THE EFFECTS OF SEEDPIECE SIZE AND SPACING RELATIONSHIPS ON THE YIELD AND QUALITY OF THREE POTATO VARIETIES

A Thesis

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Cyril Beverley Smith

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CONTENTS

INDEX OF TABLES

INDEX OF ILLUSTRATIONS

INTRODUCTION

Potatoes occupy an important place in the agricultural economy of Manitoba. Averages of the last ten years' production figures indicate that more than 32,000 acres are grown annually, producing a crop valued at around $1,750,000. This is generally absorbed by the local markets with occasional surpluses being exported.

While general recommendations are made, no experimental data are available on the best rate of planting in this province. The results of the comparatively few experiments dealing with this subject reported in the literature do not necessarily apply to any other region than that in which the work was carried on. Recommendations across Canada and in the United States show that the rate of planting is dependent primarily on the fertility and moisture condition of the soil. The need for determining the most profitable rate of planting has often been noted since a slight variation in rate affects considerably the initial outlay for planting a required area.

During the last few years Bacterial Ring Rot has become a major threat to the Manitoba potato industry. It is recommended that the only way to avoid the serious consequences of this and other tuber-born diseases is by the use of Government Certified disease-free seed. However, this is very scarce and costly at the present time. It is estimated that there is only sufficient certified seed available in Manitoba to plant two percent of the 1945 crop. Therefore, the most economical use of this seed is of prime importance.

There is considerable evidence to suggest that there may be differences in varietal response to rate of seeding. It has been pointed out by several authorities that some of the new potato varieties which produce shallow-eyed, fine appearing tubers respond differently to treatments than the older varieties. The reaction of these varieties to rate of seeding under Manitoba conditions has never been determined. There is also reason to believe that the rate of planting affects the quality of the tubers.

To seek a solution to these various angles of the problem an experiment was designed to study the effects of the two most important factors which constitute rate of planting, namely, the size of the seedpiece and the spacing of the sets in the row. Commonly grown varieties, cut seedpieces, and practical spacings were used in order that the results would apply to average conditions.

I THE EFFECTS OF SEEDPIECE SIZE AND SPACING RELATIONSHIPS ON THE TOTAL AND MARKETABLE YIELDS

REVIEW OF LITERATURE

(A) Seedpiece Size and Spacing Relstionships

Zavitz (51) carried on extensive experiments with potatoes in Ontario among which was one of the first recorded investigations dealing with seedpiece size and spacing relationships. In reporting five years results using 1-, 1½-, and 2-ounce seedpieces spaced at 12, 18, and 24 inches he concluded that the total yield was directly proportional to the amount of seed used and that the most profitable rate depended largely on the cost of the seed, but favored the 1½-ounce set planted at 12 inches.

From investigations carried on in North Dakota, Werner (45) also concluded that the 1½-ounce seedpiece spaced at 9-12 inches gave the best results. Weston (47) planted 1-, 1½-, 2-, and 2½-ounce seedpieces at spacings of 12, 18, 24, and 36 inches respectively so that all four combinations were sown at the rate of 15 bushels per acre. He found the 1-ounce seedpiece spaced at 12 inches to be much superior.

Sprague and Evaul (34) reported the results of three years rate of planting experiments using the Green Mountain variety in central New Jersey. They used ½-, 1½-, and 2-ounce cut seedpieces each with at least one strong eye and spaced these at from 6 - 22½ inches to give 12 combinations. They likewise observed that the total yields increased directly with planting

rate and pointed out that the relationship between seedpiece size and spacing was such that large seedpieces should be planted at wide spacings and smaller sets at closer spacings. In general the authors found the 1-ounce set at 9 inch spacing to be the most profitable. They pointed out that it was impractical to cut ½-ounce seedpieces and that small sets were more likely to suffer from desiccation because of the relatively greater cut surface exposed. These investigators concluded that all treatments were equal in their effect on the percentage marketable and that increased yields from increased rates were due to the larger number of marketable tubers produced per hill and not to size of individual tubers.

Bushnell (6) in Ohio reported the results of planting 1- and 2-ounce sets at 3 - 24 inches. He disagreed with Sprague and Evaul, stating that higher rates of seeding produced a larger percentage of small tubers, and thus increased yields from increased rates were largely made up of unmarketable tubers. He favored 1-ounce sets at 9- to 12-inch spacing. Jensen and Morris (21) in Washington concluded from investigations on irrigated land that 1-ounce seedpieces at 6 - 12 inches gave the best results.

According to Miller and Kimbrough (27) of Louisiana who ran tests using ½- to 2½-ounce seedpieces and spacings of 8 - 16 inches, the 1½-ounce set at 14"was most suitable.

In 1938, Findlay and Sykes (14) in England reported three years results from a rate of planting experiment using the Variety King Edward VII. The experiment was designed as a

latin square and the data was statistically analysed. In this investigation whole seed was graded as small (1-ounce), medium (1½-ounces), and large (2½-ounces) and these were spaced at 12, 15, 18, and 21 inches. They showed that the total yield increased with the weight of seed used but that the increase was made up largely of small tubers. No significant differences were found in the yields of ware (marketable). This is also contradictory to the results of Sprague and Evaul. These workers considered the increase in seedpiece size an essential consequence of increasing the spacing. When the seed was deducted from the ware to give "net ware" larger seedpieces gave significant increases over small but spacing had no significant effect. In this report they proposed that it would be more economical to separate small potatoes out and plant the 1-ounce tubers at 12 inches, 1½- at 15, and 2½- at 21 inches than planting them all at one distance.

The authors summed up their work by stating that wide spacing reduced the total yields and yields of small tubers but increased the yields of large ware and average-sized tubers. Yields of ware and "net ware" were not significantly affected by spacing. On the other hand large seed produced the greatest total yield and the greatest net of ware and seed. Seed size didn't influence the yield of the large ware but the average size of these was greatest from small seed.

Singh and Wakankar (30) working in India, explained that the lack of cold storage facilities make seed very scarce and ex-

tremely costly during the planting season. Therefore, they planned an experiment to determine the most suitable seed size and spacing which would be economically suitable and profitable under conditions prevailing at Benares, India. The Darjeeling red variety and ½-, 1-, and 1½-ounce sets spaced at 6, 9, and 12 inches were used in a split-plot design. These authors agreed with Findlay and Sykes that the size of the seed and the spacing affected only the yields of small tubers. They found that the yield was reduced with 12-inch but not with 9-inch spacing when compared to the 6-inch planting distance, and concluded that a ½-ounce set placed at 9 inches was the most economical under their conditions.

An experiment showing varietal differences to seeding rate was reported by Smith, Hommel and Kelly (32) working at Cornell University which showed that the old Pioneer Rural variety was best when a 1½-ounce seedpiece was spaced at 14 inches. However, with Sebago, one of the new varieties, they found that a seedpiece of 2 ounces planted at 11 inches gave much superior results. An increase in total yield of 121 bushels per acre was noted when a 2-ounce set was spaced at 11 inches rather than a 1½-ounce seedpiece at 14-inch spacing. These investigators emphasized that Sebago and several other new varieties of the same type required heavier planting rates.

(B) Weight of the Seedpiece

Hume (19) of South Dakota compared small, medium, and large seedpieces from the same tuber and found that the yield increased directly with the size of the set. From Ontario Zavitz (51)

reported the results of five-year investigations using seed-pieces ranging from 1/16- to 2-ounces in weight. He favored the 1-ounce sets although the marketable and net total yields increased directly with the seedpiece size. Rosa (28) also advocated the use of 1-ounce seedpieces and found the increase in marketable yield insignificant with the heavier sets.

Stewart (38) of the U.S.D.A. reviewed the literature on the size of sets dating from 1793 - 1922. He presented the results from experiments in several States and concluded that seasonal conditions greatly influenced the size of set and that with abundant moisture and plant food maximum returns could be expected from large-sized sets but when conditions were less favorable, smaller sets were better because fewer tubers were formed. Hurst (20) in Prince Edward Island, agreed that larger sets gave greater yields but also greater percentages of culls.

Tingey and Stewart (39) used sets of 1-8 ounces in weight and concluded that the 2-ounce seedpiece gave the best all-round results. They also observed that as the size of the set increased, tubers per hill and weight of hill increased, while percentages of marketable tubers, weight of individual tubers, and the number of tubers per stem decreased.

That seedpieces from 1½ - 2 ounces in weight were a factor in considerably reducing hollow heart in wet seasons was observed by Wheeler (49) of Michigan. Ware (41) noted that the recovery of the plants after frost damage was almost wholly dependent on the set size. Seedpieces of 1½ - 2 ounces in weight showed much better recovery than smaller ones. Scannel (29)

reported from Saskatchewan that "potato eyes" weighing 0.65 ounces gave much better yields than those weighing 0.4 or 0.2 ounces. Miller and Kimbrough (27) agreed with Ware that plants from large seedpieces due to their greater food reserve made a much better recovery from frost damage.

Ware (43) showed the relation between seedpiece size and the rate of applying fertilizer in Alabama when he used ½- to 1½-ounce seedpieces and 1000 - 2000 pounds per acre of fertilizer. He found the 1½-ounce set used with 1500 pounds of fertilizer gave the greatest return above the cost of materials but claimed this would vary depending on the various costs.

(C) Comparison of Whole and Cut Seed

Conflicting opinions have resulted from the many investigations concerning the relative value of whole and cut seedpieces. Zavitz (51), reporting the results of six years experiments in Ontario, preferred small whole seed to cut seedpieces.

It was claimed by Aicher (1) of Idaho that whole sets emerged more quickly and produced larger tops than cut seed. He showed that total yields from whole sets were almost 15% greater than those from cut seed but that cut seedpieces yielded 18% more marketable tubers. Welch (44), also in Idaho, agreed with Aicher but claimed that whether the seed was whole or cut had no effect on the time of emergence. Rosa (28) found little difference between whole and cut seed in Missouri except that whole sets produced a larger percentage of culls. A report from New York by Stewart (36) stated that "for seed purposes uncut tubers between 1 and 2 ounces in weight are at least as

good as and probably a little better than pieces of equal weight cut from large tubers of the same plant".

Albright (3) of the Beaverlodge Station, Alberta, obtained greater yields but a larger percentage of culls from whole seed. Stewart (38) of the U.S.D.A. gave an extensive review of literature and a report of investigations in several states in 1924 from which he concluded that whether whole or cut sets were superior depended largely on seasonal conditions. Hurst (20) of Prince Edward Island compared whole and cut sets of various sizes and found that while the whole tubers produced heavier and more vigorous plants, they gave a much larger percentage of culls. His 1½-ounce cut set produced almost as great a marketable yield as the 3-ounce whole seed. He thus favored cut sets and advised that small whole tubers be used only when seed was scarce or high-priced.

Gardner (15) showed that cut seed was much more perishable in storage than whole seed. This was very important in Kentucky because conditions often demanded that seed be cut several weeks before planting. Butler (9), working in New Hampshire, ran experiments to determine whether leaf roll and mosaic were more common in fields grown from small whole tubers than from sets which had been cut from large tubers. He concluded that the percentage of disease in plants grown from good quality certified seed was not affected by the size of the seed.

Bushnell (7 and 8) of Ohio claimed that cut seed gave a poor

stand due to drying out, while small whole tubers made excellent seed if free from disease. The four years results obtained by MacLeod (25) in the Canadian Fraser Valley showed that whole seed gave a much better stand and greatly increased yields especially in seasons having cold and damp spring weather. He reported an increase of 4.0 tons per acre in total and 3.1 tons per acre in marketable yields when whole and cut seed were compared. He used his results to support certification being given to small-sized seed because he considered it very important that this seed be disease-free. Edmundson (12) of the U.S.D.A. produced evidence to prove that cut seed was injured by direct exposure to sunlight during planting operations while whole seed was uninjured.

(D) The Number of Eyes per Seedpiece

The question has often arisen whether it was the weight of the set or the number of eyes it contained that exerted the greatest influence on the yields obtained.

Zavitz (51) reported experiments in which he used one-eyed sets of different weights and sets of the same weight containing from 1 - 5 eyes. He concluded that the weight of the seedpiece had a much greater effect than the number of eyes present. The same conclusions were reached by Werner (45) and Albright (3) working in North Dakota and Alberta respectively. Stewart (38) concluded that the increase in vigor with larger sets was due to a greater number of eyes as well as the larger weight.

However, Wakankar (40), working in India, concluded that large seedpieces gave higher yields due to their capacity to produce more sprouts per hill. From the results of chemical tests he presumed that the amount of stored food had no effect on the resultant yields.

(E) Comparison of Fresh and Suberized Seedpieces

Recommendations vary as to the advisability of using freshly cut or suberized (corked over) seedpieces. Westover (48) of West Virginia reported that five years results showed freshly cut seed to give better total and marketable yields than those cut and stored for various periods.

Lombard (23) reviewed the literature on suberization and found the results to be very contradictory. He reported the results from six years investigations in several states. Freshly cut sets were compared with those cut and stored 10, 20, 30, 40, and 50 days. He concluded that seedpieces could be stored under normal conditions for 10 - 30 days but not longer without injurious effects.

Edmundson (12) of the U.S.D.A. compared 1½- and 2-ounce sets, fresh and suberized, planted immediately and placed in the sun for 2 and 4 hours. He showed that freshly cut seed was much more severely injured during planting operations than suberized sets depending on the length of exposure.

(F) Comparison of Apical and Basal Seedpieces

For many years there has been much controversy over the relative value of potato seedpieces cut from the apical and basal

ends of the tuber. Zavitz (51), in a five year test in Ontario compared one-ounce, one-eyed seedpieces from the stem end, seed end, and middle portion of the tuber. He showed that the sets from the middle portion were superior in every respect but could find little to choose between those from the stem and seed ends. These sets were not sprouted before planting.

From the results of experiments carried on in New York, Stewart (37) concluded that apical sets were much superior to basal sets in many respects. He cut both the apical and basal seedpieces from the same sprouted tuber. Smith (31), in reviewing Stewart's work, stated that the results of experiments he had carried on indicated that the type and extent of sprout growth at the time of planting and not the position of the eye on the tuber accounted for the differences obtained between apical and basal sets and that these differences would not be noted if the tubers were cut before sprouting.

In a report presented in 1936, Lombard and Stewart (24) of the U.S.D.A. reviewed the literature on this question and concluded that the contradictory results were due either to the experiments being on too small a scale or to the fact that the workers were not careful in controlling other variables. Therefore the authors ran extensive tests for three years using the Irish Cobbler and Green Mountain varieties. They were especially careful to control all the errors by using weighed seedpieces from tubers of uniform size with sprouts of equal strength. The latter were obtained by cutting the seedpieces first and sprouting them later. Their results were statistically analysed

and showed that when errors were removed, basal and apical sets were equally productive.

These investigations seemed to solve the problem and prove that differences were due wholly to variation in dormancy between eyes on the same tuber. However, Ellis, (13) working in Indiana, claimed that Stewart's results did not apply to the new type of tuber such as in the Chippewa variety. His data showed much higher yields were obtained from apical than from basal sets when Chippewa was used. He suggested that there may be a varietal difference in the reaction to apical dominance but stated that the problem required further investigation.

(G) Spacing as Affected by Other Factors

Several investigators have found optimum spacings to vary depending on moisture conditions, fertility, date and depth of planting, variety etc. Martin (26) planted 1-ounce seedpieces at 9- to 12-inch spacings, and at various depths. He found that with shallow planting the greatest yields and net returns over the cost of seed but the lowest percentage of marketable tubers were obtained at 9-inch spacing. He therefore recommended 9- to 11-inch spacings depending on the fertility.

Bird (5) ran an experiment to correlate spacing, fertilizers, and date of planting. He found that closer spacing (12-18 inches) gave a higher yield and a greater percentage marketable even in drought years and also cut down the amount of hollow heart. He preferred early planting and found that the use of fertilizer gave good results even during drought periods.

Wessels (46) of New York quoted Hardenburg in stating that it was the general opinion that "in regions where mineral nutrients and moisture are likely to be limited, wider spacing of plants and less seed per acre are recommended". However, he concluded from one year's investigations, in which he used four spacings and various fertilizers, that the level of fertility did not influence optimum spacing.

Edmundson (11) reported a spacing test carried on by the U.S.D.A. in which spacings from 8 - 14 inches and the varieties Rural New Yorker #2 and Triumph were used. He found that yields of tubers between 3 and 12 ounces increased with closer planting and that hollow heart and growth cracking increased with distance. He observed that Triumph was not as susceptible to hollow heart as Rural New Yorker and could thus be planted at a greater distance.

Ware (42) of Alabama showed that there was a definite relationship between spacing and the amount of fertilizer used. He spaced his sets at from 8 - 20 inches and used fertilizers at the rate of 1000 - 2000 pounds per acre. He concluded that 2000 pounds per acre of fertilizer and 12-inch spacing was the most desirable and economical.

