing to the limited supply of seed only two replications were made. The rows were fifty-six hills long and the hills were spaced eighteen inches in the row with the rows spaced thirty-six inches apart.

The seed was cut into uniform pieces averaging one and one-half to two ounces in weight.

Seed used for the check plats was obtained from a single tuber strain developed by the Michigan State College in 1924. Check rows were planted on the outside as borders. The second row of the plat was planted with check seed which was harvested and considered as the outside check. Mature seed

was planted next to the check then followed a row of immature seed followed by another check row.

Figure II.

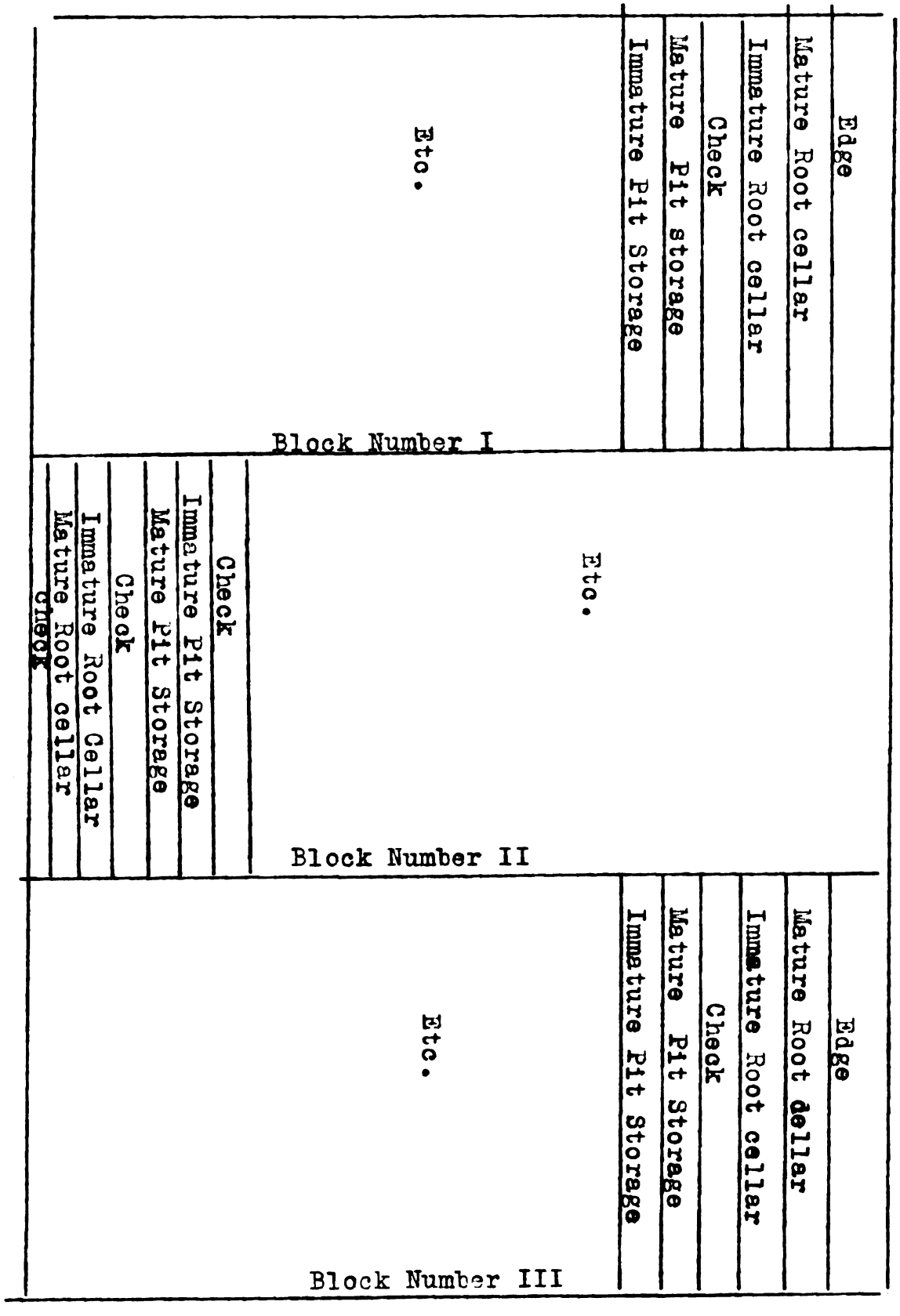

Edge
Mature Root cellar
Immature Root cellar
Check
Mature Pit storage
Immature Pit Storage
Etc.
Block Number I
Check
Immature Pit Storage
Mature Pit Storage
Check
Immature Root Cellar
Mature Root cellar
check
Etc.
Block Number II
Edge
Mature Root cellar
Immature Root cellar
Check
Mature Pit Storage
Immature Pit Storage
Etc.
Block Number III

Figure 2 shows in detail how the lots of seed were planted. In block No. 2 the mature seed in the root cellar storage was put on the other side of the test plat and the other rows following the mature root cellar storage in Block No. 2 were planted as in Block No. 1. Block No. 3 had the rows arranged so that lots of seed having the same storage treatment were in no case directly in line with each other.

