THE INFLUENCE OF CERTAIN ENVIRONMENTAL FACTORS ON THE PRODUCTION AND QUALITY OF POTATOES FOR THE POTATO CHIP INDUSTRY

By

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A THESIS

Submitted to the School of Graduate Studies of Michigan State College of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

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To

Farmers--with whose friendly associations the author finds recreation, education, and inspiration--the results are herewith affectionately dedicated.

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PREFACE

"More than half the people of the world go to bed hungry every night. This need not be so if the known methods of improved agricultural production and nutritional practices were widely adopted; food production could be greatly increased and family levels of living materially raised. . . . [Norris E. Dodd (23), Director General, Food and Agricultural Organization, United Nations]."

In consideration of this thought, a thorough diagnosis of the vital question of simple sustenance is needed. This diagnosis should be based primarily on an investigation of the issue of getting enough to eat and should be followed by an application designed toward furthering not only food production but also adequate distribution. These problems deserve acute attention from those who respect humanity and who have its welfare and progress at heart.

The current and urgently important problem of hunger in many parts of the world, especially in Asia, is twofold: first, that of improving the food situation by increasing per capita consumption through increasing quantity; second, that of enriching the faulty and unbalanced diets of these poorly fed people by providing a greater variety of food materials of better quality.

The author, therefore, thought that he could do service, not only to his Mother India, but also to the free world, by acquainting himself with, and developing interest in, some of the current techniques in crop production and food production.

D. K. Salunkhe

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INTRODUCTION

Horticultural quality of a potato crop depends upon genetic, climatic, biotic, and edaphic factors: genetic--the varietal characteristics as determined by its hereditary make-up; climatic--precipitation, temperature, and duration of sunshine; biotic--man, animals, other plants, and the crop itself in relation to its environment; edaphic--physical, chemical, and biological properties of the soil influencing the capacity to supply the crop with necessary nutrients and water. The successful production of potatoes of high quality is fundamentally influenced by the individual as well as the cumulative effect of these four factors. Though these are well recognized factors, their effects on quality need further exploration and definition.

The purpose of the investigation presented herein was to explore the effects of certain environmental factors on the quality of several varieties of potatoes used by the potato chip industry. The particular agronomic factors involved in this study were: dates of planting, mineral fertilizers, different levels of irrigation, and two different locations in Michigan; namely, Lake City in 1950, 1951, and 1952, and East Lansing in 1951. The study also included the influence

of duration and temperature of tuber storage. The specific gravity of the tuber, picric acid test for the content of reducing sugars in the tuber, and the color of the potato chips, were the quality factors used to evaluate the influence of agronomic and storage practices.

It is the author's sincere hope that these investigations will be of value to the potato growers as well as to the potato chip manufacturers.

REVIEW OF LITERATURE

More than five hundred papers on the quality study of potatoes and potato chips were examined, but only those directly concerned with this study are reviewed here.

Dates of Planting

Smith and Nash (49) mentioned that potatoes obtained from early planting were more mature than were those from late planting.

Pyke and Johnson (42) reported that late planting gave more immature tubers at harvesting and that this immaturity resulted in a greater tendency to develop dark chip color on frying.

MikuljskiI (36) emphasized that the ripening of the tubers of potato is characterized by an increase in the content of dry matter, starch, and total nitrogen, and by an increase in the ratio of soluble nitrogen to protein nitrogen and a decrease in the ratio of sucrose to reducing sugars.

Appleman and Miller (4) noted that in general immature potatoes contained less starch, more total sugar, less protein, and more reducing sugars than did mature tubers. Reducing sugars were always

high in immature potatoes even at the time of harvest, as well as after a rest period. Moisture content in immature tubers was high.

Sweetman (54) concluded that immature potatoes which were in cold storage responded less slowly to warmth during a conditioning period than mature potatoes and that chips made from immature potatoes were uneven in color. For high-quality chips, the use of mature potatoes high in starch content was recommended.

McLean (34) observed that the best date of planting potatoes varies with the locality.

Wheeler and Salunkhe (64) reported that the Russet Rural potatoes planted on May 18, June 6, and June 21, 1951, were used to determine the effect of date of planting and specific gravity on color of potato chips. The three dates were separated into five groups of specific gravity ranging from a low of 1.062 to a high of 1.090. The potatoes of high specific gravity of the May 18 planting made excellent chips. The chips from the June 21 planting of high specific gravity gave a dark color. The May 18 planting produced tubers giving a high specific gravity. A few tubers graded into the lower specific-gravity group. Chips from the high specific-gravity tubers were white, and progressed darker as the specific gravity of the tubers lowered.

Fertilizers

It is a well-recognized fact that various fertilizers, when added to the soil, at least to those soils that have been under cultivation for a considerable period of years, will materially influence the rate of maturity, and sometimes the quality of the crops grown.

Smith and Nash (48) reported that the specific gravity and the percentage of dry matter of potatoes decreased as applications of 3-12-12 were increased from 1,000 pounds to 3,000 pounds per acre.

Dunn and Nylund (24) stated that the greatest differences in average specific gravity were found between locations. The use of nitrogen alone delayed the maturity but had no apparent effect on specific gravity. Potash fertilizer containing chloride caused marked reduction in specific gravity and the higher the application of potash the greater the depression in specific gravity values. Potash as a rule seemed to delay maturity.

Smith and Nash (49) found that tubers from unfertilized plots and from the plots fertilized with 5-10-0 had a higher specific gravity than tubers from plots fertilized with 5-10-5, 5-10-10, 0-10-10, 10-10-10, 5-0-10, 5-20-10, and 5-10-10 (on the basis of 1,000 pounds per acre). The tubers from the 5-0-10 plot were lowest in specific gravity.

Terman (55) experimented with muriate, chloride, and sulphate of potash, and found that sulphate of potash consistently resulted in higher starch content of the tubers, and in higher yields of starch per acre than did the chloride, indicating that the chloride ion may be responsible for decreasing the starch content of the potato. It has been repeatedly reported that potash fertilizer containing chloride lowered the dry-matter content (8, 9, 13, 25, 27, 30, 56, 57).

Nail and Whittemore (39) noted that potash had very little effect on the quality of chips.

Irrigation

High quality of potatoes can be obtained by frequent irrigation and by maintaining the moisture content midway between the field capacity and the permanent wilting point (14, 15).

Wagar (62) pointed out that wet seasons result in potatoes with a low dry-matter content which varies somewhat from season to season.

According to Edmundson (26), early irrigation produced an earlier set and more rapid development of tubers than did an initial irrigation later in the season.

Varieties

Varieties of potatoes differ in genetic characters that influence the quality of potatoes and potato chips.

Metzger et al. (35) demonstrated statistically significant differences in the composition of potato varieties. They also noted that potatoes from one locality differed in starch and dry matter from those of another locality.

Vanasse et al. (61) noted that variety has a significant effect on the specific gravity-dry matter relationship.

Page (40) reported that the different characteristics of potato varieties are important in selecting the right one for "crisp"[1] making.

Wright and Whiteman (68) and Wright et al. (66) stated that the quality of potato chips depends largely on the variety of potatoes used. Some of the varieties preferred by the manufacturers were Russet Rural, Russet Burbank, Irish Cobbler, and Kennebec. Some varieties were unsuitable for chipping, even when conditioned at 70° F. (21° C.), such as Green Mountain, Pontiac, and Triumph.

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[1] In England, "crisp" is synonymous with "chip."

Stuart (52) and Denny and Thornton (18) found that the superiority of the Rural group for the production of potato chips of good color was clearly shown, and that these varieties were low in reducing-sugars content.

Specific Gravity

The specific gravity of potatoes has long been used as a rapid measure of the content of dry matter. According to Burton (10), Vanscheels and his co-workers presented their results on 560 samples, including a number of varieties, and found highly significant correlations between specific gravity and dry matter and starch content of potatoes.

The specific gravity is determined accurately by weighting the tuber in air and in water.

$$\text{Specific Gravity} = \frac{\text{Weight in Air}}{\text{Weight in Air - Weight in Water}}$$

Clark et al. (11) suggested a new method that consists of the use of salt solutions of known densities for the specific-gravity determination of potatoes. This method is comparatively accurate, rapid, and simple.

Vanasse et al. (61) observed that the location of production and the variety of potato has a statistically significant effect on the specific gravity-dry matter relationship.

Cochran et al. (12) said that the reducing sugar content was found to vary inversely with specific gravity.

Sparks (51) found that there might be a concentration of some material in the stem end of potato tubers which could be readily detected by mice or rats. This substance was correlated with high starch content and must be either relished by them or necessary for their growth.

Thiessen (58) reported that there was a higher percentage of water and crude fiber with a lower percentage of starch in the bud as compared with the stem end of the tuber. Protein was slightly higher in the stem end of the tuber.

Alexander et al. (1) stated that the potatoes of higher specific gravity desugared earlier than those of lower specific gravity.

Wright and Whiteman (69) reported that the potato chips of best appearance and quality are processed from the tubers having a relatively high specific gravity.

Stutz and Burris (53) reported that the tubers with least moisture content usually take up least oil in frying.

Kunkle et al. (33) found that high-specific-gravity (1.0916) potatoes averaged almost 3.5 percent more salable chips per bushel than the low-specific-gravity (1.0777) potatoes, and that the color of potato chips from the higher-specific-gravity potatoes was lighter than that of chips made from the low-specific-gravity group. It was also found that the chips made from the tubers low in specific gravity absorbed on an average 4.4 percent more fat than did the chips made from the tubers high in specific gravity.

Storage

Because of the very nature of the potato tuber, care must be taken in its storage. The storage temperature plays an important role in the physico-chemical behavior of potato tubers. Too low temperatures, freezing or lower, will permanently damage the tissues due to their high water content. High temperatures, on the other hand, will promote desiccation and deterioration.

Muller-Thurgau (38) discovered that cooling of potatoes resulted in sugar formation at 32° to 42° F. (0° to 6° C.). This was later confirmed by Wolff (65) and Rogers et al. (45).

Barker (6) claimed that sugar content gradually increased in potatoes when they were transferred to low temperatures. The

maximal concentration was attained at the lowest temperature. If, however, potatoes, rendered sweet by a prolonged period of storage at low temperature, or partially sweet by a short period, were then transferred to 59° F. (15° C.), a rapid desweetening occurred.

Appleman (2, 3) explained that the carbohydrate transformations are dependent entirely upon changing the storage temperatures of potatoes. When the potatoes were stored at the cooler temperatures, generally below 38° F. (1.6° C.), the rate of sugar transformation was most rapid between 32° F. (0° C.), and 29° F. (-1.6° C.).

According to Arreguin-Lozano and Bonner (5), the starch-to-sucrose conversion is accomplished by the enzyme phosphorylase, an enzyme of the carbohydrate metabolism of the plant. This enzyme attacks starch with the production of glucose-1-phosphate at low (32° F., 0° C.) storage temperature. But at high temperatures (68° to 86° F., 20° to 30° C.), though the potatoes possess as much phosphorylase as potatoes stored at low temperature, the starch remains unattacked by phosphorylase. This might be due to an inhibitor of phosphorylase activity at high temperatures, which might be absent at low temperatures.

Harris (28) showed that the sugar content increased directly with length of storage at 40° F. (4.4° C.). The rate of increase of

sugar content was inversely related to the storage temperatures. His results showed that 40° F. (4.4° C.) is a minimum safe storage temperature. If the temperature goes below 40° F. (4.4° C.), it is difficult to "condition" the potatoes for chipping (67).

Chemistry of the Color of Potato Chips

Several investigators have proved that potatoes high in sugar content are particularly susceptible to the formation of a dark brown color in potato chips (17, 18, 54).

Thornton (59) reported that only the reducing sugars are responsible for brown color of chips and that sucrose is not involved.

Denny and Thornton (17) found a direct correlation between the amount of reducing sugar in the juice of potato tubers and the extent of browning when chips were made from them.

Dexter and Salunkhe (20, 21, 22) showed that the amount of reducing sugars seems to be one of the causes for the formation of the dark brown color of potato chips.

Smith (47) stated that the content of reducing sugars determines the color of potato chips and hence the quality of chips.

Kirkpatrick (31) concluded that the concentration of reducing sugars in raw samples is negatively correlated with palatability, score for color, crispness, and flavor of french fries.

Rogers et al. (43) observed that the dark brown objectionable color of potato chips develops in relatively high temperatures used during the frying process. Lowering the immersion temperature and lengthening the frying time assisted in producing chips of acceptable color.

The development of color of potato chips was generally thought to be a caramelization of sugars (7, 17, 18, 19), and the forming of hydroxymethyl furfural (70) at higher frying temperatures.

Danehy and Pigman (16) reported that the color development in chips is due to the catalytic effect of nitrogen on the process of caramelization.

Patton and Pyke (41) presented evidence that the Maillard Reaction is responsible for the color of potato chips, and that the browning of chips is caused by the combined effect of reducing sugars and amino acids in the potato slices and not solely by the presence of reducing sugars.

In support of this theory, Shallinberger (45) reported studies on the nature of the Maillard reaction at the temperature used to fry potato chips (370.4° F., 188° C.). Using filter-paper discs comparable to potato chips, he demonstrated that the condensation between the soluble nitrogenous and carbohydrate fractions gave a brown

coloration. Glucose may condense with the amino acid glycine in a Mole/Mole ratio, but more than one mole of glycine condenses with each mole of sucrose. However, the color produced by a sucrose-glycine system is consistently less dark than that given with an equal concentration of glucose and glycine. Shallinberger (46) also stated that the browning reaction that may occur in the manufacture of potato chips is due to condensation of sucrose and ascorbic acid with the amino acid, glycine. Because potatoes that test low for reducing sugars sometimes result in undesirably colored chips, it was thought that reactions involving sucrose and ascorbic acid might be responsible.

Dexter and Salunkhe (22) reported that the discoloration of potato chips was of various types. Reducing sugars gave one type of dark brown color and the intensification of that color was manifested in the combined reaction of reducing sugars with some other insoluble constituent or constituents of the potato. The mechanism of the color development of potato chips needs systematic formulation, since there appear to be different types of discolorations.

Chip Color Ratings

Dexter and Salunkhe (21) and Salunkhe et al. (44) described a method to score the color of potato chips: 1 = extremely dark; 10 = light yellow; 7.5 to 10 = acceptable; and 8.5 to 9 = golden yellow (most desirable).

MATERIALS AND METHODS

In 1950, 1951, and 1952, several varieties of potatoes were grown in various ways at two locations in Michigan. After harvest, specific-gravity determinations were made on a random sample of potatoes from each of the treatments. Following the determination of the specific gravity, the potatoes were subjected to various storage treatments. The potatoes were removed from storage, processed into chips, and scored for chip color.

Cultural

Potatoes were grown at Lake City in 1950, 1951, and 1952, and at East Lansing in 1951. The soil was a productive Hillsdale sandy loam at both locations. Balbo rye was drilled for green manuring in the month of August at a rate of approximately one bushel per acre. The rye was turned under the following April to help in the control of scab (63). The potatoes were planted in rows 36 inches apart with seed pieces at 12-inch intervals. The method of planting was similar in all three years and at both locations. A randomized block design with four replications was used.

The plots in all the experiments were planted at three or four different dates of planting from May 1 to June 25.

The several analyses of fertilizers used were applied at the rate of 1,000 pounds per acre by the band method at Lake City and by hand-spreading at East Lansing. The kind of fertilizers used varied from year to year and are mentioned in detail under each experiment.

The plots were divided as to water supply, some receiving only rainfall, and others, supplemental irrigation. This supplemental irrigation was at two rates: normal, in which irrigations were made for a period of two hours at each time; and twice normal, in which the sprinklers ran for four hours.

The plots were sprayed with standard fungicides and insecticides.[1]

Potatoes in all the plots were harvested in the latter part of September. After harvest, a random sample of ten to forty U. S. No. 1 tubers from each replicate of each treatment of each variety was taken for subsequent analyses.

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[1] Under the kind supervision of Dr. J. H. Muncie, pathologist. Bordeaux mixture and D.D.T. were used.

Specific Gravity

The specific-gravity determinations were made on the individual tubers by the brine-flotation method described by Clark et al. (11). In this method, salt solutions of 1.064, 1.070, 1.076, and 1.088 specific gravity were prepared in four different containers and arranged in an ascending order of specific gravity. The specific gravity of each tuber was marked by a rating of 1, 2, 3, 4, or 5 by means of a saturated solution of potassium permanganate.

Rating	Specific-Gravity Class	Mid-Class Value
1.	Less than 1.064 (the potato floats in 1.064)	1.062
2.	Between 1.064 and 1.070 (the potato sinks in 1.064 but floats in 1.070)	1.067
3.	Between 1.070 and 1.076 (the potato sinks in 1.070 but floats in 1.076)	1.073
4.	Between 1.076 and 1.088 (the potato sinks in 1.076 but floats in 1.088)	1.082
5.	Over 1.088 (the potato sinks in 1.088) . .	1.090

Each random sample was placed in a numbered Kraft paper bag.

Storage

(1) Lake City: The potatoes from the experiments of 1950 and 1951 were subjected to cold storage at 41° F. (5° C.) for the

period of two months, then conditioned at a room temperature of 78° F. (25.5° C.) for thirty days. The range of all storage temperatures was ±2° F. The potatoes from the 1952 crop were never subjected to cold storage but were stored at 60° F. (15.5° C.) for four months and then conditioned at 78° F. (25.5° C.) for thirty days. This conditioning period is essential for the possible development of desirable and commercially acceptable chip color (19, 54, 60, 67). The conditioned potatoes were processed into chips and scored for color of the chips.

(2) East Lansing: The potatoes were grown only in 1951 at East Lansing, and were subjected to cold storage at 41° F. (5° C.) for two months or five months. Immediately after two or five months cold storage at 41° F. (5° C.), each tuber was cut into longitudinal halves. A representative slice from one-half of each tuber was made into chips at once and scored. The other half was conditioned at 78° F. (25.5° C.) for thirty days and then processed into chips and scored for color.

Picric Acid Test

The picric acid test (37) for estimating the amount of reducing sugars in the potato tuber was made on the crop grown in 1950

at Lake City. The test consisted of pipetting 2 c.c. of saturated aqueous solution of picric acid and 1 c.c. of 20 percent anhydrous sodium carbonate solution into each test tube. The middle half section of a 3/12-inch-diameter round core obtained from the center of a potato with a cork borer was inserted in a test tube. The test tube was then loosely stoppered and heated in a boiling-water bath for thirty minutes. The test tube and contents were cooled and the core section removed. The liquid in the test tube was matched with a set of color standards (32) which ranged from dark red to yellow, and was given a color rating as follows:

Rating	Color
1	Dark red (high amount of reducing sugars)
2	Red
3	Light red
4	Orange
5	Yellow (low amount of reducing sugars)

Chip Making

Each tuber was sliced longitudinally; i.e., parallel to the axis from apex to basal end. The sixth to eighth slice from the outside, with a uniform thickness of 3/64 inch to 4/64 inch, was retained for

frying. For identification, either certain patterns of holes were punched in the slices or the slices were threaded together and labeled; approximately 200 grams were washed under running tap water to remove adhering starch and to separate the slices; then they were fried in Primex[1] at an "initial" or "immersion" temperature of 385° F. (196° C.). Frying was judged to be completed when bubbling in the oil stopped. The temperature at this stage was read as an "exit" or "removal" temperature. During the rapid evaporation of water in frying oil, the temperature of the oil fell rapidly, but near the end of the cooking the temperature sometimes rose, when cooking times were prolonged. However, the exit temperature was about 350° F. (177° C.) for the standard 200 gram samples for a uniform volume of frying oil.

Chip Color Rating

The fried samples were separated and arranged on the table for chip color rating. Each chip was then matched to a set of chips showing ten different colorations and rated according to the numbers assigned to these colors. The following are the colors and ratings:

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[1] Proctor and Gamble product, Cincinnati, Ohio.

Color	Rating
Black, charred	1
Very dark brown	2
Dark brown	3
Brown	4
Slightly lighter brown	5
Light brown	6
Light brownish yellow	7
Yellow tinged with brown	8
Golden yellow--no brown tinge	9
Very light yellow, almost white	10

In the cases where the cortical area and the pith area were not given the same color rating, an unweighted arithmetic average of the two ratings was given to the chip. Ratings of 7.5 to 10 were considered acceptable and of 8.5 to 9 most desirable (21, 44).

Computations

The specific gravity of each tuber from each replication of each treatment was obtained, but, due to the fact that not all specific-gravity classes were represented by the tubers from one plot, the determinations from four replications were combined. A weighted

average specific gravity per treatment was then obtained by multiplying the specific gravity mid-class value by the corresponding percentage of tubers in that specific-gravity class.

Each chip from each sound tuber was rated for its color. Chip color ratings of tubers in each specific gravity class were averaged to obtain a score for that class. Replications then were combined for two reasons: first, because, as mentioned above, not all specific-gravity classes were represented by the tubers of one plot; and second, because some of the tubers rotted during storage. The class ratings were weighted by the percentage of tubers in each class to obtain the plot rating.

The data obtained in these investigations were analyzed for statistical significance (50).

RESULTS

Lake City, 1950 Crop

Russet Rural, Irish Cobbler, and Pontiac potatoes were planted on May 1, May 25, and June 16. At each date of planting, 3-12-12 fertilizer at the rate of 1,000 pounds per acre was applied to the row by the band method. During the growing period the field received five normal supplemental irrigations.