White-Stevens and Wessels (50) showed results contrary to Wessel's former work. They concluded that on irrigated land, 15-inch spacing was best with low fertility applications but a distance of 11 inches was superior when fertilizer was applied at the rate of 2000 pounds per acre.

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x CURRENT RECOMMENDATIONS FOR THE CANADIAN PROVINCES

Prince Edward Island

Authorities recommend a 1½-ounce seedpiece spaced at 10-12 inches in the row and a distance of 36 inches between the rows. However, for the varieties Katahdin and Sebago, 9-inch spacing has been found more satisfactory because it is claimed that these varieties "miss badly" due to having relatively few and weak eyes.

Nova Scotia

A seedpiece size of 1½-2 ounces planted at 9-12 inches for Irish Cobbler and 12-15 inches for Green Mountain in rows 33 inches apart are the recommendations given. It is suggested that the varieties Katahdin and Sebago, while late, be planted at a spacing not greater than 12 inches because fewer and over-sized tubers are common at the wider spacings.

New Brunswick

In this province the use of 1½- to 2-ounce seedpieces, preferably of the latter weight, is advised. Sets were formerly spaced at 12 inches but as the majority of potato growers use 2000 pounds of high-grade complete fertilizer per acre it was found that over-sized tubers were common. Thus 9-inch spacing is now suggested for all varieties.

Quebec

Small whole tubers or cut pieces both on the large side of 1 ounce are recommended. Planting at 10 - 12 inches in rows 36 Inches apart is favored for all varieties.

x This information was obtained by correspondence with Dominion Experimental Stations and Universities across Canada.

Ontario

Ottawa authorities recommend the use of 2- to 3-ounce sets and 12- to 14-inch spacing for early varieties (Irish Cobbler) while spacing of 16-18 inches is held to be superior for late varieties (Green Mountain). Investigators at Guelph suggest in general the use of 1½-ounce seedpieces with one good strong eye spaced at 12 inches. This is supported by the extensive work of Dr. C.A. Zavitz. However, spacing recommendations vary depending on the variety grown, purpose for which intended, and the fertility and the moisture content of the soil. Sets are spaced closer if the fertility is high or when the crop is grown for seed in order to produce the desirable size.

Manitoba

The use of 2-ounce seedpieces spaced at 12-15 inches in 36-inch rows is generally recommended. No special planting rates have been proposed for varieties such as Katahdin but closer spacing has been advocated for highly fertile soil.

Saskatchewan

Seedpieces around 2 ounces in weight with at least two strong eyes are the practical recommendations given. Spacing at 18 inches in four-foot rows is advised when planted by hand but a spacing wider than 15 inches is not considered practical when a potato planter is used. Much wider spacings are advised when drought is a problem. These vary from 15 - 24 inches in the row and from 3 - 6 feet between the rows depending on the moisture conditions. Late varieties such as Katahdin are not grown to any extent.

Alberta

In the southern part of the province 2-ounce sets spaced at 14 inches are recommended under irrigation but workers have found that higher yields can be obtained if late varieties (Netted Gem) are planted at a 9-inch spacing. In central Alberta 1½- to 2-ounce seedpieces spaced at 15-18 inches in 30- to 36-inch rows are recommended. The use of smaller sets and closer spacings is advised where the soil is rich and fertile. In the Peace River district 2-ounce sets planted at 14 - 16 inches are recommended but wider spacing is advocated for the Katahdin variety.

British Columbia

A seedpiece size of about 2 ounces in weight planted at around 14 inches is recommended but this varies somewhat with the variety used.

MATERIALS AND EXPERIMENTAL PROCEDURE

The varieties Warba, Irish Cobbler, and Katahdin were used in this rate of planting investigation which was carried on for two years, 1943 and 1944. Manitoba grown certified seed in good condition was obtained each year. Four sizes of seedpiece (1, 2, 3, and 4 ounces) were planted at each of four spacings (9, 12, 15, and 18 inches) to give sixteen combinations or rates of planting which ranged from 10.1 - 80.6 bushels per acre. Seedpieces planted at approximately 10, 24, and 81 bushels per acre respectively are illustrated in Figure 4. The distance between the rows was 36 inches throughout.

The experiment was planted on an area of fairly heavy well-drained Red River Clay which was considered fairly typical of the Red River Valley. The plots covered about two-thirds of an acre each year. The soil used had grown vegetable crops for several years but no potatoes. No commercial fertilizer was used but a dressing of barnyard manure was applied in the fall of 1942.

The experiment was designed as a randomized block. The field plans used in 1943 and 1944 are shown in Figures 1 and 2. There were four replicates, each of which was made up of three blocks which were randomized. Each block consisted of one variety. Within each block the above mentioned sixteen rates were randomized. The plots consisted of only one row with guard hills planted at each end. Guard rows were included along each side of the main block. It will be noted that the plans for each year are identical except for the randomizations.

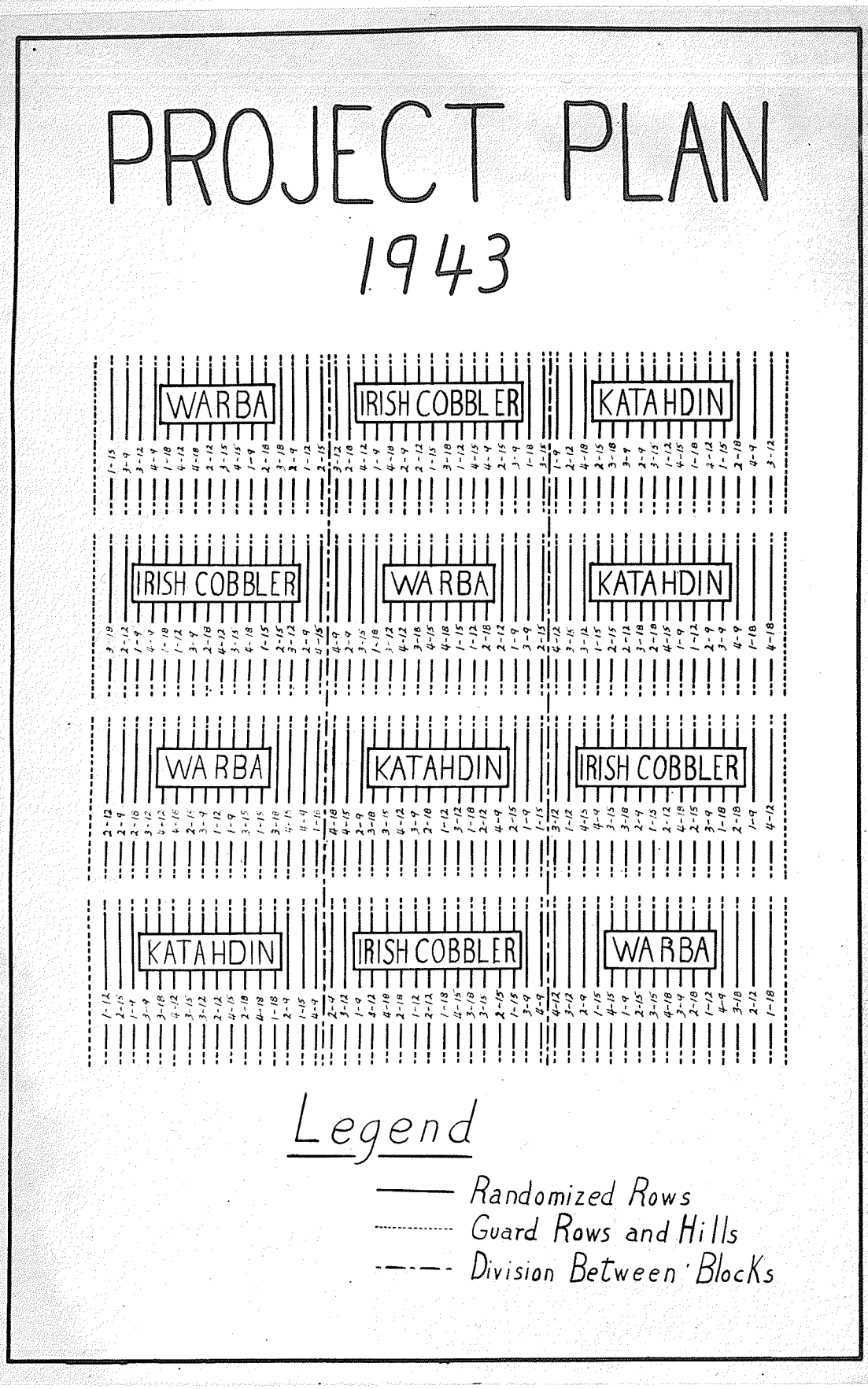


Figure 1 - Field Plan Used in 1943 Showing the Complete Randomizations.

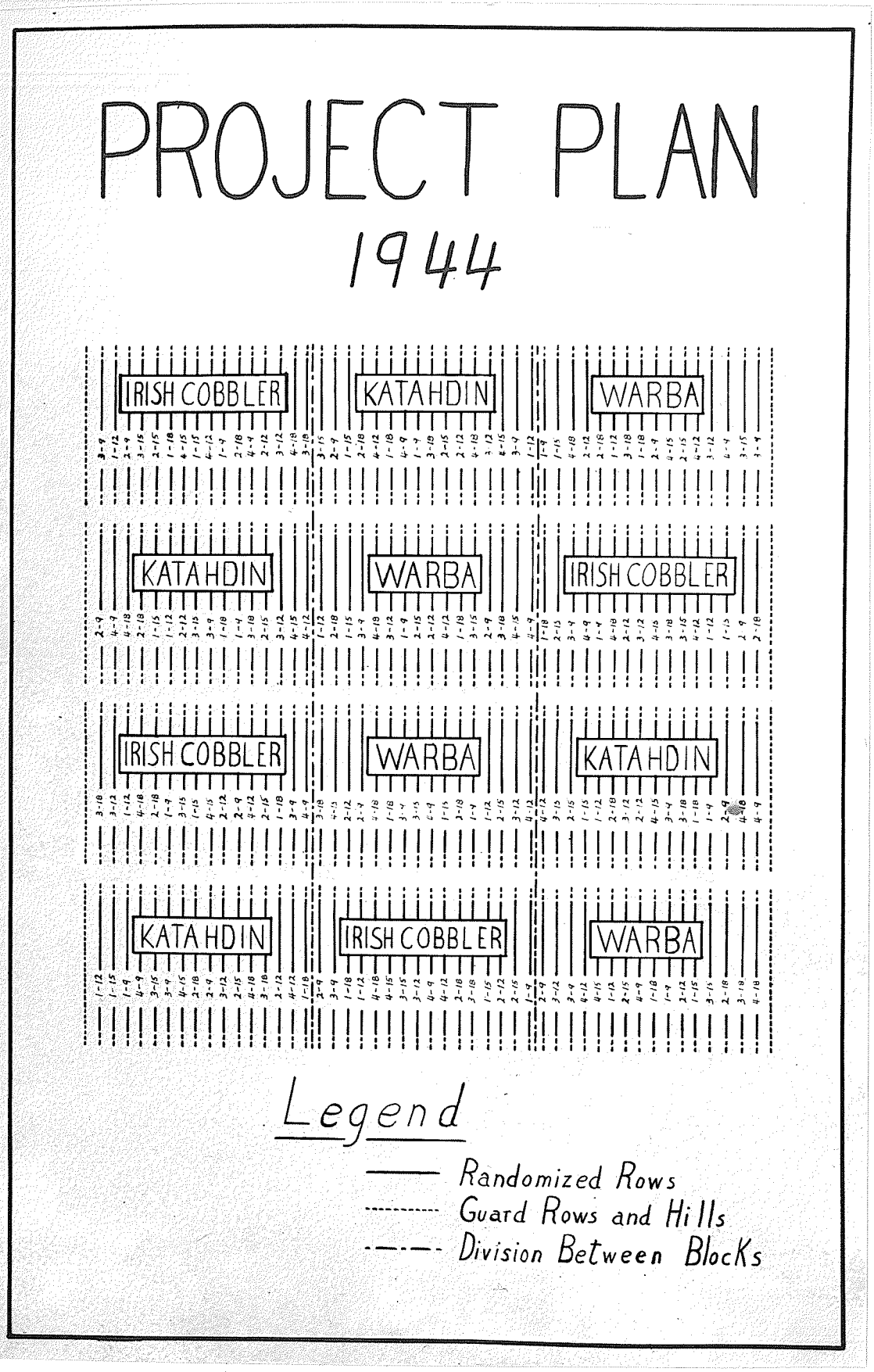


Figure 2 - Field Plan Used in 1944 Showing the Complete Randomizations.

The Varieties

Warba

The variety Warba was chosen for this investigation because it is the earliest potato produced commercially and has been steadily gaining popularity in Manitoba for several years. It was developed at the Minnesota Agricultural Experimental Station from a cross between Bliss Triumph and a selected seedling and was introduced by the University of Minnesota in 1933. Usually it is about 10 - 14 days earlier than Irish Cobbler and gives a slightly higher yield. The vines are upright and sturdy while the blossoms are few and light pink in color. It is highly resistant to mild mosaic. This variety produces short, round, blocky white tubers with pink eyes. Its main disadvantage is its numerous deep eyes which give the tubers a rough appearance. It has good quality, fine texture and stores well for an early variety.

Irish Cobbler

The variety Irish Cobbler has been grown extensively as an early potato for many years throughout Canada. It is more widely grown in Manitoba than any other variety. It is early and productive and is noted for maintaining its vitality better than many other varieties. The eyes are deep and the tubers are not of the best shape but it has often replaced more attractive varieties due to its dependability in producing good crops. The variety is characterized by purple flowers, strong growth, round and somewhat flattened creamy-white tubers, and very high quality.

Katahdin

This was chosen because it is the best known of the new, late,

shallow-eyed, attractive-appearing varieties. It is grown extensively in Eastern Canada and is probably the most popular late variety in Manitoba. It was introduced by the United States Department of Agriculture in 1935 and resulted from a cross between two seedlings which in turn were bred from the four varieties Sutton Flourball, Aroostock Wonder, Busola, and Rural New Yorker #2. Katahdin generally matures at least three weeks later than Irish Cobbler. It is resistant to mild mosaic and is noted for its abundant and fertile pollen. The tops are green until frost but it is claimed that the tubers are set early.

The tubers are roundish and medium thick while the skin is white but inclined to be russetted under some conditions. The eyes are few and shallow and the yield good. This variety sets its tubers rather high so that deep planting to avoid sunburning is advisable. The cooking quality varies considerably with environmental conditions but is probably never as high as Irish Cobbler. It produces few tubers per hill and thus they are inclined to be oversized. Despite these undesirable features, Katahdin is considered to be the best of the late varieties at the present time.

The Seedpieces

About two weeks prior to the time when the seedpiece cutting was commenced, the seed was placed in crates under the greenhouse benches and allowed to green sprout.

The seedpieces were then cut carefully to their respective 1-, 2-, 3-, and 4-ounce sizes and checked on a fine balance so that they were all within 5% of the required weight. The seedpieces used are shown in Figure 3. In order to prevent drying out as

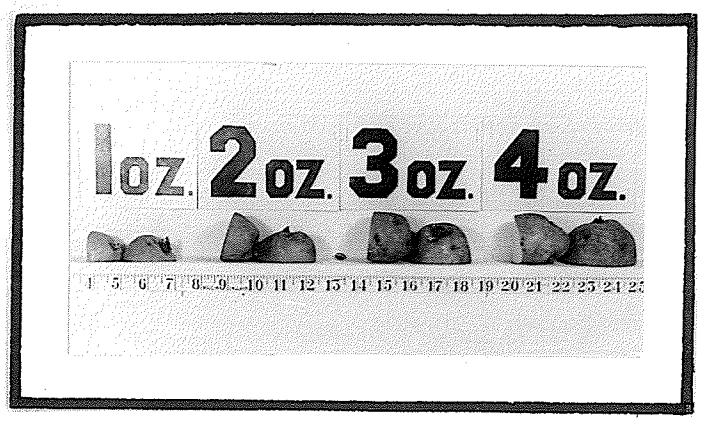


Figure 3 - Photograph Showing the Four Sizes of Seedpiece Used.