The mature and immature seed planted between two checks represented a single storage condition. The mature and immature seed between the first two checks in block No. 1 was stored in the same storage, namely College root cellar. The plats were alternated according to the method of plat planting recommended by the Plant Breeding Section of the Farm Crops Department of Michigan State College.

Records of the germination of each row were taken at three different times during the first six weeks of growth. At the last germination count a record was made of the number of weak hills in each row. When the plants were twelve inches high the number of stalks was recorded. The hills having one, two, three or more stalks were averaged separately and a comparison of the number of one, two,

three or more stalk hills was made.

Culture and spraying work was carried on the same as they would be in a field of potatoes grown for certified seed. The vines were sprayed seven times with a 4-4-50 mixture of bordeaux. Calcium arsenate was used in the first two sprays to kill Colorado Potato Beetles. The potatoes were cultivated a sufficient number of times to insure weed control.

The plats were harvested on the 25th and 26th of September. Each lot was graded and weighed separately. The grades were U. S. No. 1; U. S. No. 2 and culls. The total weight of each lot was recorded, the probable error and results were determined and are taken up in a discussion of the experimental data.

DISCUSSION OF EXPERIMENTAL DATA.

There are two phases of the experimental data connected with this work. One is the comparison of mature and immature seed and the other is the testing of the seed stored under the different storage conditions. Both phases are worked out in detail and a discussion of each is here presented.

1. Mature vs. Immature seed potatoes.

Mature and immature seed were stored and planted under the same conditions and a comparison of the yields and the general vigor of each lot was determined.

Eight tubers each from the mature and immature seed were planted each month from November to April in pots in the greenhouse. Notes were taken on the time the plants appeared above ground. Table I. shows a comparison of the mature and immature seed in the planting made November 4. Table I shows the notes that were taken from the planting. It is quite evident that mature seed started earlier than the immature seed, also the vigor of the plants in the more mature seed was better.

The greater vigor of the mature seed as evidenced by the November 4 planting is no doubt explained by the experiments of C. O. Appleman, Journal of Agricultural Research 33: 569-577, who made a chemical analysis of mature and immature potatoes. His conclusions were that at harvest time the mature and immature potatoes differ chemically, the immature potatoes in the fall having more proteins than the mature seed. Toward spring, however, the mature and immature potatoes are practically the same, containing equal amounts of starch, sugar and other compounds. Dr. Appleman concludes that there should be no difference between the mature and immature seed.

John Bushnell of the Ohio Agricultural Experiment Station in the Bimonthly Bulletin, Volume XII, No. 5, reports that a temperature storage of 38° is best for seed potatoes. Potatoes were planted from a storage where the temperature registered 38° F. in comparison with potatoes stored in a commercial cold storage held at 33° F. The seed stored at 38° F. germinated more rapidly and it consistently yielded more than the cold storage seed.

Time of Sprouting of Mature and Immature Tubers

Planted November 4, 1927.

Table I.

	Mature		Immature	
Pot No.	Weight of tubers ounces	Date of appear-ance	Weight of tubers ounces	Date of appear-ance
1	7	Jan. 18	4	Feb. 3
2	5	Feb. 14	4	Feb. 23
3	4	Jan. 18	3.5	Mar. 11
4	4	Feb. 4	3.5	Jan. 18
5	8	Feb. 17	6	Jan. 20
6	8	Jan. 25	7	Feb. 17
7	7	Feb. 2	7	Jan. 20
*8	5	Jan. 17	5	Feb. 15

* The sprout in this pot came up, but remained short and never grew. No disease apparent, likely due to the soil being packed too hard.

Time of Sprouting of each Individual Tuber Planted December 4, 1927, from Mature and Immature seed.

Table II.

	Mature		Immature	
Pot No.	Weight of tubers ounces	Date of appear-ance	Weight of tubers ounces	Date of appear-ance
1	10	Feb. 23	7	Feb. 6
2	6	Jan. 25	8	Feb. 14
3	5	Feb. 16	7	Feb. 17
4	5	Feb. 26	7	Feb. 17
5	4	Feb. 28	6	Decayed
6	3	Feb. 16	5	Feb. 28
7	4	Jan. 25	4	Feb. 14
8	3	Feb. 16	4	Feb. 14

Time of Sprouting of each Individual Tuber Planted January 4, 1927, from Mature and Immature seed.

Table III.

	Mature		Immature	
Pot No.	Weight of tubers ounces	Date of appear-ance	Weight of tubers ounces	Date of appear-ance
1	4	Mar. 1	5	Mar. 1
2	6	Feb. 26	5	Mar. 6
3	4	Mar. 1	5.5	Mar. 10
4	5	Mar. 6	4.5	Mar. 1
5	3	Mar. 1	3.5	Mar. 1
6	4.5	Mar. 1	5	Mar. 1
7	3.5	Mar. 1	4	Mar. 1
8	3.5	Feb. 26	4	Feb. 26

Time of Sprouting of each Individual Tuber Planted February 4, 1937, from Mature and Immature seed.

Table IV.