After harvest, specific-gravity determinations were made on the potatoes. From each of the three dates of planting ten tubers having a specific gravity of 1.076 to 1.088 from the Russet Rural variety and from Irish Cobbler variety, and of 1.064 to 1.070 from the Pontiac variety were involved in the investigation. These ranges were chosen because preliminary observations had shown that they were the modal classes for these varieties. Following the specific-gravity determinations, the potatoes were stored for a period of two months at 41° F. (5° C.), and then conditioned at 78° F. (25.5° C.) for thirty days. The picric acid test (37) was made for estimating the content of reducing sugars in each potato. Slices from each

potato were made into chips and were rated for color. The results of this trial are shown in Table 1.

Potatoes from the early planting (May 1) of the varieties Russet Rural and Irish Cobbler had higher average picric acid test ratings than those from the late planting (June 16); while the potatoes of Pontiac variety from the early date of planting had the same average ratings as those from the late planting. Russet Rural gave the highest picric acid test ratings on each of the three dates, and Pontiac, the lowest. Irish Cobbler was closer to Russet Rural than to Pontiac in its picric acid reaction.

The early-planted Russet Rural and Irish Cobbler yielded lighter-colored and more-acceptable chips than did the late-planted. Chips made from Pontiac potatoes were commercially unacceptable regardless of the dates of planting.

There was a direct relation between the picric acid test ratings and the chip color ratings. This means, the less the reducing sugars in potatoes, the lighter the color of chips.

Lake City, 1951 Crop

In this 1951 crop, the cultural and storage practices were the same as in 1950.

Table 1. Average picric acid test ratings and average chip color ratings for three varieties from three dates of planting, Lake City, 1950.

Varieties	Specific-Gravity Class	Dates of Planting						Average	
		May 1		May 25		June 16			
		P.A.[1]	C.C.[2]	P.A.	C.C.	P.A.	C.C.	P.A.	C.C.
Russet Rural	1.076-1.088	3.4	8.8	3.2	7.9	2.9	7.6	3.2	8.1
Irish Cobbler	1.076-1.088	3.1	8.6	2.8	7.0	2.7	6.7	2.9	7.4
Pontiac	1.064-1.070	1.2	3.1	1.1	3.0	1.2	3.2	1.2	3.1

[1] Picric acid test ratings (1 = dark red; 5 = yellow).

[2] Chip color ratings (1 = very dark; 10 = almost white).

Approximately fifteen to twenty tubers from each of the four replications of each of three dates of planting (May 4, May 23, and June 4), from each of six varieties (Chippewa, Irish Cobbler, Katahdin, Kennebec, Russet Rural, and Sebago) were taken for analyses as to specific gravity and the color of chips.

The percentage distribution of the tubers and the average chip color ratings by variety and date of planting in each specific-gravity class are given in Appendix Table I.

Variety was found to have a considerable effect on the average specific gravity of the potatoes (Table 2). Russet Rural, Kennebec, Irish Cobbler, and Sebago were in the high range of 1.076 or above. Katahdin might be classed as a borderline variety, while Chippewa had a decidedly low average specific gravity.

Date of planting had a marked influence on the average specific gravity of potatoes but not to the extent that variety had.

The average specific gravity for the May 4 planting was 1.079; for May 23, 1.076; and for June 4, 1.071.

Within a variety, in general, the tubers from the first planting had higher average specific gravity than the tubers of the second and the third dates of planting. Kennebec and Katahdin were the two exceptions.

Table 2. Average specific gravity for each variety from each date of planting, Lake City, 1951.

Dates of Planting	Varieties						Avg.
	Russet Rural	Kennebec	Irish Cobbler	Sebago	Katahdin	Chippewa	
May 4	1.083	1.080	1.080	1.080	1.079	1.071	1.079
May 23	1.080	1.075	1.077	1.077	1.079	1.066	1.076
June 4	1.076	1.080	1.073	1.070	1.065	1.062	1.071
Avg.	1.080	1.078	1.077	1.076	1.074	1.066	1.075

Analysis of variance indicates highly significant differences between varieties and between dates.

Least significant difference between varieties: 5% level, 0.006; 1% level, 0.008.

Least significant difference between dates: 5% level, 0.004; 1% level, 0.006.

The average chip color ratings (Table 3) for the varieties Russet Rural and Irish Cobbler were graded as the most desired by the consumers. The chip color of Katahdin and Kennebec were slightly above and Sebago and Chippewa decidedly below the line of acceptance.

Chips were of acceptable color from the May 4 and May 23 plantings, with the exception of Chippewa on the May 23 date. Dark and unsalable chips were obtained from the June 4 planting, with the exception of Russet Rural and Kennebec.

In each of the varieties the late planting, June 4, was found to increase the development of the dark color of chips in comparison with the first date of planting.

East Lansing, 1951 Crop

Irish Cobbler, Katahdin, Kennebec, Russet Rural, and Sebago varieties were planted on May 21, June 13, and June 25. The plots were subjected to the following irrigation and fertilizer treatments:

1. No supplemental irrigation with 3-12-12 fertilizer.
2. Supplemental irrigation and no fertilizer.
3. Supplemental irrigation with 0-0-18 fertilizer.
4. Supplemental irrigation with 3-12-12 fertilizer.

Table 3. Average chip color ratings for each variety from each date of planting, Lake City, 1951.

Dates of Planting	Varieties						Avg.
	Russet Rural	Irish Cobbler	Katahdin	Kennebec	Sebago	Chippewa	
May 4	9.6	9.3	9.6	8.7	8.0	7.5	8.8
May 23	9.3	8.9	9.0	7.5	8.0	6.7	8.2
June 4	8.7	7.4	5.8	7.5	5.6	5.3	6.7
Avg.	9.2	8.5	8.1	7.9	7.0	6.5	7.9

Analysis of variance indicates highly significant differences between varieties and between dates.

Least significant difference between varieties: 5% level, 0.8; 1% level, 1.2.

Least significant difference between dates: 5% level, 1.2; 1% level, 1.7.

The fertilizers were spread by hand. The irrigated plots received five normal supplemental irrigations in addition to rain.

The plots were harvested in the latter part of September. Following harvest, specific-gravity determinations were made on a random sample consisting of twenty to thirty tubers from each of the four replicates of each of the treatments of each of varieties from each of the planting dates. Each sample was divided into two sets. Each set consisted of ten to fifteen tubers.

One set of samples of all the varieties was stored for two months at 41° F. (5° C.) and another set of only two varieties, Russet Rural and Katahdin, was stored for five months at the same temperature.

Chips were made and scored for color from half of each tuber immediately after storage at 41° F. (5° C.) and again after conditioning for thirty days at 78° F. (25.5° C.). The remaining halves were chipped and scored.

The percentage distribution of tubers and the average chip color ratings by variety, date of planting, and treatment in each specific-gravity class are given in Appendix Tables II and III.

Specific gravity of tubers. The average specific gravity of potatoes (Table 4) of the Kennebec variety (1.077) was significantly

Table 4. Average specific gravity for each variety from each date of planting on each treatment, East Lansing, 1951.

Dates of Planting	Treatments		Varieties					Avg.
	Irrigation	Fertilizer	Kennebec	Russet Rural	Irish Cobbler	Sebago	Katahdin	
May 4	No	3-12-12	1.077	1.077	1.076	1.074	1.071	1.075
	Yes	0-0-0	1.079	1.078	1.077	1.074	1.074	1.076
	Yes	3-12-12	1.077	1.078	1.072	1.074	1.072	1.075
	Yes	0-0-18	1.074	1.073	1.075	1.072	1.071	1.073
	Avg.		1.077	1.077	1.075	1.074	1.072	1.075
May 23	No	3-12-12	1.079	1.073	1.069	1.070	1.068	1.072
	Yes	0-0-0	1.079	1.076	1.077	1.070	1.070	1.074
	Yes	3-12-12	1.076	1.072	1.071	1.067	1.068	1.071
	Yes	0-0-18	1.079	1.076	1.070	1.067	1.067	1.072
	Avg.		1.078	1.074	1.072	1.069	1.068	1.072
June 4	No	3-12-12	1.076	1.071	1.074	1.072	1.069	1.072
	Yes	0-0-0	1.078	1.071	1.073	1.076	1.069	1.073
	Yes	3-12-12	1.076	1.071	1.074	1.076	1.066	1.073
	Yes	0-0-18	1.072	1.073	1.070	1.072	1.065	1.070
	Avg.		1.076	1.072	1.073	1.074	1.067	1.072
Grand average			1.077	1.074	1.073	1.072	1.069	1.073

Analysis of variance indicates highly significant differences between varieties, between dates, and between treatments.

Least significant difference between varieties: 5% level, 0.002; 1% level, 0.002.

Least significant difference between dates: 5% level, 0.001; 1% level, 0.002.

Least significant difference between treatments: 5% level, 0.001; 1% level, 0.002.

higher than that of Russet Rural (1.074), Irish Cobbler (1.073), Sebago (1.072), and Katahdin (1.069). There was no marked difference between the specific gravity of Russet Rural and Irish Cobbler potatoes; but Russet Rural potatoes had significantly greater specific gravity than did Sebago.

The average specific gravity of the potatoes from the May 4 planting (1.075) was statistically greater (1 percent level) than that of May 23 planting (1.072), and of June 4 planting (1.072).

Three of the varieties, Kennebec, Russet Rural, and Katahdin, had progressively lower average specific gravity as the planting date was delayed. Such was not true of Irish Cobbler and Sebago (Table 4).

The average specific gravity, 1.075, of the potatoes from the treatment which was irrigated but had no fertilizer was significantly greater than those of the other treatments: 1.073 for no irrigation with 3-12-12, 1.073 for irrigation with 3-12-12, and 1.072 for irrigation with 0-0-18. The latter three were not statistically different from each other.

Varieties tended to give similar responses to the various treatments (Table 5), but dates and treatments showed no definite trends (Table 6) on average specific gravity.

Table 5. Two-way table for varieties and treatments, for average specific gravity of tubers, East Lansing, 1951.

Varieties	Treatments				Avg.
	Irrigation, No Fertilizer	No Irrigation 3-12-12	Irrigation 3-12-12	Irrigation 0-0-18	
Kennebec	1.079	1.077	1.076	1.075	1.077
Russet Rural	1.075	1.074	1.074	1.074	1.074
Irish Cobbler	1.076	1.073	1.072	1.072	1.073
Sebago	1.073	1.072	1.072	1.070	1.072
Katahdin	1.071	1.069	1.067	1.068	1.069
Average	1.075	1.073	1.072	1.072	1.073

Table 6. Two-way table for dates of planting and treatments, for average specific gravity of tubers, East Lansing, 1951.

Dates of Planting	Treatments				Avg.
	No Fertilizer	No Irrigation 3-12-12	Irrigation 3-12-12	Irrigation 0-0-18	
May 4	1.076	1.075	1.075	1.073	1.075
May 23	1.074	1.072	1.071	1.072	1.072
June 4	1.073	1.072	1.073	1.070	1.072
Average	1.075	1.073	1.072	1.072	1.073

Chip color ratings: chipped immediately after cold storage of tubers for two months and for five months. The color of chips (Table 7) made from the tubers of the Russet Rural (5.5) and Irish Cobbler (5.2) varieties which had been in cold storage for two months were comparatively lighter than that of Sebago (4.7), Kennebec (4.7), and Katahdin (4.2).

Two varieties, Russet Rural and Katahdin, were held for an additional three months in cold storage. The chip color of tubers (Table 8) was darker than those obtained from tubers stored for only two months, but their ratings were in the same order as those from tubers stored for the shorter period.

Dates of planting appeared to have only a slight effect on chip ratings of the tubers processed immediately after removal from two months of cold storage. Less effect was observed on those tubers held for five months than for two months (Tables 7 and 8).

The varieties did not react in the same manner to the different dates of planting as judged by the chip color ratings obtained immediately after removal from storage whether they were stored for two months or five months.

It is very apparent from Tables 7 and 8 that the chip color of tubers from various irrigation-fertilizer treatments was darker

Table 7. Average chip color ratings immediately following cold storage (41° F.) for two months for each variety, date of planting, and treatment, East Lansing, 1951.

Dates of Planting	Treatments		Varieties					Avg.
	Irrigation	Fertilizer	Russet Rural	Irish Cobbler	Sebago	Kennebec	Katahdin	
May 4	No	3-12-12	5.8	6.3	4.6	5.1	4.6	5.3
	Yes	0-0-0	5.6	3.3	4.4	4.6	4.5	4.9
	Yes	3-12-12	5.2	5.4	4.8	4.9	4.3	4.9
	Yes	0-0-18	5.2	5.3	4.9	5.5	4.2	5.0
	Avg.		5.5	5.6	4.7	5.0	4.4	5.0
May 23	No	3-12-12	5.8	5.1	5.0	5.0	4.3	5.0
	Yes	0-0-0	5.6	4.7	4.2	4.7	4.2	4.7
	Yes	3-12-12	5.3	4.6	3.5	4.7	3.8	4.4
	Yes	0-0-18	5.7	4.7	4.8	4.5	4.2	4.8
	Avg.		5.6	4.8	4.3	4.7	4.1	4.7
June 4	No	3-12-12	6.0	4.9	4.9	4.9	4.8	5.1
	Yes	0-0-0	5.6	5.4	5.6	4.1	4.3	5.0
	Yes	3-12-12	5.3	5.4	4.9	3.9	3.2	4.5
	Yes	0-0-18	5.4	4.9	4.9	4.4	3.5	4.6
	Avg.		5.6	5.2	5.1	4.3	3.9	4.8
Grand average			5.5	5.2	4.7	4.7	4.2	4.8

Analysis of variance indicates highly significant differences (1% level) between varieties and between treatments, but only significant differences (5% level) between dates.

Least significant difference between varieties: 5% level, 0.3; 1% level, 0.4.

Least significant difference between dates: 5% level, 0.2; 1% level, 0.3.

Least significant difference between treatments: 5% level, 0.3; 1% level, 0.4.

Table 8. Average chip color ratings immediately following cold storage (41° F.) for five months for each variety, date of planting, and treatment, East Lansing, 1951.

Dates of Planting	Treatments		Varieties		Average
	Irrigation	Fertilizer	Russet Rural	Katahdin	
May 4	No	3-12-12	5.2	3.8	4.5
	Yes	0-0-0	4.2	1.9	3.1
	Yes	3-12-12	3.9	3.3	3.6
	Yes	0-0-18	3.8	2.9	3.4
	Avg.		4.3	3.0	3.6
May 23	No	3-12-12	5.2	2.7	4.1
	Yes	0-0-0	4.2	2.7	3.7
	Yes	3-12-12	4.2	2.3	3.3
	Yes	0-0-18	4.8	2.5	3.7
	Avg.		4.7	2.6	3.6
June 4	No	3-12-12	5.1	2.5	3.8
	Yes	0-0-0	4.8	3.4	4.1
	Yes	3-12-12	4.9	1.7	3.3
	Yes	0-0-18	5.6	1.9	3.8
	Avg.		5.1	2.4	3.7
Grand average			4.7	2.6	3.6

Analysis of variance indicates highly significant differences between varieties but not between treatments nor between dates.

Least significant difference for varieties: 5% level, 0.6; 1% level, 1.0.

after five months storage than after two months. In both cases no irrigation with 3-12-12 fertilizer produced lighter-colored chips than any other treatment.

Varieties did not respond the same to irrigation-fertilizer treatments, as judged by their chip color ratings after two months of cold storage. The two varieties kept in storage for a five-months period did show similar responses to the several treatments (Tables 9 and 10).

Chip color ratings: chipped after conditioning for thirty days following two months cold storage. The average chip color ratings, Table 13 (after conditioning the potatoes at 78° F. [25.5° C.] subsequent to cold storage at 41° F. [5° C.] for the period of two months), of Russet Rural (8.8) and Kennebec (8.5) were in the grade most desired by consumers, and those of Irish Cobbler (8.2) and Katahdin (7.8) were in the grade of acceptable, while that of Sebago (7.4) was in the unacceptable grade.

Chip color from the May 4 planting (8.7) was significantly lighter than those of May 23 (8.2) and of June 6 (7.5). Also, the chip color from the May 23 planting was significantly lighter than that of the June 6 planting.

Table 9. Two-way table for varieties and treatments, for chip color ratings immediately after cold storage at 41° F. of tubers for two months, East Lansing, 1951.

Varieties	Treatments				Avg.
	No Irrigation 3-12-12	Irrigation No Fertilizer	Irrigation 0-0-18	Irrigation 3-12-12	
Russet Rural	5.8	5.6	5.4	5.3	5.5
Irish Cobbler	5.4	5.1	5.0	5.1	5.2
Sebago	4.9	4.7	4.9	4.4	4.7
Kennebec	5.0	4.5	4.8	4.5	4.7
Katahdin	4.6	4.3	4.0	3.7	4.2
Average	5.1	4.9	4.8	4.6	4.8

Table 10. Two-way table for varieties and treatments, for chip color ratings immediately after cold storage at 41° F. of tubers for five months, East Lansing, 1951.

Varieties	Treatments				Avg.
	No Irrigation 3-12-12	Irrigation 0-0-18	Irrigation No Fertilizer	Irrigation 3-12-12	
Russet Rural	5.3	4.7	4.4	4.3	4.7
Katahdin	3.0	2.4	2.7	2.4	2.6
Average	4.1	3.6	3.6	3.4	3.6

Table 11. Two-way table for dates of planting and treatments, for chip color ratings immediately after cold storage at 41° F. of tubers for two months, East Lansing, 1951.

Dates of Planting	Treatments				Avg.
	No Irrigation 3-12-12	Irrigation No Fertilizer	Irrigation 0-0-18	Irrigation 3-12-12	
May 4	5.3	4.9	5.0	4.9	5.0
June 4	5.1	5.0	4.6	4.5	4.8
May 23	5.0	4.7	4.8	4.4	4.7
Average	5.1	4.9	4.8	4.6	4.8

Table 12. Two-way table for dates of planting and treatments, for chip color ratings immediately after cold storage at 41° F. of tubers for five months, East Lansing, 1951.

Dates of Planting	Treatments				Avg.
	No Irrigation 3-12-12	Irrigation 0-0-18	Irrigation No Fertilizer	Irrigation 3-12-12	
June 4	3.8	3.8	4.1	3.3	3.7
May 4	4.5	3.4	3.1	3.6	3.6
May 23	4.1	3.7	3.7	3.3	3.6
Average	4.1	3.6	3.6	3.4	3.6

Table 13. Average chip color ratings after conditioning of potatoes at 78° F. for thirty days following two months cold storage at 41° F. for each variety, from each date of planting, and treatment, East Lansing, 1951.

Dates of Planting	Treatments		Varieties					Avg.
	Irrigation	Fertilizer	Russet Rural	Kennebec	Irish Cobbler	Katahdin	Sebago	
May 4	No	3-12-12	9.7	9.4	9.6	8.3	7.7	8.9
	Yes	0-0-0	8.7	9.1	9.2	8.4	7.7	8.6
	Yes	3-12-12	9.4	8.6	9.0	8.2	8.0	8.6
	Yes	0-0-18	9.3	9.2	9.0	8.2	8.2	8.8
	Avg.		9.3	9.1	9.2	8.3	7.9	8.7
May 23	No	3-12-12	9.7	9.1	8.6	8.5	7.3	8.6
	Yes	0-0-0	8.8	8.4	8.1	7.2	7.0	7.9
	Yes	3-12-12	8.9	8.9	7.8	7.7	7.1	8.1
	Yes	0-0-18	9.2	8.4	8.8	7.2	7.5	8.2
	Avg.		9.2	8.7	8.3	7.6	7.2	8.2
June 6	No	3-12-12	8.8	8.8	7.2	8.5	7.8	8.2
	Yes	0-0-0	7.7	8.0	7.2	8.0	7.3	7.6
	Yes	3-12-12	8.5	7.0	6.8	6.3	6.5	7.0
	Yes	0-0-18	7.4	7.4	7.0	7.1	7.2	7.2
	Avg.		8.1	7.8	7.1	7.5	7.2	7.5
Grand average			8.8	8.5	8.2	7.8	7.4	8.2

Analysis of variance indicates highly significant differences between varieties, dates, and treatments.

Least significant difference between varieties: 5% level, 0.4; 1% level, 0.5.

Least significant difference between dates: 5% level, 0.3; 1% level, 0.4.

Least significant difference between treatments: 5% level, 0.3; 1% level, 0.5.

Within a variety, the date of planting had striking effect on the color of potato chips; that is, the later the planting date, the darker the color of chips. This was especially true of Russet Rural, Kennebec, and Irish Cobbler.

No irrigation with 3-12-12 fertilizer produced significantly lighter color chips (8.6) than irrigation with 0-0-18 (8.1), irrigation with no fertilizer (8.1), and irrigation with 3-12-12 (7.9), Table 13. The differences between the average chip color ratings of the latter three were not significant.

It is very apparent from Table 14 that the varieties did not react similarly to the treatments as indicated by the color of chips.

The first and second dates of planting gave similar trends in average chip color rating from one treatment to another (Table 15), but the third date of planting deviated from this pattern. Within a given treatment the chip color became darker as planting was delayed. These differences in rating were not exactly equal, but they were in the same direction.

