THE EFFECT OF VARIETY, LOCATION, AND YIELD ON THE SPECIFIC GRAVITY OF POTATOES GROWN IN MANITOBA

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INTRODUCTION

The Manitoba Potato Breeding Program was begun at the University of Manitoba in 1942, for the purpose of developing potato varieties suitable to Manitoba conditions, and for improving the quality of potatoes grown in the province. By 1946, several promising selections had been made. A number of varieties had also been introduced by the United States Department of Agriculture, the Dominion Experimental Farm Service, and private potato breeders in Canada. In order to obtain a measure of the cooking quality of such selections and of recently introduced varieties under Manitoba conditions, the study reported here was undertaken during 1946 and 1947.

The soil of the University of Manitoba experimental plots is Red River clay. This soil is not representative of all areas of the province where potatoes are a crop of economic importance. Therefore it became necessary to determine the differences in degrees of cooking quality of the varieties and selections when grown in areas outside of the Red River Valley. No experimental work had been done in the province, prior to this date, to determine whether or not differences in cooking quality developed when the same variety was grown in different areas.

In carrying out this study, information was sought on three general phases of variety performance:

1. The comparative cooking qualities of varieties and selections.

2. Comparisons of the cooking quality of the same variety or selection when grown in different areas of the province.

3. The relation between total yields and cooking quality.

REVIEW OF LITERATURE

Good cooking quality is largely a relative term, because certain qualities in a cooked potato may be desired by some people while different qualities might be regarded as important by others. Therefore the standards of cooking quality which potato producers and potato breeders should endeavor to attain must be the standards which are desired by the majority of consumers.

In order to determine what these preferences are, Hotchkiss, Wood and Findlen (14) made a survey of the qualities by which housewives and institutional buyers in the United States judged the excellence of cooked potatoes. Mealiness was considered the most important factor, with whiteness next in order of preference. Rinear (23) made a similar survey in which 1,653 people were interviewed. Seventy-one per cent considered mealiness most important, 14.1 per cent desired a tuber which remained very white after boiling. Flavor was important to 0.6 per cent of the people interviewed and only 0.8 per cent preferred watery potatoes.

A definition of mealiness is given by Langworthy, of the United States Department of Agriculture, quoted by Bewell (4) as follows:

> " In this country, the chief test of excellence is mealiness, which means that, when cooked, a potato should form a crystalline-like mass, with almost distinct starch-like particles. This quality depends largely upon the amount of starch present. If it is abundant and evenly distributed throughout the tuber, the cells burst open in cooking, and a light, flaky, uniform mass results."

Sweetman (32), on the other hand, found that cooking of the potato tuber resulted in separation of the cells, without bursting. The greater the ease with which the cells separate, the greater the mealiness of the cooked product. Sweetman (33) also stated that the taste of a cooked potato us partly due to solanin, ash constituents, and sugar. Flavor is a composite of taste and odor, and the odoriferous components are not known. Stevenson and Whiteman (31) in a discussion of cooking quality, pointed out that ".... starch content and other chemical constituents, texture, flavor, and color of the flesh, must all be given consideration in any estimation of quality."

Child and Willaman (6) were among the first workers who attempted to determine what made a potato tuber mealy when cooked. They investigated the correlation between the texture (mealiness) of the cooked tuber, and the amount of dry matter which it contained. They found that in both boiled and baked potatoes, there was a high positive correlation between mealiness and amount of dry matter. Mealiness was determined by judges and the content of dry matter was determined by drying the tubers. Bewell (4) stated that a "high" dry matter content of thirty per cent was associated with good quality while poor quality in the tubers was associated with a dry matter content of fifteen per cent.

Various workers have developed methods by which the dry matter content of the tubers could be determined more rapidly and with greater ease than by drying the tubers. Clark, Lombard and Whiteman (7)

developed a method of determining the dry matter content of potato tubers by the use of sodium chloride solutions of known specific gravity. They used eleven solutions ranging in specific gravity from 1.060 to 1.110 in intervals of 0.005. They compared this method of determining the specific gravity of tubers with the method of weighing tubers in air and water and found a positive correlation of 0.9567 between results obtained by the two methods. They calculated the regression coefficients for mealiness and specific gravity of potatoes grown in Maine during 1937 and 1938 and found the highly significant positive regression of 0.4715 of mealiness on specific gravity. Haddock and Blood (12) developed essentially the same method and they found that this method was satisfactory for determining mealiness if a sample of at least fifty, and preferably one hundred, tubers were selected at random from the variety to be tested. They reported that varieties which had the same specific gravity in the raw state were similar in cooking quality.

LeClerg (15), Dunn and Nylund (9), and Bewell (4) have also determined the relation between dry matter and specific gravity of potato tubers. LeClerg reported a positive linear correlation coefficient of 0.81 to 0.85 between specific gravity and dry matter content of Louisiana grown potatoes. Soil and climatic conditions did not change the relationship of specific gravity to dry matter. Dunn and Nylund found a positive correlation coefficient of 0.8686 between specific gravity and dry matter content of potatoes grown in Minnesota. Bewell reported a positive correlation coefficient between dry matter

and specific gravity of 0.823 ±.055.