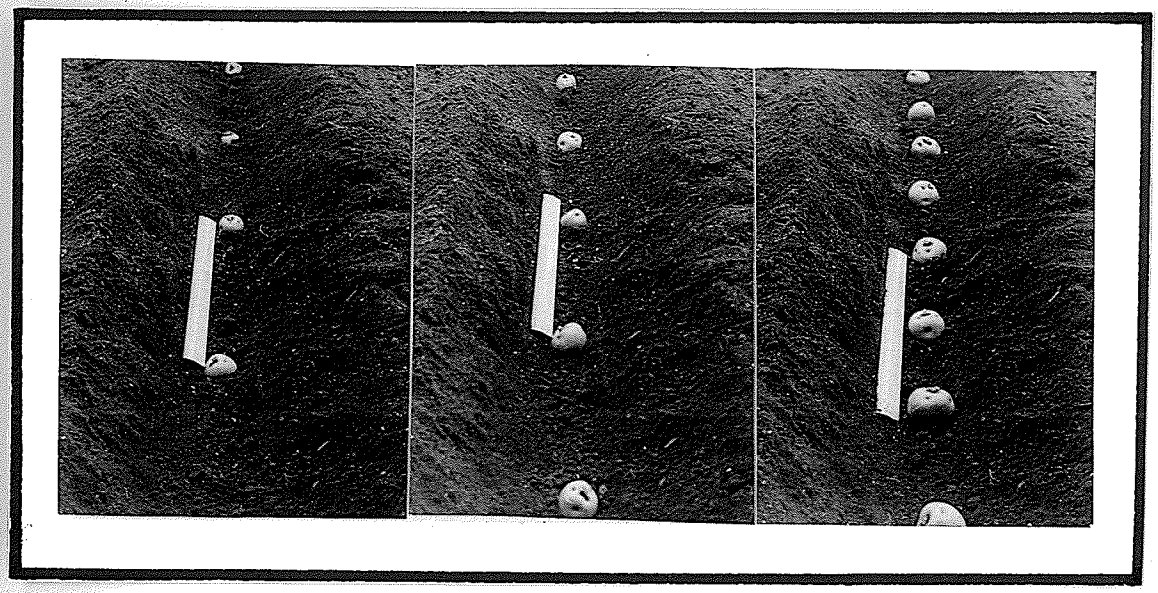


Figure 4 - Photographs Showing:

Left: 1-oz. Seedpieces Spaced at 18" (approx. 10 bus./acre).
Centre: 2-oz. Seedpieces Spaced at 15" (approx. 24 bus./acre).
Right: 4-oz. Seedpieces Spaced at 9" (approx. 81 bus./acre).
An 18" Rule is Shown for Comparison. These Are Cut Seedpieces with the Cut Surfaces Placed Downward.

much as possible, all the large sized seedpieces were prepared first which meant that the 1-ounce sets were cut only a day or two before planting.

The only stipulation made besides that of weight was that each seedpiece must have at least one strong eye. Other than that the number of eyes per seedpiece was not taken into consideration. Likewise sets were cut from both the apical and basal ends. However, due to the number of eyes and the position of these eyes on the tuber being selected entirely at random, the effects of the number of eyes and whether these were cut from the apical or the basal end were eliminated and thus the whole effect of the seedpiece was considered to be due to its weight.

A total of 536 seedpieces were cut for each block and 2144 for each variety which meant that a total of around 6,500 sets were cut and weighed individually each year. After being cut, the sets were packed in slatted boxes in horticultural peat and stored in a cool place. They were taken to the field before being unpacked. Cutting commenced about a week before planting in 1944 but due to heavy rains in 1943 the seedpieces were stored for over two weeks before being planted.

The Spacings

The actual plots or rows in each replicate were 30 feet in length with two or three guard hills on each end (depending on the spacing) which made the total length of the rows 36 feet. 30-foot rows were used because it was felt that this was large enough to give accurate results and yet not too large to be practical. This length was also chosen due to the fact that all the spacings (9, 12, 15, and 18

inches) divide into it evenly. Thus, as it is noted in the Outline of Spacing shown in Figure 5, the ends of the actual plots are all even. Special care was taken to space all the sets accurately by means of long wooden scantlings which were marked off in the appropriate spacings.

Planting and Summer Care

Furrows 36 inches apart were taken out with the plough attachment of the garden tractor. Tight wires were strung across each end of the replicates and the markers were laid between these wires. The seedpieces were carefully placed in the bottom of the furrows alongside the markers. The sets were planted four inches deep throughout but only covered to a depth of 2 inches at the time of planting. The furrows were filled in later.

In 1943 the planting was delayed until June 15 and 16 due to continued rains. However, in 1944, the spring being more normal, the seeding dates were May 16 and 17.

During the summer the plots were hilled only slightly and were sprayed twice with a calcium arsenate-bordeaux mixture.

Harvesting and Grading

The plots were harvested when the tubers were mature but before the tops had died down completely. In 1943 the harvesting of the Warba, Irish Cobbler, and Katahdin was completed on September 6, September 14, and October 7 respectively. In 1944, Warba was harvested on August 24, Irish Cobbler on September 4 but the harvesting of Katahdin was delayed until October 3 due to very wet conditions.

In harvesting, the guard rows and hills were discarded. If any hills were missing the hills on either side of the missing one

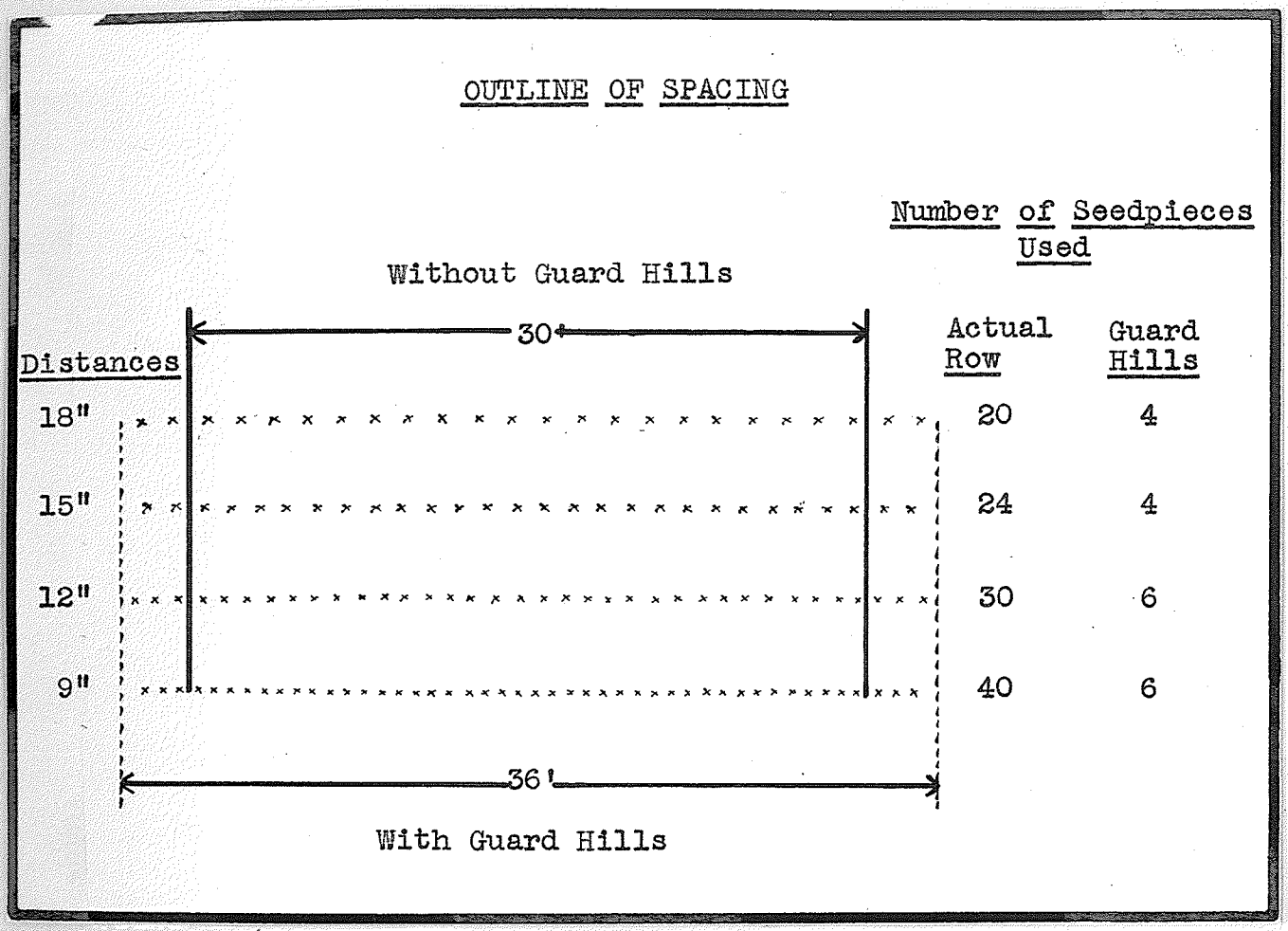


Figure 5 - Diagram Showing Outline of Spacing.

were also discarded. The number of remaining hills was carefully recorded. The plots were thus harvested on a "perfect stand" basis which was felt to be the most accurate and practical method of correcting yields for stand.

All tubers including the very small ones were picked up when harvesting. The yield from each plot was placed in a separate container and taken inside where the individual tubers were graded into the three classes 0-3, 3-12, and over 12 ounces. Those from 3 - 12 ounces were classed together as marketable. Both total and marketable yields were corrected for stand. The yields were divided by the number of hills per row to give the number of ounces per hill. Bushels per acre were calculated from these "ounces per hill" figures. Total and marketable yields were statistically analysed according to the methods outlined by Goulden (17).

EXPERIMENTAL DATA AND RESULTS

In general the results obtained showed certain trends which applied to both the total and the marketable yields. The weight per plot (30-foot row) increased directly with the weight of seed planted per acre. The weight of tubers per hill in ounces decreased as the rate of planting increased. The calculated bushels per acre were directly proportional to the planting rates.

The 1943 Results

The results obtained for each variety in 1943 are shown in Tables 1, 2, and 3. The statistical analyses for total and marketable yields are presented in Tables 4 and 5. Tables 6 and 7 show the effects of the seedpiece sizes and the spacings individually.

It is noted in Table 6 that there is little difference between the yields for Warba and Irish Cobbler when either total or marketable are considered but Katahdin yields are much higher than either of these.

Since the analyses of variance show that differences of 51.96 and 27.29 bushels per acre for total and marketable yields respectively are required for significance between the varieties, both total and marketable yields for Katahdin are significantly greater than those for Warba or Irish Cobbler. However, there is no significant difference in yields between these two varieties.

Table 1 - Treatment Means for Warba in 1943.

Size of Seed-piece (ozs.)	Spacing (Ins.)	TOTAL YIELDS: Wt. per 30' Row (lbs.)	TOTAL YIELDS: Ounces per Hill	TOTAL YIELDS: Bushels per Acre	MARKETABLE YIELDS (5-12ozs.): Wt. per 30' Row (lbs.)	MARKETABLE YIELDS (5-12ozs.): Ounces per Hill	MARKETABLE YIELDS (5-12ozs.): Bushels per Acre	Percentage Marketable (Per cent)	Amt. of Seed Used (Bus./Ac.)	"Net Marketable" Marketable loss Seed Used (Bus./Acre)
1	18	39.3	31.4	316.6	24.2	19.4	195.6	61.6	10.1	185.5
1	15	41.2	27.4	331.5	27.5	18.6	225.1	66.7	12.1	213.0
1	12	43.2	23.1	349.4	26.9	14.3	216.3	62.3	15.1	201.2
1	9	45.6	18.3	369.0	30.6	12.3	248.0	67.1	20.2	227.8
2	18	46.3	37.1	374.1	25.5	20.4	205.7	55.1	20.2	185.5
2	15	44.8	29.9	361.8	27.6	18.4	222.6	61.6	24.2	198.4
2	12	51.3	27.4	414.4	32.6	17.4	263.2	63.5	30.3	232.9
2	9	52.5	21.0	423.5	31.5	12.6	254.1	60.0	40.3	213.8
3	18	46.8	37.5	378.1	26.3	21.0	211.7	56.2	30.2	181.5
3	15	50.5	33.6	406.6	30.9	20.6	249.3	61.2	36.3	213.0
3	12	47.6	25.4	384.2	28.0	14.9	225.4	58.8	46.5	178.9
3	9	54.5	21.8	439.6	29.6	11.8	238.0	54.3	60.5	177.5
4	18	48.2	38.6	389.2	26.8	21.5	216.8	55.6	40.3	176.5
4	15	50.7	33.8	409.0	31.1	20.7	250.5	61.3	48.4	202.1
4	12	53.4	28.5	431.1	31.6	16.9	255.6	59.2	60.5	195.1
4	9	55.7	22.5	449.7	33.5	13.4	270.2	60.1	80.6	189.6

Table 2 - Treatment Means for Irish Cobbler in 1943.

Size of Seed-piece (ozs.)	Spacing (Ins.)	TOTAL YIELDS 'Wt. per '30' Row '(lbs.)	TOTAL YIELDS Ounces per Hill	TOTAL YIELDS Bushels per Acre	MARKETABLE YIELDS (5-12ozs.) 'Wt. per '30' Row '(lbs.)	MARKETABLE YIELDS (5-12ozs.) Ounces per Hill	MARKETABLE YIELDS (5-12ozs.) Bushels per Acre	'Percentage 'Marketable '(Per cent)	Amount of Seed Used (Bus./Ac.)	"Net Marketable" Marketable less Seed Used (Bus./Acre)
1	18	36.1	28.9	291.4	22.9	18.3	184.5	63.4	10.1	174.4
1	15	40.3	26.8	324.3	26.7	17.8	215.4	66.3	12.1	203.3
1	12	41.9	22.3	337.3	27.5	14.5	219.5	65.2	15.1	204.2
1	9	40.6	16.2	326.7	25.9	10.3	207.7	63.8	20.2	187.5
2	18	45.3	34.7	349.9	30.6	24.5	247.0	70.7	20.2	226.8
2	15	46.9	31.3	378.7	32.2	21.5	260.2	68.7	24.2	256.0
2	12	46.9	25.0	378.1	32.2	17.2	260.2	68.7	30.3	229.9
2	9	51.3	20.6	415.4	36.5	14.6	294.4	71.2	40.3	254.1
3	18	40.7	32.6	328.7	26.2	21.0	211.7	64.4	30.2	181.5
3	15	51.7	34.5	417.4	32.5	21.6	261.4	62.9	36.3	225.1
3	12	51.9	27.6	417.5	35.7	19.1	288.9	68.8	45.5	243.4
3	9	52.8	21.2	427.5	36.2	14.5	292.4	69.2	60.5	231.9
4	18	47.6	38.1	381.2	32.4	25.9	261.2	68.1	40.3	220.9
4	15	53.2	35.5	429.6	35.0	23.3	281.9	65.8	48.4	233.5
4	12	50.1	26.7	403.8	35.5	18.9	286.9	70.9	60.5	226.4
4	9	52.2	20.9	421.5	37.8	15.1	304.5	72.4	80.6	223.9

Table 3 - Treatment Means for Katahdin in 1945.

Size of Seed-piece (ozs.)	Spacing (Ins.)	TOTAL YIELDS: Wt. per 30' Row (lbs.)	TOTAL YIELDS: Ounces per Hill	TOTAL YIELDS: Bushels per Acre	MARKETABLE TUBERS (3-12ozs.): Wt. per 30' Row (lbs.)	MARKETABLE TUBERS (3-12ozs.): Ounces per Hill	MARKETABLE TUBERS (3-12ozs.): Bushels per Acre	Percentage Marketable (Per cent)	Amount of Seed Used (Bus./Ac.)	"Net Marketable" Marketable less Seed Used (Bus./Acre)
1	18	54.9	27.9	281.5	24.5	19.6	197.6	70.2	10.1	187.5
1	15	40.0	26.7	323.1	26.2	17.4	210.5	65.5	12.1	198.4
1	12	46.8	25.0	378.1	33.3	17.8	269.2	71.2	15.1	254.1
1	9	65.4	26.2	528.4	42.3	16.9	340.8	64.7	20.2	320.6
2	18	55.2	44.1	444.7	30.8	24.5	247.0	55.8	20.2	226.8
2	15	49.8	33.2	401.7	32.0	21.3	257.7	64.3	24.2	233.5
2	12	52.7	27.8	420.5	36.2	19.2	290.4	68.7	30.3	260.1
2	9	65.6	26.3	530.4	45.0	18.0	363.0	68.6	40.3	322.7
3	18	47.4	37.9	382.2	30.1	24.1	245.0	63.5	30.2	212.8
3	15	55.4	37.0	447.7	38.6	25.8	312.2	69.7	36.3	275.9
3	12	68.5	36.6	555.6	44.7	23.9	361.5	65.3	45.5	316.0
3	9	74.0	29.6	596.9	51.2	20.5	413.4	69.3	60.5	352.9
4	18	56.5	45.2	455.8	36.8	29.4	296.4	65.1	40.3	256.1
4	15	64.6	43.0	508.2	46.0	30.6	370.3	71.2	48.4	321.9
4	12	64.9	34.6	523.5	51.6	27.5	416.0	79.5	60.5	355.5
4	9	67.1	26.8	540.5	49.2	19.7	397.3	73.3	80.6	316.7

Table 4 - Analysis of Variance for Total Yields in 1943.