	Mature		Immature	
Pot No.	Weight of tubers ounces	Date of appear-ance	Weight of tubers ounces	Date of appear-ance
1	3	Mar. 28	9	Mar. 28
2	3	Apr. 3	7	Decayed
3	5	Mar. 28	9	Mar. 28
4	7	Apr. 4	4	Mar. 28
5	6	Apr. 1	3	Mar. 28
6	8	Apr. 6	4	Apr. 1
7	5	Mar. 28	7	Mar. 27
8	3	Mar. 28	4	Mar. 28

Time of Sprouting of each Individual Tuber Planted March 4, 1927, from Mature and Immature seed.

Table V.

	Mature	Immature
Pot No.	Date of appearance	Date of appearance
1	April 11	April 11
2	April 12	April 16
3	April 17	April 16
4	April 18	April 18
5	April 12	April 22
6	April 12	April 18
7	April 9	April 9
8	April 11	April 19

Time of Sprouting of each Individual Tuber Planted April 4, 1927, from Mature and Immature seed.

Table VI.

	Mature		Immature	
Pot No.	Weight of tubers ounces	Date of appear-ance	Weight of tubers ounces	Date of appear-ance
1	3	May 2	6	May 7
2	2	May 3	3	May 4
3	3	Apr. 22	3	Decayed
4	2	Apr. 29	2	May 5
5	4	May 2	3	May 9
6	2	Apr. 30	2	May 7
7	3	May 1	3	May 9
8	2	May 9	3	Decayed

The lots of mature and immature seed were planted in pots in the greenhouse, November 4, Table I. The dates of the appearance of the first sprout are given. The mature seed sprouted two to three weeks before the immature seed in the November 4 planting. In the December 4 planting the matured sprouted two to three weeks before the immature seed, Table 2.

In the January 4 planting, Table 3, there is very little difference between the time of the appearance of sprouts in the mature and immature seed.

Plantings made February 4, Table 4; March planting, Table 5 and April planting, Table 6, gave the same results as the January 4 planting. The experiment would indicate that the mature seed planted in November and December sprouted quicker than immature seed, but in January, February, March and April plantings there was no significant difference between the time of appearance of the first sprouts in the mature and immature seed.

Photographs were taken of three of the plantings, November 4, January 4 and March 4 to show plants produced from mature and from immature seed.

In Figure 3 the plants came from mature seed planted November 4, 1926. Figure 4 shows plants grown from immature seed planted November 4, 1926. There was much better growth in most of the plants from mature seed than from the immature seed.

Photographs of mature and immature seed planted January 4, (Figure 5 and 6) show the same contrast of plant growth as in the November 4 planting. There is less contrast between the vine growth in the mature and immature seed of March 4 planting (Figure 7 and 8) than in either of the other two dates of planting. Evidence indicates that there is a difference in time of sprouting of the mature and immature tubers when planted at the same date early in the storage season, but later in the storage season there is very little difference in the time of appearance of the sprouts and in the general vigor of the vine growth.

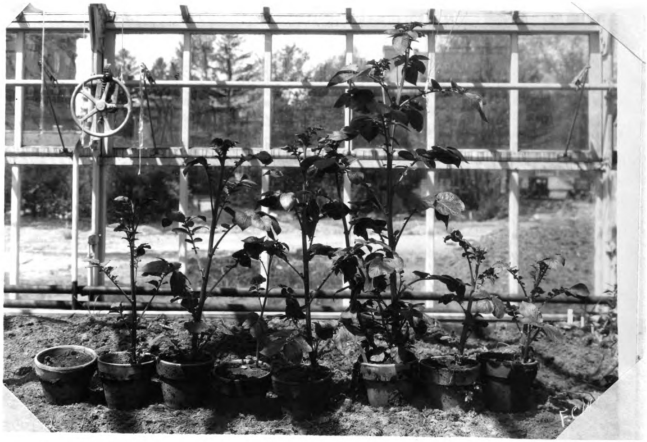


Figure III. Plants grown from mature seed that were planted November 4, 1927.

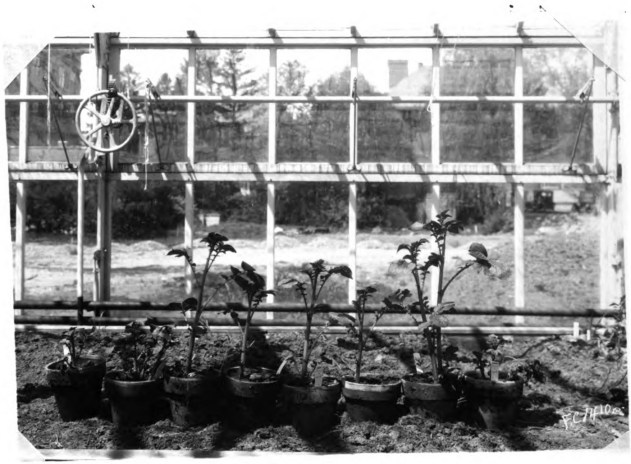


Figure IV. Plants grown from immature seed that were planted November 4, 1927.

Figure V. Plants grown from mature seed that were planted January 4, 1926.

Figure VI. Plants grown from immature seed planted January 4.

Figure VII. Plants grown from mature seed planted March 4, 1927.