The relation between specific gravity of potato tubers and the percentage of starch which they contain, and the relation between dry matter and starch content has also been determined. Goldthwaite (10) has found a fairly constant ratio of starch to dry matter of 1:1.25 in potato tubers. Metzger, et. al. (19) observed a positive correlation coefficient of 0.8586 between percentage of starch and dry matter content in Colorado potatoes. Blood and Prince (5) point out that Von Scheele and co-workers in Germany have reported a positive correlation coefficient of 0.947 between specific gravity and starch content of the tuber. They quote Von Scheele as follows;" It may be assumed that the starch content of single samples may be obtained with an error of ±1.5% by means of the determination of specific gravity." Akeley and Stevenson (1) have pointed out that since the greatest part of the solids content of the potato is in the form of starch, and since there is a high correlation between specific gravity and starch content, it is possible to estimate one from the other with a fair degree of accuracy. The authors presented a table which gives the percentages of starch which correspond to various specific gravities.

There is not unanimous agreement on the relation of starch content to mealiness. Smith and Nash (26) reported that the percentage of starch, and the starch: protein ratio did not affect the mealiness of potatoes. Whittemore and Kuschke (37) stated that during 1928 and 1929 in Rhode Island the most mealy potatoes contained the least

starch. The consensus of opinion, however, seems to be that mealiness in potatoes is correlated with the specific gravity of the raw tuber, and that mealiness contributes to cooking quality. In the words of Cobb (8), " Evidence from cooking and chemical tests seems sufficient to conclude that good cooking quality is closely associated with high starch and dry matter content of the tuber, and low nitrogen content."

Most workers have found that the specific gravity of potato tubers is affected by various factors. LeClerg (16) reported that both variety and environment played an important part in the development of dry matter content of potatoes during two years of experiments. Green Mountain exceeded seven other varieties in dry matter content but he also observed significant differences in behavior among varieties in different years. Therefore, some varieties behaved in a differential manner in response to environment. Haddock and Blood (12) have tested potato varieties in New Hampshire for cooking qualities and have noted that the quality of varieties varied from field to field if conditions differed. Some varieties, however, notably Green Mountain and Red McLure, possessed relatively higher quality than other varieties, regardless of environmental conditions. Stevenson (30) reported that the variety Parnassia, which produced eighteen to twenty per cent starch in Germany, gave a mean reading of 13.5 per cent when grown in Maine. Potatoes were grown in three counties in New York by Nash (20) and differences in cooking quality were attributed to variety and environment. Environment had an

effect in that potatoes which matured under the coolest conditions were relatively more mealy. Metzger, et. al., (19) found that in Colorado-grown potatoes, the percentage of starch, dry matter, protein, and ash varied with locality, with variety, and with the year in which the tubers were produced. Potatoes grown on irrigated land were higher in starch and dry matter than those grown on dry land. Akeley and Stevenson (1) noted that early varieties as a group tended to be lower in starch content than later varieties.

Clark, Lombard and Whiteman (7), LeClerg (15), and Sweetman (33) have reported that specific gravity is not correlated with the weight or size of the tubers.

Several workers have attempted to analyse the environmental factors which produce good cooking quality in potatoes. Ashby (2) believed that temperature and water supply had the greatest effect. In a warm, dry climate, heavy soil provided the optimum temperature and water conditions and in a moist climate, these conditions were supplied by a light soil. Wager (35) after three years work in England, found that the average content of dry matter in potatoes depended upon the available water content of the soil. During wet seasons, tubers were relatively lower in dry matter. In any one season, fen and blackland soils gave the lowest dry matter content and the highest dry matter content was produced by potatoes on sands, gravels, and light loams.

Regarding the effect of temperature and rainfall, Cobb (8) found that temperatures varying from 65.5 degrees Fahrenheit to

67.8 degrees Fahrenheit during July, August, and September produced better cooking quality in potatoes than when they developed under temperatures varying from 72.5 degrees Fahrenheit to 79.4 degrees Fahrenheit. Moderate rainfall during those months produced better quality potatoes than excessive rainfall.

Smith (25) observed that potatoes grown under very hot and very dry conditions were slightly mealy to "soggy" and did not break apart during boiling, nor blacken after cooking.

Smith and Nash (29) noted that potatoes planted earliest and harvested latest contained the most dry matter. Those harvested on the latest date had the highest specific gravity, but tended to blacken more after cooking than those which were harvested earlier.

Smith and Nash (29) and Nash and Smith (21) found that a relationship existed between light conditions during the latter part of the growing season and the specific gravity, dry weight, color, and the mealiness of the boiled tubers. Periodic shading of the plants reduced the specific gravity, dry matter and mealiness. Where nitrogen had been added to the shaded plots, blackening of the tubers after cooking was increased.

Smith (24), (25) and Smith and Nash (27), (28) have found that soils of pH 5.64 to 6.05 produced tubers with the highest dry matter and starch content. Tubers grown on soils varying in pH between 7.92 and 7.16 were of a more attractive color and broke apart least in cooking. In other experiments it was noted that soil of pH 6.36 produced tubers of lower quality than soil of higher

or lower pH. Tubers of the highest specific gravity were secured from soil which had a pH of 7.88. In another test of the effect of soil reaction, the average specific gravity increased as the soil pH rose from 4.88 to 7.19. Cooked tubers blackened the least when produced on soils with higher pH ranges.