Chip color ratings: chipped after conditioning for thirty days following five months cold storage. After conditioning for a period of thirty days at 78° F. (25.5° C.) following cold storage at 41° F. (5° C.) for five months, the average chip color over all dates and

Table 14. Two-way table for varieties and treatments, for chip color ratings after thirty days conditioning of tubers at 78° F. subsequent to cold storage at 41° F. for two months, East Lansing, 1951.

Varieties	Treatments				Avg.
	No Irrigation 3-12-12	Irrigation 0-0-18	Irrigation No Fertilizer	Irrigation 3-12-12	
Russet Rural	9.4	8.6	8.4	8.9	8.8
Kennebec	9.1	8.3	8.5	8.2	8.5
Irish Cobbler . .	8.5	8.3	8.2	7.9	8.2
Katahdin	8.4	7.5	7.9	7.4	7.8
Sebago	7.6	7.6	7.3	7.2	7.4
Average	8.6	8.1	8.0	7.9	8.2

Table 15. Two-way table for dates of planting and treatments, for chip color ratings after thirty days conditioning of tubers at 78° F. subsequent to cold storage at 41° F. for two months, East Lansing, 1951.

Dates of Planting	Treatments				Avg.
	No Irrigation 3-12-12	Irrigation 0-0-18	Irrigation No Fertilizer	Irrigation 3-12-12	
May 4	8.9	8.8	8.6	8.6	8.7
May 23	8.6	8.2	7.9	8.1	8.2
June 4	8.2	7.2	7.6	7.0	7.5
Average	8.6	8.1	8.0	7.9	8.2

treatments (Table 16) of Russet Rural was golden yellow (9.0). This rating was in the most desirable range as to chip color. That of Katahdin was dark brown (7.4), which was dark for commercial acceptance.

The planting dates had no significant effect on the color of chips of either variety (Table 16).

No irrigation with 3-12-12 fertilizer (8.9) and irrigation with 0-0-18 fertilizer (8.4) yielded the chips of lighter color than those of irrigation with 3-12-12 (7.9) and of irrigation with no fertilizer (7.5) (Tables 17 and 18). The responses of the two varieties to treatment were similar (Table 17), in that the no irrigation with 3-12-12 had the best chip color, while the irrigation with no fertilizer produced the poorest chip color.

The responses shown between dates of planting and treatments were rather similar to each other (Table 18).

Lake City, 1952 Crop--Experiment A

The preplanting and the planting methods practiced were the same as in 1950 and 1951. Chippewa, Irish Cobbler, Katahdin, Kennebec, Pontiac, Russet Rural, and Sebago varieties, and a seedling, 505-3, were planted on May 1, May 16, June 2, and June 16. At

Table 16. Average chip color ratings after conditioning of potatoes at 78° F. for thirty days, following five months cold storage at 41° F. for each variety, from each date of planting and treatment, East Lansing, 1951.

Dates of Planting	Treatments		Varieties		Avg.
	Irrigation	Fertilizer	Russet Rural	Katahdin	
May 4	No	3-12-12	9.4	8.2	8.8
	Yes	0-0-0	8.9	6.4	7.7
	Yes	3-12-12	9.1	7.4	8.3
	Yes	0-0-18	9.8	7.6	8.7
	Avg.		9.3	7.4	8.4
May 23	No	3-12-12	9.4	8.3	8.8
	Yes	0-0-0	8.7	6.4	7.6
	Yes	3-12-12	9.0	7.4	8.2
	Yes	0-0-18	9.4	7.5	8.5
	Avg.		9.1	7.4	8.3
June 6	No	8-12-12	9.4	8.8	9.1
	Yes	0-0-0	8.4	6.3	7.4
	Yes	3-12-12	7.3	7.4	7.4
	Yes	0-0-18	9.3	7.2	8.3
	Avg.		8.6	7.4	8.0
Grand average			9.0	7.4	8.2

Analysis of variance indicates highly significant differences between varieties and between treatments, but no significant differences between dates of planting.

Least significant difference for varieties: 5% level, 0.3; 1% level, 0.5.

Least significant difference for treatment: 5% level, 0.4; 1% level, 0.7.

Table 17. Two-way table for varieties and treatments, for chip color ratings after thirty days conditioning of tubers at 78° F. subsequent to cold storage at 41° F. for five months, East Lansing, 1951.

Varieties	Treatments				Avg.
	No Irrigation 3-12-12	Irrigation 0-0-18	Irrigation 3-12-12	Irrigation No Fertilizer	
Russet Rural	9.4	9.5	8.4	8.6	9.0
Katahdin	8.4	7.4	7.4	6.4	7.4
Average	8.9	8.4	7.9	7.5	8.2

Table 18. Two-way table for dates of planting and treatments, for chip color ratings after thirty days conditioning of tubers at 78° F. subsequent to cold storage at 41° F. for five months, East Lansing, 1951.

Dates of Planting	Treatments				Avg.
	No Irrigation 3-12-12	Irrigation 0-0-18	Irrigation 3-12-12	Irrigation No Fertilizer	
May 4	8.8	8.7	8.3	7.7	8.4
May 23	8.8	8.5	8.2	7.6	8.3
June 4	9.1	8.3	7.4	7.4	8.0
Average	8.9	8.4	7.9	7.5	8.2

each of the planting times the rows received 3-12-12 fertilizer on the basis of 1,000 pounds per acre by the band method. The plots were subjected to three levels of irrigation: (1) no supplemental irrigation; (2) normal supplemental irrigation; and (3) heavy or twice the normal supplemental irrigation. (See methods for more detailed description.)

The plots were harvested in the last week of September and a random sample of ten tubers was taken from each plot. Specific-gravity determinations were made on each tuber of each random sample.

The samples were stored at 60° F. (15.5° C.) for the period of four months and then conditioned at 78° F. (25.5° C.) for one month before they were processed into chips and scored for chip color.

The percentage distribution of tubers and the average chip color ratings by variety, date of planting, and irrigation level, in each specific-gravity class are given in Appendix Table IV.

Specific gravity of tubers. Average specific gravity of tubers was found to vary considerably with variety. The average specific gravity for each variety was as follows: Russet Rural (1.086),

Sebago (1.083), Kennebec (1.082), Katahdin (1.081), Irish Cobbler (1.081), Pontiac (1.074), 505-3 (1.074), and Chippewa (1.071) (Table 19).

The date of planting had a marked influence on the average specific gravity of potatoes, with the later dates of planting giving the higher specific gravities. This is in marked contrast with previous experiments. The average specific gravity of the tubers in order of magnitude for the third date of planting, June 2, was 1.082; for the fourth date, June 16, 1.080; for the second date, May 16, 1.078; and for the first date, May 1, 1.076. The successive differences were significant.

It is evident from Table 19 that the varieties reacted approximately the same to the differences in planting dates.

The average specific gravity of the potatoes from the no supplemental irrigation, the normal supplemental irrigation, and the twice normal supplemental irrigation was approximately the same (1.079) (Tables 20 and 21).

The three levels of moisture supply apparently had no effect on the specific gravity of the several varieties. There were slight discrepancies (Table 20), but these were of minor value. The same may be said with regard to the relationship between date of planting and levels of irrigation (Table 21).

Table 19. Average specific gravity for each variety, from each date of planting, and irrigation level in Experiment A, Lake City, 1952.

Dates of Planting	Varieties								Avg.
	Russet Rural	Sebago	Kennebec	Irish Cobbler	Katahdin	Pontiac	505-3	Chippewa	
Twice Normal Supplemental Irrigation									
5/1	1.080	1.080	1.079	1.078	1.077	1.070	1.070	1.070	1.075
5/16	1.087	1.082	1.081	1.079	1.079	1.069	1.078	1.072	1.078
6/2	1.087	1.086	1.083	1.082	1.084	1.078	1.077	1.069	1.081
6/16	1.088	1.085	1.083	1.083	1.081	1.076	1.073	1.069	1.080
Avg.	1.086	1.083	1.082	1.081	1.080	1.073	1.075	1.070	1.079
Normal Supplemental Irrigation									
5/1	1.084	1.079	1.080	1.078	1.078	1.073	1.070	1.069	1.076
5/16	1.086	1.082	1.081	1.079	1.080	1.068	1.073	1.073	1.078
6/2	1.089	1.087	1.083	1.084	1.083	1.080	1.076	1.078	1.083
6/16	1.088	1.085	1.084	1.083	1.081	1.076	1.074	1.073	1.081
Avg.	1.087	1.083	1.082	1.081	1.080	1.074	1.073	1.073	1.079
No Supplemental Irrigation									
5/1	1.083	1.075	1.077	1.079	1.081	1.073	1.068	1.071	1.076
5/16	1.085	1.083	1.083	1.080	1.084	1.073	1.073	1.064	1.078
6/2	1.090	1.087	1.085	1.082	1.084	1.080	1.079	1.076	1.083
6/16	1.089	1.086	1.084	1.082	1.081	1.077	1.077	1.073	1.081
Avg.	1.087	1.083	1.082	1.081	1.083	1.076	1.074	1.071	1.080
Grand Avg.	1.086	1.083	1.082	1.081	1.081	1.074	1.074	1.071	1.079

Analysis of variance indicates highly significant differences between varieties and between dates, but no significant differences in irrigation levels.

Least significant difference between varieties: 5% level, 0.002; 1% level, 0.002.

Least significant difference between dates: 5% level, 0.001; 1% level, 0.002.

Table 20. Two-way table for varieties and irrigation levels, for average specific gravity of tubers, Experiment A, Lake City, 1952.

Varieties	Irrigation Levels			Avg.
	None	Normal	Heavy	
Russet Rural	1.087	1.087	1.086	1.086
Sebago	1.083	1.083	1.083	1.083
Kennebec	1.082	1.082	1.082	1.082
Katahdin	1.083	1.080	1.080	1.081
Irish Cobbler	1.081	1.081	1.081	1.081
Pontiac	1.076	1.074	1.073	1.074
505-3	1.074	1.073	1.075	1.074
Chippewa	1.071	1.073	1.070	1.071
Average	1.079	1.079	1.079	1.079

Table 21. Two-way table for dates of planting and irrigation levels, for average specific gravity of tubers, Experiment A, Lake City, 1952.

Dates of Planting	Irrigation Levels			Avg.
	None	Normal	Heavy	
June 2	1.083	1.083	1.081	1.082
June 16	1.081	1.081	1.080	1.080
May 16	1.078	1.078	1.078	1.078
May 1	1.076	1.076	1.075	1.076
Average	1.079	1.079	1.079	1.079

Chip color ratings. The average chip color rating for each of the varieties was as follows: Russet Rural (9.5), Kennebec (9.4), Irish Cobbler (8.6), Katahdin (8.6), Sebago (8.4), Chippewa (8.0), 505-3 (7.3), and Pontiac (6.9). It is evident from Table 22 that the chip color of Russet Rural, Kennebec, Irish Cobbler, and Katahdin were in the grade of "excellent"; Sebago and Chippewa, "acceptable"; and 505-3 and Pontiac, "commercially unsalable."

The average chip color ratings of the potatoes from the June 16 planting (8.6) was significantly greater than those from June 2 (8.3), May 16 (8.3), and May 1 (8.2) (Table 24). There was no statistically significant difference in the chip color from June 2, May 16, and May 1 plantings.

Irrigation was found to have considerable effect on chip color: No irrigation (8.8), normal irrigation (8.2), and twice the normal irrigation (8.1). There was no significant difference between the latter two.

Table 22 indicates that the varieties responded similarly to the dates of planting.

Within a variety, supplemental irrigation seemed to have a harmful effect on the color quality of chips, that is, no supplemental irrigation produced comparatively lighter-colored chips than those of normal and twice normal irrigation (Table 23).

Table 22. Average chip color ratings for each variety, from each date of planting, and irrigation level, in Experiment A, Lake City, 1952.

Dates of Planting	Varieties								Avg.
	Russet Rural	Kennebec	Irish Cobbler	Katahdin	Sebago	Chippewa	505-3	Pontiac	
				Twice Normal Supplemental Irrigation					
5/1	9.6	9.4	8.3	8.7	8.1	7.8	6.6	6.3	8.1
5/16	9.6	9.4	7.9	7.6	8.1	7.6	7.8	6.7	8.1
6/2	9.1	9.2	8.7	7.9	7.8	7.9	6.8	5.9	7.9
6/16	9.2	9.3	8.6	8.7	8.1	8.2	7.3	6.7	8.3
Avg.	9.4	9.3	8.4	8.2	8.0	7.9	7.1	6.4	8.1
				Normal Supplemental Irrigation					
5/1	9.5	9.6	8.0	8.0	8.2	7.7	6.9	6.4	8.0
5/16	9.6	9.1	8.4	8.4	8.2	7.9	7.4	6.1	8.1
6/2	9.0	8.9	8.4	8.7	8.4	8.1	6.4	6.9	8.1
6/16	9.2	9.3	9.0	8.2	8.3	8.3	7.5	7.6	8.4
Avg.	9.3	9.2	8.5	8.3	8.3	8.0	7.1	6.8	8.2
				No Supplemental Irrigation					
5/1	9.2	9.7	9.2	9.3	9.0	8.3	7.0	6.9	8.6
5/16	9.8	9.9	9.0	9.6	8.6	7.3	7.1	7.4	8.6
6/2	9.9	9.6	8.8	9.4	8.7	8.1	8.3	7.9	8.8
6/16	9.8	9.8	9.4	9.3	9.0	8.6	8.1	8.0	9.0
Avg.	9.6	9.8	9.1	9.4	8.8	8.1	7.6	7.6	8.8
Grand Avg.	9.5	9.4	8.6	8.6	8.4	8.0	7.3	6.9	8.3

Analysis of variance indicates highly significant differences between varieties, between treatments, and between dates.

Least significant difference between varieties: 5% level, 0.3; 1% level, 0.4.

Least significant difference between treatments: 5% level, 0.2; 1% level, 0.2.

Least significant difference between dates: 5% level, 0.2; 1% level, 0.3.

Table 23. Two-way table for varieties and irrigation levels, for chip color ratings, Experiment A, Lake City, 1952.

Varieties	Irrigation Levels			Avg.
	None	Normal	Heavy	
Russet Rural	9.6	9.3	9.4	9.5
Kennebec	9.8	9.2	9.3	9.4
Irish Cobbler	9.1	8.5	8.4	8.6
Katahdin	9.4	8.3	8.2	8.6
Sebago	8.8	8.3	8.0	8.4
Chippewa	8.0	8.0	7.9	8.0
505-3	7.6	7.1	7.1	7.3
Pontiac	7.6	6.8	6.4	6.9
Average	8.8	8.2	8.1	8.3

Table 24. Two-way table for dates of planting and irrigation levels, for chip color ratings, Experiment A, Lake City, 1952.

Dates of Planting	Irrigation Levels			Avg.
	None	Normal	Heavy	
June 16	9.0	8.4	8.3	8.6
June 2	8.8	8.1	7.9	8.3
May 16	8.6	8.1	8.1	8.3
May 1	8.6	8.0	8.1	8.2
Average	8.8	8.2	8.1	8.3

Dates of planting reacted similarly to the levels of irrigation with no irrigation giving the highest chip color rating on every date and heavy irrigation lowest or near the lowest on each date (Table 24).

Lake City, 1952 Crop--Experiment B

Potatoes of Russet Rural and Irish Cobbler varieties were planted on May 1, May 16, and June 16. Cultural techniques such as irrigation and harvesting, and sampling methods, specific-gravity determinations, storage practices, chip making, and chip rating were the same as described in Experiment A. In addition to the above, the plots were subdivided for four fertilizer treatments; namely, no fertilizer, 3-12-12, 3-0-0, and 0-0-12. The fertilizers were applied at the rate of 1,000 pounds per acre.

The percentage distribution of tubers, the average chip color ratings by variety, by date of planting, by irrigation level, and by fertilizer analysis in each specific-gravity class are given in Appendix Table V.

Specific gravity of tubers. The average specific gravity of the tubers of Russet Rural (1.087) was significantly greater than that of Irish Cobbler (1.082) (Table 25).

Table 25. Average specific gravity for each variety, from each date of planting, irrigation level, fertilizer analysis in Experiment B, Lake City, 1952.

Dates of Planting	Fertilizer Treatments	Irrigation Levels			
		Irish Cobbler			
		Heavy	Normal	None	Avg.
May 1	0-0-0	1.084	1.082	1.087	1.084
	3-12-12	1.078	1.078	1.079	1.078
	3-0-0	1.079	1.080	1.086	1.082
	0-0-12	1.081	1.079	1.080	1.080
	Avg.	1.081	1.080	1.083	1.081
May 16	0-0-0	1.084	1.084	1.081	1.083
	3-12-12	1.079	1.079	1.080	1.079
	3-0-0	1.083	1.080	1.080	1.081
	0-0-12	1.078	1.082	1.080	1.080
	Avg.	1.081	1.081	1.080	1.081
June 16	0-0-0	1.084	1.083	1.084	1.084
	3-12-12	1.083	1.083	1.082	1.083
	3-0-0	1.086	1.087	1.086	1.086
	0-0-12	1.079	1.081	1.082	1.081
	Avg.	1.083	1.084	1.084	1.084
Grand average . . .		1.082	1.082	1.082	1.082

Analysis of variance indicates highly significant differences between varieties, between dates, and between fertilizers, but not between irrigations.

Least significant difference between varieties: 5% level, 0.001; 1% level, 0.001.

Least significant difference between dates: 5% level, 0.001; 1% level, 0.001.

Least significant difference between fertilizers: 5% level, 0.001; 1% level, 0.002.

Table 25 (continued)

Irrigation Levels							
Russet Rural				Average			
Heavy	Normal	None	Avg.	Heavy	Normal	None	Grand Avg.
1.087	1.084	1.087	1.086	1.086	1.083	1.087	1.085
1.080	1.084	1.083	1.082	1.079	1.081	1.081	1.080
1.088	1.087	1.088	1.088	1.084	1.084	1.087	1.085
1.084	1.085	1.088	1.086	1.083	1.082	1.082	1.082
1.085	1.085	1.087	1.086	1.083	1.083	1.084	1.083
1.089	1.089	1.090	1.089	1.087	1.087	1.086	1.087
1.087	1.086	1.085	1.086	1.083	1.083	1.083	1.083
1.085	1.089	1.084	1.086	1.084	1.085	1.082	1.084
1.084	1.087	1.089	1.087	1.081	1.085	1.085	1.084
1.086	1.088	1.087	1.087	1.084	1.085	1.084	1.084
1.087	1.090	1.088	1.088	1.086	1.087	1.086	1.086
1.088	1.088	1.089	1.088	1.086	1.086	1.086	1.086
1.090	1.090	1.090	1.090	1.088	1.089	1.088	1.088
1.088	1.087	1.088	1.088	1.084	1.084	1.085	1.084
1.088	1.089	1.089	1.089	1.086	1.086	1.086	1.086
1.086	1.087	1.087	1.087	1.084	1.084	1.085	1.084

The average specific gravity of tubers from the June 16 planting (1.086) was significantly higher than that of the May 16 planting (1.084), and of the May 1 planting (1.083). The specific gravity for May 16 planting was only significantly greater at the 5 percent level than that of the May 1 planting.

The application of additional amounts of water by supplemental irrigation either normal or twice normal appeared to have but slight effect on the average specific gravity (Table 26).

No fertilizer (1.086) and 3-0-0 (1.085) produced potatoes of significantly higher specific gravity than those of 0-0-12 (1.083) and 3-12-12 (1.083) (Table 27).

From Tables 25, 27, and 28 it can be seen that varieties responded in a similar manner to dates of planting and to fertilizer treatments, and that the different levels of irrigation gave similar reactions to the various fertilizers. This was not true for dates of planting with fertilizers (Table 29), and for dates of planting with levels of irrigation (Table 30).

Chip color ratings. The average chip color ratings for the variety Russet Rural (9.4) were significantly greater than that of Irish Cobbler (8.5); in fact, in every treatment Russet Rural gave a higher chip color rating than did Irish Cobbler (Table 31).

Table 26. Two-way table for varieties and irrigation levels, for average specific gravity of tubers, Experiment B, Lake City, 1952.

Varieties	Irrigation Levels			Avg.
	None	Normal	Heavy	
Russet Rural	1.087	1.087	1.086	1.087
Irish Cobbler	1.082	1.082	1.082	1.082
Average	1.085	1.084	1.084	1.084

Table 27. Two-way table for varieties and fertilizer treatments, for average specific gravity of tubers, Experiment B, Lake City, 1952.

Varieties	Fertilizer Treatments				Avg.
	No Fertilizer	3-0-0	0-0-12	3-12-12	
Russet Rural	1.088	1.088	1.087	1.086	1.087
Irish Cobbler	1.084	1.083	1.080	1.080	1.082
Average	1.086	1.085	1.083	1.083	1.084

Table 28. Two-way table for irrigation levels and fertilizer treatments, for average specific gravity of tubers, Experiment B, Lake City, 1952.

Irrigation Levels	Fertilizer Treatments				Avg.
	No Fertilizer	3-0-0	0-0-12	3-12-12	
None	1.086	1.086	1.084	1.083	1.085
Normal	1.085	1.085	1.083	1.083	1.084
Heavy	1.086	1.085	1.082	1.082	1.084
Average	1.086	1.085	1.083	1.083	1.084

Table 29. Two-way table for dates of planting and fertilizer treatments, for average specific gravity of tubers, Experiment B, Lake City, 1952.