Figure VIII. Plants grown from immature seed planted March 4, 1927.

CONDITIONS OF THE SEED AFTER STORAGE.

Representative tubers from each storage were selected and a photograph taken of each lot as they were removed from storage May 10, 1927. All of the storage lots were represented with the exception of the cold storage 32° F. lot stored within closed containers.

The lot stored in tight containers at 32°F. completely decayed due either to the lack of air or to the low temperature or both.

The condition of the seed from each storage can be determined from the following photographs.

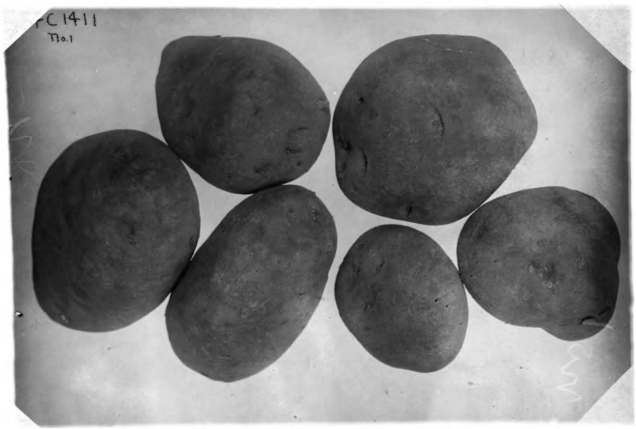


Figure IX. The three tubers on the left were stored in cold storage 36°F. Three tubers on right stored in closed container cold storage 36° F.

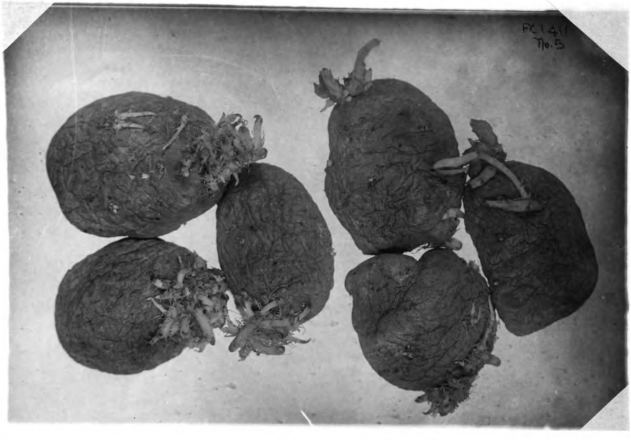


Figure X. Mature and Immature tubers stored in room storage (40-70°F). Three tubers on the left are immature contrasted with three mature tubers at the right.

Figure XI. Mature and Immature tubers as they were when removed from pit storage. Three tubers on the left came from mature stock. Immature stock on the right.

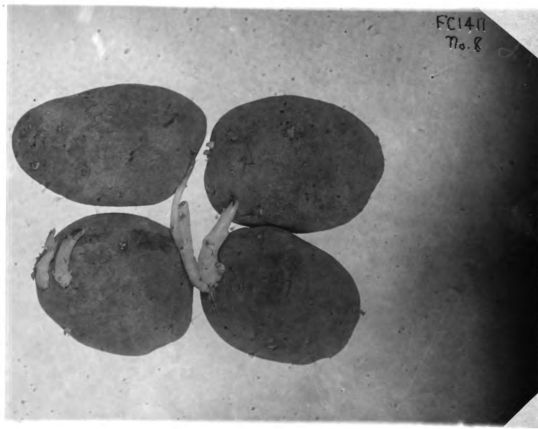


Figure XII. Mature tubers stored in the root cellar at the College.

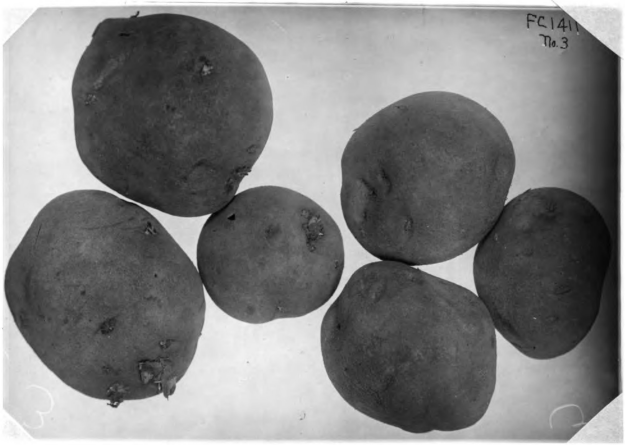


Figure XIII. Mature tubers stored in common potato cellar having relatively low temperature during winter and relatively high temperature in the spring. Three tubers on the left were stored in the open and the three tubers on the right were stored in a closed container.