Blackening of tubers after boiling is a very undesirable character which appears to be controlled by both environmental and genetic factors. Low levels of available potash in the soil, low soil pH, low moisture content of the tubers, and high nitrogen content of the soil have been reported by Smith and Nash (28), Tottingham and Nagy (34), Bandemer, Sciable and Wheeler (3), and Mader and Mader (18) to cause blackening of cooked tubers.

Varieties have been observed by Rieman, Tottingham and McFarlane (22) to vary in the amount of blackening shown after boiling the tubers. After five years of trials at nine locations in Wisconsin, they reported that consistent differences in the expression of this character existed in twenty three varieties. Triumph and Chippewa were whitest when boiled, Rural New Yorker and Russet Rural were darkest when boiled.

The review of literature indicates that variety characteristics are important in determing specific gravity of potatoes, but that environmental factors alter or mask the expression of genetic character to varying degrees. The specific gravity of raw tubers was found to be a rapid and reasonably accurate measure of dry matter content, starch content, and mealiness of potato tubers.

Cooking quality is influenced by many environmental and genetic factors.

MATERIALS AND METHODS

Experimental plots of potato varieties and selections were grown in eight areas of Manitoba during 1946 and 1947. Trials were carried on at Balmoral, Morden, Portage la Prairie, Steinbach, Sprague, and Fort Garry during both years and an additional trial was conducted at Benito in 1946 and at Melrose in 1947. The potato is a commercial crop in these areas, either for table stock or for certified seed production. The soil texture of the experimental field at each station where an experiment was located is shown in Table I.

During 1946, ten named varieties and six numbered selections were included in the trials at all stations except Sprague, where ten named varieties and four numbered selections were included. During the following year, six named varieties and ten numbered selections were compared at all of the stations. A list of the varieties and selections which were placed in the trials each year is given in Table II.

Irish Cobbler was used as a standard variety with which to compare the other varieties and selections. This variety was chosen because it is planted more widely than any other variety in the province, yields well, and has good cooking and keeping quality.

Identical experimental designs, field sizes, and cultural procedures were followed each year. All of the trial grounds were placed on summerfallowed land. They were ninety-two and one half

TABLE I

STATIONS AND SOIL TEXTURES ON WHICH POTATO VARIETY TRIALS WERE CONDUCTED

1946		1947	
Station	Soil texture	Station	Soil texture
Balmoral	very fine sandy loam	Balmoral	very fine sandy loam
Benito	clay loam*	Melrose	clay
Morden	sandy loam	Morden	sandy loam
Portage la Prairie	clay	Portage la Prairie	silty clay loam
Steinbach	fine sandy loam*	Steinbach	sandy loam*
Sprague	sandy loam*	Sprague	loam*
Fort Garry	clay	Fort Garry	clay

*Author's estimate of the soil texture. Detailed soil maps of the areas are not available.

NOTE: The Fort Garry plot was located on the University of Manitoba experimental grounds.

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feet long by fifty-four feet wide and covered approximately one-ninth of an acre. The 1946 field trial at Sprague covered an area six feet narrower. The randomized block design, as recommended by LeClerg and Henderson (16) for sixteen varieties, was employed at each station. Three replicates were used and each consisted of sixteen single row plots. The plots were planted three feet apart with the plants fifteen inches apart in the plot rows. Each replicate plot

TABLE II

VARIETIES AND NUMBERED SELECTIONS INCLUDED IN THE FIELD TRIALS

1946	1947
Canus	Canus
Bovee	Columbia Russet
Irish Cobbler	Irish Cobbler
Pontiac	Pontiac
Red Warba	Red Warba
Warba	Warba
Netted Gem	Netted Gem
Bliss Triumph	178-3
Gold Nugget	182-M16
Kasota	292-M2
Pawnee	129-10
Minn 47.38	148-84
181-M7	148-99
279-M9	279-M3
ND-1	279-M7
134-19	134-19
144-114	144-114

NOTE: Netted Gem was included only in the trials at Sprague. Canus, 279-M9, and 134-19 were not included in the trials at Sprague during 1946.

contained twenty four plants and was thirty feet in length. This length of plot row was found to be suitable by Westover (39). The three replicates were placed end to end to give a seventy-two hill row, ninety feet in length. A guard row was planted at each side of the field, three feet from the outer plot, and a guard hill was planted at each end of every row.

The seed stocks used were produced at the University of Manitoba, Fort Garry, during 1945 and 1946. Seed tubers of uniform size, which could each be cut into four seed pieces, were selected from all varieties and selections. They were treated with Semesan Bel to aid in the control of common scab and rhizoctonia before they were taken to the country points for planting.

All of the plots were planted during the last week of May, 1946 and 1947. A planting depth of four inches was used throughout.

The plots were harvested during the last ten days of September, 1946 and 1947. The total yields were recorded. One forty-five tuber sample of each variety and selection was collected at all stations. These samples were brought to the University where the specific gravity of the tubers was determined.