Dates of Planting	Fertilizer Treatments				Avg.
	No Fertilizer	3-0-0	0-0-12	3-12-12	
June 16	1.086	1.088	1.084	1.086	1.086
May 16	1.087	1.084	1.084	1.083	1.084
May 1	1.085	1.085	1.082	1.080	1.083
Average	1.086	1.085	1.083	1.083	1.084

Table 30. Two-way table for dates of planting and irrigation levels, for average specific gravity of tubers, Experiment B, Lake City, 1952.

Dates of Planting	Irrigation Levels			Avg.
	None	Normal	Heavy	
June 16	1.086	1.086	1.086	1.086
May 16	1.084	1.085	1.084	1.084
May 1	1.084	1.083	1.083	1.083
Average	1.085	1.084	1.084	1.084

Table 31. Average chip color ratings for each variety, from each date of planting, irrigation level, fertilizer analysis in Experiment B, Lake City, 1952.

Dates of Planting	Fertilizer Treatments	Irrigation Levels			
		Irish Cobbler			
		Heavy	Normal	None	Avg.
May 1	0-0-0	8.7	8.4	9.8	8.9
	3-12-12	8.3	8.0	9.2	8.5
	3-0-0	8.0	7.8	9.4	8.4
	0-0-12	8.3	8.0	8.9	8.4
	Avg.	8.3	8.1	9.3	8.6
May 16	0-0-0	8.0	7.5	8.3	7.9
	3-12-12	7.9	8.4	9.0	8.4
	3-0-0	8.0	7.7	8.8	8.1
	0-0-12	8.5	8.6	9.0	8.7
	Avg.	8.1	8.1	8.8	8.3
June 16	0-0-0	8.0	7.9	9.3	8.4
	3-12-12	8.6	9.0	9.4	9.0
	3-0-0	8.4	8.6	9.4	8.8
	0-0-12	8.2	7.9	8.9	8.3
	Avg.	8.3	8.4	9.3	8.6
Grand average . . .		8.2	8.2	9.1	8.5

Analysis of variance indicates highly significant differences between varieties and between irrigations, but no significant differences between dates nor between fertilizer treatments.

Least significant difference between varieties: 5% level, 0.2; 1% level, 0.2.

Least significant difference between irrigations: 5% level, 0.2; 1% level, 0.3.

Table 31 (continued)

Irrigation Levels							
Russet Rural				Average			
Heavy	Normal	None	Avg.	Heavy	Normal	None	Grand Avg.
9.5	8.8	9.6	9.3	9.1	8.6	9.7	9.1
9.6	9.2	9.2	9.3	8.9	8.6	9.2	8.9
8.9	9.3	9.9	9.3	8.5	8.6	9.7	8.9
9.3	9.7	9.9	9.6	8.8	8.9	9.4	9.0
9.3	9.3	9.7	9.4	8.8	8.7	9.5	9.0
9.5	9.7	9.9	9.7	8.8	8.6	9.1	8.8
9.6	9.8	9.8	9.7	8.8	9.1	9.4	9.1
8.9	9.2	9.3	9.1	8.5	8.4	9.1	8.7
9.3	9.4	10.0	9.5	8.9	9.0	9.5	9.1
9.3	9.5	9.8	9.5	8.7	8.8	9.3	8.9
8.6	9.8	9.4	9.2	8.3	8.9	9.4	8.8
9.2	9.8	9.8	9.6	8.9	9.4	9.6	9.3
8.8	8.8	8.8	8.8	8.6	8.7	9.1	8.8
9.6	9.5	9.4	9.5	8.9	8.7	9.2	8.9
9.1	9.5	9.4	9.3	8.7	8.9	9.3	9.0
9.2	9.4	9.6	9.4	8.7	8.8	9.4	9.0

No significant differences were observed between chip color ratings of May 1, May 16, and June 16 plantings.

The average chip color ratings from the no irrigation plots (9.4) were significantly higher than those from the normal irrigation (8.8) and the twice normal irrigation (8.7) plots (Table 32).

The average chip color ratings for each of the fertilizer treatments were as follows: 3-12-12 (9.0), 0-0-12 (9.0), no fertilizer (8.9), and 3-0-0 (8.8) (Table 33). There was no statistically significant difference between them.

Russet Rural and Irish Cobbler did not respond similarly from one date of planting to another (Table 31), nor to the three levels of irrigation (Table 32), but they did react similarly to fertilizers with the one exception of Russet Rural to 0-0-12 (Table 33).

Dates of planting did not give similar responses to levels of irrigation, but the interaction was not significant (Table 34). The same may be said for dates of planting with the several fertilizers (Table 35).

The responses given by the several fertilizers to the levels of irrigation (Table 36) tended to be similar as far as no irrigation compared with irrigation was concerned, with the no irrigation treatment giving the higher chip color ratings. Within irrigations the responses to fertilizers showed no definite trends.

Table 32. Two-way table for varieties and irrigation levels, for chip color ratings, Experiment B, Lake City, 1952.

Varieties	Irrigation Levels			Avg.
	None	Normal	Heavy	
Russet Rural	9.6	9.4	9.2	9.4
Irish Cobbler	9.1	8.2	8.2	8.5
Average	9.4	8.8	8.7	9.0

Table 33. Two-way table for varieties and fertilizer treatments, for chip color ratings, Experiment B, Lake City, 1952.

Varieties	Fertilizer Treatments				Avg.
	3-12-12	0-0-12	No Fertilizer	3-0-0	
Russet Rural	9.5	9.6	9.4	9.1	9.4
Irish Cobbler	8.6	8.4	8.4	8.5	8.5
Average	9.1	9.0	8.9	8.8	9.0

Table 34. Two-way table for dates of planting and irrigation levels, for chip color ratings, Experiment B, Lake City, 1952.

Dates of Planting	Irrigation Levels			Avg.
	None	Normal	Heavy	
May 1	9.5	8.7	8.8	9.0
June 16	9.3	8.9	8.7	9.0
May 16	9.3	8.8	8.7	8.9
Average	9.4	8.8	8.7	9.0

Table 35. Two-way table for dates of planting and fertilizer treatments, for chip color ratings, Experiment B, Lake City, 1952.

Dates of Planting	Fertilizer Treatments				Avg.
	3-12-12	0-0-12	No Fertilizer	3-0-0	
May 1	8.9	9.0	9.1	8.9	9.0
June 16	9.3	8.9	8.8	8.8	9.0
May 16	9.1	9.1	8.8	8.7	8.9
Average	9.1	9.0	8.9	8.8	9.0

Table 36. Two-way table for irrigation levels and fertilizer treatments, for chip color ratings, Experiment B, Lake City, 1952.

Irrigation Levels	Fertilizer Treatments				Avg.
	3-12-12	0-0-12	No Fertilizer	3-0-0	
None	9.4	9.4	9.4	9.3	9.4
Normal	9.0	8.9	8.7	8.6	8.8
Heavy	8.9	8.9	8.7	8.5	8.7
Average	9.1	9.0	8.9	8.8	9.0

DISCUSSION OF RESULTS

Specific Gravity of Potatoes

Frequency distribution of tubers into specific-gravity classes. In Appendix Tables I, II, IV, and V may be seen the percentage distribution of the tubers into the five specific-gravity classes. There was considerable variation between varieties, dates of planting, irrigation treatments, fertilizer applications, location, and seasons.

The Russet Rural and Kennebec varieties always produced a high percentage of tubers in the high-specific-gravity (4 and 5) classes. Irish Cobbler and Sebago potatoes were rated midway in specific gravity with most of the tubers in Class 3. Katahdin, Pontiac, Chippewa, and Seedling 505-3 had a high percentage of tubers in low-specific-gravity (1 and 2) classes.

It is interesting to note that in 1951 the date of planting also affected the distribution of tubers in various specific-gravity classes. The large percentage of tubers from early-planted plots was in the high-specific-gravity classes, and this percentage declined progressively with later dates of planting. However, observations of the experiments of 1952, at Lake City, present contradictory results to

those of 1951. That is, late-planted (June 2 and June 16) potatoes had a higher percentage of tubers in high-specific-gravity classes than those planted earlier (May 1 and May 16). The probable explanation of these contradicting results may be as follows: The year 1952 was not normal for Lake City because heavy rains in the latter part of July hampered the growth of early-planted potatoes; there was enough sunshine and warmth and an absence of frost to allow the late-planted potatoes to mature. Hence, these seasonal weather changes were responsible for results so different from the previous season.

Data of 1951, at East Lansing, suggest that irrigation with no fertilizer treatment tended to yield a higher proportion of high-specific-gravity tubers than any other treatment. No irrigation with 3-12-12 and irrigation with 3-12-12 plots produced high percentages in medium-specific-gravity classes and the plots which received irrigation with 0-0-18 yielded the largest percentage of potatoes in low-specific-gravity classes.

The extensive study of the 1952 crop from Lake City indicates that there was no marked effect of various levels of irrigation on the distribution of potatoes into specific-gravity classes. The potatoes from the unfertilized plots had a large percentage of tubers in the

high-specific-gravity classes. The plots receiving 0-0-12 fertilizer produced many tubers of low specific gravity, and the plots which were fertilized with 3-0-0 and 3-12-12 yielded potatoes of medium specific gravity. This is parallel to the findings of 1951 from East Lansing.

Figures 1, 2, and 3 point out that the location where potatoes were grown made a great difference in the distribution of tubers into various specific-gravity classes. Figure 1, presenting the data from East Lansing, 1951, indicates that there was a distinct division (Class 3) between low- and high-specific-gravity classes. This suggests that there may have been two different tuber settings in the life of the potato crop, which could have been encouraged by the environmental influences. The pattern of distribution of tubers in specific-gravity classes from the crops at Lake City in 1951 and 1952 were to a large extent the same (Figure 2 and 3), except there were some slight seasonal variations, with 1952 tubers averaging higher in specific gravity.

Average specific gravity of tubers. The average specific gravity of tubers followed the same pattern as discussed previously. That is, Russet Rural and Kennebec potatoes had high, Irish Cobbler and Sebago had medium, and Chippewa, Pontiac, and Seedling 505-3

Figure 1. Percentage distribution of tubers into five specific-gravity classes from the first (May 21), second (June 13), and third (June 25) dates of planting. The curves show the average of five varieties, grown under normal irrigation with 3-12-12 fertilizer, 1,000 pounds per acre, East Lansing, 1951.

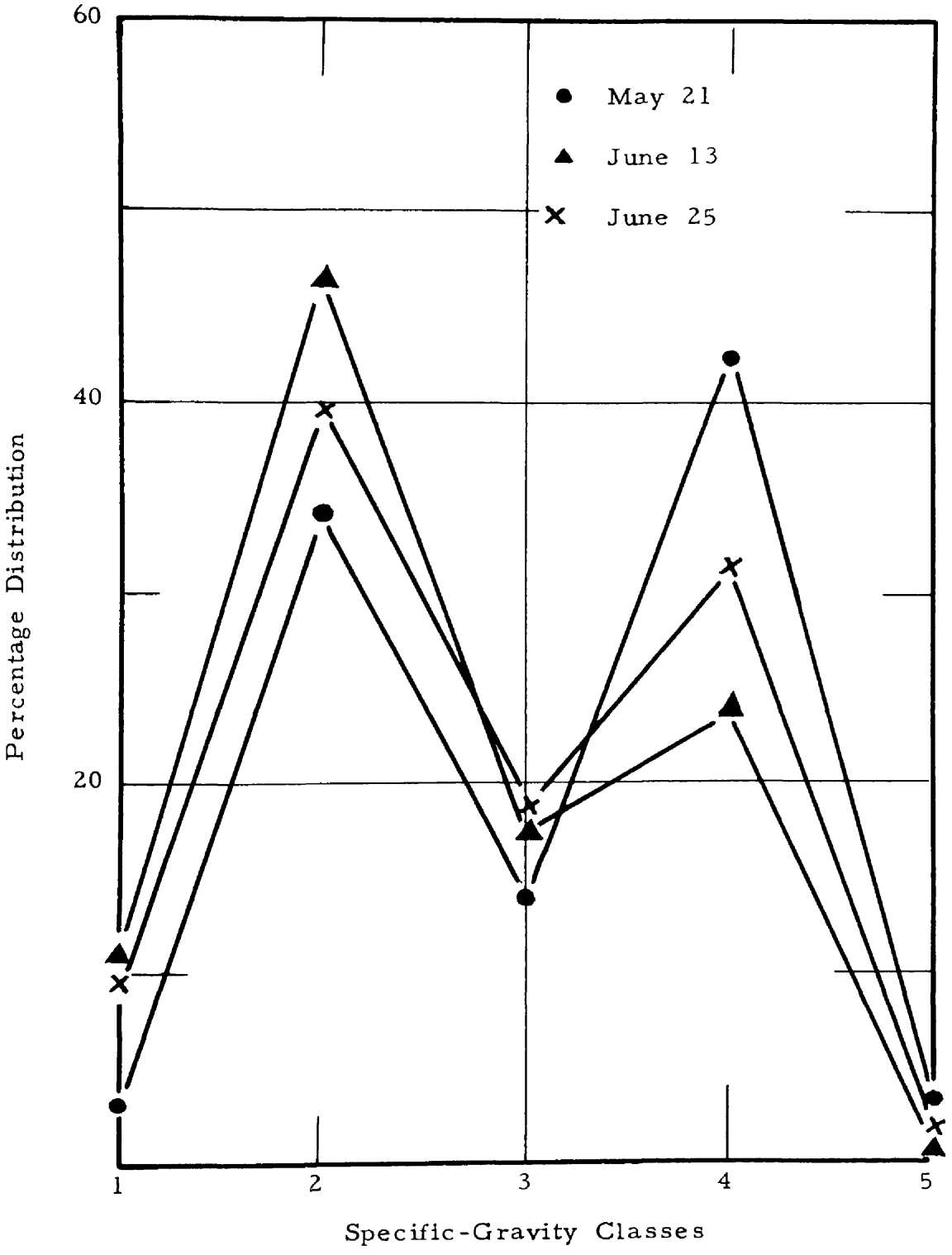

60
40
20
May 21
June 13
June 25
Percentage Distribution
1
2
3
4
5
Specific-Gravity Classes

Figure 2. Percentage distribution of tubers into five specific-gravity classes from the first (May 4), second (May 23), and third (June 4) dates of planting. The curves show the average of six varieties, grown under normal irrigation with 3-12-12 fertilizer, 1,000 pounds per acre, Lake City, 1951.

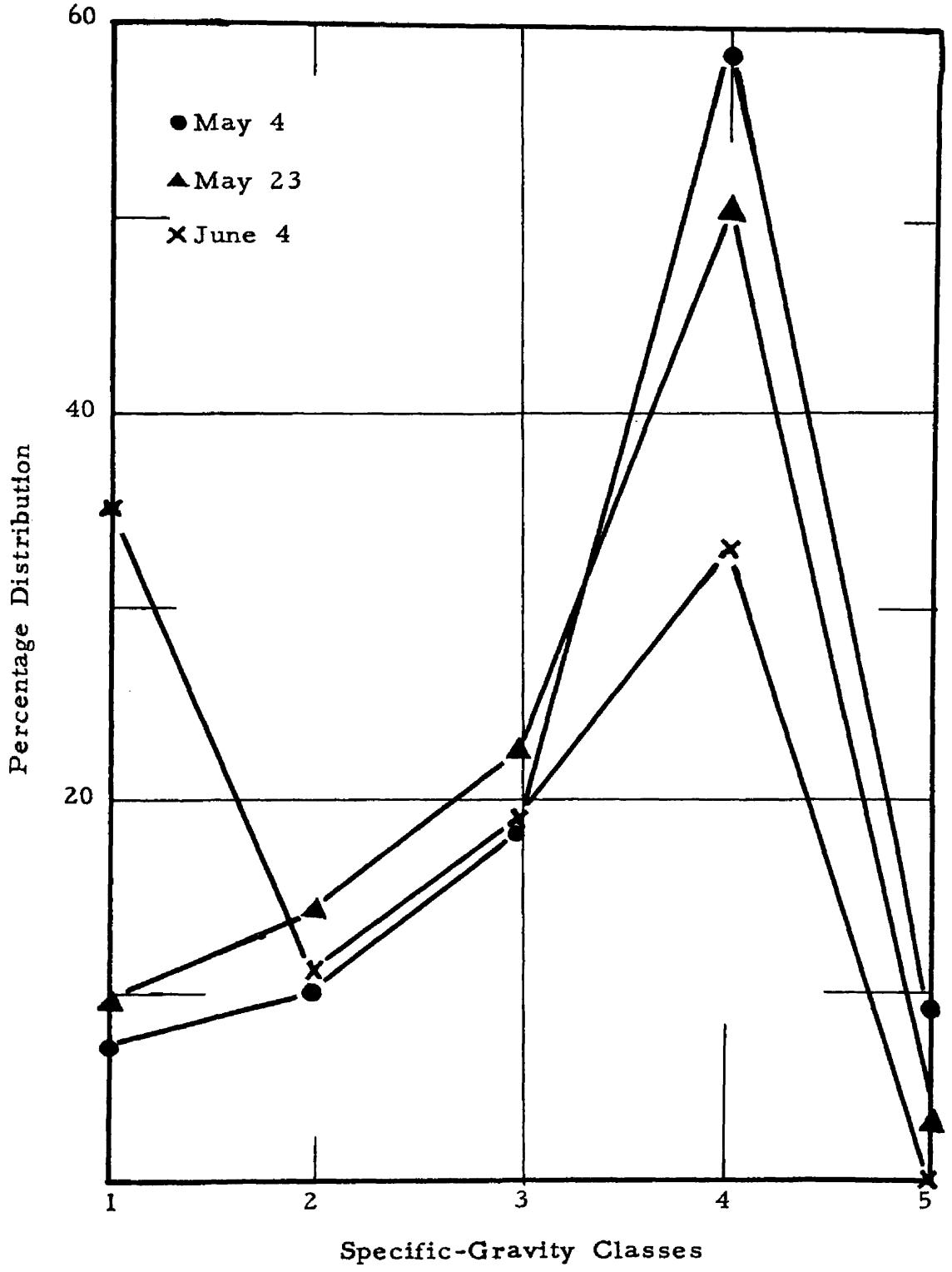
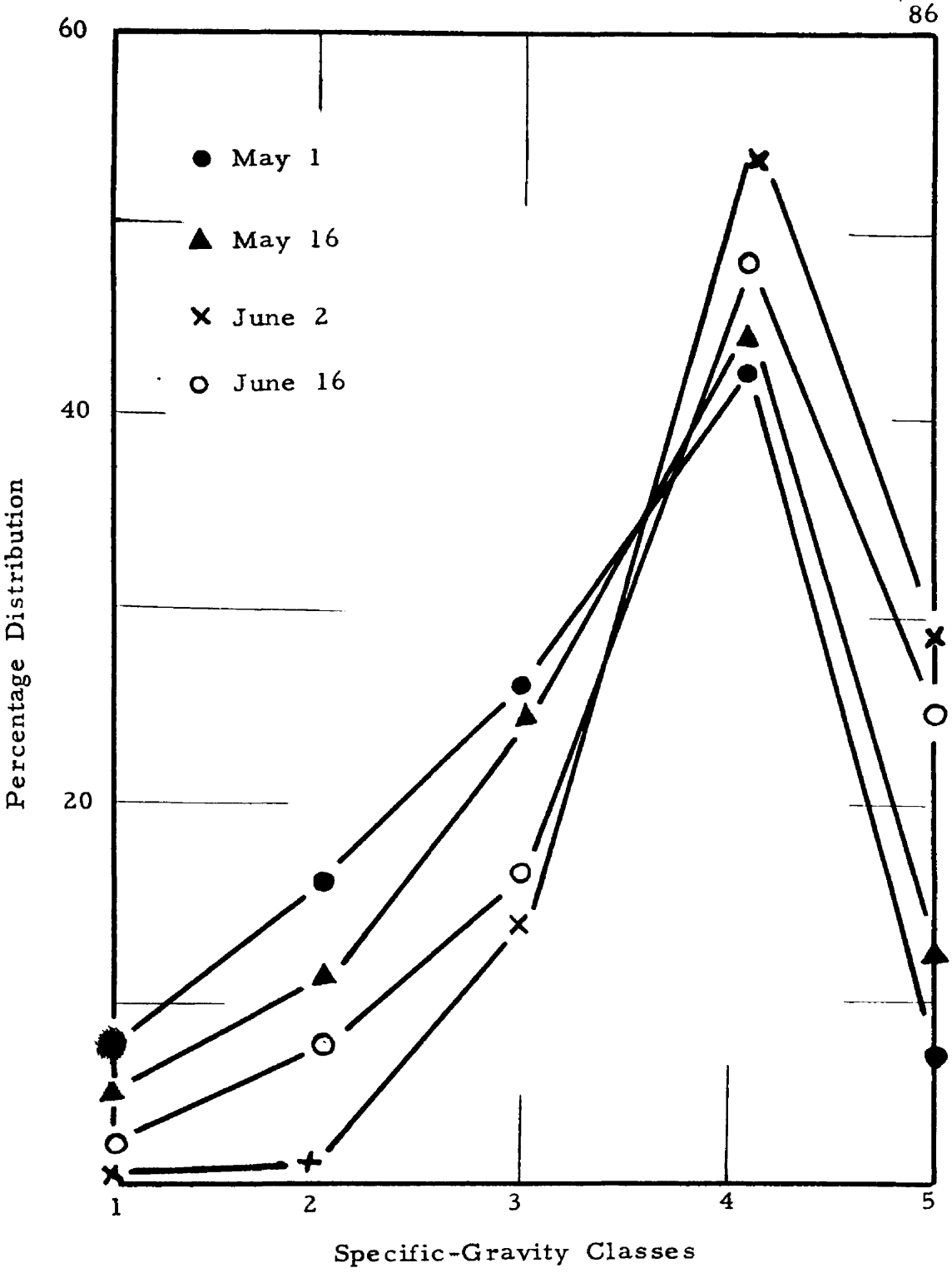

60
40
20
May 4
May 23
June 4
Percentage Distribution
1
2
3
4
5
Specific-Gravity Classes

Figure 3. Percentage distribution of tubers into five specific-gravity classes from the first (May 1), second (May 16), third (June 2), and fourth (June 16) dates of planting. The curves show the average of eight varieties, grown under normal irrigation with 3-12-12 fertilizer, 1,000 pounds per acre, Lake City, 1952.