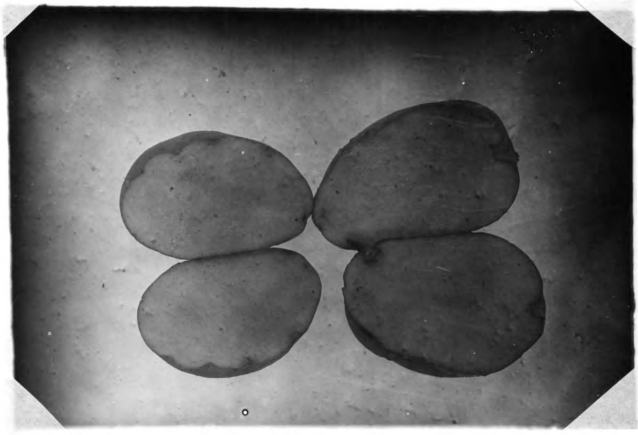


Figure XIV. Small tubers at left stored in closed container and contrasted with a tuber stored in open storage at the right.

High temperature storage caused the tubers to shrivel considerably, Figure 10. Where the temperature ranged from 36° - 40° F. during the winter and increased during the spring, the tubers showed considerable sprouting, Figure 12.

Open storage caused the tubers to sprout more than did the closed containers, Figure 13. When the tubers were stored in cold storage there was very little difference in the sprouting of the tubers whether stored in the open or closed containers. Low temperature retarded the development of sprouts in all cases.

Per cent Stand of Mature and Immature Seed Stored under Various Conditions.

Table VII.

Treatment	Per cent stand June 9	Per cent stand July 15	Per cent stand July 30	Per cent of weak hills
Check average of all	42.9	54.9	55.5	1.6
Root cellar mature	73.2	96.4	96.4	3.7
Root cellar, immature	69.6	96.4	98.2	3.6
Pit Storage, Mature	62.5	98.2	98.2	3.6
Pit Storage, Immature	60.7	94.6	96.4	5.6
Room Storage (40-70°F) Mature	14.3	33.9	37.5	57.1
Room Storage (40-70°F) Immature	30.3	50.0	58.9	57.5
Cold Storage 36°F open Mature	30.3	98.2	98.2	7.2
Cold Storage 36°F open Immature	26.7	96.4	96.4	3.7
Cold Storage 36° F closed, Mature	32.1	98.2	100.0	3.5
Cold Storage 36°F closed, Immature	2.6	94.6	94.6	3.8
Cold Storage 32°F open Mature	5.3	50.0	58.9	30.3
Cold Storage 32°F open Immature	7.1	64.2	69.6	23.1

Results as indicated from the data in Table 7 show that room storage (40-70° F) produced only 37.5 and 58.9 per cent stand, whereas, the tubers stored at a temperature of 36° F. or in the cold storage produced 98.2 and 96.4 per cent stand on July 30, seven weeks after the tubers were planted. The per cent stand on July 15 for the 32° F. was 58.9 for mature seed and 69.6 for immature seed.

The immature seed increased the stand by 10.6 per cent over the mature seed in the cold storage at 32° F. The immature seed increased the per cent stand in the high temperature storage (40-70° F) by 21.4 per cent. The per cent of stand in the other treatments was nearly the same for the mature seed as it was for the immature seed.

Along with the records taken July 30 on per cent stand, the per cent of weak hills in each treatment was recorded. The only two treatments showing a high percentage of weak hills were in the high and low temperature storages represented by room storage (40-70°F) and cold storage 32°F. 57.1 per cent of the hills in the high temperature storage were weak. There was very little difference in the per cent of weak hills in the mature and immature seed stored at a high temperature. The low temperature storage produced 30.3 per cent weak hills in the mature seed and 23.1 per cent weak hills

in the immature seed. Mature seed averaged 7.2 per cent better stand than the immature seed in the low temperature storage.

There was no significant difference between the percentage of stand and the percentage of weak hills in the mature and immature seed when compared in each treatment. The chief difference in percentage of stand and weak hills was between the high and low temperature storages and the other storage conditions.

NUMBER OF STALKS PER HILL EXPERIMENT.

Another phase of experimental work was taken up in recording the number of stalks per hill. Unpublished data of the Michigan State College Experiment Station shows that three to five good healthy stalks per hill will yield better than one or two stalks per hill.

The table on the following page gives the per centage of stalks per hill in the mature and immature lots of seed also percentage of stalks per hill in the different storage conditions.

Percentage of Stalks per hill obtained from seed stored under Various Conditions.

Table VIII

Treatment	One stalk	two stalk	three stalk	four stalk	five stalk	seven stalk
Average of check	14.8	45.1	28.8	9.0	1.5	
Root cellar storage Mature	5.5	35.2	42.6	13.0	3.7	
Root cellar storage Immature	9.0	41.8	38.1	9.0	1.8	
Pit storage Mature	14.5	38.2	32.7	10.9	1.8	1.8
Pit Storage Immature	25.9	50.0	18.5	5.6		
Furnace room Mature	61.9	28.5	4.8	4.8		
Furnace room Immature	65.6	28.1	6.3			
Cold Storage 36° open Mature	10.7	37.5	35.7	14.3	1.8	
Cold Storage 36° open Immature	7.4	45.2	38.9	5.6	3.7	
Cold Storage 36° closed Mature	10.7	44.6	28.6	14.3	1.8	
Cold Storage 36° closed Immature	17.0	52.8	26.4	1.9	1.9	
Cold Storage 32° open Mature	63.6	24.2	6.1	6.1		
Cold Storage 32° open immature	51.3	41.0	7.7			

Table 8 shows the per cent of stalks in each hill. The stalks range from one to seven per hill. Different treatments did not seem to have any influence on the number of stalks in the mature and immature stock when stored under the same storage condition.