	Sums of Squares	Degrees of Freedom	Variance	F	5% Point	1% Point	Necessary Difference
Blocks	361,708.15						
Replicates	35,515.51	3	11,838.50	0.82	4.76	9.78	.....
Varieties	239,794.40	2	119,897.20	8.33	5.14	10.92	51.96
Error (a)	86,398.22	6	14,399.70				
Total	1,263,352.31						
Seedpiece	275,299.98	3	91,766.66	55.93	2.68	3.94	16.35
Spacing	210,212.79	3	70,070.92	42.70	2.68	3.94	16.35
Seed.x Spac.	54,581.02	9	5,842.33	3.34	1.95	2.56	32.07
Vars.x Seed.	19,127.57	6	3,187.91	1.94	2.17	2.95	.....
Vars.x Spac.	78,979.95	6	13,163.31	8.02	2.17	2.95	28.35
Vars.x Seed. x Spac.	61,927.97	18	3,440.43	2.10	1.70	2.10	.....
Error (b)	221,514.90	135	1,640.85				

Table 5 - Analysis of Variance for Marketable Yields in 1943.

	Sums of Squares	Degrees of Freedom	Variance	F	5% Point	1% Point	Necessary Difference
Blocks	267,477.69						
Replicates	14,038.49	3	4,679.49	0.59	4.76	9.78	.....
Varieties	205,781.32	2	102,890.65	12.95	5.14	10.92	27.29
Error (a)	47,657.88	6	7,942.98				
Total	832,603.15						
Seedpiece	133,929.48	3	44,643.16	39.45	2.68	3.94	13.58
Spacing	147,411.27	3	49,137.08	43.42	2.68	3.94	13.58
Seed.x Spac.	8,572.18	9	952.46	0.84	1.95	2.56	.....
Vars.x Seed.	46,729.54	6	7,788.52	6.88	2.17	2.95	23.54
Vars.x Spac.	48,234.90	6	8,039.15	7.10	2.17	2.95	23.54
Vars.x Seed. x Spac.	27,466.43	18	1,525.91	1.35	1.70	2.10	.....
Error (b)	152,781.26	135	1,131.71				

Table 6 - Mean Total and Marketable Yields and Percentages Marketable of Each Variety for Each of the Four Seedpiece Sizes in 1945.

Seedpiece Sizes		Marba Yield	Marba %age	Irish Cobbler Yield	Irish Cobbler %age	Katahdin Yield	Katahdin %age	Mean Yield	Mean %age
1-oz.	Total	341.22	64.6	320.13	64.6	377.35	67.4	346.23	65.6
	Mark.	220.48		206.87		254.36		227.24	
2-oz.	Total	393.14	60.1	380.56	69.7	449.02	64.5	407.57	64.7
	Mark.	256.38		265.27		289.55		263.73	
3-oz.	Total	401.95	57.5	397.35	66.2	494.98	67.1	451.43	63.9
	Mark.	231.31		263.24		332.18		275.57	
4-oz.	Total	419.59	59.1	408.71	69.4	506.81	73.0	445.04	67.5
	Mark.	247.99		285.74		369.89		300.54	
Mean	Total	388.98	60.2	376.69	67.6	457.04	68.2		
	Mark.	234.04		254.78		311.50			

Table 7 - Mean Total and Marketable Yields and Percentages Marketable of Each Variety for Each of the Four Spacings in 1945.

Spacings		Marba Yield	Marba %age	Irish Cobbler Yield	Irish Cobbler %age	Katahdin Yield	Katahdin %age	Mean Yield	Mean %age
18"	Total	364.26	56.9	357.66	66.9	391.04	62.9	364.32	62.2
	Mark.	207.33		226.06		246.09		226.49	
15"	Total	377.31	62.5	387.20	65.8	420.03	68.5	394.85	65.7
	Mark.	235.89		254.71		287.64		259.41	
12"	Total	394.29	60.9	384.37	68.5	468.69	71.2	415.79	67.1
	Mark.	240.22		265.47		333.89		279.19	
9"	Total	420.03	60.2	397.51	69.2	548.40	69.0	455.31	66.3
	Mark.	252.72		274.89		378.36		301.99	

In comparing the mean total yields obtained from the use of each of the four seedpiece sizes (Table 6) a difference of 16.35 bushels per acre is required. When this is applied, it is noted that differences between the 1- and 2- and the 2- and 3-ounce seedpieces are significant but that the difference between the 3- and 4-ounce seedpieces is not large enough to be significant.

When the marketable yields are considered, it is noted that the analysis of variance shows both the seedpieces and the interaction of varieties by seedpieces to be significant beyond the 1% point. The significance of this interaction indicates that varieties respond differently to the effect of seedpiece sizes as far as the marketable yields are concerned. When the marketable mean yields are examined in Table 6, the range between the 1- and the 4-ounce seedpieces is 27.51 bushels per acre for Warba, 76.87 bushels per acre for Irish Cobbler and 115.53 bushels per acre for Katahdin. Thus it can be concluded that the size of seedpiece does not have much effect on marketable Warba yields but that marketable yields from Irish Cobbler and Katahdin are affected by seedpiece size.

When the yields from the four different spacings as shown in Table 7 are considered, it is noted that the interaction of varieties by spacings is significant far beyond the 1% point for both total and marketable yields. This means that there is a variation between the varieties in their response to the four spacings. When the mean total and marketable yields in Table 7 are compared, differences of 55.77, 59.85 and 157.36 bushels per acre are noted between the 18- and the 9-inch spacings in the total yields of

Warba, Irish Cobbler, and Katahdin respectively. In the marketable yields, differences of 45.39, 48.83 and 132.27 bushels per acre are observed between the 18- and the 9-inch spacings for Warba, Irish Cobbler, and Katahdin respectively. Thus it may be concluded that the different spacings have a much greater effect on the total and marketable yields for Katahdin than on those for the other two varieties.

The percentages of marketable tubers varied only slightly. The "net marketable" yield which was obtained by subtracting the amount of seed used from the marketable yields was very variable with no evident trends for Warba and Irish Cobbler but with Katahdin they were much higher at closer spacings.

The 1944 Results

The results obtained for each variety in 1944 are shown in Tables 8, 9, and 10. The statistical analyses for total and marketable yields are presented in Tables 11 and 12. Tables 13 and 14 show the effects of the seedpiece sizes and the spacings individually. The total and marketable yields of Warba from ten-foot rows for each rate of planting are shown in Figure 6.

As shown in Table 13, the yields for the Katahdin variety were very similar to those for Warba and Irish Cobbler and were thus much lower than in 1943. The analyses of variance show that the differences between the varieties are not significant.

The analysis of variance for total yields shows the interaction of varieties by seedpieces to be significant beyond the 1% point.

Table 8 - Treatment Means for Warba in 1944.

Size of Seed-piece (ozs.)	Spacing (ins.)	TOTAL YIELDS: Wt. per 30' Row (lbs.)	TOTAL YIELDS: Ounces per Hill	TOTAL YIELDS: Bushels per Acre	MARKETABLE YIELDS (3-12ozs.): Wt. per 30' Row (lbs.)	MARKETABLE YIELDS (3-12ozs.): Ounces per Hill	MARKETABLE YIELDS (3-12ozs.): Bushels per Acre	Percentage Marketable (Per cent)	Amount of Seed Used (Bus./Ac.)	"Net Marketable" Marketable less Seed Used (Bus./Acre)
1	18	29.0	25.2	253.9	19.7	15.8	159.3	67.9	10.1	149.2
1	15	31.8	21.2	256.5	20.9	13.9	168.2	65.7	18.1	156.1
1	12	34.9	18.6	281.3	22.8	12.2	184.5	65.3	15.1	169.4
1	9	41.4	16.6	334.8	24.3	9.7	195.6	58.7	20.2	175.4
2	18	38.5	30.8	310.6	24.5	19.5	196.6	63.6	20.2	176.4
2	15	46.3	30.8	372.7	28.7	19.1	231.1	62.0	24.2	206.9
2	12	48.7	26.0	393.3	29.3	15.6	235.9	60.2	30.3	205.6
2	9	51.8	20.7	417.4	30.0	12.0	242.0	57.9	40.3	201.7
3	18	45.0	36.0	363.0	27.4	21.9	220.8	60.9	30.2	190.6
3	15	51.1	34.1	412.6	31.4	20.9	252.9	61.4	36.3	216.6
3	12	54.1	28.8	435.6	31.7	16.9	255.6	58.6	45.5	210.1
3	9	58.2	23.3	469.4	32.1	12.8	258.1	55.2	60.5	197.6
4	18	52.7	42.2	425.5	33.0	26.4	266.2	62.6	40.3	225.9
4	15	56.3	37.5	453.8	34.3	22.9	277.1	60.9	48.4	228.7
4	12	61.2	32.6	493.1	35.9	18.0	272.5	55.4	60.5	211.8
4	9	63.6	25.5	514.2	34.8	13.9	280.3	54.7	80.6	199.7

WARBA

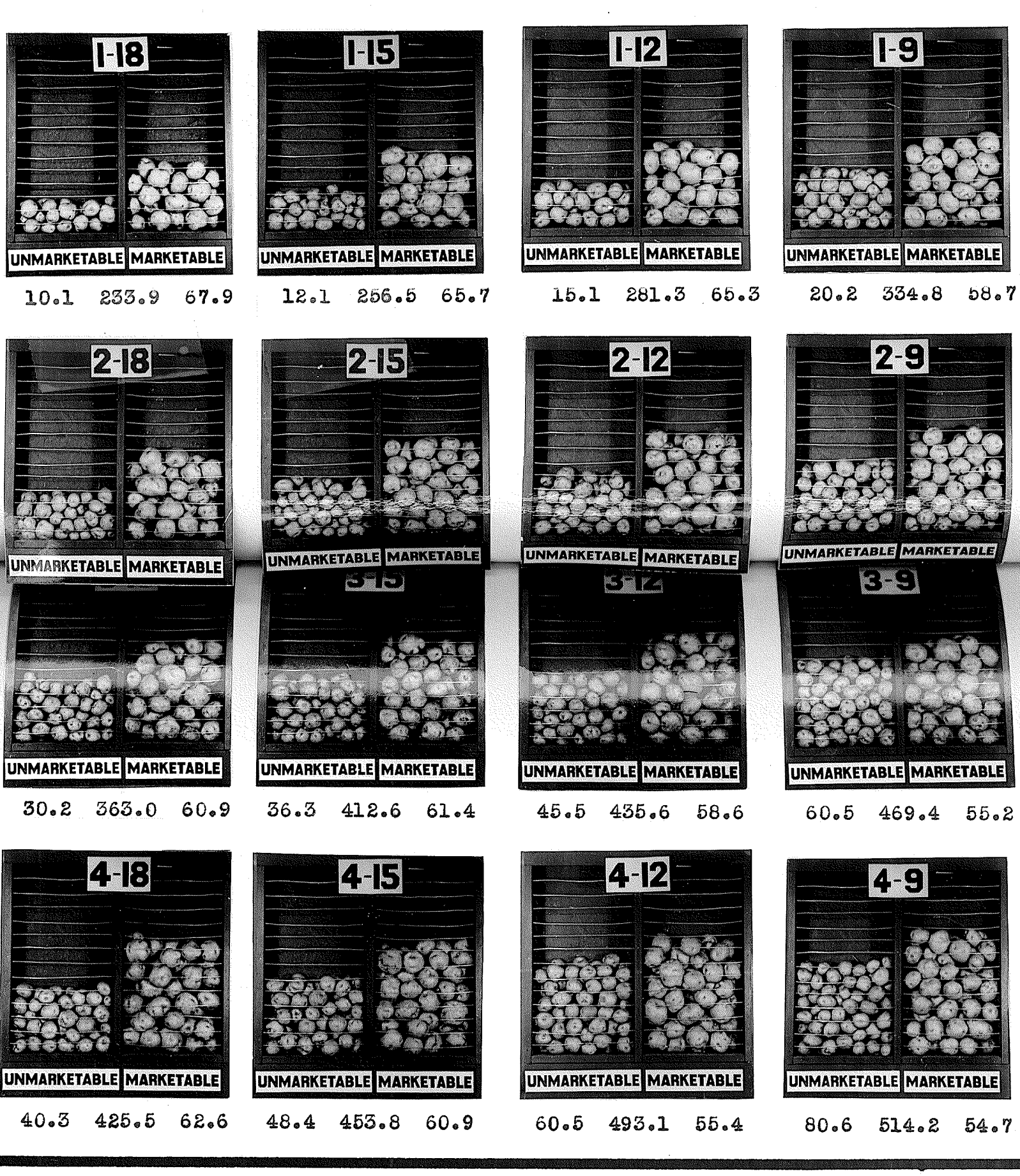


FIGURE 6

Photographs showing the yields obtained from each of the sixteen combinations of seedpiece size and spacing used. These yields are from ten-foot rows and are of the variety Warba. The figures at the top of the photographs refer to the seedpiece size and spacing. For example, 1-18 means one ounce seedpieces were spaced at 18 inches in the row. The information below the photographs gives (1) Seed sown per acre in bushels, (2) Total yield per acre in bushels and (3) Percentage of tubers marketable. Tubers between 3 and 12 ounces were considered to be marketable.

Table 9 - Treatment Means for Irish Cobbler in 1944.

Size of Seed-piece (ozs.)	Spacing (ins.)	TOTAL YIELDS Wt. per 50' Row (lbs.)	TOTAL YIELDS Ounces per Hill	TOTAL YIELDS Bushels per Acre	MARKETABLE YIELDS (3-12ozs.) Wt. per 50' Row (lbs.)	MARKETABLE YIELDS (3-12ozs.) Ounces per Hill	MARKETABLE YIELDS (3-12ozs.) Bushels per Acre	Percentage Marketable (Per cent)	Amount of Seed Used (Bus./Ac.)	"Net Marketable" Marketable less Seed Used (Bus./Acre)
1	18	29.3	23.5	257.0	17.7	14.1	142.2	60.4	10.1	132.1
1	15	35.6	23.7	286.8	22.5	15.0	181.5	63.2	12.1	169.4
1	12	38.5	20.5	310.1	23.5	12.5	189.1	61.0	15.1	174.0
1	9	41.0	16.4	330.7	22.6	9.0	181.5	55.1	20.2	161.3
2	18	38.8	31.1	313.6	25.2	20.2	203.7	64.9	20.2	183.5
2	15	43.8	29.2	353.3	26.4	17.6	213.0	60.3	24.2	188.8
2	12	46.7	24.9	376.6	27.4	14.6	220.8	58.7	30.3	190.5
2	9	46.0	18.4	371.1	21.2	8.5	171.4	46.1	40.3	131.1
3	18	44.5	35.7	360.0	24.1	19.3	194.6	54.2	30.2	164.4
3	15	49.5	33.0	399.3	26.0	17.4	210.5	52.5	36.3	174.2
3	12	55.1	29.4	444.7	28.0	14.9	225.4	50.8	45.5	209.9
3	9	58.7	23.5	473.9	28.5	11.4	229.9	48.5	60.5	169.4
4	18	52.6	42.1	424.5	25.9	20.7	208.7	49.2	40.3	168.4
4	15	55.5	37.0	447.7	28.0	18.7	226.3	50.4	48.4	177.9
4	12	56.4	30.1	453.3	27.1	14.5	219.3	48.0	60.5	158.8
4	9	60.3	24.1	486.0	28.5	11.4	229.9	47.3	80.6	149.3

Table 10 - Treatment Means for Katahdin in 1944.

Size of Seed-piece (ozs.)	Spacing (Ins.)	TOTAL YIELDS: Wt. per 30' Row (lbs.)	TOTAL YIELDS: Ounces per Hill	TOTAL YIELDS: Bushels per Acre	MARKETABLE TUBERS (5-12ozs.): Wt. per 30' Row (lbs.)	MARKETABLE TUBERS (5-12ozs.): Ounces per Hill	MARKETABLE TUBERS (5-12ozs.): Bushels per Acre	Percentage Marketable (Per cent)	Amount of Seed Used (Bus./Ac.)	"Net Marketable" Marketable less Seed Used (Bus./Acre
1	18	32.0	25.6	258.1	22.9	18.4	185.5	71.6	10.1	175.4
1	15	37.8	25.2	304.9	26.8	18.8	227.5	74.6	12.1	215.4
1	12	36.6	19.5	295.0	26.7	14.8	214.8	73.0	15.1	199.7
1	9	43.5	17.4	350.9	30.0	12.0	242.0	69.0	30.2	231.8
2	18	37.7	30.1	303.5	26.4	21.2	213.8	70.0	20.2	193.6
2	15	42.5	28.4	343.6	31.5	21.0	254.1	74.1	24.2	229.9
2	12	42.2	22.6	341.8	27.0	14.4	217.8	64.0	30.3	187.5
2	9	45.1	17.3	348.9	28.0	11.2	225.8	65.0	40.3	185.5
3	18	47.3	37.8	381.1	31.1	24.9	251.1	65.8	30.2	220.9
3	15	48.5	32.4	391.5	31.9	21.3	227.7	65.8	36.3	191.4
3	12	50.0	26.7	403.8	31.6	16.9	255.6	63.2	45.5	210.1
3	9	55.5	22.2	447.7	33.9	13.6	274.3	61.1	60.5	213.8
4	18	46.4	37.2	375.1	28.3	22.6	227.9	61.1	40.3	187.6
4	15	48.4	31.2	377.5	28.1	18.7	226.3	58.1	48.4	177.9
4	12	54.1	28.8	436.6	31.2	16.7	252.5	57.7	60.5	192.1
4	9	56.8	22.7	457.8	33.2	13.3	268.2	58.5	80.6	187.6

Table 11 - Analysis of Variance for Total Yields in 1944.