60
40
20
May 1
May 16
June 2
June 16
Percentage Distribution
1
2
3
4
5
Specific-Gravity Classes

had low average specific gravity. The Katahdin variety produced tubers of low specific gravity in 1951 at East Lansing, but of medium specific gravity for both years, 1951 and 1952, at Lake City. This confirms the observations of Vanasse et al. (61), who reported that variety had a significant effect on the specific gravity, and of Metzger et al. (35) and Dunn and Nylund (24), who stated that potatoes from one locality differed in dry-matter content from those of another.

The tubers from early planting had conspicuously higher specific gravity than those from late plantings in the year 1951 from East Lansing and Lake City. But in 1952, the Lake City crop gave contrasting results. That is, late plantings (third and fourth dates) yielded potatoes of slightly higher specific gravity than the early plantings (first and second dates). (The probable explanation of seasonal variation is discussed above).

In 1951, East Lansing data show that irrigation with no fertilizer gave tubers with an average high specific gravity. No irrigation with 3-12-12, irrigation with 3-12-12, and irrigation with 0-0-18 treatments tended to produce low-specific-gravity potatoes. This indicates that irrigation did not influence the specific gravity of tubers. This was later confirmed from the results of 1952, Lake City.

In 1952, the highest average specific-gravity ratings were given to tubers from the unfertilized plots, followed by those which received 3-0-0 and 3-12-12, while the lowest ratings were found in treatments 0-0-18 or 0-0-12. This higher specific gravity of tubers from unfertilized plots contrasted with those from plots fertilized with different types of fertilizers is in agreement with the findings of Smith and Nash (49).

It can be seen from Appendix Tables I and II that the average specific gravity of the tubers of a given variety from Lake City was comparatively higher than those from East Lansing. A similar effect due to locational differences was given by Vanasse et al. (61). Furthermore, the specific gravity of any variety was higher in 1952 than in 1951, which confirms the findings of Wager (62) on seasonal influences on specific gravity of tubers.

Color of Potato Chips

In the three years of observation, Russet Rural, Kennebec, and Irish Cobbler varieties produced marketable, delectable, and eye-appealing golden yellow chips. Chips from Katahdin tubers were in the grade of acceptable; Chippewa, Pontiac, Sebago, and 505-3 made commercially unsalable chips (68).

The date of planting had some influence on color quality of potato chips. The results of 1950 and 1951 from Lake City and of 1951 from East Lansing indicate that the chips from the early-planted potatoes were of a lighter color than those of late-planted (64). The results of 1952 from Lake City contradicted the results of 1950 and 1951. That is, the late-planted potatoes made slightly lighter-colored chips than those from the early-planted (Figures 4 and 5), although all were acceptable in the better varieties.

It can be seen from Appendix Tables IV and V that there seemed to be a more or less direct relationship between the specific gravity of tubers and the color of the chips (33) processed from them. That is, the higher the specific gravity, the lighter the chip color when the date of planting effects are also considered. It is observed that, while, within the late date of planting, the higher-specific-gravity tubers produced lighter-colored chips than the

Figure 4. Average chip color ratings for the May 21, June 13, and June 25 dates of planting in five specific-gravity classes. The curves show the average of five varieties, normal irrigation with 3-12-12 fertilizer, 1,000 pounds per acre, East Lansing, 1951. The largest portion of chips from the May 21 planting was acceptable.

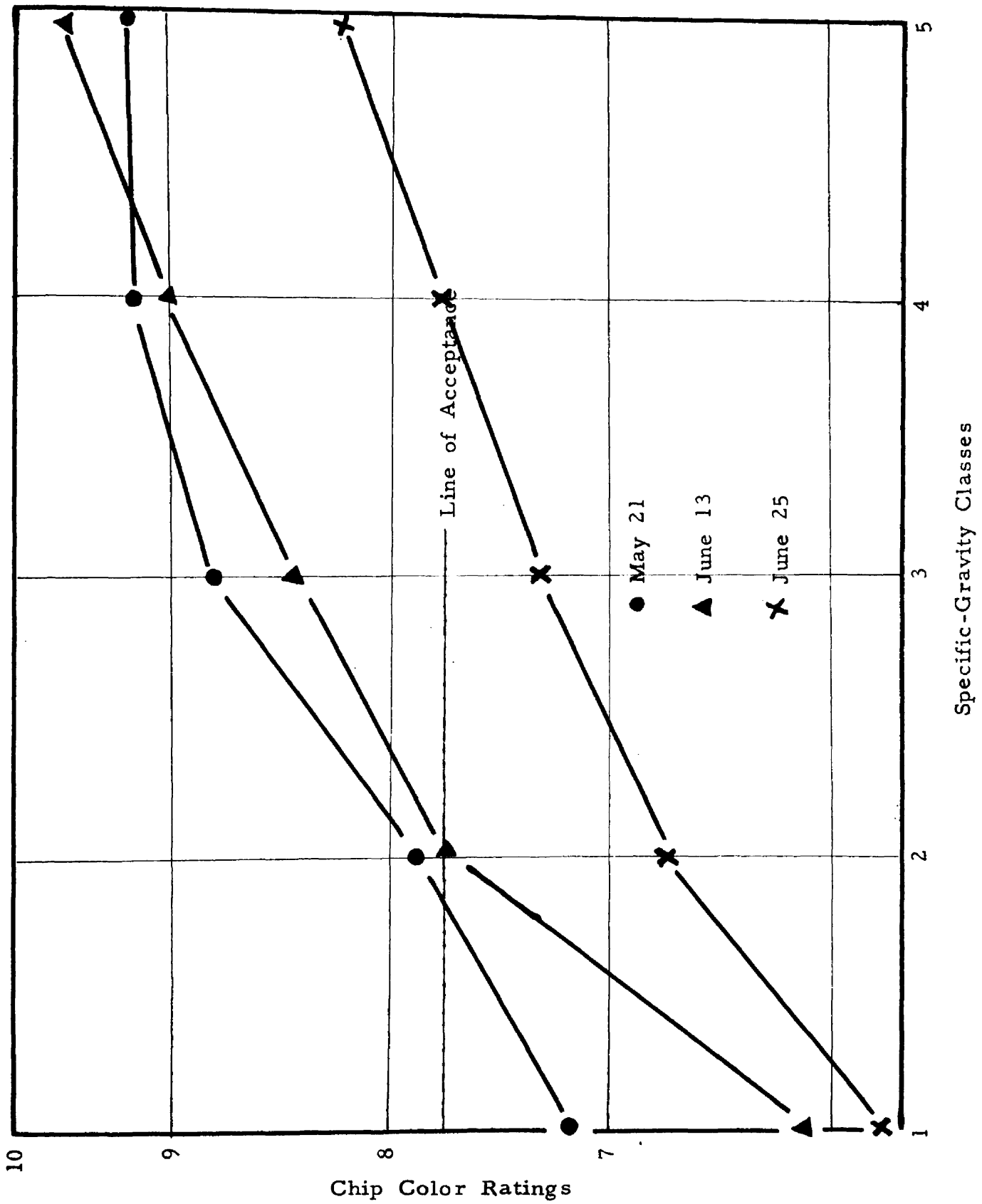
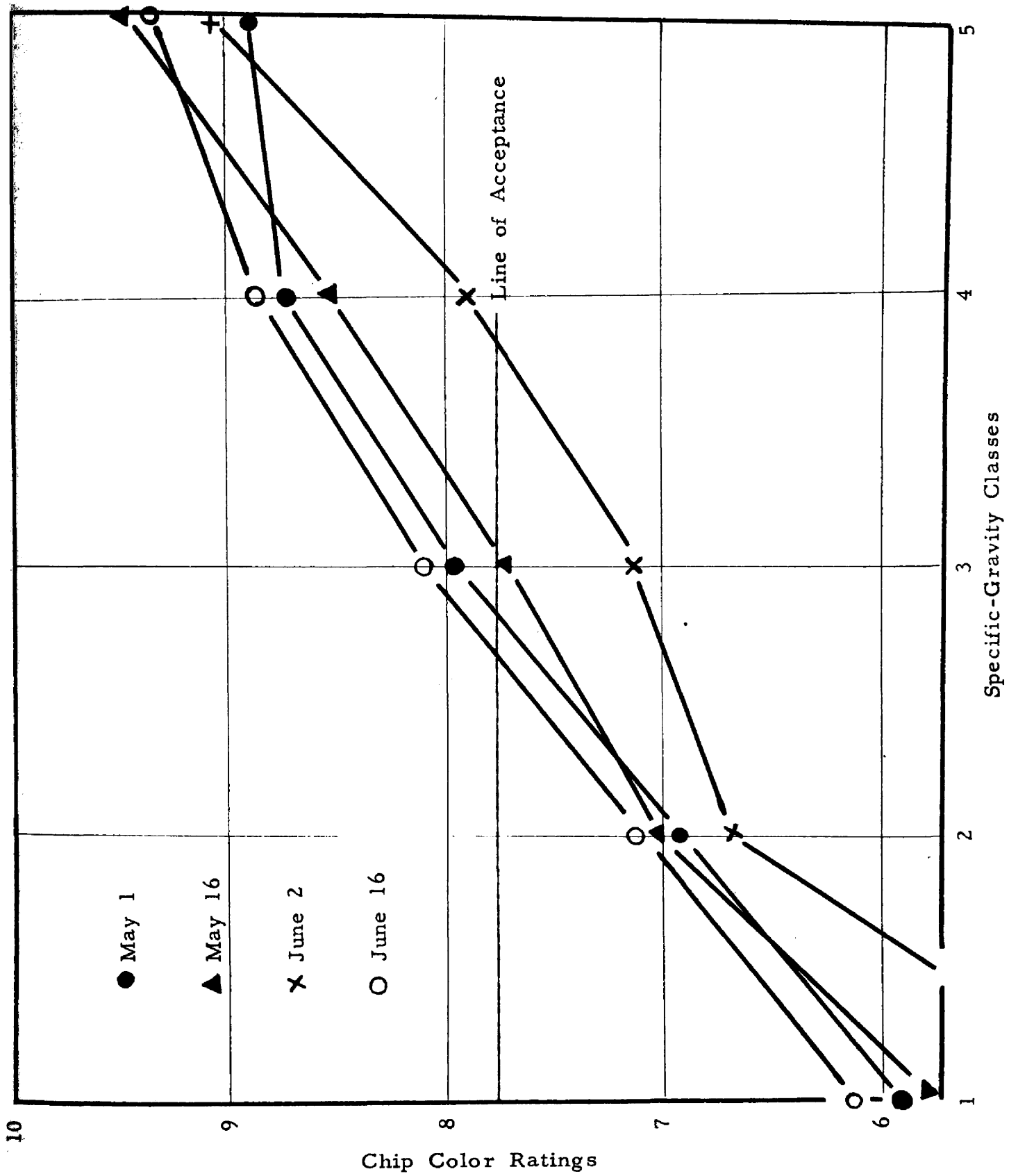

Line of Acceptance
May 21
June 13
June 25
10
9
8
7
1
2
3
4
5
Chip Color Ratings
Specific-Gravity Classes

Figure 5. Average chip color ratings for the May 1, May 16, June 2, and June 16 dates of planting in five specific-gravity classes. The curves show the average of eight varieties, normal irrigation with 3-12-12 fertilizer, 1,000 pounds per acre, Lake City, 1952. The largest portion of chips from the June 16 planting was acceptable.


Line of Acceptance
May 1
May 16
June 2
June 16
Chip Color Ratings
10
9
8
7
6
Specific-Gravity Classes
1
2
3
4
5

lower-specific-gravity tubers, yet these chips were not as light as those from the corresponding specific-gravity class from the early planting (64).

Table 1 shows that the amount of reducing sugars and the color of chips varied not only from variety to variety, but also within a variety, and within the same specific-gravity class from one date of planting to another.

The experiments of 1951 from East Lansing and of 1952 from Lake City show that tubers from no-irrigation plots produced lighter-colored chips than those from irrigated, in spite of the fact that there was no difference in specific gravity. It may further be observed from the experiment at East Lansing, 1951, and Experiment B, at Lake City, 1952, that the plots which were fertilized with 3-12-12 at the rate of 1,000 pounds per acre made comparatively more-acceptable chips than the potatoes from plots with other fertilizer analyses. It is interesting to note that potash (KCl) fertilizer (0-0-18 and 0-0-12) decreased the average specific gravity below that of 3-12-12. This was probably due to the chloride ion (55). It is suggested that the chloride might be playing some role in the enzyme system or carbohydrate system of the potato. Tubers of any given specific gravity from plots fertilized with 3-12-12, 0-0-18,

or 0-0-12 produced lighter-colored chips than did tubers of the same specific gravity from unfertilized or 3-0-0 plots. But the latter two plots produced tubers with higher average specific gravities than any of the other plots.

Considering both specific gravity and chip color, a fertilizer balanced in potash and phosphorus seems advisable.

Potatoes grown at Lake City (1950, 1951, and 1952) made lighter-colored chips than those that were grown at East Lansing (1951). This might be due to higher temperature, nonuniform soil (low-lying areas), a high population of weeds and diseased plants at East Lansing (60).

The year 1952 seemed to be a more favorable year for growing potatoes for the manufacturing of potato chips than did 1950 and 1951. The color of chips in 1952 was lighter than in 1950 and 1951, for the same variety, and the same specific-gravity class; no matter what date of planting or treatment.

In 1951, experiments were conducted at East Lansing to study the effects of storage temperature and duration on the color of potato chips. Russet Rural yielded comparatively lighter-colored chips than did Katahdin, after two, as well as five, months cold storage (41° F.). Chip color after five months storage was darker than after two months

storage, suggesting the transformation and accumulation of large percentages of reducing sugars in the tubers.

The data on high-temperature conditioning of potatoes subsequent to two months cold storage suggest that tubers of Kennebec conditioned faster than Irish Cobbler, and that Katahdin conditioned faster than Sebago. After high-temperature conditioning of potatoes following five months cold storage, Russet Rural made lighter-colored chips than after two months. With the Katahdin variety, the opposite was true: darker chips were produced after five months than after two months cold storage.

Date of planting appeared to have only a slight effect on color quality of chips processed immediately after the removal from cold storage. All chips were too dark for commercial acceptance.

The order of ranking as to color was almost identical for chips processed from tubers directly out of cold storage and for the chips from the same tubers after conditioning at a higher temperature. The same was true whether or not the tubers had been previously stored for two or five months in cold storage.

Potatoes from no irrigation with 3-12-12 plots produced lighter chips throughout (after two as well as five months cold storage and after conditioning) than irrigated 3-12-12 plots. It is

suggested that irrigation is the controlling factor in activation of the enzyme, phosphorylase. Irrigation with 0-0-18 markedly influenced Russet Rural potatoes to make lighter-colored chips than Katahdin potatoes. Some anatomical observations (29) are shown in Figures 6, 7, and 8.

Figure 6. Appearance of potato chips: Irish Cobbler variety, Lake City, 1951.

From the tubers of specific-gravity class 3 (1.067 - 1.073).

TOP: Chips of the tubers from May 4 planting, general appearance is light, pith rays are dark.

BOTTOM: Chips of the tubers from June 4 planting. General appearance is dark; cortex is lighter than pith.

In both the cases, fibrovascular ring is prominently dark.

Figure 7. Appearance of potato chips: Russet Rural variety, East Lansing, 1951.

TOP: From the tubers of high specific gravity, general appearance is light; cortical and pith regions are equally light, basal part of chip is darker than apical. Fibrovascular ring is prominently dark.

BOTTOM: From the tubers of low specific gravity, general appearance is dark; cortical area is lighter than the central pith. Fibrovascular ring is prominently dark.

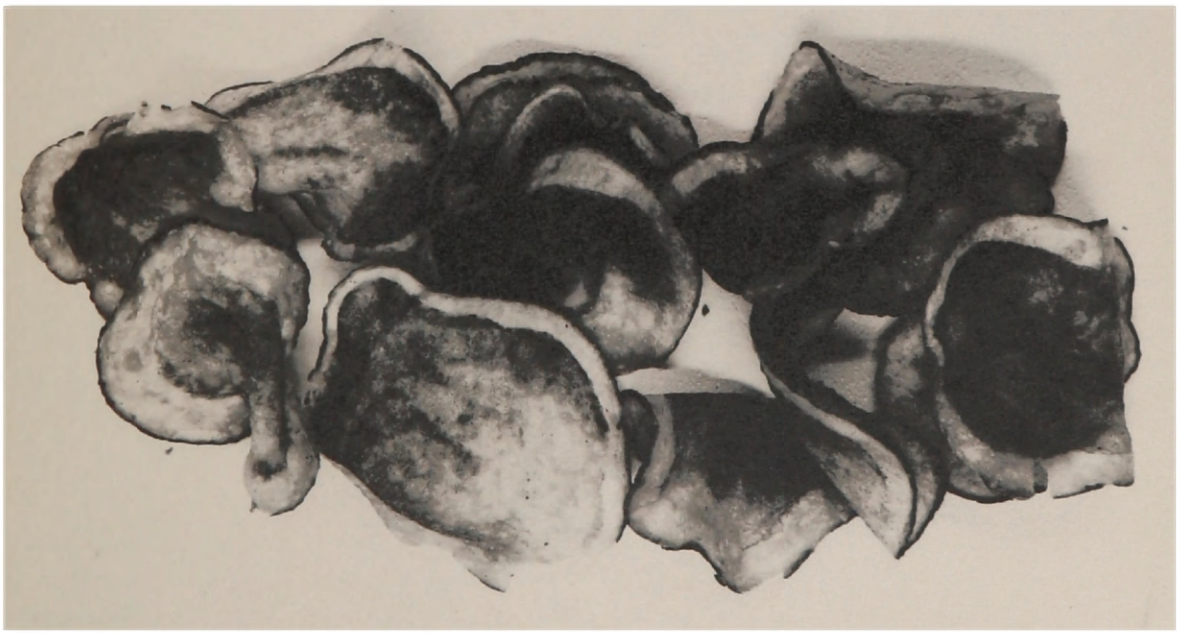
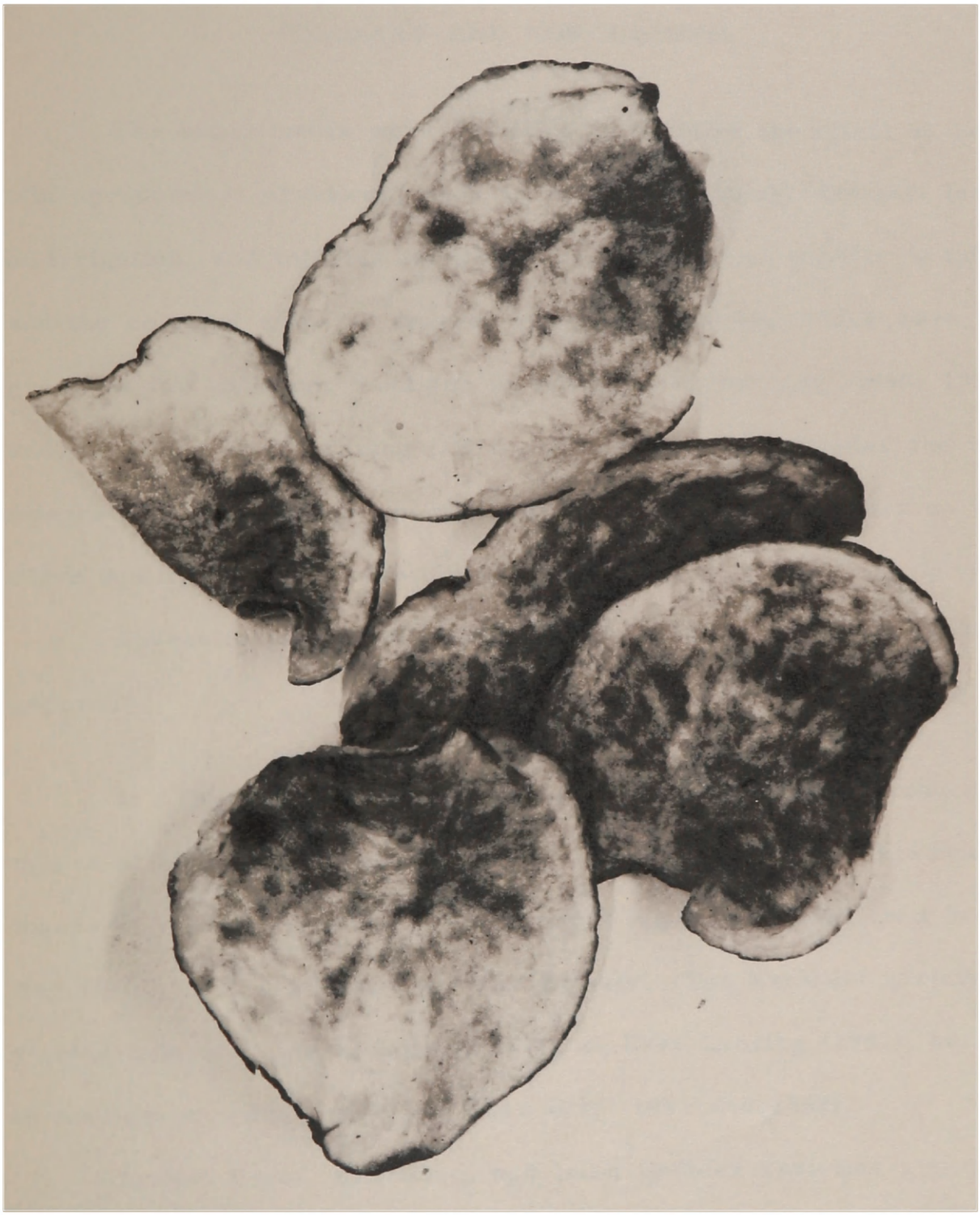


Figure 8. Appearance of potato chips: Katahdin variety, East Lansing, 1951.