There was a difference in the number of one stalk hills between lots of seed stored under various conditions. There was very little difference between the storage condition where the temperature ranged from (36-45°F), but where the temperature was lower or higher there was a decided difference in the number of stalks per hill. The check plots that were stored in the root cellar where the temperature ranged from 35-48° F. throughout the storage season had 14.8 per cent one stalk hills and the high temperature storage (40-70° F) had when averaged (mature and immature lots of seed) 63.7 per cent one stalk hills or 46.9 per cent more one stalk hills in the high temperature storage (40-70° F) than in the check plots. The cold storage 32° F. had 57.4 per cent one stalk hills or 42.6 per cent more one stalk hills than the check plots.

In unpublished data of the Michigan Experiment Station it was shown that hills having more than one stalk gave better yields than one stalk hills. Studying Table 8 we note that the average storage condition (35-48° F) gave a greater number of two or more stalk hills than either the low or high temperature storages.

The check and root cellar stock was stored in the same storage. The seed used for the stage of maturity test was of a better strain than that planted in the check plots which accounts for the average 11.5 per cent more three stalk hills than there were in the check plats.

Room storage (40-70°F) gave 5.4 per cent three stalk hills. The check plats had 23.4 per cent more three stalk hills than the room storage.

Cold storage 32° F. averaged 6.9 per cent three stalk hills or 21.9 per cent three stalk hills less than the check.

All of the storage conditions yielded the same number of one, two, three or more stalks per hill with the exception of the room storage (40-70°F) and the cold storage 32° F. which had less two and three stalk hills, but more hills having one stalk.

Room storage (40-70° F) and cold storage 32° F. gave a significant larger number of one stalk hills than either of the other storage conditions. The results would indicate that a potato grower should avoid storing potatoes in a cellar at a temperature below 34° F. or above 48° F. if he is to be assured of having the minimum number of one stalk hills.

There is no significant difference between the mature and immature seed as to the number of stalks per hill when compared under the same storage condition. The conclusions are that there is no difference between the mature and immature seed as affecting the number of stalks.

In cold storage 36°F. there was a comparison of the number of stalks per hill between tubers stored in a closed container and tubers stored in the open. There was 4.8 per cent more one stalk hills, 2.6 per cent more two stalk hills, 9.8 per cent more four stalk hills and .9 per cent less five stalk hills in the open storage at 36° F. than in the closed container.

There was no significant difference between the open storage and closed container as affecting the number of stalks per hill.

Comparative Yields of Mature and Immature Seed Stored Under Various Conditions.

Table IX.

Storage	Maturity	Bushels per acre	Probable error	
Root cellar	Mature	120.44	plus-minus	5.95
Root cellar	Immature	121.00	"	" 5.98
Pit	Mature	108.49	"	" 5.36
Pit	Immature	101.34	"	" 5.01
Room Storage (40-70° F)	Mature	46.77	"	" 2.41
Room Storage (40-70° F)	Immature	60.88	"	" 3.01
Cold Storage 36°F. open	Mature	118.63	"	" 5.86
Cold Storage 36°F. open	Immature	131.58	"	" 6.50
Cold Storage 36° F. closed	Mature	121.92	"	" 6.02
Cold Storage 36° F. closed	Immature	111.84	"	" 5.52
Cold Storage 32° F. open	Mature	75.76	"	" 3.74
Cold Storage 32° F. open	Immature	95.66	"	" 4.72

The error of a single determination was calculated by obtaining the deviation between the standard values and corresponding points on the best straight line possible throughout that years data.

Root Cellar

Mature mean yield	20.44	plus-minus	5.95
Immature " "	121.00	" "	5.98
Difference	.56		8.5

As the difference is not as great as 3.3 x P. E. it is concluded that there is no difference in the yield of the mature and immature stock stored in the root cellar.

Pit Storage.

Mature mean yield	108.49	plus-minus	5.36
Immature " "	101.34	" "	5.01
Difference	7.15		7.34

Room Storage (40 - 70° F)

Mature mean yield	48.74	plus-minus	2.41
Immature " "	60.88	" "	3.01
Difference	12.14		3.85

Cold Storage 36° Open.

Mature mean yield	118.63	plus-minus	5.86
Immature " "	131.58	" "	6.50
Difference	13.95		8.75

Cold Storage 36° Closed container.

Mature mean yield	121.92	plus-minus	6.02
Immature " "	111.84	" "	5.52
Difference	10.08		8.17

Cold Storage 32° Open.

Mature mean yield	75.76	plus-minus	3.74
Immature " "	95.66	" "	4.72
Difference	19.90		6.02

As the difference in the different storage conditions is not as great as 3.3 x P. E. it is concluded that there is no difference in the yield of the mature and immature seed stock.

Assuming that there is no difference between the yields of mature and immature seed, according to the P/C method of calculation the average of

the mature and immature yields in each storage condition was taken and from that the total yield was calculated. All of the storage conditions were compared with the root cellar storage which corresponds to the majority of potato storages in Michigan.