	Sums of Squares	Degrees of Freedom	Variance	F	5% Point	1% Point	Necessary Difference
Blocks	66,663.01						
Replicates	16,666.67	3	5,555.56	1.03	4.76	9.78	.....
Varieties	17,735.34	2	8,867.67	1.65	5.14	10.92	.....
Error (a)	32,261.00	6	5,376.83				
Total	1,229,657.09						
Seedpiece	685,502.29	3	227,767.43	130.46	2.68	3.94	16.77
Spacing	182,281.80	3	60,760.61	33.80	2.68	3.94	16.77
Seed.x Spac.	9,298.44	9	1,033.16	.59	1.95	2.56	.....
Vars. x Seed.	34,227.70	6	5,704.62	3.26	2.17	2.95	29.24
Vars. x Spac.	5,176.38	6	862.73	.49	2.17	2.95	.....
Vars. x Seed. x Spac.	13,003.05	18	722.59	.35	1.70	2.10	.....
Error (b)	235,684.42	135	1,745.81				

Table 12 - Analysis of Variance for Marketable Yields in 1944.

	Sums of Squares	Degrees of Freedom	Variance	F	5% Point	1% Point	Necessary Difference
Blocks	100,939.17						
Replicates	14,952.93	3	4,987.65	0.91	4.76	9.78	.....
Varieties	53,014.06	2	26,507.03	4.82	5.14	10.92	.....
Error (a)	32,972.18	6	5,495.36				
Total	478,175.20						
Seedpiece	93,327.88	3	31,109.29	20.33	2.68	3.94	15.80
Spacing	51,502.54	3	10,500.85	6.86	2.68	3.94	15.80
Seed.x Spac.	6,280.33	9	697.81	0.46	1.95	2.56	.....
Vars. x Seed.	18,595.23	6	3,099.21	2.03	2.17	2.95	.....
Vars. x Spac.	5,890.03	6	981.67	0.64	2.17	2.95	.....
Vars. x Seed. x Spac.	15,052.64	18	836.26	0.55	1.70	2.10	.....
Error (b)	206,587.38	135	1,530.28				

Table 13 - Mean Total and Marketable Yields and Percentages Marketable of Each Variety for Each of the Four Seedpiece Sizes in 1944.

Seedpiece Sizes		Warba Yield	Warba %age	Irish Cobbler Yield	Irish Cobbler %age	Katahdin Yield	Katahdin %age	Mean Yield	Mean %age
1-oz.	Total	276.61	66.2	291.10	59.7	302.22	72.0	289.98	66.0
	Mark.	183.07		173.92		217.49		191.49	
2-oz.	Total	373.60	65.1	355.52	57.2	354.06	71.6	353.73	65.8
	Mark.	235.78		202.16		259.34		225.76	
3-oz.	Total	422.14	60.0	419.12	51.3	405.84	60.4	415.70	57.2
	Mark.	253.23		215.07		245.16		237.82	
4-oz.	Total	471.53	59.4	453.54	48.7	410.18	61.3	445.02	56.4
	Mark.	280.19		220.72		251.46		250.79	
Mean	Total	385.97	61.7	379.27	53.5	368.08	65.6		
	Mark.	238.07		202.97		238.36			

Table 14 - Mean Total and Marketable Yields and Percentages Marketable of Each Variety for Each of the Four Spacings in 1944.

Spacings		Warba Yield	Warba %age	Irish Cobbler Yield	Irish Cobbler %age	Katahdin Yield	Katahdin %age	Mean Yield	Mean %age
18"	Total	335.01	62.9	333.51	56.2	329.41	66.9	332.64	62.0
	Mark.	210.86		187.41		220.32		206.20	
15"	Total	374.20	62.1	371.84	55.8	352.88	68.0	366.31	61.9
	Mark.	232.56		207.61		239.96		226.71	
12"	Total	400.72	65.9	396.56	53.9	368.83	66.7	388.70	62.1
	Mark.	264.21		213.55		245.90		241.22	
9"	Total	433.96	56.4	415.16	49.0	401.19	61.6	416.77	55.6
	Mark.	244.64		205.29		247.27		231.73	

Thus the effects of the size of seedpieces were not the same for all varieties. When the total yield means in Table 13 are examined, the range in total yield is 194.92, 162.24, and 107.96 bushels per acre between the 1- and the 4-ounce seedpieces for Warba, Irish Cobbler, and Katahdin respectively. Therefore, the seedpiece size had a greater effect on Warba and Irish Cobbler total yields than on those of Katahdin.

When the marketable yields resulting from the use of the four different seedpiece sizes are compared, a difference of 15.80 bushels per acre is required for significance. Since the interaction of varieties by seedpieces is not significant, all varieties responded in a similar manner to seedpiece size as far as marketable yields are concerned. When the above necessary difference is applied to the seedpiece size means in Table 13, a significant difference is observed only between the 1- and 2-ounce seedpieces.

In comparing the spacing effects shown in Table 14, necessary differences are 16.77 and 15.80 bushels per acre for total and marketable yields respectively. When these are applied there is a significant difference between each spacing for total yields but only between the 18- and 15-inch spacings for marketable yields. The interaction of varieties by spacings is not significant and thus all the varieties responded in a similar manner to the different spacings.

In the percentage of marketable tubers there was a variation of 13% between the lightest and the heaviest rates for each variety. While the marketable yields increased as the rate increased, the

"net marketable " yields showed a decided decrease with the heavier rates of planting.

The 1943 and 1944 Combined Results

The combined results for each variety are shown in Tables 15, 16, and 17. The statistical analyses for the combined years results are presented in Tables 18 and 19. Histograms comparing the total and marketable yields with the amount of seed used for each variety are presented in Figures 7, 8, and 9.

In comparing the variety means for total yields it is noted in Table 18 that the differences between the varieties are not significant but that the interaction of varieties by years is significant beyond the 1% point.

This indicates that there was a variation in the total yields between the years. When the variety mean total yields which are shown in Tables 6 and 13 for 1943 and 1944 respectively are compared, it is observed that the yields for Katahdin are much higher in 1943 than in 1944. This undoubtedly accounts for the significant interaction.

When marketable yields are considered, the analysis of variance shows significant differences for both varieties and the interaction of varieties by years. A necessary difference of 22.32 bushels per acre is required for significance between the variety means shown in Table 20. Thus when marketable yields are compared there are significant differences between Katahdin and the other two varieties but not between Warba and Irish Cobbler.

Table 15 - Treatment Means for Werba in 1945 and 1944 (combined).

Size of Seed-piece (ozs.)	Spacing (Ins.)	TOTAL YIELDS: Wt. per 50' Row (lbs.)	TOTAL YIELDS: Ounces per Hill	TOTAL YIELDS: Bushels per Acre	MARKETABLE YIELDS (3-12ozs.): Wt. per 50' Row (lbs.	MARKETABLE YIELDS (3-12ozs.): Ounces per Hill	MARKETABLE YIELDS (3-12ozs.): Bushels per Acre	Percentage Marketable (Per cent)	Amount of Seed Used (Bus./Ac.)	"Net Marketable" Marketable less Seed Used (Bus./Acre)
1	18	34.2	27.3	275.3	22.0	17.6	177.5	64.3	10.1	167.4
1	15	36.5	24.3	294.0	24.2	16.3	197.2	66.3	12.1	186.1
1	12	39.1	20.9	316.1	24.9	15.3	201.2	63.7	15.1	186.1
1	9	43.5	17.5	352.9	27.5	11.1	223.8	63.2	20.2	203.6
2	18	42.4	34.0	342.8	25.0	20.0	201.7	59.0	20.2	181.5
2	15	45.6	30.4	367.8	28.2	18.8	227.5	61.8	24.2	205.3
2	12	50.0	26.7	405.8	31.0	16.5	249.6	62.0	30.3	219.3
2	9	52.2	20.9	421.5	30.8	12.3	248.0	59.0	40.3	207.7
3	18	45.9	56.8	371.1	26.9	31.5	216.8	58.6	30.3	186.6
3	15	50.8	33.9	410.2	31.2	20.8	251.7	61.4	36.3	215.4
3	12	50.9	27.1	409.9	29.9	15.9	240.5	58.7	45.5	194.0
3	9	56.4	22.6	455.8	30.9	12.4	250.1	54.8	60.5	189.6
4	18	50.5	40.4	407.4	29.9	24.0	242.0	59.2	40.3	201.7
4	15	53.5	35.7	432.0	32.7	21.8	263.8	61.1	48.4	215.4
4	12	57.3	30.6	462.8	32.8	17.5	264.7	57.2	60.5	204.2
4	9	59.7	25.9	482.0	34.2	13.7	276.3	57.3	80.6	195.7

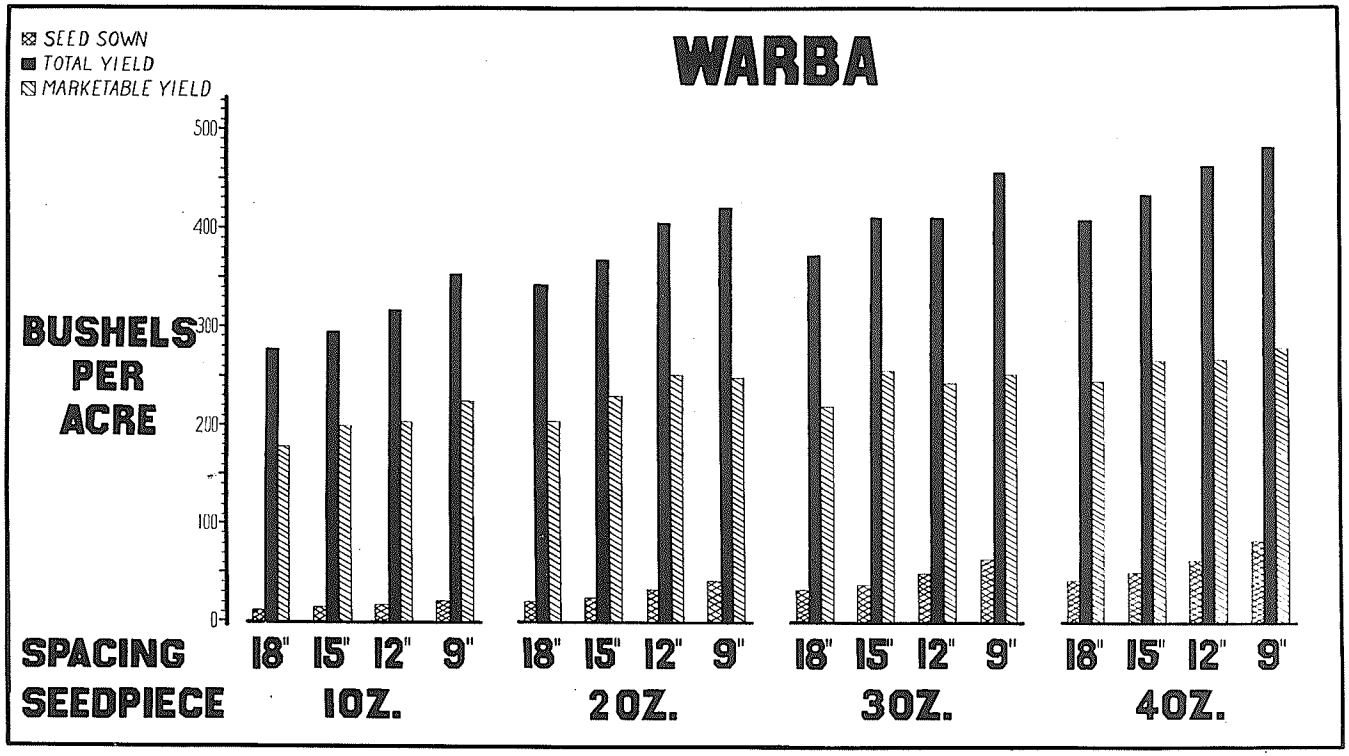


Figure 7 - Histograms Illustrating the Total and Marketable Yields of Warba Compared to the Amount of Seed Sown for Each Treatment in 1943 and 1944 (Combined).

Table 16 - Treatment Means for Irish Cobbler in 1943 and 1944 (combined).

Size of Seed-piece (ozs.)	Spacing (Ins.)	TOTAL YIELDS: Wt. per 30' Row (lbs.)	TOTAL YIELDS: Ounces per Hill	TOTAL YIELDS: Bushels per Acre	MARKETABLE YIELDS (3-12ozs.): Wt. per 30' Row (lbs.)	MARKETABLE YIELDS (3-12ozs.): Ounces per Hill	MARKETABLE YIELDS (3-12ozs.): Bushels per Acre	Percentage Marketable (Per cent)	Amount of Seed Used (Bus./Ac.)	"Net Marketable" less Seed Used (Bus./Acre)
1	18	32.7	26.2	264.2	20.3	16.2	163.3	62.1	10.1	153.2
1	15	38.0	25.3	306.1	24.6	16.4	198.4	64.7	12.1	186.3
1	12	40.2	21.4	325.7	25.4	13.5	204.2	63.2	15.1	189.1
1	9	40.8	16.3	328.7	24.3	9.7	195.6	58.6	20.2	175.4
2	18	41.1	32.5	331.7	27.9	22.4	225.9	67.9	20.2	205.7
2	15	45.4	30.3	366.6	29.3	19.6	237.2	64.5	24.2	213.0
2	12	46.8	25.0	378.1	29.8	15.9	240.5	63.7	30.3	210.2
2	9	48.7	19.5	393.2	28.9	11.6	253.9	59.3	40.3	193.6
3	18	42.6	34.2	344.8	25.2	20.2	203.7	59.2	30.2	173.5
3	15	50.6	33.8	409.0	29.3	19.5	235.9	57.9	36.3	199.6
3	12	53.5	28.5	431.1	31.9	17.0	257.1	59.6	45.5	211.6
3	9	55.8	22.4	451.7	32.4	13.0	262.2	58.1	60.5	201.7
4	18	50.1	40.1	404.3	29.2	23.3	234.9	58.3	40.3	194.6
4	15	54.4	36.3	439.2	31.5	21.0	254.1	57.9	48.4	205.7
4	12	53.3	28.4	429.6	31.3	16.7	252.6	58.7	60.5	192.1
4	9	56.3	22.5	455.7	33.2	13.3	268.2	58.9	80.6	187.6

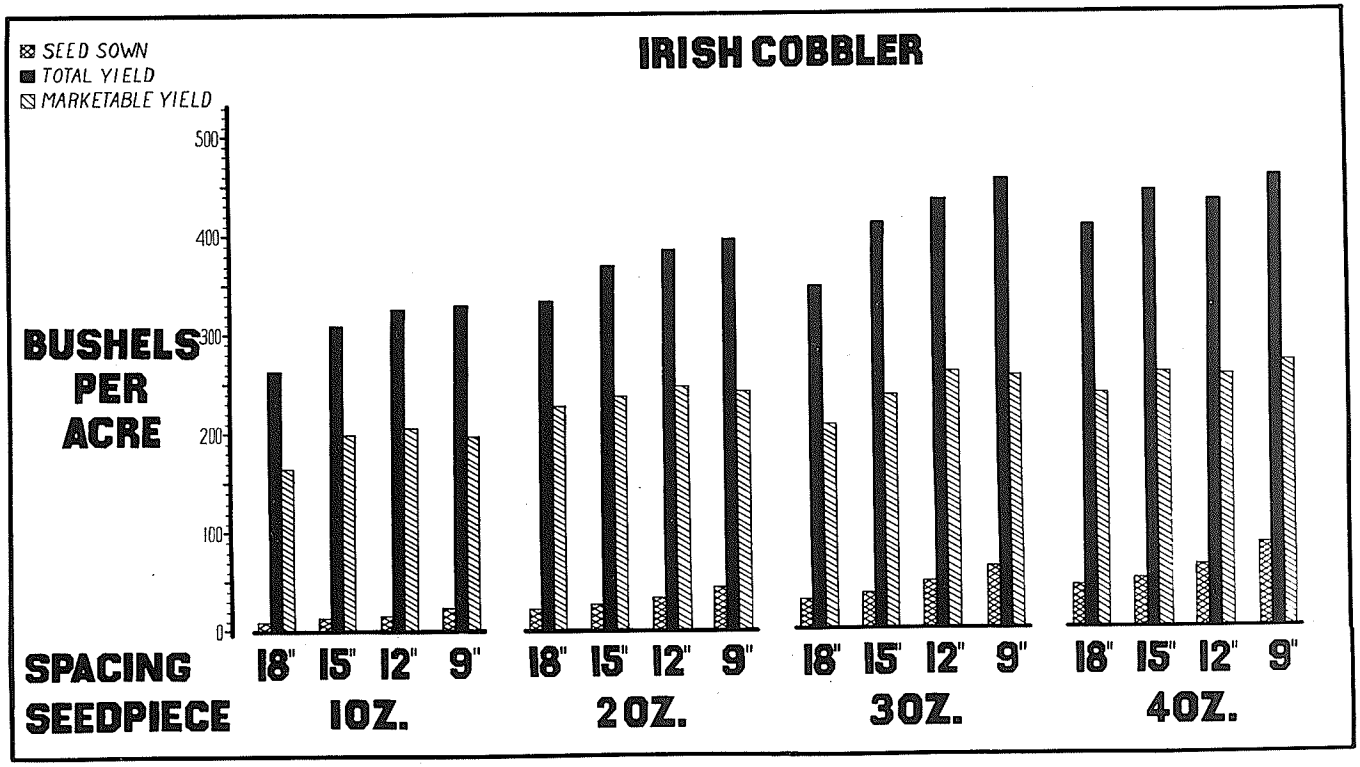


Figure 8 - Histograms Illustrating the Total and Marketable Yields of Irish Cobbler Compared to the Amount of Seed Sown for Each Treatment in 1943 and 1944 (Combined).