Fibrovascular ring is not prominently dark.



SUMMARY AND CONCLUSIONS

The experiments were designed to evaluate the effect of certain agronomical practices, such as dates of planting, different levels of irrigation, and mineral fertilizers on the specific gravity of tubers and the color of chips of several varieties of potato, which were grown at two different locations in Michigan--Lake City (1950, 1951, and 1952) and East Lansing (1951). The study also included the influence of temperatures and duration of storage of the tubers on the color quality of potato chips.

Approximately 15,000 tubers were analyzed in these investigations.

1. Variety. Russet Rural and Kennebec varieties produced tubers of high specific gravity. Irish Cobbler and Sebago produced tubers of medium specific gravity; and Chippewa, Pontiac, and Seedling 505-3, of low average specific gravity. The Katahdin variety yielded tubers of low specific gravity at East Lansing (1951), but of medium specific gravity at Lake City (1951 and 1952).

Russet Rural, Kennebec, and Irish Cobbler varieties processed golden yellow colored chips. Chips of Katahdin tubers were in the

grade of commercially acceptable; while Chippewa, Pontiac, Sebago, and 505-3 made unsalable chips.

2. Date of planting. Tubers from early plantings had higher specific gravity than those from late plantings at both East Lansing and Lake City in 1951. But the Lake City crop of 1952 contradicted these results.

Results from Lake City (1950 and 1951) and from East Lansing (1951) show that early-planted potatoes made lighter-colored chips than those of late-planted. But the Lake City (1952) late-planted potatoes made slightly lighter-colored chips than those of early-planted. These contradictory results on specific gravity and color of chips are probably due to seasonal variations.

In 1951, tubers of a given specific-gravity class from an early date of planting produced lighter-colored chips than those from the same specific-gravity class of late planting.

3. Irrigation. Various levels of irrigation did not influence the average specific gravity of tubers, but the tubers from nonirrigated plots yielded significantly lighter-colored chips than those from irrigated plots.

4. Fertilizer. Tubers from the unfertilized plots had highest average specific gravity, followed by those which received 3-0-0 and 3-12-12 fertilizers (at the rate of 1,000 pounds per acre), while the lowest ratings were found in treatments of 0-0-18 or 0-0-12 fertilizers.

Tubers from 3-12-12 fertilized plots yielded more-acceptable chips than those from plots with other fertilizer analyses. Though potash fertilizer lowered the specific gravity, it lightened the color of chips.

5. Location. Average specific gravity of the tubers of a given variety was higher and color of chips was lighter from Lake City than from East Lansing.

6. Season. Considering varietal averages, specific-gravity ratings and chip color ratings were higher in 1952 than those from 1950 and 1951.

7. Reducing sugars. The content of reducing sugars and color of potato chips varied not only from variety to variety, but also within a variety and within the same specific-gravity class from one date of planting to another.

8. Storage.

a. Chip color immediately after five months cold storage (41° F.) was darker than after two months. But after conditioning (78° F.) of potatoes following five months cold storage, Russet Rural made lighter-colored chips than after two months, but Katahdin processed darker chips after five months than after two months.

b. Subsequent to two months cold storage, tubers of Kennebec conditioned faster than Irish Cobbler, and Katahdin faster than Sebago.

c. The order of ranking as to color was identical for chips processed directly out of cold storage (two or five months) as for chips from the same tubers after conditioning.

d. Date of planting had only a slight effect on color quality of chips made immediately after two as well as five months cold storage. The striking effect of date of planting showed up in potatoes conditioned after two months cold storage. The first date of planting gave significantly lighter-colored chips than the later plantings. However, there were no apparent differences between the dates of planting as judged by the color of chips of the tubers conditioned after five months in cold storage.

9. Some anatomical aspects are shown.

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APPENDIX

Appendix Table I. The percentage of tubers in each specific-gravity class and the averages of the chip color ratings[1] of the tubers of six varieties and three dates of planting, Lake City, 1951.

Dates of Planting	Sp.-Gr.[2] Class	Chippewa		Irish Cobbler		Ketahdin	
		% of Tubers	Chip Color[3]	% of Tubers	Chip Color	% of Tubers	Chip Color
May 4	1	21.8	7.0	-	-	7.7	6.6
	2	23.6	7.0	2.9	7.0	11.5	9.0
	3	24.5	7.4	10.0	8.5	5.8	9.4
	4	20.1	9.0	82.8	9.5	71.2	10.0
	5	-	-	4.3	10.0	3.8	10.0
	Avg.[4]	1.071	7.5	1.080	9.3	1.079	9.6
	Tubers	55		70		52	
May 23	1	44.0	6.5	-	-	2.9	5.7
	2	32.0	6.5	12.4	8.4	2.9	6.0
	3	17.3	7.1	34.8	8.5	20.6	9.0
	4	6.7	7.8	49.4	9.2	69.2	9.3
	5	-	-	3.4	10.0	4.4	10.0
	Avg.	1.066	6.7	1.077	8.9	1.079	9.0
	Tubers	75		89		68	
June 4	1	96.2	5.3	10.4	5.9	62.7	5.5
	2	3.8	6.5	26.9	6.5	20.8	5.6
	3	-	-	23.8	8.0	16.5	7.0
	4	-	-	38.9	8.2	-	-
	5	-	-	-	-	-	-
	Avg.	1.062	5.3	1.073	7.4	1.065	5.8
	Tubers	52		67		67	

[1] 1 = extremely dark; 10 = light yellow; 8.5 to 9 = golden yellow (most desirable); 7.5 to 10 = acceptable.

[2] Specific-gravity classes: 1 = below 1.064; 2 = 1.064; 3 = 1.070 to 1.076; 4 = 1.076 to 1.088; 5 = 1.088 and over. Class values for weighted averages: 1 = 1.064; 2 = 1.067; 3 = 1.073; 4 = 1.082; 5 = 1.090.

Appendix Table I (Continued)

Kennebec		Russet Rural		Sebago		Average	
% of Tubers	Chip Color	% of Tubers	Chip Color	% of Tubers	Chip Color	% of Tubers	Chip Color
-	-	-	-	9.8	5.5	6.6	6.4
15.9	7.5	3.9	6.3	-	-	9.6	7.4
38.6	8.0	9.8	9.2	9.8	5.8	18.1	8.2
45.5	9.8	56.9	9.7	65.9	8.3	57.1	914
-	-	29.4	10.0	14.5	9.5	8.6	9.9
1.080	8.7	1.083	9.6	1.080	8.0	1.078	8.8
44		51		41		313	
10.5	6.0	-	-	1.4	5.2	9.8	5.9
23.7	6.5	2.6	8.0	11.4	6.5	14.2	6.9
15.8	7.2	12.8	9.0	34.3	8.2	22.6	8.1
50.0	8.3	79.4	9.4	50.0	8.5	50.8	8.7
-	-	5.2	9.5	2.9	8.8	2.6	9.5
1.075	7.5	1.080	9.3	1.077	8.0	1.076	8.0
38		78		70		418	
1.8	3.8	10.0	8.0	36.2	5.0	36.2	5.5
1.8	6.3	2.0	8.2	13.1	5.4	11.4	6.4
9.4	7.6	34.0	8.6	30.4	5.5	19.0	7.3
87.0	7.7	54.0	9.0	20.3	7.2	33.4	8.0
-	-	-	-	-	-	-	-
1.080	7.5	1.076	8.7	1.070	5.6	1.071	6.8
54		50		69		359	

[3] Averages of the chip color rating for the tubers in that specific-gravity class.

[4] These average values are weighted according to the percentage of tubers in the several specific-gravity classes. The first value of each pair is the weighted average specific gravity. The second value is the weighted average of the chip color ratings for the several specific-gravity classes.

Appendix Table II. The percentage of tubers in each specific-gravity class and the averages of the chip color ratings[1] of one-half of each tuber after cold storage at 41° F. for two months and of the remaining halves, following thirty days of conditioning at 78° F., for five varieties, on three dates of planting and four irrigation-fertilizer treatments, East Lansing, 1951.

Dates of Planting	Sp.-Gr. Class	Irish Cobbler			Katahdin		
		% of Tubers	Chip Color[3]		% of Tubers	Chip Color	
			0[5]	30[5]		0	30
No Irrigation, with 3-12-12							
May 21	1	-	-	-	3.3	r	r
	2	26.7	5.8	9.2	56.6	4.3	8.0
	3	33.3	6.4	9.6	18.3	5.0	8.5
	4	33.3	6.5	9.9	21.7	5.1	8.9
	5	6.7	r	r	-	-	-
	Avg.[4]	1.076	6.3	9.6	1.071	4.6	8.3
	Tubers	60			60		
June 13	1	-	-	-	23.3	4.3	8.3
	2	80.0	5.0	8.5	63.3	4.3	8.6
	3	6.7	5.1	8.9	3.3	4.5	8.8
	4	13.3	5.3	9.3	10.1	r	r
	5	-	-	-	-	-	-
	Avg.	1.069	5.1	8.6	1.068	4.3	8.5
	Tubers	30			60		
June 25	1	-	-	-	3.3	r	r
	2	37.9	4.0	6.0	59.0	4.6	8.2
	3	24.3	5.0	7.8	18.0	5.0	9.0
	4	34.4	5.8	8.0	19.7	5.7	9.2
	5	3.4	6.0	8.5	-	-	-
	Avg.	1.074	4.9	7.2	1.069	4.8	8.5
	Tubers	60			60		

Appendix Table II (Continued)

Kennebec			Russet Rural			Sebago			Average		
% of Tubers	Chip Color		% of Tubers	Chip Color		% of Tubers	Chip Color		% of Tubers	Chip Color	
	0	30		0	30		0	30		0	30
				No Irrigation, with 3-12-12							
10.8	3.5	8.0	-	-	-	-	-	-	2.8	3.5	8.0
9.9	5.0	9.0	20.7	5.3	9.2	45.0	3.7	6.5	31.8	4.8	8.4
17.2	5.3	9.5	24.1	5.8	9.8	18.3	4.2	7.2	22.2	5.3	8.9
60.0	5.3	9.6	55.2	6.0	9.9	36.7	6.0	9.3	41.4	5.8	9.5
2.1	6.0	9.6	-	-	-	-	-	-	1.8	6.0	9.6
1.077	5.1	9.4	1.077	5.8	9.7	1.074	4.6	7.7	1.075	5.3	9.0
60			60			60			300		
-	-	-	-	-	-	20.0	4.5	6.7	8.7	4.4	7.5
10.1	3.5	7.0	35.0	6.1	9.7	35.0	5.0	7.2	44.7	4.8	8.2
13.3	5.0	8.2	41.7	5.6	9.8	31.0	5.1	7.7	19.3	5.0	8.7
71.6	5.2	9.6	23.3	6.0	9.9	13.3	5.6	8.0	26.3	5.5	9.2
5.1	5.6	9.8	-	-	-	-	-	-	1.0	5.6	9.8
1.079	5.0	9.1	1.073	5.8	9.7	1.070	5.0	7.3	1.072	4.9	8.5
60			60			60			270		
5.3	3.8	7.0	4.9	5.0	6.5	18.3	3.5	6.7	6.5	4.1	6.7
17.8	4.8	8.8	41.0	6.0	8.6	30.1	4.2	7.5	37.2	4.7	7.8
28.6	5.0	9.0	33.5	6.1	9.0	23.3	5.5	8.2	25.6	5.3	8.6
48.3	5.1	9.0	18.6	6.2	9.6	28.3	6.1	8.8	29.9	5.7	8.9
-	-	-	-	-	-	-	-	-	0.7	6.0	8.5
1.076	4.9	8.8	1.071	6.0	8.8	1.072	4.9	7.8	1.071	5.1	8.3
60			60			60			295		

Appendix Table II (Continued)

Dates of Planting	Sp.-Gr. Class	Irish Cobbler			Katahdin		
		% of Tubers	Chip Color		% of Tubers	Chip Color	
			0	30		0	30
Irrigation, with 3-12-12							
May 21	1	5.8	4.5	8.0	4.3	4.0	7.0
	2	47.1	5.0	8.6	50.2	4.1	8.0
	3	21.3	5.7	9.5	15.4	4.5	8.5
	4	25.8	6.1	9.8	30.1	4.6	8.5
	5	-	-	-	-	-	-
	Avg.	1.072	5.4	9.0	1.072	4.3	8.2
	Tubers	116			117		
June 13	1	3.3	4.0	6.5	25.9	3.2	6.3
	2	51.2	4.5	7.4	49.3	3.7	8.0
	3	20.8	4.8	8.2	14.9	4.0	8.6
	4	24.7	5.0	8.5	9.9	5.5	9.0
	5	-	-	-	-	-	-
	Avg.	1.071	4.6	7.8	1.068	3.8	7.7
	Tubers	120			120		
June 25	1	-	-	-	22.6	3.0	5.6
	2	36.7	4.8	7.1	67.2	3.3	6.5
	3	30.0	5.5	6.5	6.8	3.0	7.0
	4	33.3	6.0	7.0	3.4	3.0	7.0
	5	-	-	-	-	-	-
	Avg.	1.074	5.4	6.8	1.066	3.2	6.3
	Tubers	91			120		
Irrigation, with No Fertilizer							
May 21	1	1.9	4.0	7.0	16.9	3.8	7.7
	2	23.4	5.0	8.8	21.3	4.2	7.9
	3	16.1	5.3	9.6	13.5	4.5	8.1
	4	49.7	5.4	9.2	44.9	5.0	9.0
	5	8.9	6.0	9.8	3.3	r	r
	Avg.	1.077	5.3	9.2	1.074	4.5	8.4
	Tubers	120			116		

Appendix Table II (Continued)

Kennebec			Russet Rural			Sebago			Average		
% of Tubers	Chip Color		% of Tubers	Chip Color		% of Tubers	Chip Color		% of Tubers	Chip Color	
	0	30		0	30		0	30		0	30
						Irrigation, with 3-12-12					
1.7	3.5	r	-	-	-	10.0	3.3	6.5	4.4	3.7	7.2
18.4	4.2	7.5	24.1	5.0	8.5	36.7	4.2	7.2	34.2	4.5	7.9
22.7	5.5	8.5	3.3	5.3	8.8	8.3	5.2	8.7	14.2	5.2	8.8
49.4	5.0	9.1	70.3	5.4	9.8	41.7	5.6	9.0	43.5	5.3	9.2
7.7	5.0	9.2	2.3	r	r	8.3	r	r	3.7	5.0	9.2
1.077	4.9	8.6	1.078	5.2	9.4	1.074	4.8	8.0	1.074	4.9	8.6
119			69			60			481		
1.8	4.0	r	3.3	3.5	6.5	20.9	3.1	6.0	11.0	3.6	6.3
25.9	4.0	8.5	41.5	4.8	8.7	65.2	3.5	7.2	46.6	4.1	7.9
14.9	4.3	8.8	30.9	5.7	9.1	5.3	4.3	7.6	17.4	4.6	8.5
51.5	5.1	9.1	24.3	6.1	9.6	8.6	5.0	8.8	23.8	5.3	9.0
5.9	5.5	9.6	-	-	-	-	-	-	1.2	5.5	9.6
1.076	4.7	8.9	1.072	5.3	8.9	1.067	3.5	7.1	1.071	4.4	8.1
120			67			120			547		
5.5	3.0	4.0	9.7	4.5	7.4	3.3	r	r	8.2	3.5	5.7
25.9	4.0	5.0	47.7	4.9	8.5	21.0	4.0	5.8	39.7	4.2	6.6
11.3	4.3	8.0	19.4	5.5	8.7	25.0	4.8	6.1	18.5	4.6	7.3
55.6	4.0	8.1	23.2	6.5	8.8	46.7	5.3	7.1	32.4	4.7	7.6
1.7	5.0	9.0	-	-	-	4.0	5.5	7.5	1.2	5.3	8.3
1.076	3.9	7.0	1.071	5.3	8.5	1.076	4.9	6.5	1.072	4.3	7.0
119			75			120			525		
						Irrigation, with No Fertilizer					
1.6	3.0	5.0	-	-	-	16.7	4.0	6.0	7.4	3.7	6.4
20.0	3.5	8.0	8.7	5.5	9.0	25.0	4.1	7.5	23.5	4.3	8.3
8.9	4.5	9.0	8.7	5.5	9.0	25.0	4.5	8.0	14.4	4.8	8.7
54.9	4.9	9.7	53.5	6.0	9.6	16.8	5.0	9.5	44.0	5.3	9.4
14.6	5.0	r	10.1	6.5	10.0	16.7	r	r	10.7	5.8	9.9
1.079	4.6	9.1	1.078	5.6	8.7	1.074	4.4	7.7	1.077	4.9	8.9
120			60			30			446		

Appendix Table II (Continued)

Dates of Planting	Sp.-Gr. Class	Irish Cobbler			Katahdin		
		% of Tubers	Chip Color		% of Tubers	Chip Color	
			0	30		0	30
Irrigation, with No Fertilizer (Continued)							
June 13	1	1.6	5.0	7.0	11.7	3.5	6.0
	2	23.5	4.5	7.5	58.3	4.1	7.0
	3	16.1	4.5	7.6	10.0	4.5	8.0
	4	49.2	5.0	8.6	20.0	4.7	8.1
	5	9.6	r	r	-	-	-
	Avg.	1.077	4.7	8.1	1.070	4.2	7.2
	Tubers	120			120		
June 25	1	1.6	4.0	6.0	25.9	3.4	7.8
	2	13.2	5.1	7.8	42.5	4.4	7.9
	3	30.6	6.0	7.8	11.5	4.4	7.2
	4	51.3	5.3	6.8	21.6	5.3	9.0
	5	3.3	6.0	7.0	-	-	-
	Avg.	1.073	5.4	7.2	1.069	4.3	8.0
	Tubers	90			120		
Irrigation, with 0-0-18							
May 21	1	3.3	4.0	7.1	10.0	3.7	7.7
	2	33.3	4.8	8.5	56.6	4.2	8.1
	3	18.3	5.5	9.3	20.0	4.4	8.5
	4	45.1	5.8	9.4	13.3	4.5	8.5
	5	-	-	-	-	-	-
	Avg.	1.075	5.3	9.0	1.071	4.2	8.2
	Tubers	120			120		
June 13	1	33.5	r	r	27.0	4.1	7.0
	2	27.1	4.3	8.2	57.9	4.3	7.0
	3	14.1	5.0	9.6	10.8	4.2	8.5
	4	25.3	5.0	9.2	4.2	r	r
	5	-	-	-	-	-	-
	Avg.	1.070	4.7	8.8	1.067	4.2	7.2
	Tubers	98			120		

Appendix Table II (Continued)

Kennebec			Russet Rural			Sebago			Average		
% of Tubers	Chip Color		% of Tubers	Chip Color		% of Tubers	Chip Color		% of Tubers	Chip Color	
	0	30		0	30		0	30		0	30
Irrigation, with No Fertilizer (Continued)											
1.7	2.9	r	1.9	r	r	9.1	4.5	7.0	5.2	3.9	6.6
13.6	4.3	7.0	18.6	5.2	8.0	60.3	4.1	6.8	34.9	4.4	7.2
19.6	4.5	8.3	28.6	5.3	8.5	11.5	4.5	8.1	17.2	4.7	8.1
48.3	5.0	8.6	50.9	6.1	9.4	19.1	r	r	37.5	5.2	8.6
16.8	5.0	9.5	-	-	-	-	-	-	5.2	5.0	9.6
1.079	4.7	8.4	1.076	5.6	8.8	1.070	4.2	7.0	1.075	4.6	8.0
120			91			90			541		
2.0	3.0	7.0	23.9	5.2	6.5	6.6	4.0	6.0	12.0	3.9	6.6
17.6	3.3	7.7	33.6	5.5	7.5	36.7	5.2	7.0	28.6	4.7	7.5
15.6	4.5	7.3	10.9	5.8	8.1	35.0	6.0	8.0	20.6	5.3	7.6
63.1	4.4	8.3	31.6	6.0	8.9	21.7	6.5	8.6	37.8	5.5	8.3
1.7	r	r	-	-	-	-	-	-	1.0	6.0	7.0
1.078	4.1	8.0	1.071	5.6	7.7	1.076	5.6	7.3	1.073	5.0	7.7
117			117			60			504		
Irrigation, with 0-0-18											
5.6	r	r	3.2	5.0	7.3	8.3	4.0	7.5	6.1	4.2	7.4
37.3	5.0	9.0	44.2	5.1	9.0	48.3	4.7	8.0	43.9	4.8	8.5
22.7	5.0	9.0	21.4	5.3	9.7	16.7	5.0	8.3	19.8	5.0	8.9
29.5	6.6	9.5	31.2	5.5	9.8	26.7	5.6	8.6	29.2	5.6	9.2
5.0	r	r	-	-	-	-	-	-	1.0	r	r
1.074	5.5	9.2	1.073	5.2	9.3	1.072	4.9	8.2	1.072	5.0	8.7
120			90			60			510		
3.2	3.5	5.5	-	-	-	36.6	4.0	7.0	20.1	3.9	6.5
12.9	4.0	6.8	28.8	4.6	8.4	38.3	5.1	7.4	33.0	4.4	7.5
11.3	4.5	8.1	14.4	6.0	9.0	16.6	5.7	8.3	13.4	5.1	8.7
63.7	4.7	9.6	56.8	6.2	9.7	8.5	6.0	9.0	31.7	5.5	9.3
9.0	4.6	9.6	-	-	-	-	-	-	1.8	4.6	9.6
1.079	4.5	8.4	1.076	5.7	9.2	1.067	4.8	7.5	1.071	4.7	8.1
120			80			120			538		

Appendix Table II (Continued)

Dates of Planting	Sp.-Gr. Class	Irish Cobbler			Katahdin		
		% of Tubers	Chip Color		% of Tubers	Chip Color	
			0	30		0	30
Irrigation, with 0-0-18 (Continued)							
June 25	1	11.5	4.0	5.5	34.6	3.3	6.1
	2	52.4	4.9	6.7	56.8	3.7	7.6
	3	13.9	5.4	7.5	8.6	4.0	8.0
	4	24.2	5.3	8.3	-	-	-
	5	-	-	-	-	-	-
	Avg.	1.070	4.9	7.0	1.065	3.5	7.1
	Tubers	90			118		

[1] 1 = extremely dark; 10 = light yellow; 8.5 to 9 = golden yellow (most desirable); 7.5 to 10 = acceptable.