Yields of Potatoes in Bushels per acre from the various Storage Conditions

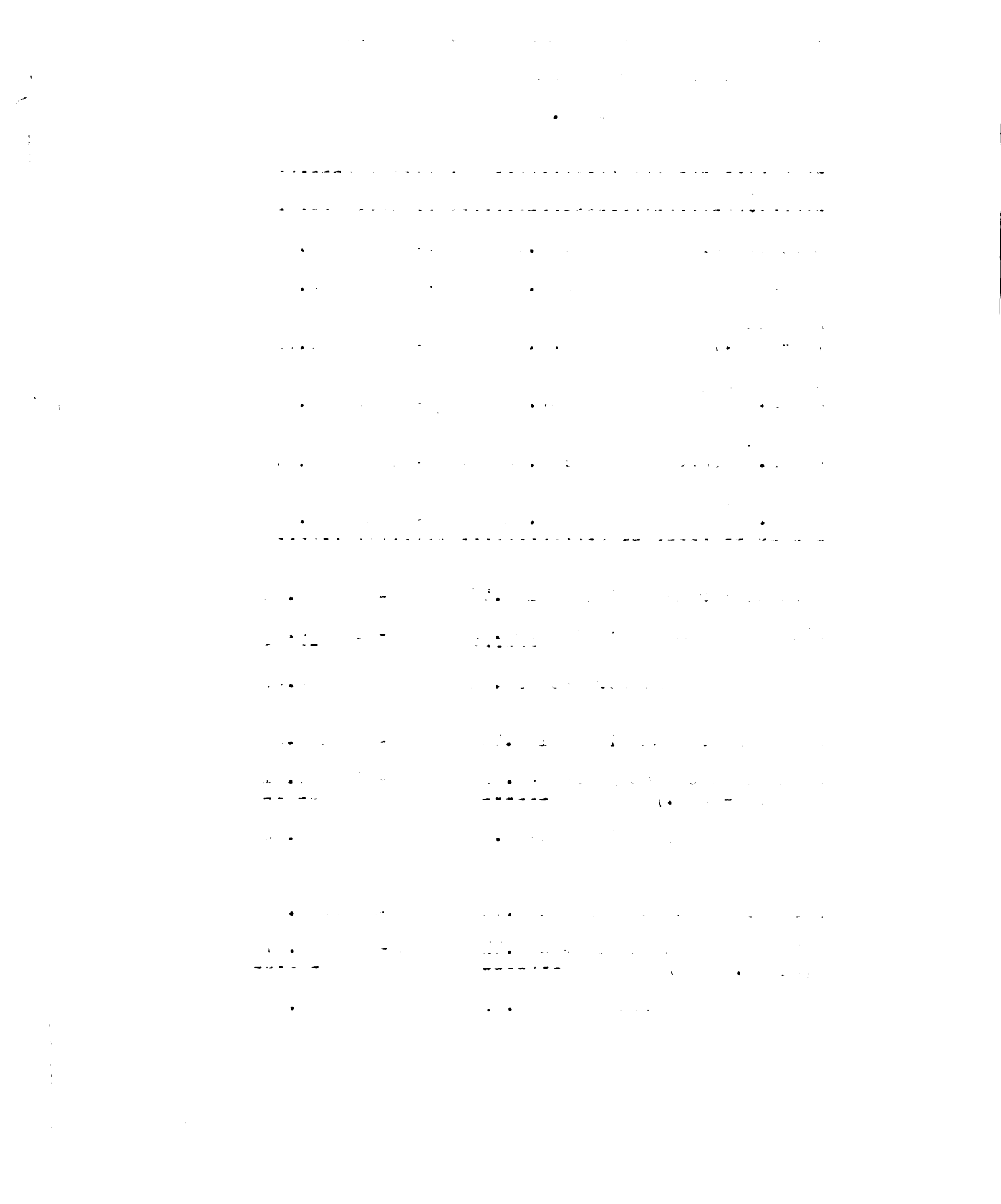
Table X.

Storage	Bushels per acre		
Root Cellar	120.72	plus-minus	4.22
Pit Storage	104.91	plus- minus	3.66
Room Storage (40-70°F.)	54.81	plus-minus	1.91
Cold Storage 36° F. open	125.11	plus-minus	4.37
Cold Storage 36° F. closed	116.43	plus-minus	4.07
Cold Storage 32° F. open	85.71	plus-minus	2.99

Root Cellar mean yield	120.72	plus-minus	4.22
Pit Storage mean yield	104.91	plus-minus	3.66
Difference	15.81		5.59

Root Cellar mean yield	120.72	plus-minus	4.22
Room Storage mean yield (40-70°F.)	54.81	plus-minus	1.91
Difference(significant)	65.91		4.63

Root Cellar mean yield	120.72	plus-minus	4.22
Cold Storage mean yield (32° F. open)	125.11	plus-minus	4.37
Difference	4.39		6.08



Root Cellar mean yield	120.72	plus-minus	4.22
Cold Storage mean yield (36°F. closed)	116.43	plus-minus	4.07
Difference	4.29		5.86

Root cellar mean yield	120.72	plus-minus	4.22
Cold Storage mean yield (32°open)	85.71	plus-minus	2.99
Difference(significant)	35.01		5.17

6.7 x P. E.