Table 17 - Treatment Means for Katahdin in 1943 and 1944 (combined).

Size of Seed-piece (ozs.)	Spacing (Ins.)	TOTAL YIELDS: Wt. per 30' Row (lbs.)	TOTAL YIELDS: Ounces per Hill	TOTAL YIELDS: Bushels per Acre	MARKETABLE YIELDS (6-12ozs.): Wt. per 30' Row (lbs.)	MARKETABLE YIELDS (6-12ozs.): Ounces per Hill	MARKETABLE YIELDS (6-12ozs.): Bushels per Acre	Percentage Marketable (Per cent)	Amount of Seed Used (Bus./Ac.)	"Net Marketable" Marketable less Seed Used (Bus./Acre)
1	18	33.5	26.8	270.2	23.7	19.0	191.6	70.7	10.1	181.5
1	15	38.9	26.0	314.6	27.2	18.1	219.0	69.9	12.1	206.9
1	12	41.7	22.5	337.5	30.0	16.0	242.0	71.9	15.1	226.9
1	9	54.2	21.3	439.6	36.2	14.5	292.4	66.4	20.2	272.2
2	18	46.5	37.1	374.1	28.6	22.9	230.9	61.5	20.2	210.7
2	15	46.2	30.8	372.7	31.8	21.2	256.5	68.8	24.2	232.3
2	12	47.5	25.2	381.2	31.6	16.8	254.1	66.5	30.3	223.8
2	9	54.4	21.8	439.6	36.5	14.6	294.4	67.1	40.3	254.1
3	18	47.4	37.9	382.1	30.6	24.5	247.0	64.6	30.2	216.8
3	15	52.0	34.7	419.9	35.3	23.6	285.6	67.9	36.3	249.3
3	12	59.3	31.7	479.5	38.2	20.4	308.5	64.4	45.5	263.0
3	9	64.8	25.9	522.3	42.6	17.1	344.8	65.7	60.5	284.3
4	18	51.5	41.2	415.4	32.6	26.0	262.2	63.3	40.3	221.9
4	15	56.5	36.4	440.4	37.1	25.0	302.5	65.7	48.4	254.1
4	12	59.5	31.7	479.5	41.4	22.1	334.3	69.6	60.5	273.8
4	9	62.0	24.8	500.1	41.2	16.5	332.7	66.5	80.6	252.1

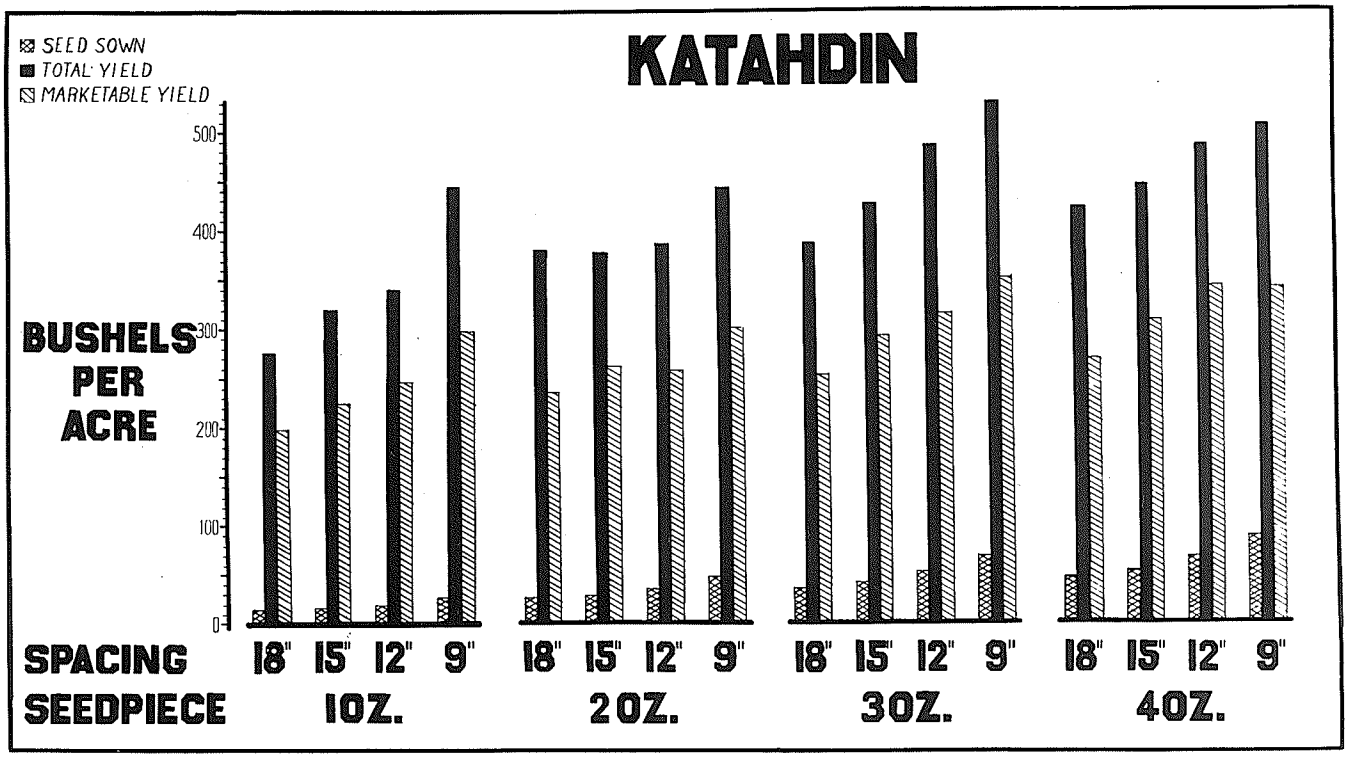


Figure 9 - Histograms Illustrating the Total and Marketable Yields of Katahdin Compared to the Amount of Seed Sown for Each Treatment in 1943 and 1944 (Combined).

Table 18 - Analysis of Variance for Total Yields in 1943 and 1944 (combined).

	Sums of Squares	Degrees of Freedom	Variance	F	5% Point	1% Point	Necessary Difference
Years	95,026.18	1					
Blocks	428,371.14						
Replicates	52,182.18	6	8,697.03	0.88	3.00	4.82	.....
Varieties	69,517.70	2	34,758.85	3.51	3.88	6.93	.....
Vars. x Years	188,012.04	2	94,006.02	9.50	3.88	6.93	38.30
Error (a)	118,659.22	12	9,888.27				
Total	2,492,989.40						
Seedpiece	902,158.53	3	300,719.51	224.19	2.64	3.86	10.40
Seed.x Years	56,443.74	3	18,814.58	14.03	2.64	3.86	14.79
Spacing	390,623.54	3	130,207.85	97.07	2.64	3.86	10.40
Spac.x Years	1,871.05	3	623.68	.46	2.64	3.86	.....
Seed.x Spac.	19,909.95	9	2,212.22	1.65	1.91	2.48	.....
Seed.x Spac. x Years	23,969.51	9	2,663.27	1.99	1.91	2.48	29.45
Vars.x Seed.	10,097.77	6	1,682.96	1.25	2.13	2.88	.....
Vars.x Seed. x Years	43,257.50	6	7,209.58	5.37	2.13	2.88	25.49
Vars.x Spac.	34,940.21	6	5,823.36	4.34	2.13	2.88	18.02
Vars.x Spac. x Years	49,216.12	6	8,202.69	6.12	2.13	2.88	25.49
Vars.x Seed. x Spac.	54,435.32	18	3,024.18	2.25	1.64	1.98	36.07
Vars.x Seed. x Spac.xYears	20,495.70	18	1,138.65	.85	1.64	1.98	.....
Error (b)	362,173.14	270	1,341.38				

Table 19 - Analysis of Variance for Marketable Yields in 1943 and 1944 (combined).

	Sums of Squares	Degrees of Freedom	Variance	F	5% Point	1% Point	Necessary Difference
Years	155,969.07	1					
Blocks	368,416.86						
Replicates	28,991.42	6	4,831.90	0.72	3.00	4.82	.....
Varieties	157,178.94	2	78,589.47	11.70	3.88	6.93	22.32
Vars. x Years	101,616.45	2	50,808.22	7.56	3.88	6.93	31.59
Error (a)	80,630.06	12	6,719.17				
Total	1,310,778.35						
Seedpiece	224,330.34	3	74,776.78	99.26	2.64	3.86	7.80
Seed.x Years	2,927.02	3	975.67	1.30	2.64	3.86	.....
Spacing	146,260.60	3	48,753.53	64.72	2.64	3.86	7.80
Spac.x Years	32,653.21	3	10,884.40	14.45	2.64	3.86	11.03
Seed.x Spac.	4,651.33	9	516.81	0.69	1.91	2.48	.....
Seed.x Spac. x Years	10,201.18	9	1,133.46	1.50	1.91	2.48	.....
Vars.x Seed.	7,772.41	6	1,295.40	1.72	2.13	2.88	.....
Vars.x Seed. x Years	57,552.76	6	9,592.13	12.73	2.13	2.88	19.11
Vars.x Spac.	25,492.69	6	4,248.78	5.64	2.13	2.88	13.51
Vars.x Spac. x Years	28,632.24	6	4,772.04	6.33	2.13	2.88	19.11
Vars.x Seed. x Spac.	28,601.18	18	1,588.95	2.11	1.64	1.98	27.03
Vars.x Seed. x Spac.xYears	13,917.89	18	773.21	1.03	1.64	1.98	.....
Error (b)	203,599.57	270	753.33				

Table 20 - Mean Total and Marketable Yields and Percentages Marketable of Each Variety For Each of the Four Seedpiece Sizes in 1943 and 1944 (Combined).

Seedpiece Sizes		Warba Yield	Warba %age	Irish Cobbler Yield	Irish Cobbler %age	Katahdin Yield	Katahdin %age	Mean Yield	Mean %age
1-oz.	Total	308.92	65.3	305.61	62.3	339.78	69.4	318.10	65.8
	Mark.	201.78		190.39		235.93		209.36	
2-oz.	Total	383.57	61.6	367.04	63.7	391.54	67.5	380.65	64.3
	Mark.	236.08		233.71		264.44		244.74	
3-oz.	Total	412.04	58.8	408.23	58.6	450.41	64.1	423.56	60.6
	Mark.	242.27		239.15		288.67		256.70	
4-oz.	Total	445.56	59.3	431.03	58.5	458.49	67.8	445.03	61.9
	Mark.	264.09		252.23		310.68		275.67	
Mean	Total	387.47	60.9	377.98	60.6	410.06	67.0		
	Mark.	236.05		228.87		274.93			

Table 21 - Mean Total and Marketable Yields and Percentages Marketable of Each Variety For Each of the Four Spacings in 1943 and 1944 (Combined).

Spacing		Warba Yield	Warba %age	Irish Cobbler Yield	Irish Cobbler %age	Katahdin Yield	Katahdin %age	Mean Yield	Mean %age
18"	Total	349.63	59.9	335.58	61.6	360.22	64.7	348.48	62.1
	Mark.	209.10		206.73		233.20		216.34	
15"	Total	375.76	62.3	379.52	60.9	386.45	68.3	380.58	63.9
	Mark.	234.23		231.16		263.80		243.06	
12"	Total	397.51	63.4	390.47	61.1	418.76	69.2	402.24	64.7
	Mark.	252.22		238.51		289.90		260.21	
9"	Total	426.99	58.2	406.34	58.8	474.79	65.9	436.04	61.4
	Mark.	248.67		239.09		312.81		267.52	

As with the total yields, Katahdin marketable yields were much higher in 1943 than in 1944 which accounts for the significant interaction of varieties by years.

In comparing the mean total yields from each seedpiece size as presented in Table 20, a difference of 10.40 bushels per acre is required for significance. When this necessary difference is applied it is noted that significant differences occur between mean yields from each seedpiece size.

Since the interaction of seedpieces by years is also significant far beyond the 1% point, the effects of the seedpiece sizes were not constant for each year. When the mean yields for each seedpiece size for each year (shown in Tables 6 and 13) are compared, a range of 98.81 and 155.04 bushels per acre between the yields from the 1- and the 4-ounce seedpieces is observed for 1943 and 1944 respectively. Thus the seedpiece size had a much greater effect in 1944 than in the previous year.

When the marketable yields are considered, the analysis of variance (Table 19) shows that a difference of 7.80 bushels is required for significance between the mean yields per acre from each seedpiece size. When this is applied to the means in Table 20, significant differences are noted between each. As the seedpieces by years interaction is not significant, there is no difference between the years in their response to different seedpiece sizes.

Histograms showing the general means of the total and marketable yields compared to the amount of seed used for each seedpiece size are shown in Figure 10. The total and marketable yields obtained

from 10-foot rows of each seedpiece size at a constant spacing of 12 inches are shown in Figure 11.

The mean total and marketable yields resulting from the use of the four different spacings are shown in Table 21. Since when the mean total yields are compared, a difference of 10.40 bushels per acre is required for significance, the differences between the total yields from each spacing are significant. The interaction of spacings by years is not significant which means that the response to the different spacings was similar for each year.

In considering the mean marketable yields, the analysis of variance shows a necessary difference of 7.80 bushels per acre between the means. When this difference is applied, significant differences are noted between the yields from each spacing except that between the 12- and 9-inch. The interaction of spacings by years is also significant. This means that the effects of the spacings were not constant for each year. The range between the marketable yields produced at 18- and 9-inch spacings is 75.50 and 25.53 bushels per acre (Tables 7 and 14) for 1943 and 1944 respectively. Thus the spacings produced a much greater effect in 1943 than in 1944.

Histograms showing the general means of the total and marketable yields compared to the amount of seed used for each spacing are shown in Figure 10. Total and marketable yields obtained from 10-foot rows of each spacing using a constant seedpiece size of 3 ounces are shown in Figure 12.