The specific gravity of each sample of the tubers was determined by the method of Clark, Lombard and Whiteman (7). Sodium chloride solutions were made up in two and one half gallon earthenware crocks. Fifteen solutions were used which ranged in specific gravity from 1.0550 to 1.1250 in intervals of 0.0050. Each forty-five tuber sample was divided into three fifteen tuber lots and the

average specific gravity of each lot was ascertained.

As indicated by the research summarized in the review of literature, the specific gravity of the potato tubers is directly associated with the mealiness of cooked potato tubers, and therefore in the cooking quality. For this reason, the degree of mealiness of the varieties and selections included in this experiment are assumed to vary directly with the variations in the specific gravity of the tubers.

The data secured at each station were analysed by separate analyses of variance, and necessary differences between varieties were calculated at the five percent level. The Chi-square test for the homogeneity of the error variances among stations was made by the method outlined by Hayes and Immer (13). Data from all of the stations except Sprague were then combined into one analysis of variance and the necessary differences among stations and among varieties were calculated at the five percent level. Since the same varieties and selections were not used each year, the sets of data for 1946 and 1947 were treated by separate analyses. Because the same varieties and selections were not tested at Sprague, separate analyses of variance were made on the 1946 and 1947 data.

The relation between total yields and specific gravity of the potato tubers was investigated by determining the following correlations. Simple correlation coefficients were calculated from the 1946 data, from the 1947 data, and from the data for 1946 and 1947 combined, between rates of total yield and the average specific

gravity of all potatoes produced at each station. Correlation coefficients were also calculated from the total yield and specific gravity data of Irish Cobbler, Canus, Pontiac, Red Warba, and Warba, using the results of the two years. In order to determine the effect of year on the correlation between yield and specific gravity, the significance of the difference between the correlations of rates of total yield and specific gravity for 1946 and 1947 was determined. The corresponding coefficients of linear regression were calculated. The methods outlined by Goulden (11) were used in the statistical examinations of the data.

EXPERIMENTAL RESULTS AND DISCUSSION

I. SPECIFIC GRAVITY AND STARCH CONTENT OF TUBERS OF VARIETIES AND SELECTIONS

The result of the Chi- square test of the homogeneity of the error variances at all stations indicated that the variances at the different stations were not homogeneous. Therefore, if the sets of data from each station were combined into one analysis of variance, the tests of significance used to compare the averages of specific gravity among varieties and among stations would not be strictly accurate. Since the error variances of the stations were of such magnitude (the majority were low) that the significance of differences would be under-estimated rather than over-estimated, the combined analyses of variance were carried out.

These analyses showed that highly significant differences were present among stations in the development of specific gravity levels of all potatoes. Also, the average specific gravity of each variety and selection differed by highly significant amounts. Highly significant variety by station interactions were obtained which indicated that all varieties did not exhibit the same relative development of specific gravity at every station. The outline of the combined analyses of variance comparing the averages of the specific gravity at stations and among varieties is shown in Table III.

The readings of specific gravity of the tubers of all varieties and selections were converted to the percentages of starch in the

TABLE III

OUTLINE OF ANALYSIS OF VARIANCE USED TO ANALYSE SPECIFIC GRAVITY OF VARIETIES AND SELECTIONS IN 1946 and 1947

		F (calc.)		F (req'd)	
	D.F.	1946	1947	5% level	1% level
Station	5	488	1078	3.11	5.06
Error (a)	12				
Variety	15	122	183	1.76	2.20
Variety x station	75	8	10	1.37	1.56
Error (b)	180				
Total	287				

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tubers, using the scale of values established by Akeley and Stevenson, (1). In the tables to follow, the specific gravity and the corresponding percentage starch are presented side by side or in consecutive tables.

The averages of the specific gravity of the potatoes produced at each station each year are tabulated in Table IV. Although the data for the two years could not be compared statistically, it is apparent from this table that no station produced potatoes which were consistently high or low in starch content during the two years. The percentage of starch varied from 17.20 per cent at Balmoral in 1946 to 12.18 per cent at Fort Garry in 1947. All of the stations except Melrose and Steinbach differed significantly from each other

in the averages of the specific gravity of all potatoes. Therefore during the two years in which the trials were conducted the soil texture did not appear to affect the specific gravity of the potato tubers.

The overall averages of the specific gravity and the percentages of starch in the tubers of each variety and selection are given in Table V. The percentage of starch varied from a high of 17.20 per cent for ND-1 in 1946 to a low of 12.66 per cent for 178-3 in 1947. The specific gravity of Gold Nugget and ND-1 exceeded the specific gravity of Irish Cobbler in 1946. In 1947, Irish Cobbler was exceeded in specific gravity by Columbia Russet, 182-M16, 148-99and 134-19. More than half of the varieties and selections were lower than Irish Cobbler in specific gravity, as may be seen from the table.

