EFFECTS OF SIZE OF SEED PIECE AND RATE OF NITROGEN APPLICATION ON THE PRODUCTION OF TRUE SEED IN THE POTATO

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By

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TABLE OF CONTENTS

	Page
INTRODUCTION	1
REVIEW OF LITERATURE	1
METHODS AND MATERIALS	2
DATA AND DISCUSSION	4
Treatment 1	6
Treatment 2	7
Treatment 3	9
Treatment 4	9
CONCLUSIONS	21
LITERATURE CITED	22

INTRODUCTION

Since the establishment of the National Potato Breeding Program in 1929 workers have become particularly interested in potato breeding and its attending problems. One of the most provoking of these problems is flower abscission and subsequent failure to produce fruit.

Preliminary observations made in the greenhouse at East Lansing in 1939 indicated that large sizes of seed piece (8 - 9 ounces) and nitrogen applications might be conducive to flowering and setting of seed.

It was thought that the organic reserves in the seed piece were transferred to the growing plant and thus reduced the necessity for a normal length of day. It was believed that an experiment set up to determine the effects of size of seed piece and varying nitrogen applications might be useful in potato breeding work when crossing was involved.

REVIEW OF LITERATURE

The study of the flowering habits of the Irish potatoes has concerned many workers. From the work reported, it appears that many factors enter in to affect normal flower production. Dorsey (3) asks what the relation of dropping of flowers bears to the normal functioning of pollen and pistil. He states that a complete abortion of pollen occurs in many forms in which the pistil functions normally and that this factor is not necessarily a cause for dropping. Also, the flowers are cut off before the stimulation resulting from pollination or fertilization takes place, this

factor can be eliminated. Bloom, likewise, precedes any considerable storage of food material in the tuber. He concludes that there appears to be physiological influences operating independently of pollen or pistil development which cause the potato flowers to drop.

Stevenson (8) has made an extensive literature review on many phases of potato breeding that are concerned with potato flowering.

Clarke and Lombard (1) show that the length of day is an important factor in the production of mature flowers and fruits by various varieties of potatoes. Varieties differ in their light requirements for the production of flowers and seed balls. A greater number of flowers is produced with the longer photoperiods. In it appears that satisfactory conditions for both flowering and fruiting were provided at Beltsville, Md., by a day length of approximately 16 hours.

Jones and Borthwick (4) in a study of the influence of photoperiod and other factors found that the small size of seed piece (5 grams), high temperature (80° during the day, and 55° at night) and the short photoperiod had a tendency to increase the node number to the first inflorescence. Also, flower primordia were differentiated in total darkness.

MATERIALS AND METHODS

On February 14, 1940 thirty-six 10 inch glazed clay pots were planted to each of the Russet Rural and Chippewa varieties in the greenhouse at East Lansing to be used as female parents. In addition several pots of the Katahdin variety were planted for use as the pollinating parent.

Twelve pots in each variety were planted with 2-3 ounce seed pieces, twelve with 5-6 ounce seed pieces and the remaining twelve with 8-9 ounce seed pieces.

The potatoes were grown in quartz sand throughout the experiment. With the exception of two treatments, all plants received a three salt nutrient solution. Type 1 R_2S_4 (4) was used as a basis for calculating the amounts of nutrients to be applied in the treatments. The following solutions were used:

Treatment Number	Partial volume - Molecular Concentrations		
	KH_2PO_4	$Ca(NO_3)_2$	$MgSO_4$
1	0.0000	0.0000	0.0000
2	0.0045	0.0000	0.0045
3	0.0045	0.0090	0.0045
4	0.0045	0.0180	0.0045

Treatment 1 received tap water only throughout the experiment. Calcium chloride was substituted for calcium nitrate in Treatment 2. Treatments 1 and 2 will be referred to as minus nitrogen treatments and Treatments 3 and 4 as plus nitrogen treatments in this discussion. The nutrients were supplied to the plants by the slop culture method.

Tap water was used to keep the plants moist in the intervals between nutrient applications and to leach the accumulation of salts from the cultures.

The temperature was controlled between 70 - 75° F. during the night and on cloudy days, but on sunny days it frequently reached 90° F. The higher temperatures were more frequent during the latter part of the blossoming period. No artificial light was used during the duration of the experiment.

On March 21, five weeks after planting, nutrient solutions were applied for the first time, followed by applications at three day intervals until April 7. After this date, applications were made less frequently, depending upon the growth requirements of the cultures.