The interaction of seedpieces by spacings is not significant

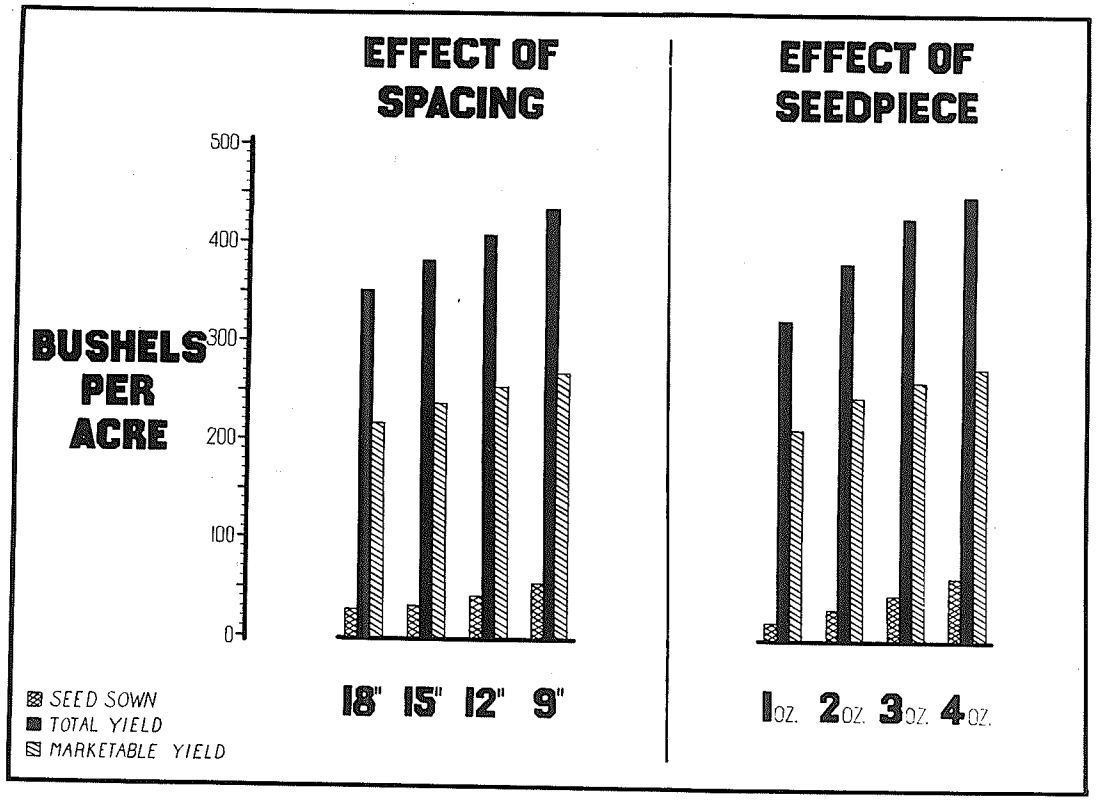


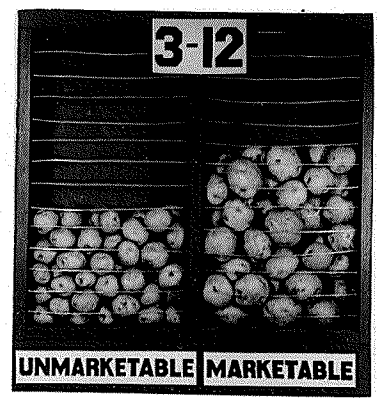
Figure 10 - Histograms Illustrating the Mean Total and Marketable Yields of the Combined Varieties for Each Spacing and Each Seedpiece Size Compared to the Amount of Seed Sown in 1943 and 1944 (Combined).

EFFECT OF SEEDPIECE

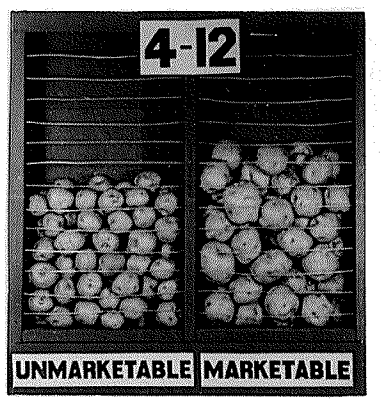
WARBA

15.1 281.3 65.3

30.3 393.3 60.2

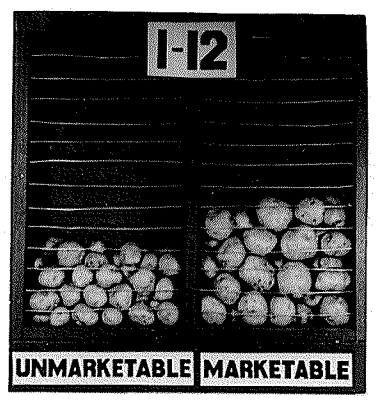


45.5 435.6 58.6



60.5 493.1 55.4

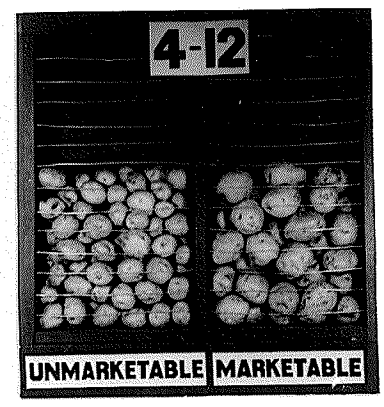
IRISH COBBLER



15.1 310.1 61.0

30.3 376.6 58.7

45.5 444.7 50.8



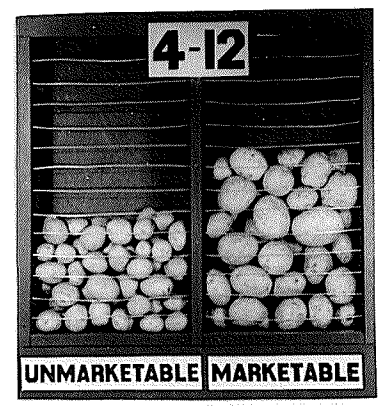
60.5 455.3 48.0

KATAHDIN

15.1 295.0 73.0

30.3 341.8 64.0

45.5 403.8 63.2



60.5 435.6 57.7

FIGURE 11

Photographs showing the yields obtained from plots sown with 1, 2, 3, and 4 ounce seedpieces (left to right). These yields were taken from ten-foot rows the seedpieces of which were all spaced at 12 inches. The information below the photographs gives (1) Seed sown per acre in bushels. (2) Total yield per acre in bushels and (3) Percentage of tubers marketable. Tubers between 3 and 12 ounces were considered to be marketable.

for either total or marketable yields (Tables 18 and 19) which indicates that there is no significant relationship between seedpiece size and spacing.

The interaction of varieties by seedpieces is likewise not significant which indicates that the seedpiece sizes responded in a similar manner for each variety over the two years.

When the interaction of varieties by spacings is considered, significant differences are shown for both total and marketable yields. This proves that the varieties did not all respond in a similar manner to the different spacings. When the mean total and marketable yields are compared in Table 21, the range in yield between the 18- and the 9-inch spacings is 77.36, 70.76, and 114.57 bushels per acre for total and 39.57, 32.36, and 79.61 bushels per acre for marketable for Warba, Irish Cobbler, and Katahdin respectively. Thus it may be concluded that the spacing does not have much effect on Warba and Irish Cobbler yields but with Katahdin much greater yields are obtained at closer spacings.

Therefore, the analyses of variance for the two years combined results have shown that the total and marketable yields increased significantly as the seedpiece increased in size but that significantly greater yields were obtained at the closer spacings only with Katahdin.

When the percentages of marketable tubers resulting from the use of the four seedpiece sizes are compared (Table 20), slight decreases are observed as the seedpiece increases in size for the Warba and Irish Cobbler varieties but with Katahdin no distinct trend can be noted. No consistent differences are observed when the percentages

EFFECT OF SPACING

WARBA

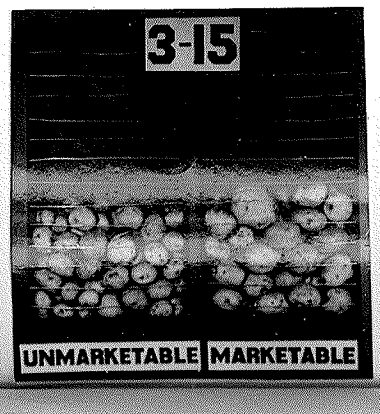
30.2 363.0 60.9

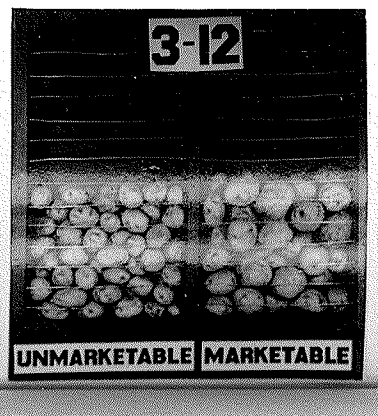
36.3 412.6 61.4

45.5 435.6 58.6

60.5 469.4 55.2

IRISH COBBLER





30.2 381.1 65.8

36.6 391.5 65.7

45.5 403.8 63.2

60.5 447.7 61.1

FIGURE 12

Photographs showing the yields obtained from plots the seedpieces of which were spaced at 18, 15, 12, and 9 inches in the row (left to right). These yields were taken from ten-foot rows sown with three ounce seedpieces. The information below the photographs gives (1) Seed sown per acre in bushels. (2) Total yield per acre in bushels and (3) Percentage of tubers marketable. Tubers between 3 and 12 ounces were considered to be marketable.

of marketable tubers resulting from the use of the four spacings are compared (Table 21).

DISCUSSION

The 1943 Results

It was noted under experimental procedure that the plots were planted very late (June 15 and 16) in 1943. This was due to the excessive rains in May. It is observed in the weather records (Table 22) that the precipitation during May was well above normal. Nevertheless, very good yields were produced.

The autumn was fine and dry as shown by the below normal precipitation and the above normal sunshine. This undoubtedly accounts for the very high yields obtained from the Katahdin variety which made strong growth up until frost.

Due to the favorable growing conditions, considerable percentages of very large tubers were produced, especially with Katahdin. This accounts for the small amount of variation between the percentages of marketable tubers for the different rates. Those planted with small seedpieces or at wide spacings produced a considerable percentage of tubers over 12 ounces but few small tubers under 3 ounces, whereas those planted with large seedpieces or at close spacings produced a good percentage of tubers below 3 ounces but very few over 12 ounces. Thus the percentages of tubers between 3 and 12 ounces varied only slightly.

The 1944 Results

While the plots were planted in mid-May, slow growth was made during June due to very heavy rains. It is noted in the weather

records (Table 22) that the precipitation for June was twice that of normal. The fall was also excessively wet and dull, the precipitation for August being also over twice that of normal, while the sunshine for August and September was below normal. These conditions were extremely unfavorable for a late variety and thus the yields for Katahdin were much lower than in 1943.

Due to the unfavorable conditions, very few tubers over 12 ounces in weight were produced and therefore the unmarketable tubers were almost entirely under 3 ounces in weight. Thus the percentages of tubers between 3 and 12 ounces decreased as the rate of planting increased for all varieties.

The 1943 and 1944 Combined Results

Since the total and marketable yields showed an upward trend as the rate of planting increased and because the yields from the heavier rates of planting are significantly higher than those from the lower planting rates, it can be stated that the total and marketable yields of all the varieties increased directly with the rate of planting within the limits of the experiment. Therefore, the highest rate of planting (4-ounce seedpieces spaced at 9 inches using 80.6 bushels of seed per acre) gave the greatest total and marketable yields per acre when the quantity of seed used was disregarded. However, the lowest rate of planting (1-ounce seedpiece spaced at 18 inches using 10.1 bushels of seed per acre) gave the greatest total and marketable yields from a given quantity of seed.

The weight per hill decreased as the seedpiece size decreased or as the spacing became closer. The percentages of marketable tubers,

Table 22 - x Winnipeg Weather Records for the Years 1943 & 1944 Compared to Normal.

Month	Mean Temperature (degrees)			Precipitation (inches)			Sunshine (percent of possible)		
	1943	1944	Normal	1943	1944	Normal	1943	1944	Normal
April	39.7	40.8	37.6	0.28	0.32	1.32	57	62	49
May	48.6	56.0	52.0	3.20	1.91	2.21	42	42	51
June	58.6	60.2	62.0	3.81	6.74	3.07	43	42	51
July	70.7	66.5	67.0	3.46	1.58	2.95	69	64	60
August	65.4	65.8	64.2	2.90	5.44	2.49	61	53	58
September	53.5	55.2	54.2	1.57	1.53	2.20	55	35	47
October	46.9	44.7	41.2	0.46	1.06	1.40	64	58	39

x Official Records Compiled by the Meteorological Division, Air Services, Dept. of Transport.

that is, tubers between 3- and 12-ounces in weight decreased slightly as the seedpiece size increased or as the spacing diminished. In general, there was a larger percentage below three ounces with large seedpieces or close spacings while on the other hand there was a larger percentage over 12-ounces when the seedpiece was small or the spacing wide. This varied depending on the weather conditions and the variety as has been shown.

It would appear from the yields obtained that in using a constant amount of seed per acre, planting small seedpieces at close spacing will give much higher yields than larger seedpieces sown at wider spacings. This is clearly shown when the yields from the 1-ounce sets planted at 9-inches and the 2-ounce seedpieces spaced at 18-inches are compared in Table 15.

The analyses of variance show that the interaction of seedpieces by spacings is not significant for either total or marketable yields. This shows that there is no relationship between seedpiece size and spacing and therefore these can be treated independently. This means that the seedpiece size producing the best yields will do so regardless of spacing whereas the spacing giving the largest yields will do so regardless of the size of seed used.

Therefore, the seedpiece size and spacing beyond which no significant increases are obtained can be combined to give the rate of planting beyond which significantly increased yields are not produced. The marketable yields are of first importance. When these are considered, the limits mentioned above have been shown by the analyses of variance (Page 57).

These limits, however, do not take into consideration the amount of seed planted. The rate of planting was very high when the larger seedpieces were used. To compensate for this "net marketable" yields were calculated. The "net marketable" are the marketable yields with the amount of seed deducted and thus show the most profitable planting rate. These increased to a certain point for each variety and then diminished as the amount of seed planted per acre became excessive (shown in Tables 15, 16 and 17). For instance, when the 1-ounce at 18-inch rate was used, the marketable yield was about ten-fold greater than the amount of seed used. However, when 4-ounce sets were planted at 9 inches, the seed planted amounted to around 35% of the resulting marketable yields (Illustrated in Figures 7, 8, and 9). This point of diminishing returns was reached when the increase in marketable yield failed to equal the increase in seed required.

Rates of 2-ounce seedpiece at 12-inch spacing for Warba, 2-ounce seedpiece at 15-inch spacing for Irish Cobbler, and 3-ounce seedpiece at 9-inch spacing for Katahdin produced the highest "net marketable" yields.

The most profitable planting rate combinations are more clearly shown when the "net return per acre" is considered. This is the value per acre minus the cost of seed and is shown in Table 23. The cost of seed used is a ten-year average of cost figures for certified seed in the spring while the value per acre was derived as the mean value for table stock in the fall over a ten-year period.

While the 1-ounce seedpieces show good net returns, the data presented doesn't take the stand of the plants into consideration.

Table 23 - The Calculation of "Net Return per Acre" for Warba, Irish Cobbler, and Katahdin.

Size of Seed-piece (ozs.)	Spacing (ins.)	Cost of Seed at $1.35 per Bu.	Value per Acre at $0.55 per Bushel			"Net Return per Acre" Value per Acre minus the Cost of Seed		
			Warba	Irish Cobbler	Katahdin	Warba	Irish Cobbler	Katahdin
1	18	$13.64	$ 97.63	$ 89.82	$ 105.38	$ 83.99	$ 76.18	$ 91.74
1	15	16.34	108.46	109.12	120.45	92.12	92.78	104.11
1	12	20.39	110.66	113.31	133.10	90.27	91.92	112.71
1	9	27.27	125.09	107.58	160.82	95.82	80.31	133.55
2	18	27.27	110.94	124.25	127.00	83.67	96.98	99.73
2	15	32.67	125.13	130.46	141.08	92.46	97.79	108.41
2	12	40.91	137.28	132.28	139.76	96.37	91.37	98.85
2	9	54.41	136.40	128.65	164.67	81.99	74.24	110.26
3	18	40.77	119.24	112.04	135.85	78.47	71.27	95.08
3	15	49.01	138.44	129.75	157.08	89.43	80.74	108.07
3	12	61.45	132.28	141.41	169.68	70.83	79.98	108.25
3	9	81.68	137.56	144.21	189.64	55.88	62.53	107.96
4	18	54.41	133.10	129.20	144.21	78.69	74.79	89.80
4	15	65.34	145.09	139.76	166.38	79.75	74.42	101.04
4	12	81.68	145.59	138.93	183.87	63.91	57.25	102.19
4	9	108.81	151.97	147.51	182.99	43.16	38.70	74.18

Obtaining a good stand is much more difficult with sets as small as 1-ounce in weight because they are more perishable under adverse weather conditions. If too dry they become desiccated and if conditions are wet they rot very readily. It is also considered impractical to cut seedpieces as small as 1-ounce because a good portion of the tuber, especially if large, is wasted.

When these "net returns per acre" are compared the highest returns are shown to be obtained from the use of 2-ounce seedpieces spaced at 12 inches for Warba and 2-ounce seedpieces spaced at 15-inches for Irish Cobbler. The Katahdin results are more variable but when the 1-ounce seedpieces are eliminated, a rate of 2-ounce seedpiece at 9 inches gave the highest returns.

Therefore, with the Warba variety, 2-ounce seedpieces spaced at 12 inches using 30.3 bushels per acre was the most profitable and practical rate while with Irish Cobbler 2-ounce seedpieces spaced at 15 inches using 24.2 bushels per acre was the most profitable. The Katahdin variety gave the highest returns at a rate of 2-ounce seedpiece at 9-inch spacing which required 40.3 bushels per acre.

II EFFECTS OF SEEDPIECE SIZE AND SPACING RELATIONSHIPS ON THE SIZE AND WEIGHT OF POTATO TOPS

Larger seedpieces produce a greater number of sprouts and young plants with larger, more vigorous growing tops than smaller seedpieces. This has been noted by several investigators including Aicher (1), Findlay and Sykes (14), Singh and Warkankar (30), Sprague and Evaul (34), and Tingey and Stewart (39).