The specific gravity data for 1946 and the percentages of starch in the tubers of the varieties and selections, except in those grown at Sprague, are shown in Tables VI and VII, respectively. The necessary differences and calculated "F" values given in Table VI were calculated from the separate analyses of variance of the data from each station. These analyses showed that the specific gravities of varieties and selections differed among themselves by highly significant amounts at every station. No variety or selection consistently exceeded Irish Cobbler in specific gravity of the tubers, but at the same time, the specific gravity of this variety was surpassed by one or another of the varieties and selections at every station. It might also be pointed out that the specific gravity of Canus, Pontiac, Kasota, and 181-M7

TABLE IV

AVERAGE SPECIFIC GRAVITY OF POTATOES PRODUCED AT EACH STATION

Station	1946 Specific Gravity	1946 Starch Percentage	1947 Specific Gravity	1947 Starch Percentage
Balmoral	1.0953	17.20	1.0862	15.14
Benito	1.0774	13.30		
Melrose			1.0805	14.00
Morden			1.0945	17.10
P.L.P.	1.0800	13.90	1.0879	15.62
Steinbach	1.0825	14.40	1.0804	13.98
Fort Garry	1.0847	14.90	1.0722	12.18
Sprague*	1.0844	14.70	1.0808	14.10
Necessary difference (5% pt.)#	0.0009		0.0007	

* Not included in the analysis because different varieties were used.
\# Necessary differences do not apply to the yields at Sprague.

NOTE: P.L.P. in "Station" column is an abbreviation for Portage la Prairie.

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was significantly lower than that of Irish Cobbler at all of the stations.

The highly significant variety by station interaction, shown by the analysis of variance of the data combined over all stations except Sprague, may be illustrated by Red Warba, 134-19, and Minnesota 47.38, which produced specific gravities greater than that of Irish Cobbler

TABLE V

SPECIFIC GRAVITY AND PERCENTAGE STARCH OF TUBERS AT ALL STATIONS FOR EACH VARIETY AND SELECTION

1946			1947		
Variety	Specific Gravity	% Starch	Variety	Specific Gravity	% Starch
I. Cobbler	1.0894	15.86	I. Cobbler	1.0873	15.38
Bovee	1.0900	16.10	Col. Russ.	1.0915#	16.54
Canus	1.0794*	13.70	Canus	1.0811*	14.10
Pontiac	1.0759*	13.10	Pontiac	1.0776*	13.50
Red Warba	1.0867*	15.38	Red Warba	1.0839*	14.70
Warba	1.0857*	15.14	Warba	1.0832*	14.50
B. Triumph	1.0785*	13.50	178-3	1.0737*	12.66
G. Nugget	1.0930#	16.76	182-M16	1.0900#	16.10
Kasota	1.0809*	14.10	292-M2	1.0803*	13.90
Pawnee	1.0865*	15.14	129-10	1.0776*	13.50
Minn. 47.38	1.0887	15.86	148-84	1.0872	15.38
181-M7	1.0790*	13.70	148-99	1.0915#	16.54
279-M9	1.0828	14.50	279-M3	1.0874	15.38
ND-1	1.0946#	17.20	279-M7	1.0751*	12.90
134-19	1.0872*	15.38	134-19	1.0893#	15.86
144-114	1.0837*	14.70	144-114	1.0812*	14.10
Necessary difference (5% level)	.0014			.0012	

Significantly higher than Irish Cobbler.
* Significantly lower than Irish Cobbler.

TABLE VI

SPECIFIC GRAVITY OF VARIETIES AND SELECTIONS AT SIX STATIONS IN 1946

Variety	Station					
	Balmoral	Benito	Morden	P.L.P.	Steinbach	Fort Garry
I. Cobbler	1.1004	1.0817	1.0990	1.0813	1.0853	1.0881
Bovee	1.0985	1.0828	1.0977	1.0839	1.0909#	1.0857
Canus	1.0889*	1.0720*	1.0828*	1.0751*	1.0761*	1.0790*
Pontiac	1.0881*	1.0670*	1.0801*	1.0711*	1.0764*	1.0723*
Red Warba	1.0943*	1.0784*	1.0934*	1.0823	1.0801*	1.0915#
Warba	1.0943*	1.0781*	1.0952	1.0793	1.0812*	1.0859
B. Triumph	1.0828*	1.0734*	1.0801*	1.0773	1.0773*	1.0797*
G. Nugget	1.1067#	1.0880#	1.0965	1.0864#	1.0876	1.0923#
Kasota	1.0891*	1.0766*	1.0869*	1.0726*	1.0797*	1.0804*
Pawnee	1.0982	1.0803	1.0945	1.0824	1.0805*	1.0826*
Minn. 47.38	1.1063#	1.0734*	1.0906*	1.0866#	1.0792*	1.0957#
181-M7	1.0874*	1.0726*	1.0826*	1.0742*	1.0769*	1.0802*
279-M9	1.0930*	1.0790	1.0857*	1.0779	1.0790*	1.0820*
ND-1	1.1049#	1.0801	1.1080#	1.0881#	1.0947#	1.0917#
134-19	1.0977*	1.0783*	1.0931*	1.0839	1.0885#	1.0817*
144-114	1.0928*	1.0764*	1.0870*	1.0769*	1.0836	1.0853
Necessary difference 5% point	0.0026	0.0031	0.0046	0.0042	0.0032	0.0030
F value (calc.)	63.31	21.16	24.99	12.45	24.17	34.95

F value required for significance at the 1% level ---- 2.70

Significantly higher than Irish Cobbler.
* Significantly lower than Irish Cobbler.