[2] Specific-gravity classes: 1 = below 1.064; 2 = 1.064 to 1.076; 3 = 1.070 to 1.076; 4 = 1.076 to 1.088; 5 = 1.088 and over. Class values for weighted averages: 1 = 1.062; 2 = 1.067; 3 = 1.073; 4 = 1.082; 5 = 1.090.

[3] Averages of the chip color ratings for the several specific-gravity classes.

[4] These average values are in sets of three and are obtained by weighting according to the percentage of tubers in the several specific-gravity classes. The first value of each set is the weighted average specific gravity. The second and third values are the weighted averages of the chip color ratings.

[5] Potatoes were stored at 41° F. for two months; one-half of each potato was chipped immediately following 41° F. (0) and the remaining halves were conditioned at 78° F. for 30 days and then chipped (30).

[r] Indicates potatoes had become rotten in storage.

Appendix Table II (Continued)

Kennebec			Russet Rural			Sebago			Average		
% of Tubers	Chip Color		% of Tubers	Chip Color		% of Tubers	Chip Color		% of Tubers	Chip Color	
	0	30		0	30		0	30		0	30
Irrigation, with 0-0-18 (Continued)											
10.0	3.0	3.5	5.2	5.0	7.0	12.9	3.6	5.5	14.9	3.7	5.5
35.0	4.0	6.5	42.3	5.3	7.2	38.1	4.8	7.2	44.9	4.5	7.0
23.3	5.0	8.3	16.8	5.8	8.0	16.5	5.4	7.5	15.6	5.1	7.8
31.7	5.0	9.0	30.6	r	r	32.5	5.5	7.8	23.6	5.3	8.4
-	-	-	5.1	r	r	-	-	-	1.0	r	r
1.072	4.4	7.4	1.073	5.4	7.4	1.072	4.9	7.2	1.070	4.6	7.2
120			57			90			475		

Appendix Table III. The average chip color ratings[1] of one-half of each tuber after the cold storage at 41° F. for five momths and of the remaining halves following thirty days of conditioning at 78° F. for two varieties on three dates of planting, and four irrigation-fertilizer treatments, East Lansing, 1951.

Dates of Planting	Sp.-Gr. Class[2]	No Irrigation 3-12-12				Irrigation, 0-0-0			
		Russet Rural Chip Color[3]		Katahdin Chip Color		Russet Rural Chip Color		Katahdin Chip Color	
		0[5]	30[5]	0	30	0	30	0	30
May 21	1	-	-	3.0	8.0	-	-	2.0	5.9
	2	4.0	8.0	3.5	8.0	3.0	8.0	2.0	6.8
	3	5.0	9.8	3.0	8.0	3.5	8.5	1.5	r
	4	5.8	9.9	5.5	9.3	5.0	9.5	-	-
	5	-	-	-	-	r	r	-	-
	Avg.[4]	5.2	9.4	3.8	8.2	4.2	8.9	1.9	6.4
June 13	1	-	-	2.0	8.1	r	r	1.8	5.0
	2	5.8	9.2	2.9	8.4	5.0	r	2.4	6.2
	3	5.6	9.6	3.9	r	3.5	8.0	2.6	7.1
	4	5.1	9.8	r	r	4.2	9.2	4.4	8.0
	5	-	-	-	-	-	-	-	-
	Avg.	5.5	9.4	2.7	8.3	4.2	8.7	2.7	6.4

Appendix Table III (Continued)

Irrigation, 0-0-18				Irrigation, 3-12-12				Average				Avg. Chip Color	
Russet Rural Chip Color		Katahdin Chip Color		Russet Rural Chip Color		Katahdin Chip Color		Russet Rural Chip Color		Katahdin Chip Color			
0	30	0	30	0	30	0	30	0	30	0	30	0	30
4.2	8.0	2.0	7.7	-	-	-	-	4.2	8.0	2.0	6.7	3.1	7.4
3.6	9.8	2.6	7.1	4.0	8.5	3.5	6.9	3.6	8.8	3.1	7.3	3.4	8.0
4.0	9.9	3.0	8.4	3.5	8.5	3.6	7.8	4.3	9.5	2.9	8.0	3.6	8.7
4.0	9.9	4.5	9.1	4.0	9.3	3.0	8.5	4.7	9.6	4.1	8.9	4.4	9.2
-	-	-	-	r	r	-	-	-	-	-	-	-	-
3.8	9.8	2.9	7.6	3.9	9.1	3.3	7.4	4.3	9.3	3.2	7.8	3.8	8.6
-	-	2.0	7.2	3.0	r	1.6	6.8	3.0	r	1.9	7.0	2.4	7.0
5.2	9.0	2.5	7.6	3.9	8.6	2.5	7.7	4.9	8.9	2.5	7.5	3.7	8.2
6.0	10.0	3.0	7.7	4.0	9.0	2.6	7.7	4.8	9.1	2.8	7.5	3.8	8.3
4.2	9.5	3.5	8.9	5.1	9.6	r	r	4.5	9.5	4.2	8.1	4.4	8.8
-	-	-	-	-	-	-	-	-	-	-	-	-	-
4.8	9.4	2.5	7.5	4.2	9.0	2.3	7.4	4.6	9.1	2.6	7.4	3.7	8.2

Appendix Table III (Continued)

Dates of Planting	Sp.-Gr. Class	No Irrigation, 3-12-12				Irrigation 0-0-0			
		Russet Rural Chip Color		Katahdin Chip Color		Russet Rural Chip Color		Katahdin Chip Color	
		0	30	0	30	0	30	0	30
June 25	1	5.0	r	r	r	4.8	8.6	3.3	6.0
	2	4.7	9.0	2.1	8.4	5.6	8.7	3.5	6.0
	3	5.3	9.8	2.0	9.5	5.0	8.5	3.5	7.0
	4	5.5	9.8	4.1	9.5	4.0	8.0	3.6	7.1
	5	-	-	-	-	-	-	-	-
	Avg.	5.1	9.4	2.5	8.8	4.8	8.4	3.4	6.3

[1] 1 = extremely dark; 10 = light yellow; 8.5 to 9 = golden yellow (most desirable); 7.5 to 10 = acceptable.

[2] Specific gravity classes: 1 = below 1.064; 2 = 1.064 to 1.070; 3 = 1.070 to 1.076; 4 = 1.076 to 1.088; 5 = 1.088 and over. Class values for weighted averages: 1 = 1.062; 2 = 1.067; 3 = 1.073; 4 = 1.082; 5 = 1.090.

[3] Averages of the chip color rating for the tubers in that specific-gravity class.

[4] These average values are weighted according to the percentage of tubers in the several specific-gravity classes. The first value of each pair is the weighted average specific gravity. The second and third values are the weighted averages of the chip color ratings.

Appendix Table III (Continued)

Irrigation, 0-0-18				Irrigation, 3-12-12				Average				Avg. Chip Color	
Russet Rural Chip Color		Katahdin Chip Color		Russet Rural Chip Color		Katahdin Chip Color		Russet Rural Chip Color		Katahdin Chip Color			
0	30	0	30	0	30	0	30	0	30	0	30	0	30
r	r	1.9	6.0	3.0	6.5	1.2	6.7	4.4	8.0	2.2	6.2	3.3	7.1
5.2	8.9	1.8	7.7	4.8	7.0	1.7	7.8	5.0	8.3	2.2	7.5	3.6	7.9
6.7	10.0	3.5	8.6	5.0	7.7	3.0	r	5.4	9.1	2.8	8.5	4.1	8.8
r	r	-	-	6.0	8.0	3.0	7.9	5.0	8.5	3.7	8.2	4.4	8.3
r	r	-	-	-	-	-	-	-	-	-	-	-	-
5.6	9.3	1.9	7.2	4.9	7.3	1.7	7.4	5.0	8.4	2.5	7.4	3.8	8.1

[5] Potatoes were stored at 41° F. for five months; one-half of each potato was chipped immediately following 41° F. (0) and the remaining halves were conditioned at 78° F. for thirty days and then chipped (30).

[r] Indicates potatoes had become rotten in storage.

Appendix Table IV. The percentage of tubers in each specific-gravity class and average of the chip color ratings[1] of the tubers of eight varieties, four dates of planting, and three levels of irrigation, Experiment A, Lake City, 1952.

Dates of Planting	Sp.-Gr. Class[2]	Irrigation Levels					
		Heavy		Normal		None	
		% of Tubers	Chip Color[3]	% of Tubers	Chip Color	% of Tubers	Chip Color
				Chippewa			
May 1	1	25.0	6.7	17.5	6.7	25.0	7.1
	2	22.5	7.9	47.5	7.4	5.0	8.0
	3	45.0	8.1	25.0	8.4	55.0	8.6
	4	7.5	9.5	10.0	9.5	15.0	9.5
	5	-	-	-	-	-	-
	Avg.[4]	1.070	7.8	1.069	7.7	1.071	8.3
May 16	1	7.5	5.3	10.0	6.2	70.0	6.3
	2	32.5	7.0	20.0	7.5	25.0	9.6
	3	42.5	7.8	50.0	8.2	5.0	10.0
	4	17.5	9.4	20.0	8.5	-	-
	5	-	-	-	-	-	-
	Avg.	1.072	7.6	1.073	7.9	1.064	7.3
June 2	1	-	-	-	-	-	-
	2	5.0	7.5	2.5	7.8	15.0	7.5
	3	55.0	7.5	35.0	8.3	40.0	7.6
	4	40.0	8.4	62.5	8.1	45.0	8.8
	5	-	-	-	-	-	-
	Avg.	1.069	7.9	1.078	8.1	1.076	8.1
June 16	1	-	-	5.0	7.0	5.0	r
	2	17.5	7.3	25.0	7.7	15.0	8.3
	3	52.5	8.2	45.0	8.3	65.0	9.0
	4	30.0	8.8	25.0	9.2	15.0	10.0
	5	-	-	-	-	-	-
	Avg.	1.069	8.2	1.073	8.3	1.073	8.6

Appendix Table IV (Continued)

Dates of Planting	Sp.-Gr. Class	Irrigation Levels					
		Heavy		Normal		None	
		% of Tubers	Chip Color	% of Tubers	Chip Color	% of Tubers	Chip Color
		Irish Cobbler					
May 1	1	-	-	-	-	5.0	7.0
	2	17.5	8.0	5.0	5.0	15.0	9.0
	3	25.0	7.5	37.5	7.5	10.0	9.0
	4	52.5	8.8	57.5	8.6	60.0	9.3
	5	5.0	9.0	-	-	10.0	10.0
	Avg.	1.078	8.3	1.078	8.0	1.079	9.2
May 16	1	2.5	7.0	2.5	r	-	-
	2	2.5	7.0	5.0	8.0	15.0	6.0
	3	35.0	7.4	17.5	8.2	15.0	8.0
	4	50.0	8.2	70.0	8.7	45.0	9.7
	5	10.0	9.0	5.0	10.0	25.0	10.0
	Avg.	1.079	7.9	1.079	8.4	1.080	9.0
June 2	1	-	-	-	-	-	-
	2	-	-	-	-	-	-
	3	10.0	8.3	10.0	8.0	5.0	8.0
	4	82.5	8.7	53.3	8.4	85.0	8.9
	5	7.5	9.7	36.7	8.6	10.0	9.1
	Avg.	1.082	8.7	1.084	8.4	1.082	8.8
June 16	1	-	-	-	-	-	-
	2	-	-	2.5	6.0	-	-
	3	6.7	7.0	-	-	5.0	9.0
	4	73.3	8.3	82.5	9.1	85.0	9.4
	5	20.0	10.0	15.0	9.4	10.0	10.0
	Avg.	1.083	8.6	1.083	9.0	1.082	9.4

Appendix Table IV (Continued)

Dates of Planting	Sp.-Gr. Class	Irrigation Levels					
		Heavy		Normal		None	
		% of Tubers	Chip Color	% of Tubers	Chip Color	% of Tubers	Chip Color
				Katahdin			
May 1	1	5.0	5.5	-	-	-	-
	2	7.5	7.7	17.5	7.3	-	-
	3	40.0	8.7	17.5	8.0	15.0	8.0
	4	35.0	9.1	62.5	8.0	80.0	9.5
	5	12.5	9.5	2.5	9.0	5.0	10.0
	Avg.	1.077	8.7	1.078	8.0	1.081	9.3
May 16	1	-	-	-	-	-	-
	2	10.0	7.0	10.0	7.0	-	-
	3	20.0	7.3	15.0	7.6	-	-
	4	63.3	7.7	62.5	8.6	70.0	9.5
	5	6.7	8.5	12.5	9.4	30.0	10.0
	Avg.	1.079	7.6	1.080	8.4	1.084	9.6
June 2	1	-	-	-	-	-	-
	2	-	-	-	-	-	-
	3	-	-	5.0	6.3	-	-
	4	70.0	7.6	72.5	8.7	80.0	9.3
	5	30.0	8.5	22.5	9.1	20.0	9.7
	Avg.	1.084	7.9	1.083	8.7	1.084	9.4
June 16	1	-	-	-	-	-	-
	2	6.7	7.5	-	-	-	-
	3	13.3	7.4	3.3	9.0	15.0	9.3
	4	66.7	8.9	83.3	8.1	80.0	9.2
	5	13.3	9.9	13.3	8.8	5.0	10.0
	Avg.	1.081	8.7	1.081	8.2	1.081	9.3

Appendix Table IV (Continued)

Dates of Planting	Sp.-Gr. Class	Irrigation Levels					
		Heavy		Normal		None	
		% of Tubers	Chip Color	% of Tubers	Chip Color	% of Tubers	Chip Color
				Kennebec			
May 1	1	7.5	9.0	-	-	-	-
	2	12.5	8.8	5.0	8.6	20.0	9.5
	3	10.0	10.0	22.5	9.5	30.0	9.2
	4	60.0	9.5	62.5	9.5	50.0	10.0
	5	10.0	9.5	10.0	10.0	-	-
	Avg.	1.079	9.4	1.080	9.6	1.077	9.7
May 16	1	3.3	8.0	2.5	r	-	-
	2	3.3	9.0	-	-	-	-
	3	16.7	8.6	20.0	8.6	15.0	9.5
	4	60.0	9.5	65.0	9.3	50.0	10.0
	5	16.7	10.0	12.5	9.9	35.0	10.0
	Avg.	1.081	9.4	1.081	9.1	1.083	9.9
June 2	1	-	-	-	-	-	-
	2	-	-	-	-	-	-
	3	7.5	8.0	10.0	7.6	10.0	8.0
	4	77.5	9.2	65.0	8.6	40.0	9.6
	5	15.0	9.8	25.0	9.9	50.0	10.0
	Avg.	1.083	9.2	1.083	8.9	1.085	9.6
June 16	1	5.0	8.0	-	-	-	-
	2	2.5	8.0	2.5	r	-	-
	3	5.0	8.5	2.5	r	5.0	9.0
	4	55.0	9.3	57.5	9.4	60.0	9.8
	5	32.5	9.9	37.5	10.0	35.0	10.0
	Avg.	1.083	9.3	1.084	9.3	1.084	9.8

Appendix Table IV (Continued)

Dates of Planting	Sp.-Gr. Class	Irrigation Levels					
		Heavy		Normal		None	
		% of Tubers	Chip Color	% of Tubers	Chip Color	% of Tubers	Chip Color
		Pontiac					
May 1	1	32.5	5.9	17.5	5.3	15.0	5.5
	2	25.0	6.0	25.0	6.0	30.0	6.2
	3	17.5	6.7	20.0	6.3	15.0	7.6
	4	22.5	7.0	37.5	7.4	40.0	7.6
	5	2.5	7.0	-	-	-	-
	Avg.	1.070	6.3	1.073	6.4	1.073	6.9
May 16	1	20.0	6.5	32.5	5.5	20.0	6.0
	2	40.0	6.4	35.0	6.0	10.0	6.5
	3	32.5	7.2	20.0	6.3	35.0	7.4
	4	7.5	7.3	12.5	7.0	35.0	8.4
	5	-	-	-	-	-	-
	Avg.	1.069	6.7	1.068	6.1	1.073	7.4
June 2	1	-	-	-	-	-	-
	2	5.0	5.0	5.0	7.0	10.0	7.5
	3	42.5	5.5	10.0	6.1	10.0	7.5
	4	50.0	6.2	85.0	7.0	80.0	7.9
	5	2.5	7.3	-	-	-	-
	Avg.	1.078	5.9	1.080	6.9	1.080	7.9
June 16	1	5.0	6.0	6.6	5.5	10.0	8.0
	2	10.0	7.3	10.0	7.5	-	-
	3	32.5	6.6	36.7	7.3	30.0	8.0
	4	52.5	6.8	46.7	8.3	60.0	8.0
	5	-	-	-	-	-	-
	Avg.	1.076	6.7	1.076	7.6	1.077	8.0

Appendix Table IV (Continued)

Dates of Planting	Sp.-Gr. Class	Irrigation Levels					
		Heavy		Normal		None	
		% of Tubers	Chip Color	% of Tubers	Chip Color	% of Tubers	Chip Color
		Russet Rural					
May 1	1	-	-	-	-	-	-
	2	10.0	r	-	-	10.0	7.0
	3	20.0	9.0	17.5	9.3	5.0	8.6
	4	60.0	9.9	42.5	9.2	45.0	8.9
	5	10.0	9.9	40.0	9.6	40.0	10.0
	Avg.	1.080	9.6	1.084	9.5	1.083	9.2
May 16	1	-	-	-	-	-	-
	2	2.5	7.0	-	-	-	-
	3	-	-	2.5	7.5	-	-
	4	32.5	9.5	42.5	9.2	60.0	9.6
	5	65.0	9.8	55.0	9.9	40.0	10.0
	Avg.	1.087	9.6	1.086	9.6	1.085	9.8
June 2	1	-	-	-	-	-	-
	2	-	-	-	-	-	-
	3	2.5	8.0	-	-	-	-
	4	30.0	8.4	16.7	8.0	-	-
	5	67.5	9.6	83.3	9.3	100.0	9.9
	Avg.	1.087	9.1	1.089	9.0	1.090	9.9
June 16	1	-	-	-	-	-	-
	2	-	-	-	-	-	-
	3	-	-	2.5	r	-	-
	4	26.7	8.8	17.5	9.0	5.0	8.5
	5	73.3	9.3	80.0	9.5	95.0	9.9
	Avg.	1.088	9.2	1.088	9.2	1.089	9.8

Appendix Table IV (Continued)