There is no significant difference between the yield of root cellar and pit storage, but there is a significant difference between root cellar storage and room storage (40-70° F.). The difference is 14.2 x P. E. which is very significant. Root cellar storage when compared with cold storage either in open storage or in closed containers does not give a significant difference. The conclusion is that the cold storage at 36° is as good for the storage of potatoes for seed as the root cellar storage at the Experiment Station.

A significant difference is obtained when comparing the root cellar storage with cold storage at 32°. The difference is 6.7 x P. E. which is significant.

From the results obtained it is recommended that temperature above 48° F. or 32° F. and below in the potato storage will not permit the maximum stand and yield.

Comparison of High Temperature Storage with Low Temperature Storage.

Room Storage (40-70°F.) mean yield	54.81	plus-minus	1.91
Cold Storage 32° F. mean yield	85.71	" "	2.99
Difference(significant)	30.90		3.40

Potatoes stored in cold storage 32° F. yielded more than tubers stored in the room storage (40-70°F). A significant difference of 9.0 x P. E. From the results obtained, root cellar storage is one of the best. High temperature storage gives the lowest yield and cold storage 32° F. is better for storage of seed potatoes than the room storage (40-70°F.), but was inferior to root cellar storage.

The low yield of the room storage (40-70°F) and the cold storage 32°F. was caused by the low per cent germination and the large percentage of one stalk hills. The storage condition affected the viability of the seed of both the mature and immature seed in about the same degree.

CONCLUSIONS:

Seed potatoes should not be stored in a storage cellar where the temperature is lower than 36° F. or higher than 48° F. to insure seed that will produce vigorous plants.

Potatoes stored at 32° F. when air is excluded will decay and result in total loss of seed. 32° F. open storage reduces the viability of the potatoes for seed.

High temperature storage (40-70° F.) reduces the vitality of the potatoes for seed, also reduces the quality of tubers for eating purposes, causing loss in storage due to excessive shrinkage.

Low temperature 32° F. reduces the per cent germination and increases the number of one stalk hills. High temperature storage 48° F. or above reduces the per cent of germination, increases materially the number of one stalk hills and also causes an increase in the per cent of weak hills.

Mature seed potatoes gave the same yield as immature seed. Indications are that growers can be assured of the same yield of potatoes whether the tubers are planted from mature or immature seed. The experiment indicates very little difference between the stage of maturity as affecting the value of the potatoes for seed.

BIBLIOGRAPHY.

1. "Value of Immature Potato tubers as Seed". H. P. Hutchinson, jour. Bd. Agr. (London) 23, (1916) No. 6, pp 529-539.

2. App, F. (1921) Report of the Department of Agronomy and Farm Management. N. J. Agr. Exp. Sta. Ann. Rpt. (1920) 41: 251-258.

3. Appleman, C. O. (1918) "Physiological Basis for the preparation of Potatoes for Seed", Md. Agr. Exp. Sta. Bul. 212: 79-102, illus.

4. Cox, H. R. (1921) Report of the Specialist in Soil Fertility and Farm Crops, N. J. Agr. Exp. Sta. Ann. Rpt. (1920) 41: 207-210.

5. Appleman, C. O. and Miller, E. V. (1926) "A Chemical and Physiological Study of Maturity in Potatoes", Jour. Agr. Res. 33: 569-577.

6. W. T. Macoun (1918) "The Potato in Canada", Bulletin No. 90, p 22-23.

7. Stewart, J. G. (1906) A Report on Experiments with Potatoes, 1905, Univ. Leeds and Yorkshire Council Agr. Ed. (pamphlet) 55, 30 p illus.

8. Sutton and Sons (1906) Potato Demonstrations 48 p., Illus. Reading, England.

9. Davidson, W. D. (1925) Potato Growing for Seed Purposes. Jour. Dept. Lands and Agr. Ireland 24: 374-423.

10. Dunlop, J. (1914) Report on the Field Trials of the College Farms in 1914 with Ripe and Unripe Seed Potatoes. Midland Agr. and Dairy College Rpt. 1914: 21-22.

11. Dunlop, J. (1915) Report on the Field Trials on the College Farms in 1915, of ripe versus unripe seed potatoes. Midland Agr. and Dairy College Rpt. 1915: 42.

12. Helmer, R. H. (1923) Potatoes, Comparison of Yields from Mature and Immature Seed. Canada Exp. Farm Sta., Summerland, B. C. Rpt. Supt. 1922: 60-61.

13. Ramsay, J. T. (1915) Experiments in the Cultivation of potatoes. 1914-15. Jour. Dept. Agr. Victoria 13: 340-348, illus.

14. Ramsay, J. T. (1922) Potato Experiments, 1921-22 Jour. Dept. Agr. Victoria 20: 415-417.

15. Ramsay, J. T. (1925) Potato Experiments, 1924-25. Jour. Dept. Agr. Victoria 23: 467-471.

16. Bushnell, J. Bimonthly Bulletin of the Ohio Agr. Exp. Sta. Volume XII, No. 5.

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