The first crosses were made on April 15. Since the Chippewa and Russet Rural do not normally produce seed when self pollinated, the crossed flowers were not emasculated. With the exception of one cross, pollen from the Katahdin variety was used as the male parent. Flowers that were not crossed were frequently left as checks for the occurrence of natural crossing.

Pollen was applied each day to the pistil until the seed ball began to form, or until the flower abscissed. Frequently the flowers remained on the plants. The seed balls were bagged with cheesecloth and remained on the plants until harvest.

The experiment was discontinued on June 10 when the seed balls were harvested and the tubers weighed. The seeds were allowed to ripen in the seed ball and then pressed on blotters to dry.

Three hundred seeds of each treatment were planted in sand on December 20 and the germination determined on January 18, 1941.

DATA AND DISCUSSION

The Chippewa plants, sprouted first and were considerably larger than the Russet Rural plants, on March 25. Although multiple sprouting was pronounced in some cultures, this condition was not confined to any one size of seed piece or nutrient treatment.

The nutrient treatments had a decided effect on the growth of the plants by April 5. The cultures from Treatment 1 (tap water) ranged from 4 - 7 inches in height while the cultures from Treatment 4 (complete nutrient plus added nitrogen) were 24 - 28 inches in height. The cultures subjected to Treatment 3 (complete nutrient) were nearly like those from Treatment 4. The cultures from Treatment 2 (minus nitrogen) were intermediate in height between Treatments 1 and 4.

All of the rhizomes in the cultures which received nitrogen solutions were emerging from the sand on April 5, and were developing into vegetative stems.

An examination of the cultures which were minus nitrogen showed that the rhizomes had remained underground and were developing tubers. This shows that food was being stored in the new tubers of the cultures which were minus nitrogen, but was being used for vegetative growth in the cultures which received added nitrogen.

On April 12 blossom buds were well developed on the Chippewa plants from the 8 - 9 ounce seed pieces in Treatment 4. In the Russet Rural plants, with the same nutrient solution treatment, it was the plants from the 2 - 3 ounce seed pieces which were producing blossom buds. There were more buds on the Chippewa plants than on the Russet Rural plants as there were more lateral branches. Most of the buds on both varieties in Treatment 2 abscissed before they were well formed. The buds on both varieties in Treatments 1 and 3 had not formed at this date.

The first crosses were made on April 15. Katahdin pollen was applied to the stigmas of flowers of Chippewa plants from the 8 - 9 ounce seed pieces in Treatment 4 and Russet Rural plants from the 2 - 3 ounce seed pieces in the same treatment.

On April 15 the plants were not watered. The next morning the greenhouse temperature was high (95° F.) and the Chippewa plants of Treatment 4 (plus nitrogen) were wilted. After watering the leaves regained their turgidity but a number of the leaves on the plants from the 2 - 3 ounce seed piece subsequently were affected with tip burn, one leaf on a plant from the 5 - 6 ounce seed piece was burned and no leaves on the plants from the 8 - 9 ounce seed pieces were injured. There is a possibility that the size of the seed piece might have had some effect on the degree of wilting;

the plants from the 8 - 9 ounce seed pieces having had a large enough water storage to prevent the tip burn injury while the plants from the 2 - 3 ounce seed piece had a lesser amount of available water and were injured.

There was a distinct difference in the behavior of the varieties, but the behavior of the plants of the same variety, same size of seed piece, and the same treatment was very similar. For reasons of clarity each treatment will be considered separately.

Treatment 1. (Tap water)

The Russet Rural cultures exhibited progressively greater growth as the size of seed piece was increased. Figure VI. One Russet Rural culture from the 2 - 3 ounce seed piece produced seed. Only a few blossoms were produced, but of those formed, five were fertilized and formed seed balls. Figure VI and Table I.

The Chippewa cultures did not respond to the size of seed piece as did the Russet Rural. Figures VI and IX. Characteristically, the Chippewa cultures were many stalked but remained dwarfed, while the Russet Rural cultures were represented by usually single stalked plants and increased stature.

The Chippewa cultures from 2 - 3 ounce seed pieces did not produce flowers. A few flower buds formed and began to grow but quickly turned brown and abscissed before they had developed. The plants seemed to be more susceptible to the lack of mineral nutrition than were the Russet Rural plants. The leaves were crinkled and light green in color; the internodes were shortened; and the stems more numerous than were the Russet Rural plants of comparable treatment and size of seed piece. The Chippewa cultures were dead before the experiment was completed, while the Russet Rural cultures continued to live.