TABLE VII

PERCENTAGES OF STARCH IN TUBERS OF VARIETIES AND SELECTIONS AT SIX STATIONS IN 1946

Variety	Station					
	Balmoral	Benito	Morden	P.L.P.	Steinbach	Fort Garry
I. Cobbler	18.20	14.30	18.00	14.10	14.90	15.62
Bovee	17.80	14.50	17.80	14.70	16.32	15.14
Canus	15.86	12.18	14.50	12.90	13.10	13.70
Pontiac	15.62	11.07	13.90	11.94	13.10	12.18
Red Warba	16.98	13.50	16.76	14.30	13.90	16.54
Warba	16.98	13.50	17.20	13.70	14.10	15.14
B. Triumph	14.50	12.42	13.90	13.30	13.30	13.90
G. Nugget	19.70	15.62	17.40	15.14	15.62	16.54
Kasota	15.86	13.30	15.38	12.18	13.90	13.90
Pawnee	17.80	13.90	16.98	14.30	13.90	14.50
Minn. 47.38	19.50	12.42	16.32	15.38	13.70	17.40
181-M7	15.38	12.42	14.50	12.66	13.30	13.90
279-M9	16.76	13.70	15.14	13.50	13.70	14.30
ND-1	19.30	13.90	19.90	15.62	17.20	16.54
134-19	17.80	13.50	16.76	14.70	15.62	14.30
144-114	16.76	13.10	15.38	13.30	14.70	14.90

at some stations, while at other stations, the specific gravity was lower. The specific gravity of Irish Cobbler at Benito was practically the same as at Portage La Prairie, but for seven varieties and selections, namely; Canus, Pontiac, Red Warba, Bliss Triumph, Minnesota 47.38, ND-1 and 134-19, the specific gravity was higher at Portage La Prairie. Other varieties and selections revealed the same behavior, but the interactions were most apparent in the examples mentioned above.

The 1947 readings of specific gravity and percentages of starch of all varieties and selections at six stations are presented in Tables VIII and IX, respectively, together with the necessary differences and "F" values calculated from the separate analyses of variance of the data from each station. These analyses showed that the varieties and selections differed by highly significant amounts in specific gravity at each station. The specific gravity of Irish Cobbler is not exceeded by any one variety or selection at all stations. However, one or another of the varieties and selections did produce a greater specific gravity at all stations except the University. Pontiac, 178-3, and 279-M7 were surpassed in specific gravity by Irish Cobbler at all stations. Other varieties illustrated the highly significant interaction of variety by station by the production of a higher specific gravity than that of Irish Cobbler at some stations, while in other areas the opposite relationship existed. For example, 148-84 was higher than Irish Cobbler at Balmoral, Morden, and Portage La Prairie, while it was lower at Melrose, Steinbach, and Fort Garry.

Other varieties and selections did not differ from Irish Cobbler at some stations, but dropped below this variety at others, as shown by the table of results.

The specific gravity readings and the percentages of starch in the tubers of the varieties and selections grown at Sprague during 1946 and 1947 are presented in Table X. ND-1 in 1946, and Columbia Russet and Netted Gem in 1947, gave higher readings of specific gravity than did Irish Cobbler. The specific gravities of the other varieties and selections may be seen from the table on page 29.

TABLE VIII

SPECIFIC GRAVITY OF VARIETIES AND SELECTIONS AT SIX STATIONS IN 1947

Variety	Station					
	Balmoral	Melrose	Morden	P.L.P.	Steinbach	Fort Garry
I. Cobbler	1.0865	1.0849	1.0949	1.0902	1.0863	1.0808
Canus	1.0853	1.0739*	1.0917	1.0857*	1.0766*	1.0763*
Col. Russet	1.0913#	1.0786*	1.1069#	1.0971#	1.0975#	1.0774*
Pontiac	1.0822*	1.0756*	1.0866*	1.0850*	1.0732*	1.0634*
Red Warba	1.0873	1.0838	1.0948	1.0814*	1.0838	1.0721*
Warba	1.0854	1.0807*	1.0949	1.0846*	1.0796*	1.0740*
178-3	1.0731*	1.0737*	1.0824*	1.0807*	1.0687*	1.0628*
182-M16	1.0920#	1.0885#	1.1032#	1.0958#	1.0871	1.0761*
292-M2	1.0838	1.0861	1.0887*	1.0802*	1.0760*	1.0670*
148-84	1.0894	1.0820*	1.0989	1.0939#	1.0818*	1.0772*
148-99	1.0965#	1.0889#	1.1029#	1.0988#	1.0850	1.0767*
279-M3	1.0918#	1.0852	1.1011#	1.0913	1.0841	1.0712*
279-M7	1.0772*	1.0681*	1.0863*	1.0776*	1.0740*	1.0675*
134-19	1.0940#	1.0885#	1.0966	1.0939#	1.0842	1.0785
144-114	1.0828*	1.0773*	1.0909	1.0839*	1.0764*	1.0757*
Necessary difference 5% point	0.0035	0.0024	0.0041	0.0022	0.0027	0.0027
F value (calc.)	25.85	59.10	24.06	76.27	56.66	41.24

F value required for significance at the 1% level ---- 2.70

Significantly higher than Irish Cobbler.
* Significantly lower than Irish Cobbler.