Using the Warba variety in 1944, measurements of the tops were recorded for each of the sixteen rates of planting. The weight of the tops was also determined. In obtaining these weights, 15-foot rows in an extra replicate were used and therefore this determination did not interfere with the plots in Section I. When the tops were considered to be of maximum size -- that is, just before they commenced to die down -- they were cut off at ground level and weighed. These measurements and weights are shown in Table 24. The data was not extensive enough for statistical analysis.

It is noted that both the height and the spread increased directly with increased rate of planting. It was thought that the seedpiece size was largely responsible for the actual size, the larger measurements for the closer spacing being due to the fact that the tops were packed closer together, thus causing them to extend their growth in height and width as the alloted space decreased. Figure 13 shows a comparison of plants produced from 1- and 4-ounce seedpieces 25 days after emergence.

The weight of the tops varied directly with seedpiece size

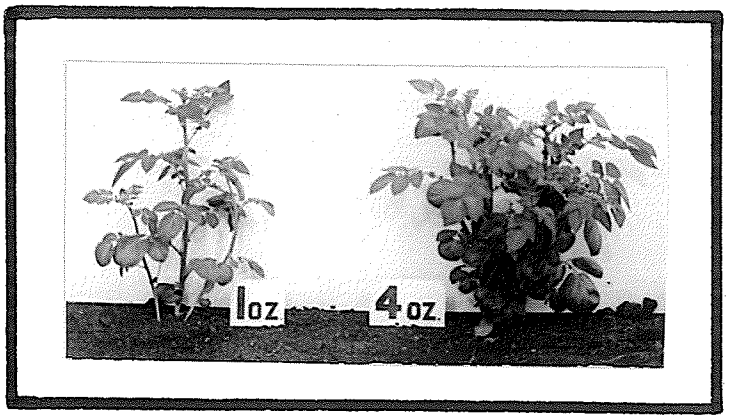


Figure 13 - Photograph Showing the Size of Tops Produced from a 1- and a 4-ounce Seedpiece 25 Days After Emergence.

Table 24 - The Size and Weight of Potato Tops of Warba for Each of the Sixteen Rates of Planting.

Size of Seed-piece (ozs.)	Spac-ing (Ins.)	Height of Top (Inches)	Spread of Top (Inches)	Weight of Tops from 15' Row. (lbs.)
1	18	17	16	7.1
1	15	18	17	7.4
1	12	18	19	8.5
1	9	19	19	9.9
2	18	20	18	7.5
2	15	21	19	7.9
2	12	22	19	9.1
2	9	22	20	10.6
3	18	21	19	9.5
3	15	22	21	9.9
3	12	23	22	10.7
3	9	24	23	11.4
4	18	23	20	10.3
4	15	23	22	11.1
4	12	24	22	11.8
4	9	25	23	12.1

and spacing. Again the differences were greatest between the seedpieces of different sizes, very little variation in weight being noted between the spacings when the seedpiece size was held constant.

Therefore it would appear that the larger yields obtained from heavier planting rates were due primarily to the much greater amount of foliage produced.

III THE EFFECTS OF SEEDPIECE SIZE AND SPACING RELATIONSHIPS ON SPECIFIC GRAVITY (QUALITY)

INTRODUCTION

Clarke and Whiteman (10) considered that cooking quality of potatoes was made up of several characteristics such as mealiness, flavor, color, and freedom from blackening on standing after cooking. In judging the quality of tubers Bewell (4) referred to the percentage dry matter, 30% being considered good and 15% poor quality. Investigators seem to be in agreement that mealiness or starch content is the most important as well as the most variable character constituting quality.

The authors referred to above as well as Smith and Nash (33), and Haddock and Blood (18) have found that the determination of the specific gravity of potato tubers was a practical and low cost method of separating mealy from less mealy potatoes on a commercial scale. Clarke and Whiteman (10) explained that specific gravity is taken as a measure of mealiness because several investigators have shown that there is a high relation between specific gravity and starch content and that starch is one of the most important factors contributing to mealiness. These same investigators compared the two common methods of specific gravity determination, namely, the salt solution method and the weighing in water and air method, and showed them both to check closely with actual cooking tests. They found that the salt solution method was much less laborious and just as accurate as the other. They also concluded that the size of the tubers used did not significantly influence

the specific gravity and that a 60-tuber sample gave as accurate results as a 120-tuber sample.

Haddock and Blood (18), among other workers, have demonstrated that varieties show differences in specific gravity. They found Irish Cobbler and Warba to be somewhat inferior in specific gravity rating to Green Mountain. Katahdin was decidedly inferior.

Several investigators have reported a wide range of variation in the composition of individual tubers within the same variety. Goldthwaite (16) in Colorado concluded from extensive experiments that no two potatoes whether from the same variety or the same hill had exactly the same composition. Johnson and Boyle (22) in Ireland have shown that the starch content within the same variety may vary from 14.65 - 20.76%. Likewise, Stevenson (35) observed that the starch content of Green Mountain varied from 9.9 - 14.5% with a mean of 12.4%.

Gilmore, according to Clarke and Whiteman, has shown that tubers located at a depth of 2 - 4 inches had superior quality to those situated at a depth of less than 2 inches or more than 4 inches. Sprague and Evaul (34) advanced the theory that increased yields from closer spacing were due to the fact that roots penetrated deeper when plants were crowded and thus obtained increased moisture and nutrient supplies. They considered that even at wide spacings roots spread laterally to fill the alloted space.

It was thus considered logical that specific gravity might vary considerably with rate of planting. Therefore, in 1944, samples were selected from each of the 192 plots and the specific gravity

ratings of these were determined.

EXPERIMENTAL PROCEDURE

The method used was that outlined by Clarke and Whiteman (10). A range of salt solutions was prepared by dissolving table salt in water, adjusting each solution to the required density by means of a hydrometer. These solutions in three-gallon earthenware crocks were arranged in order of their densities forming a graduated series made up of the following eleven classes:

Class	Density
1	1.070
2	1.075
3	1.080
4	1.085
5	1.090
6	1.095
7	1.100
8	1.105
9	1.110
10	1.115
11	1.120

Samples of 50 tubers each were chosen at random from the marketable yields. Thus all tubers tested were between 3 and 12 ounces. The washed tubers were placed individually in the crocks and the lowest numbered solution in which each tuber floated was recorded as the solution number for that tuber. When the classes had been determined for all 50 tubers, the mean specific gravity for the sample was calculated. The density of the solutions was checked at frequent intervals.

EXPERIMENTAL DATA AND RESULTS

Table 25 - Specific Gravity Ratings of 50-Tuber Samples from Marketable Yields Produced at Sixteen Different Planting Rates Using the Warba Variety.

Size of Seed-piece (ozs.)	Spacing (Ins.)	SPECIFIC GRAVITY RATINGS				
		Replication No. 1	Replication No. 2	Replication No. 3	Replication No. 4	Mean
1	18	1.096	1.100	1.097	1.102	1.099
1	15	1.095	1.099	1.100	1.104	1.100
1	12	1.098	1.102	1.103	1.102	1.101
1	9	1.098	1.102	1.098	1.103	1.100
2	18	1.098	1.102	1.100	1.098	1.100
2	15	1.099	1.095	1.102	1.107	1.101
2	12	1.100	1.094	1.104	1.100	1.100
2	9	1.097	1.095	1.101	1.095	1.097
3	18	1.099	1.097	1.101	1.097	1.099
3	15	1.099	1.099	1.099	1.100	1.099
3	12	1.095	1.105	1.100	1.095	1.098
3	9	1.095	1.100	1.095	1.095	1.096
4	18	1.093	1.102	1.104	1.098	1.099
4	15	1.100	1.096	1.097	1.105	1.099
4	12	1.099	1.096	1.096	1.102	1.098
4	9	1.094	1.098	1.097	1.104	1.098

Table 26 - Specific Gravity Ratings of 50-Tuber Samples from Marketable Yields Produced at Sixteen Different Planting Rates Using the Irish Cobbler Variety.

Size of Seed-piece (ozs.)	Spac-ing (Ins.)	SPECIFIC GRAVITY RATINGS				
		Replication No. 1	Replication No. 2	Replication No. 3	Replication No. 4	Mean
1	18	1.098	1.104	1.102	1.108	1.103
1	15	1.096	1.100	1.104	1.110	1.105
1	12	1.096	1.099	1.101	1.101	1.099
1	9	1.097	1.104	1.104	1.106	1.103
2	18	1.098	1.104	1.096	1.102	1.100
2	15	1.097	1.106	1.101	1.102	1.102
2	12	1.099	1.105	1.091	1.107	1.101
2	9	1.098	1.104	1.093	1.101	1.099
3	18	1.096	1.104	1.102	1.101	1.101
3	15	1.097	1.104	1.100	1.100	1.100
3	12	1.104	1.106	1.102	1.103	1.104
3	9	1.096	1.105	1.106	1.101	1.102
4	18	1.096	1.103	1.101	1.103	1.101
4	15	1.097	1.104	1.096	1.108	1.101
4	12	1.097	1.099	1.096	1.097	1.097
4	9	1.094	1.100	1.104	1.099	1.099

Table 27 - Specific Gravity Ratings of 50-Tuber Samples from Marketable Yields Produced at Sixteen Different Planting Rates Using the Katahdin Variety.

Size of Seed-piece (ozs.)	Spac-ing (Ins.)	SPECIFIC GRAVITY RATINGS Replication No. 1	Replication No. 2	Replication No. 3	Replication No. 4	Mean
1	18	1.087	1.082	1.092	1.090	1.088
1	15	1.088	1.084	1.089	1.087	1.087
1	12	1.097	1.084	1.095	1.091	1.092
1	9	1.089	1.085	1.094	1.090	1.090
2	18	1.089	1.085	1.099	1.093	1.091
2	15	1.097	1.089	1.095	1.093	1.093
2	12	1.093	1.099	1.100	1.097	1.097
2	9	1.092	1.089	1.099	1.095	1.094
3	18	1.090	1.092	1.099	1.096	1.094
3	15	1.096	1.093	1.100	1.097	1.097
3	12	1.090	1.095	1.102	1.094	1.095
3	9	1.102	1.091	1.106	1.103	1.101
4	18	1.099	1.091	1.105	1.097	1.098
4	15	1.100	1.101	1.104	1.099	1.101
4	12	1.094	1.099	1.096	1.105	1.098
4	9	1.097	1.097	1.097	1.097	1.097

Table 28 - The Analysis of Variance for the Data Presented in Tables 25, 26, and 27.

	Sums of Squares	Degrees of Freedom	Variance	F	5% Point	1% Point	Necessary Difference
Blocks	0.002330						
Replicates	0.000576	3	0.000125	1.32	4.76	9.78	.....
Varieties	0.001386	2	0.000693	7.30	5.14	10.92	0.0042
Error (a)	0.000568	6	0.000095				
Total	0.005044						
Seedpiece	0.000124	3	0.000041	4.10	2.68	5.94	0.00013
Spacing	0.000021	3	0.000007	0.70	2.68	5.94	.....
Seed.xSpac.	0.000116	9	0.000013	1.30	1.95	2.56	.....
Vars.x Seed.	0.000775	6	0.000129	12.90	2.17	2.95	0.0022
Vars.x Spac.	0.000088	6	0.000015	1.50	2.17	2.95	.....
Vars.x Seed. x Spac.	0.000226	18	0.000013	1.30	1.70	2.10	.....
Error (b)	0.001364	135	0.000010				

Table 29 - Mean Specific Gravity Ratings for Marketable Potato Yields Produced from Four Different Sizes of Seed-piece.

Seedpiece Size	Warba	Irish Cobbler	Katahdin	Mean
1-ounce	1.100	1.102	1.089	1.097
2-ounce	1.099	1.101	1.094	1.098
3-ounce	1.098	1.102	1.097	1.099
4-ounce	1.099	1.100	1.099	1.099
Mean	1.099	1.101	1.094	

Table 30 - Mean Specific Gravity Ratings for Marketable Potato Yields Produced at Four Different Spacings.

Spacing	Warba	Irish Cobbler	Katahdin	Mean
9-inch	1.097	1.101	1.095	1.098
12-inch	1.099	1.100	1.095	1.098
15-inch	1.100	1.101	1.094	1.099
18-inch	1.099	1.101	1.093	1.098
Mean	1.099	1.101	1.094	

The complete data for each variety are shown in Tables 25, 26, and 27. The statistical analysis for these data is shown in Table 28. Tables 29 and 30 give the mean specific gravity ratings for each variety resulting from the use of the four seedpiece sizes and the four spacings respectively.

It is noted in Tables 25, 26, and 27 that the specific gravity ratings vary considerably within each treatment (between the replicates) but the analysis of variance shows these differences to be not significant.

Since a difference in the specific gravity rating of 0.0042 is required for significance between the varieties, when the variety means as shown in Table 29 are compared, Warba and Irish Cobbler have significantly higher ratings than Katahdin but the difference in the mean rating between these two varieties is not sufficiently large to be significant. Even though Katahdin has the lowest mean rating, this is nevertheless high when compared with other results (18). However, it is well known that the ratings for this variety vary considerably with growing conditions.

The interaction of varieties by seedpieces is significant beyond the 1% point. This means that the effect of seedpiece size on specific gravity ratings was not the same for all varieties. When the ratings are compared within each variety in Table 29, differences of 0.001, 0.002, and 0.010 are observed between the ratings for the 1- and the 4-ounce seedpieces for Warba, Irish Cobbler, and Katahdin respectively. Thus it can be concluded that seedpieces of different sizes did not have much effect on the Warba and Irish

Cobbler specific gravity ratings but that the specific gravity ratings for Katahdin were affected by the size of the seedpiece.

According to Akeley and Stevenson (2), when the mean ratings for Katahdin (Table 29) are converted to starch content, the yields produced from 1-ounce seedpieces would contain about 16.0% starch while those from the 4-ounce seedpieces would contain about 18.1% starch. Thus the use of 3- or 4-ounce seedpieces would increase the starch content in the resultant crop about 2% over that obtained if 1-ounce sets were used. This difference is considered to be of little practical importance. It is probably due to a difference in maturity between hills planted with small and large seedpieces.

The statistical analysis proved that there was no significant differences in specific gravity ratings between yields produced at the four spacings.

SUMMARY AND CONCLUSIONS

An experiment dealing with the effects of seedpiece size and spacing relationships on the yields and quality (specific gravity) of potatoes was carried on for two years using the varieties Warba, Irish Cobbler, and Katahdin planted on soil considered to be fairly typical of the Red River Valley. Four sizes of seedpiece (1, 2, 3, and 4 ounces) and four spacings (9, 12, 15, and 18 inches) were combined to give sixteen rates of planting, varying from 10.1 to 80.6 bushels per acre.

The total and marketable (3- to 12-ounce tubers) yields increased directly with the rate of planting within the limits of the experiment, so that the lowest rate of planting gave the greatest returns from a given quantity of seed while the heaviest rate of planting gave the greatest yield per acre.

The relationship between seedpiece size and spacing was shown to be not significant. As the seedpiece size decreased, or as the spacing became closer, the weight per hill decreased. However, as the seedpiece size increased or as the spacing became closer, the number of bushels per acre increased but the percentage of marketable tubers decreased slightly. With the large-sized seedpieces or the close spacings the unmarketable were almost entirely under 3 ounces, but with small sized seedpieces or wide spacings the unmarketable consisted largely of tubers over 12 ounces.

Significant increases in marketable yields were obtained between all the seedpiece sizes from 1- to 4-ounces. However, as the spacing decreased from 18 to 9 inches, increases were only signi-

ficant down to a certain point, beyond which increases were not obtained by the use of closer spacings. This was 12-inch for Warba, 15-inch for Irish Cobbler, and 9-inch spacing for Katahdin.

The most profitable returns per acre for each of the three varieties were shown by calculating the "net marketable" yields which were the marketable yields minus the amount of seed used, and the "net returns per acre" using average cost figures. This showed that a rate using 2-ounce seedpieces spaced at 12 inches (30.3 bushels per acre) was the most profitable with Warba. Irish Cobbler showed the greatest returns when a rate of 2-ounce seedpieces spaced at 15 inches (24.2 bushels per acre) was used. Katahdin gave increased yields with higher rates of planting. When the 1-ounce seedpieces were eliminated due to being considered impractical, a rate of 2-ounce seedpieces spaced at 9 inches (40.3 bushels per acre) was shown to give the greatest returns.

The size and weight of the tops were found to be directly proportional to the rate of planting. Much variation was noted between tops produced from the different sized seedpieces.

No significant differences in specific gravity were obtained for the different rates except with the Katahdin variety where significantly higher specific gravity ratings were obtained from the larger seedpieces. However, these differences were considered to be of little practical importance.

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