Flowers were not formed by either variety in this treatment with the 5 - 6 and 8 - 9 ounce seed pieces. Flower buds formed but abscissed before the flowers opened. The main difference between the varieties was the manner of growth as shown in Figures VI and IX. The Chippewas responded slightly to the larger size of seed piece. As shown in Figure IX, the plant from the 8 - 9 ounce seed piece was injured less from lack of nutrients than the plant from the 5 - 6 ounce seed piece.

This treatment does not show any promise of value for the production of seed balls. However, it does indicate that varieties of potatoes do not respond to nutrient treatments in a like manner.

Treatment 2. (Nutrient solution - minus nitrogen)

The growth of the Russet Rural cultures under this condition was very similar to that of Treatment 1. Figure VIII. With this treatment the plants from the 8 - 9 ounce seed pieces produced seed while the plants from the two smaller sizes did not. This was in contrast with the Russet Rural cultures of Treatment 1 in which a plant from a 2 - 3 ounce seed piece produced seed while the plants from the large sizes of seed pieces did not produce seed.

Plants from the 5 - 6 and 8 - 9 ounce seed pieces produced normal flowers. Crosses were successfully made only on plants from the 8 - 9 ounce seed pieces.

Chippewa cultures of Treatment 2 resembled the Chippewa cultures of Treatment 1 in growth habits. Figures IV and VII. The treatments affected the variety differently in that the cultures of Treatment 2 lived throughout the experiment. Flower buds formed but abscissed.

Treatment 2 resulted in no seed setting in the Chippewa but the Russet Rural plants from the 8 - 9 ounce seed pieces produced flowers which developed normally and persisted. The latter feature was desirable as pollen

Table 1. Number of seeds harvested from crosses made on the Russet Rural and Chippewa varieties.

Treatment	Size of Seed Piece					
	2 - 3 ounce		5 - 6 ounce		8 - 9 ounce	
	Russet Rural	Chippewa	Russet Rural	Chippewa	Russet Rural	Chippewa
1 (Tap water)	1211	0	0	0	0	0
2 (Nutrient minus nitrogen)	0	0	0	0	1575	0
3 (Complete nutrient)	0	0	0	0	537	367
4 (Complete nutrient with added nitrogen)	734	0	0	881	0	543

could be applied each day until the seed ball began to form. The plants were sparsely vegetative and stocky and the flowers were convenient for pollination.

Treatment 3. (Complete nutrient solution)

The Russet Rural cultures from all sizes of seed pieces were about equal with regard to height and amount of vegetation. Flower buds formed in large numbers, but most of them abscissed before flowers were formed. This was particularly true of the plants from the 2 - 3 ounce and 5 - 6 ounce seed pieces. The flowers that did develop were not persistent enough to allow for pollination on successive days. Plants from the 8 - 9 ounce seed pieces had flowers that were more persistent and some crosses were successful. Table I.

Chippewa and Russet Rural cultures from 2 - 3 ounce seed pieces were alike in that flower buds were abundant but in each case the flowers abscissed before seed balls were formed.

Seed ball setting was successful on cultures of the Chippewa variety from the 8 - 9 ounce seed pieces. Table I.

Treatment 4. (Complete nutrient with added nitrogen)

Flower buds formed on all Russet Rural plants in Treatment 4, but most of them abscissed before the flowers developed. The flowers on the plants from the 8 - 9 ounce seed pieces were more numerous and persisted longer than on the plants from the 2 - 3 ounce seed pieces.

In this treatment, the nutrient applications apparently hastened the formation of the abscission layer of the flowers.

Seedballs formed on Chippewa plants from the 5 - 6 and 8 - 9 ounce seed pieces. Table 1.

From the results obtained with the different sizes of seed piece and nutrient solutions the 8 - 9 ounce seed piece and Treatment 4 (complete nutrient with added nitrogen) seem to offer the most possibilities for seed production in the greenhouse under winter conditions. Table 1. The 8 - 9 ounce seed piece, with all treatments, produced more seed than either of the other two sizes. (5 - 6 ounce and 2 - 3 ounce.) Treatment 4 applied to all sizes of seed pieces produced more seeds than any of the other three treatments.

The large number of comparisons and the limited greenhouse space made it necessary to limit the replications to three. In many treatments no seed was produced and in some treatments one plant produced seed while the other plants in the same treatment were barren. In cases where only one plant in a treatment produced seed it is difficult to draw a valid conclusion. An example of this is Treatment 1 in which one Russet Rural plant from a 2 - 3 ounce seed piece produced seed. The exception is difficult to explain on any other basis than that it is due to a variation which might have resulted from seed variation.