TABLE IX

PERCENTAGES OF STARCH IN TUBERS OF VARIETIES AND SELECTIONS AT SIX STATIONS IN 1947

Variety	Station					
	Balmoral	Melrose	Morden	P.L.P.	Steinbach	Fort Garry
I. Cobbler	15.14	14.90	17.20	16.10	15.14	14.10
Col. Russet	16.32	13.70	19.70	17.60	17.80	13.30
Canus	14.90	12.66	16.54	15.14	13.10	12.66
Pontiac	14.30	13.10	15.38	14.90	12.42	10.22
Red Warba	15.38	14.70	17.20	14.10	14.70	12.18
Warba	14.90	14.10	17.20	14.90	13.70	12.66
178-3	12.42	12.66	14.30	13.90	11.47	10.22
182-M16	16.54	15.62	18.86	17.40	15.38	13.10
292-M2	14.70	15.14	15.86	13.90	13.10	11.07
129-10	13.90	12.18	16.32	15.14	12.66	9.74
148-84	15.86	14.30	18.00	16.98	14.30	13.30
148-99	17.40	15.86	18.86	18.00	14.90	13.30
279-M3	16.54	14.90	18.42	16.32	14.70	11.94
279-M7	13.30	11.27	15.14	13.50	12.66	11.27
134-19	16.98	15.62	17.60	16.98	14.70	13.50
144-114	14.50	13.30	16.32	14.70	13.10	13.10

TABLE X

SPECIFIC GRAVITY AND PERCENTAGE STARCH OF TUBERS FROM VARIETIES AND SELECTIONS GROWN AT SPRAGUE

1946			1947		
Variety	Specific Gravity	% Starch	Variety	Specific Gravity	% Starch
I. Cobbler	1.0906	16.32	I. Cobbler	1.0824	14.30
Bovee	1.0908	16.32	Col. Russ.	1.0979#	17.80
Pontiac	1.0746*	12.90	Pontiac	1.0766*	13.30
Red Warba	1.0898	16.10	Red Warba	1.0806	14.10
Warba	1.0865*	15.14	Warba	1.0851	14.90
G. Nugget	1.0934	16.76	Canus	1.0771*	13.30
Netted Gem	1.0845*	14.70	Netted Gem	1.0936#	16.98
Kasota	1.0776*	13.50	178-3	1.0682*	11.27
Pawnee	1.0861*	15.14	182-M16	1.0816	14.30
B. Triumph	1.0717*	12.18	292-M2	1.0753*	12.90
Minn. 47.38	1.0829*	14.50	129-10	1.0843	14.70
181-M7	1.0749*	12.90	148-84	1.0829	14.50
ND-1	1.0944#	16.98	148-99	1.0839	14.70
144-114	1.0827*	14.50	279-M3	1.0800	13.90
			279-M7	1.0726*	12.42
			134-19	1.0741*	12.66
Necessary difference 5% level	0.0031			0.0049	
"F" (calc.)		45.20	"F" (calc.)		18.33
"F" (5% level)		2.09	"F" (5% level)		2.00

Significantly higher than Irish Cobbler.
* Significantly lower than Irish Cobbler.

II. RELATION BETWEEN YIELD OF POTATOES AND SPECIFIC GRAVITY OF THE TUBERS

The station yield totals and the average specific gravity of all potatoes produced at the stations are given in Table XI. A significant negative correlation was obtained between bushel per acre yield and the average specific gravity of the tubers grown at individual stations during 1947. Similarly, highly significant negative correlation coefficients were found for 1946, and from the data for the two years combined. The correlation coefficients are given in Table XII. The total yields and specific gravities of the five varieties which were included in the trials at all stations during the two years are shown in Tables XIII, XIV, and XV. Highly significant negative correlation coefficients were secured for Irish Cobbler, Red Warba, and Canus, and significant negative correlations were obtained from Warba and Pontiac. The correlations which were calculated are tabulated in Table XVI.

The negative correlations within varieties between total yield and specific gravity, and between the rate of yield at stations and average specific gravity indicates that the specific gravity of potato tubers varies inversely with the variations in the total yield.

The coefficients of linear regression of the average specific gravity on the total yields at each station for 1946, 1947, and for 1946-1947 combined, were found to be negative and are shown in

TABLE XI

STATION TOTAL YIELDS AND CORRESPONDING AVERAGE SPECIFIC GRAVITIES OF TUBERS

Year	Station	Yield (bu/A)	Specific gravity
1946	Fort Garry	286.29	1.0847
"	Benito	445.28	1.0774
"	Portage la Prairie	387.36	1.0800
"	Steinbach	407.37	1.0825
"	Balmoral	110.84	1.0953
1947	Fort Garry	550.31	1.0722
"	Melrose	314.52	1.0805
"	Morden	166.01	1.0945
"	Portage la Prairie	284.11	1.0879
"	Steinbach	251.20	1.0804
"	Balmoral	262.01	1.0862

TABLE XII

CORRELATION COEFFICIENTS AND COEFFICIENTS OF REGRESSION FOR SPECIFIC GRAVITY AND STATION TOTAL YIELDS

Year	Correlation coefficient	Coefficient of regression
1946	-0.9738**	-0.00004986
1947	-0.8694*	-0.00005156
1946-1947	-0.9132**	-0.00005018