Dates of Planting	Sp.-Gr. Class	Irrigation Levels					
		Heavy		Normal		None	
		% of Tubers	Chip Color	% of Tubers	Chip Color	% of Tubers	Chip Color
		Sebago					
May 1	1	-	-	-	-	15.0	8.0
	2	5.0	7.0	10.0	6.6	20.0	7.8
	3	22.5	7.6	30.0	8.1	20.0	10.0
	4	67.5	8.3	50.0	8.8	35.0	9.3
	5	5.0	8.0	10.0	7.0	10.0	10.0
	Avg.	1.080	8.1	1.079	8.2	1.075	9.0
May 16	1	3.3	7.0	-	-	-	-
	2	-	-	-	-	-	-
	3	3.3	7.0	13.3	7.3	-	-
	4	70.0	7.9	66.7	8.3	90.0	8.6
	5	23.3	9.3	20.0	8.5	10.0	8.5
	Avg.	1.082	8.1	1.082	8.2	1.083	8.6
June 2	1	-	-	-	-	-	-
	2	-	-	-	-	-	-
	3	-	-	2.5	r	-	-
	4	50.0	7.3	35.0	7.9	35.0	8.1
	5	50.0	8.4	62.5	9.0	65.0	9.1
	Avg.	1.086	7.8	1.087	8.4	1.087	8.7
June 16	1	-	-	-	-	-	-
	2	-	-	-	-	-	-
	3	5.0	7.0	7.5	8.0	-	-
	4	52.5	7.9	45.0	8.1	55.0	8.8
	5	42.5	8.7	47.5	8.6	45.0	9.3
	Avg.	1.085	8.1	1.085	8.3	1.086	9.0

Appendix Table IV (Continued)

Dates of Planting	Sp.-Gr. Class	Irrigation Levels					
		Heavy		Normal		None	
		% of Tubers	Chip Color	% of Tubers	Chip Color	% of Tubers	Chip Color
				505-3			
May 1	1	20.0	5.9	30.0	5.8	-	-
	2	26.7	6.4	15.0	7.1	60.0	6.8
	3	40.0	6.9	37.5	7.3	35.0	8.3
	4	13.3	7.5	17.5	7.8	5.0	r
	5	-	-	-	-	-	-
	Avg.	1.070	6.6	1.070	6.9	1.068	7.0
May 16	1	-	-	-	-	-	-
	2	-	-	22.5	6.6	25.0	7.0
	3	47.5	7.7	62.5	7.4	55.0	7.5
	4	50.0	8.0	15.0	8.8	20.0	6.3
	5	2.5	8.0	-	-	-	-
	Avg.	1.078	7.8	1.073	7.4	1.073	7.1
June 2	1	-	-	5.0	4.5	-	-
	2	5.0	6.0	5.0	5.5	1	1
	3	52.5	6.6	45.0	6.4	30.0	8.1
	4	42.5	7.1	45.0	6.6	70.0	8.4
	5	-	-	-	-	-	-
	Avg.	1.077	6.8	1.076	6.4	1.079	8.3
June 16	1	2.5	7.0	7.5	6.3	-	-
	2	30.0	7.2	22.5	7.1	35.0	7.5
	3	42.5	7.4	40.0	7.6	10.0	8.5
	4	25.0	7.5	30.0	8.0	45.0	8.3
	5	-	-	-	-	10.0	9.0
	Avg.	1.073	7.3	1.074	7.5	1.077	8.1

Appendix Table IV (Continued)

Dates of Planting	Sp.-Gr. Class	Irrigation Levels					
		Heavy		Normal		None	
		% of Tubers	Chip Color	% of Tubers	Chip Color	% of Tubers	Chip Color
		Average					
May 1	1	11.3	6.6	8.1	5.9	7.5	6.9
	2	15.8	7.4	15.6	6.9	20.0	8.6
	3	27.5	8.0	25.9	8.0	23.1	8.7
	4	39.7	8.7	42.5	8.6	41.2	9.1
	5	5.6	8.8	7.8	8.9	8.1	10.0
	Avg.	1.074	8.1	1.075	8.0	1.075	8.8
May 16	1	4.6	6.7	5.9	5.8	11.2	6.1
	2	11.3	7.2	11.5	7.0	9.4	7.3
	3	24.7	7.5	25.1	7.6	15.6	8.4
	4	43.8	8.4	44.3	8.5	46.3	8.8
	5	15.5	9.1	13.1	9.5	17.5	9.7
	Avg.	1.077	8.1	1.077	8.1	1.078	8.5
June 2	1	-	-	0.6	4.5	-	-
	2	1.9	6.1	1.5	6.7	3.2	7.5
	3	21.3	7.3	14.7	7.1	11.8	7.8
	4	55.3	7.8	54.3	7.9	54.3	8.7
	5	21.6	8.8	28.8	9.1	30.6	9.5
	Avg.	1.082	7.8	1.082	8.1	1.082	8.8
June 16	1	1.6	7.0	2.4	6.2	1.8	8.0
	2	8.3	7.4	7.8	7.0	6.2	7.9
	3	19.6	7.4	16.9	8.0	16.2	8.8
	4	47.7	8.2	48.5	8.6	50.6	9.0
	5	22.7	9.5	24.2	9.3	25.0	9.6
	Avg.	1.079	8.2	1.079	8.5	1.079	9.0

Footnotes to Appendix Table IV

[1] 1 = extremely dark; 10 = light yellow; 8.5 to 9 = golden yellow (most desirable); 7.5 to 10 = acceptable.

[2] Specific-gravity classes: 1 = below 1.064; 2 = 1.064 to 1.070; 3 = 1.070 to 1.076; 4 = 1.076 to 1.088; 5 = 1.088 and over. Class values for weighted averages: 1 = 1.062; 2 = 1.067; 3 = 1.073; 4 = 1.082; 5 = 1.090.

[3] Averages of the chip color rating for the tubers in that specific-gravity class.

[4] These average values are weighted according to the percentage of tubers in the several specific-gravity classes. The first value of each pair is the weighted average specific gravity; the second is the weighted average of chip color ratings.

[r] Indicates potatoes had become rotten in storage.

Appendix Table V. The percentage of tubers in each specific-gravity class and the averages of chip color ratings[1] of the tubers of two varieties, three dates of planting, three levels of irrigation, and four fertilizer analyses, Experiment B, Lake City, 1952.

Dates of Planting	Sp.-Gr. Class[2]	Irrigation Levels: Heavy		Normal		None	
		% of Tubers	Chip Color[3]	% of Tubers	Chip Color	% of Tubers	Chip Color
		Irish Cobbler--No Fertilizer					
May 1	1	-	-	-	-	-	-
	2	2.5	7.0	-	-	-	-
	3	12.5	8.3	17.5	7.6	5.0	9.0
	4	42.5	8.5	62.5	8.3	30.0	9.6
	5	42.5	9.2	20.0	9.4	65.0	10.0
	Avg.[4]	1.084	8.7	1.082	8.4	1.087	9.8
May 16	1	-	-	-	-	-	-
	2	3.3	6.5	-	-	-	-
	3	3.3	8.0	5.0	6.0	25.0	6.3
	4	50.0	7.8	60.0	7.5	55.0	8.8
	5	43.3	8.9	35.0	8.4	20.0	9.2
	Avg.	1.084	8.0	1.084	7.7	1.081	8.3
June 16	1	-	-	2.5	7.5	-	-
	2	2.5	8.0	-	-	-	-
	3	2.5	8.0	7.5	7.6	-	-
	4	65.0	7.7	62.5	7.8	70.0	9.2
	5	30.0	8.7	27.5	8.4	30.0	9.4
	Avg.	1.084	8.0	1.083	7.9	1.084	9.3

Appendix Table V (Continued)

Dates of Planting	Sp.-Gr. Class	Irrigation Levels: Heavy % of Tubers	Heavy Chip Color	Normal % of Tubers	Normal Chip Color	None % of Tubers	None Chip Color
		Irish Cobbler--3-12-12 Fertilizer					
May 1	1	-	-	-	-	5.0	7.0
	2	17.5	8.0	5.0	5.0	15.0	9.0
	3	25.0	7.5	37.5	7.5	10.0	9.0
	4	52.5	8.8	57.5	8.6	60.0	9.3
	5	5.0	9.0	-	-	10.0	10.0
	Avg.	1.078	8.3	1.078	8.0	1.079	9.2
May 16	1	2.5	7.0	2.5	r	-	-
	2	2.5	7.0	5.0	8.0	15.0	6.0
	3	35.0	7.4	17.5	8.2	15.0	8.0
	4	50.0	8.2	70.0	8.7	45.0	9.7
	5	10.0	9.0	5.0	10.0	25.0	10.0
	Avg.	1.079	7.9	1.079	8.4	1.080	9.0
June 16	1	-	-	-	-	-	-
	2	-	-	2.5	6.0	-	-
	3	6.7	7.0	-	-	5.0	9.0
	4	73.3	8.3	82.5	9.1	85.0	9.4
	5	20.0	10.0	15.0	9.4	10.0	10.0
	Avg.	1.083	8.6	1.083	9.0	1.082	9.4
		Irish Cobbler--3-0-0 Fertilizer					
May 1	1	-	-	-	-	-	-
	2	10.0	7.0	5.0	6.5	-	-
	3	22.5	7.5	25.0	7.4	5.0	r
	4	57.5	8.2	62.5	7.9	45.0	9.4
	5	10.0	9.3	7.5	9.2	50.0	10.0
	Avg.	1.079	8.0	1.080	7.8	1.086	9.4

Appendix Table V (Continued)

Dates of Planting	Sp.-Gr. Class	Irrigation Levels: Heavy % of Tubers	Heavy Chip Color	Normal % of Tubers	Normal Chip Color	None % of Tubers	None Chip Color
		Irish Cobbler--3-0-0 Fertilizer (Continued)					
May 16	1	2.5	8.0	5.0	7.0	-	-
	2	-	-	-	-	10.0	7.5
	3	20.0	7.0	25.0	7.1	20.0	8.0
	4	42.5	8.0	57.5	7.8	50.0	9.0
	5	35.0	8.5	12.5	8.6	20.0	9.8
	Avg.	1.083	8.0	1.080	7.7	1.080	8.8
June 16	1	-	-	-	-	-	-
	2	-	-	-	-	-	-
	3	2.5	6.0	-	-	-	-
	4	35.0	7.6	40.0	8.0	45.0	8.8
	5	62.5	9.0	60.0	9.0	55.0	9.8
	Avg.	1.086	8.4	1.087	8.6	1.086	9.4
		Irish Cobbler--0-0-12 Fertilizer					
May 1	1	-	-	5.0	6.0	-	-
	2	2.5	8.0	-	-	5.0	8.0
	3	15.0	9.0	25.0	6.8	15.0	8.0
	4	67.5	8.0	65.0	8.4	75.0	9.7
	5	15.0	9.1	5.0	10.0	5.0	r
	Avg.	1.081	8.3	1.079	8.0	1.080	8.9
May 16	1	6.7	r	-	-	5.0	7.0
	2	26.7	7.8	-	-	5.0	7.0
	3	-	-	20.0	8.0	20.0	8.3
	4	46.6	8.7	62.5	8.6	45.0	9.3
	5	20.0	9.3	17.5	9.2	25.0	10.0
	Avg.	1.078	8.5	1.082	8.6	1.080	9.0

Appendix Table V (Continued)

Dates of Planting	Sp.-Gr. Class	Irrigation Levels					
		Heavy		Normal		None	
		% of Tubers	Chip Color	% of Tubers	Chip Color	% of Tubers	Chip Color
		Irish Cobbler--0-0-12 Fertilizer (Continued)					
June 16	1	-	-	-	-	-	-
	2	7.5	7.0	-	-	5.0	6.0
	3	27.5	8.1	20.0	8.0	5.0	9.0
	4	57.5	8.4	65.0	7.8	70.0	9.0
	5	7.5	8.5	15.0	8.1	20.0	9.6
	Avg.	1.079	8.2	1.081	7.9	1.082	8.9
		Russet Rural--No Fertilizer					
May 1	1	-	-	-	-	-	-
	2	-	-	2.5	7.5	-	-
	3	-	-	12.5	7.8	-	-
	4	32.5	9.3	37.5	8.7	40.0	9.1
	5	67.5	9.6	47.5	9.2	60.0	10.0
	Avg.	1.087	9.5	1.084	8.8	1.087	9.6
May 16	1	-	-	-	-	-	-
	2	-	-	-	-	-	-
	3	-	-	-	-	-	-
	4	15.0	8.7	12.5	9.4	-	-
	5	85.0	9.7	87.5	9.7	100.0	9.9
	Avg.	1.089	9.5	1.089	9.7	1.090	9.9
June 16	1	-	-	-	-	-	-
	2	-	-	-	-	-	-
	3	-	-	-	-	-	-
	4	40.0	8.1	5.0	9.0	30.0	8.6
	5	60.0	9.0	95.0	9.8	70.0	9.7
	Avg.	1.087	8.6	1.090	9.8	1.088	9.4

Appendix Table V (Continued)

Dates of Planting	Sp.-Gr. Class	Irrigation Levels					
		Heavy		Normal		None	
		% of Tubers	Chip Color	% of Tubers	Chip Color	% of Tubers	Chip Color
		Russet Rural--3-12-12 Fertilizer					
May 1	1	-	-	-	-	-	-
	2	10.0	r	-	-	10.0	7.0
	3	20.0	9.0	17.5	9.3	5.0	8.6
	4	60.0	9.9	42.5	9.2	45.0	8.9
	5	10.0	9.9	40.0	9.6	40.0	10.0
	Avg.	1.080	9.6	1.084	9.5	1.083	9.2
May 16	1	-	-	-	-	-	-
	2	2.5	7.0	-	-	-	-
	3	-	-	2.5	7.5	-	-
	4	32.5	9.5	42.5	9.2	60.0	9.6
	5	65.0	9.8	55.0	9.9	40.0	10.0
	Avg.	1.087	9.6	1.086	9.6	1.085	9.8
June 16	1	-	-	-	-	-	-
	2	-	-	-	-	-	-
	3	-	-	2.5	r	-	-
	4	26.7	8.8	17.5	9.0	5.0	8.5
	5	73.3	9.3	80.0	9.5	95.0	9.9
	Avg.	1.088	9.2	1.088	9.2	1.089	9.8
		Russet Rural--3-0-0 Fertilizer					
May 1	1	-	-	-	-	-	-
	2	-	-	-	-	-	-
	3	-	-	2.5	8.0	-	-
	4	27.5	8.7	27.5	8.8	20.0	9.7
	5	72.5	9.1	70.0	9.5	80.0	10.0
	Avg.	1.088	8.9	1.087	9.3	1.088	9.9

Appendix Table V (Continued)

Dates of Planting	Sp.-Gr. Class	Irrigation Levels: Heavy % of Tubers	Heavy Chip Color	Normal % of Tubers	Normal Chip Color	None % of Tubers	None Chip Color
		Russet Rural--3-0-0 Fertilizer (Continued)					
May 16	1	-	-	-	-	-	-
	2	-	-	-	-	-	-
	3	10.0	8.0	-	-	25.0	8.0
	4	40.0	8.5	13.3	9.1	20.0	9.7
	5	50.0	9.4	86.7	9.2	55.0	9.8
	Avg.	1.085	8.9	1.089	9.2	1.084	9.3
June 16	1	-	-	-	-	-	-
	2	-	-	-	-	-	-
	3	-	-	-	-	-	-
	4	5.0	8.0	-	-	-	-
	5	95.0	8.9	100.0	8.8	100.0	8.8
	Avg.	1.090	8.8	1.090	8.8	1.090	8.8
		Russet Rural--0-0-12 Fertilizer					
May 1	1	-	-	-	-	-	-
	2	-	-	-	-	-	-
	3	7.5	8.0	5.0	9.0	-	-
	4	55.0	9.2	50.0	9.5	25.0	9.6
	5	37.5	9.8	45.0	10.0	75.0	10.0
	Avg.	1.084	9.3	1.085	9.7	1.088	9.9
May 16	1	-	-	-	-	-	-
	2	-	-	2.5	r	-	-
	3	5.0	8.0	-	-	-	-
	4	70.0	9.2	30.0	8.7	10.0	10.0
	5	25.0	10.0	67.5	10.0	90.0	10.0
	Avg.	1.084	9.3	1.087	9.4	1.089	10.0

Appendix Table V (Continued)

Dates of Planting	Sp.-Gr. Class	Irrigation Levels: Heavy % of Tubers	Heavy Chip Color	Normal % of Tubers	Normal Chip Color	None % of Tubers	None Chip Color
		Russet Rural--0-0-12 Fertilizer (Continued)					
June 16	1	-	-	-	-	-	-
	2	-	-	-	-	-	-
	3	-	-	-	-	-	-
	4	20.0	8.5	32.5	9.3	20.0	8.6
	5	80.0	9.9	67.5	9.6	80.0	9.6
	Avg.	1.088	9.6	1.087	9.5	1.088	9.4

[1] 1 = extremely dark; 10 = light yellow; 8.5 to 9 = golden yellow (most desirable); 7.5 to 10 = acceptable.

[2] Specific-gravity classes: 1 = below 1.064; 2 = 1.064 to 1.070; 3 = 1.070 to 1.076; 4 = 1.076 to 1.088; 5 = 1.088 and over. Class values for weighted averages: 1 = 1.062; 2 = 1.067; 3 = 1.073; 4 = 1.082; 5 = 1.090.

[3] Averages of the chip color ratings for the tubers in that specific-gravity class.

[4] These average values are weighted according to the percentage of tubers in the several specific-gravity classes. The first value of each pair is the weighted average specific gravity; the second is the weighted average of chip color ratings.

[r] Indicates potatoes had become rotten in storage.

THE INFLUENCE OF CERTAIN ENVIRONMENTAL FACTORS ON THE PRODUCTION AND QUALITY OF POTATOES FOR THE POTATO CHIP INDUSTRY

By

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AN ABSTRACT

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ABSTRACT

The investigations presented in this paper were undertaken to study the effects of some environmental factors on the specific gravity of potatoes and the color of potato chips.

1. Specific gravity in relation to variety. Russet Rural and Kennebec were high; Irish Cobbler and Sebago were medium; Chippewa, Pontiac, and Seedling 505-3 were low in average specific gravity; and Katahdin was low in specific gravity at East Lansing (1951) but medium at Lake City (1951 and 1952).

2. Specific gravity in relation to date of planting. In 1951, the potatoes from early planting had a higher average specific gravity than those from late-planted, but in 1952 these findings were reversed.

3. Specific gravity in relation to irrigation. The different levels of irrigation had no noticeable influence on the average specific gravity of potatoes in 1951 and 1952.

4. Specific gravity in relation to fertilizer. The potatoes from the unfertilized plots (0-0-0) had the highest average specific gravity, followed by 3-0-0, 3-12-12, and 0-0-18 or 0-0-12, in the

order of decreasing average specific gravity in both 1951 and 1952. (Plots were fertilized at the rate of 1,000 pounds per acre.)

5. Specific gravity in relation to location. In 1951, the potatoes from the Lake City planting gave higher specific gravity in all varieties than the potatoes from the East Lansing planting.

6. Specific gravity in relation to season. The average specific gravity of potatoes of a given variety was higher in the year 1952 than in either 1950 or 1951.

7. Color of potato chip in relation to variety. Consumer-approved, desirable golden yellow chips were obtainable from Russet Rural, Kennebec, and Irish Cobbler varieties. Commercially-acceptable brownish-yellow chips were processed from Katahdin variety, and dark, unsalable only could be made from Chippewa, Pontiac, Sebago, and Seedling 505-3.

8. Color of potato chip in relation to date of planting. In 1950 and 1951 the early-planted potatoes made lighter-colored chips, but in 1952 the late-planted potatoes made lighter-colored chips.

9. Color of potato chip in relation to irrigation. Nonirrigated plots yielded potatoes, producing lighter-colored chips than those from irrigated plots.

10. Color of potato chips in relation to fertilizer. Plots fertilized with 3-12-12 yielded potatoes producing acceptably colored chips, in this respect superior to any other fertilizer analysis. The potash fertilizer (0-0-18 or 0-0-12) lowered the average specific gravity of potatoes, but surprisingly lightened the color of chips in 1951 and 1952.

11. Color of potato chips in relation to location. Potatoes from the plantings of Lake City gave lighter-colored chips than those from East Lansing.

12. Color of potato chips in relation to season. Within a given variety, potato chips were lighter in color in 1952 than either in 1950 or 1951.

13. Color of potato chips in relation to reducing sugars. There was a direct relation between the amount of reducing sugars in the potato and the color of potato chips. In 1950, the higher the

amount of reducing sugars, the darker the color of chips. The content of reducing sugars and the color of potato chips varied not only from variety to variety, but also within a variety and within the same specific-gravity class from one date of planting to another.

14. Color of potato chips in relation to storage temperature and duration. Chip color immediately after five months cold storage (41° F.) of potatoes was darker than after two months. At the end of five months cold storage, followed by a conditioning period at 78° F., Russet Rural made lighter-colored chips than after two months cold storage, followed by a similar conditioning period, but in Katahdin potatoes these findings were reversed. Kennebec potatoes were conditioned faster than Irish Cobbler, and Katahdin potatoes conditioned faster than Sebago. With the tubers stored for five months and then conditioned at 78° F., the color distinction between late and early planting was not noticeable, but with potatoes stored for two months and conditioned likewise, the first date of planting gave lighter-colored chips than those of late plantings.

The order of ranking as to color was identical for chips processed directly out of cold storage as for chips from the same tubers after conditioning.