Nutrient solutions, as described on page 3, were supplied to the cultures throughout the entire growing period of the plants. It was noticed that the flower buds and flowers of the nitrogen containing treatments abscissed more rapidly than did the flowers of the minus nitrogen treatments. Also, the rate of abscission was most rapid immediately following the nutrient applications. The rapidity of abscission in the plus nitrogen cultures made it difficult to pollinate the blossoms for more than two days.

From observation the best technique would be to use the 8 - 9 ounce seed piece and Treatment 4 until the flower buds formed and then change to Treatment 2 (minus nitrogen). This would make it possible to take advantage of the larger number of flowers formed on plants in Treatment 4 and also the increased length of time that elapsed before abscission on Treatment 2 plants.

Figure I.

The cultures as they appeared on April 16 (two months after planting). The cultures in the left foreground comprise Treatment 1, those in the right background Treatment 2. (Minus nitrogen treatments.) The culture in the left background, the center, and right foreground comprise Treatments 3 and 4, (plus nitrogen treatments).

Figure II.

A Russet Rural plant on the left and a Chippewa plant on the right, both representative of Treatment 4. This figure shows the difference in time of blossoming. Photograph taken April 16.

Figure III.

A Chippewa plant representative of Treatment 4 and showing the number of blossoms and blossom buds that were formed. (Most of these abscissed later without setting seed.) Photograph taken April 16.

Figure IV.

Front right to left; back left to right. Showing progressively greater growth of Chippewa plants as influenced by Nutrient Treatments 1, 2, 3 and 4. Photograph taken April 16.

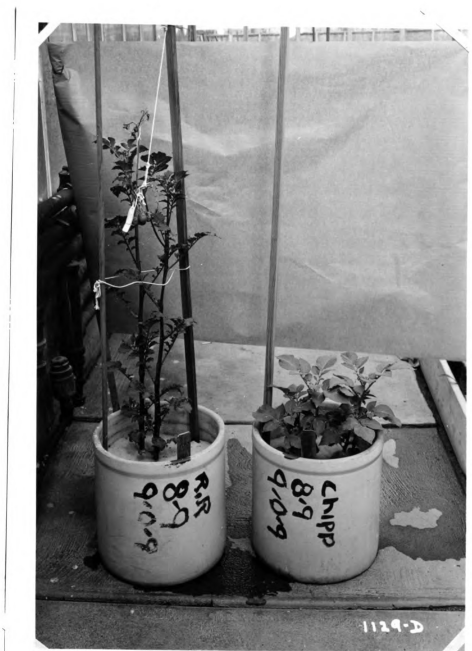
Figure V.

Front right to left and back left to right. Showing growth of Russet Rural plants as influenced by Treatments 1, 2, 3 and 4. All plants are from 5 - 6 ounce seed piences. Photograph taken April 16.

Figure VI.

Growth of Russet Rural plants as influenced by size of seed piece. The plants had no nutrients, except tap water, added. Photograph taken May 24.

Figure VII.



Showing effect of variety on growth. Both cultures are from Treatment 2. (Minus nitrogen) and taken from the same size of seed piece. Photograph taken May 24.

Figure VIII.

The effect of Treatment 2 (minus nitrogen) and size of seed piece on Russet Rural plants. Right, 2 - 3 ounce seed piece; center, 5 - 6 ounce seed piece; left, 8 - 9 ounce seed piece. Photograph taken May 24.

Figure IX.

The growth of Chippewa plants as influenced by size of seed piece and Treatment 1 (tap water). Photograph taken May 24.

CONCLUSIONS

1. The Chippewa and Russet Rural varieties responded differently to nutrient treatments. In a minus nitrogen treatment the Chippewa cultures had many stems, but were dwarfed, while the Russet Rural cultures were mostly single stalked and tall.
2. Russet Rural plants matured in quartz sand with minus nitrogen treatments, while the Chippewa plants died before reaching maturity.
3. A larger number of stems was produced on plants supplied with a complete nutrient solution bearing added nitrogen than by plants supplied with minus nitrogen solutions.
4. Potato plants which received minus nitrogen treatments responded with increased growth directly as the size of seed piece was increased.
5. In treatments where complete nutrient solutions were used the effect of size of seed piece was minimized insofar as height of plant was concerned.
6. Observation of plant behavior indicate that modified treatment 4, as described on page 11, offered the most possiblities, of the treatments used, for seed production.

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