** Significant at the 1% level.
* Significant at the 5% level.

TABLE XIII

TOTAL YIELDS OF IRISH COBBLER AND PONTIAC AND CORRESPONDING SPECIFIC GRAVITIES AT EACH STATION

		Irish Cobbler		Pontiac	
Year	Station	Yield (bu/A)	Sp. gr.	Yield (bu/A)	Sp. gr.
1946	Fort Garry	309.32	1.0881	291.41	1.0723
"	Benito	448.90	1.0817	518.78	1.0670
"	Portage la Prairie	465.02	1.0813	432.77	1.0711
"	Steinbach	438.14	1.0853	419.33	1.0764
"	Balmoral	115.35	1.1004	167.79	1.0881
"	Sprague	139.78	1.0906	143.81	1.0746
1947	Fort Garry	610.41	1.0808	606.37	1.0634
"	Melrose	410.76	1.0849	378.49	1.0756
"	Portage la Prairie	342.19	1.0902	303.73	1.0850
"	Steinbach	306.53	1.0863	244.02	1.0732
"	Balmoral	303.15	1.0865	359.61	1.0822
"	Sprague	658.73	1.0824	615.08	1.0766
"	Morden	185.53	1.0949	182.87	1.0866

Table XII. Similarly the regressions for the five varieties, calculated from the data gathered over the two years, were negative and are reported in Table XVI. Graphs of the regression equations are presented in Figures 1 and 2.

The test of the significance of the difference between the 1946 and 1947 correlation coefficients for rates of station yield and

TABLE XIV

TOTAL YIELDS OF WARBA AND RED WARBA AND CORRESPONDING SPECIFIC GRAVITIES AT EACH STATION

Year	Station	Warba		Red Warba	
		Yield (bu/A)	Sp. gr.	Yield (bu/A)	Sp. gr.
1946	Fort Garry	231.65	1.0859	324.05	1.0915
"	Benito	430.08	1.0781	502.66	1.0784
"	Portage la Prairie	377.66	1.0743	452.93	1.0823
"	Steinbach	482.50	1.0812	547.00	1.0801
"	Balmoral	111.32	1.0943	99.22	1.0943
"	Sprague	115.58	1.0865	153.22	1.0848
1947	Fort Garry	553.94	1.0740	660.82	1.0721
"	Melrose	210.38	1.0807	278.98	1.0838
"	Portage la Prairie	282.33	1.0846	314.60	1.0814
"	Steinbach	215.14	1.0796	260.15	1.0838
"	Balmoral	176.10	1.0854	229.90	1.0873
"	Sprague	584.84	1.0851	646.71	1.0806
"	Morden	146.57	1.0949	156.66	1.0948

specific gravity gave a P value greater than 0.5. This indicates that the correlations did not differ significantly in different years.

These results do not mean that a variety which is a heavy yielder will produce tubers with a low specific gravity. They do indicate that, within the same variety, an increase or decrease in yield per acre is accompanied by a certain decrease or increase, respectively, in the specific gravity of the tubers. As shown in Table

TABLE XV

TOTAL YIELDS OF CANUS AND CORRESPONDING SPECIFIC GRAVITIES AT EACH STATION

Year	Station	Yield (bu/A)	Sp. gr.
1946	Fort Garry	316.01	1.0790
"	Benito	446.21	1.0720
"	Portage la Prairie	358.85	1.0751
"	Steinbach	379.00	1.0761
"	Balmoral	96.80	1.0889
1947	Fort Garry	503.52	1.0736
"	Melrose	299.11	1.0739
"	Portage la Prairie	219.82	1.0857
"	Steinbach	278.30	1.0766
"	Balmoral	250.07	1.0853
"	Sprague	574.75	1.0771
"	Morden	154.64	1.0917

XII, page 31, and in Table XVI, page 35, the amount of decrease in specific gravity with every increase of one bushel per acre in yield varies from 0.00005156 units for the 1947 station total yields to 0.00002295 units for Warba. If the change in yield from one station to another amounts to one hundred bushels per acre, the specific gravity would change by 0.005156

TABLE XVI

CORRELATION COEFFICIENTS AND COEFFICIENTS OF REGRESSION FOR SPECIFIC GRAVITY AND VARIETY TOTAL YIELDS

Variety	Correlation Coefficient	Coefficient of Regression
Irish Cobbler	-0.7490**	-0.00002978
Pontiac	-0.6089*	-0.00002884
Warba	-0.6203*	-0.00002295
Red Warba	-0.8664**	-0.00003017
Canus	-0.7848**	-0.00003706

** Significant at 1% level.
* Significant at 5% level.

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and 0.002295 units, respectively. In terms of percentage of starch in the tubers, the difference amounts to 1.3 per cent and 0.4 per cent, respectively.

The point distribution showing the relationship between specific gravity is presented in Figure 3, page 38. This distribution diagram shows very little or no evidence of non-linearity in the correlation between yield and specific gravity.

FIGURE 1. REGRESSION OF SPECIFIC GRAVITY ON STATION TOTAL YIELDS FOR 1946, 1947, AND 1946 - 1947 COMBINED

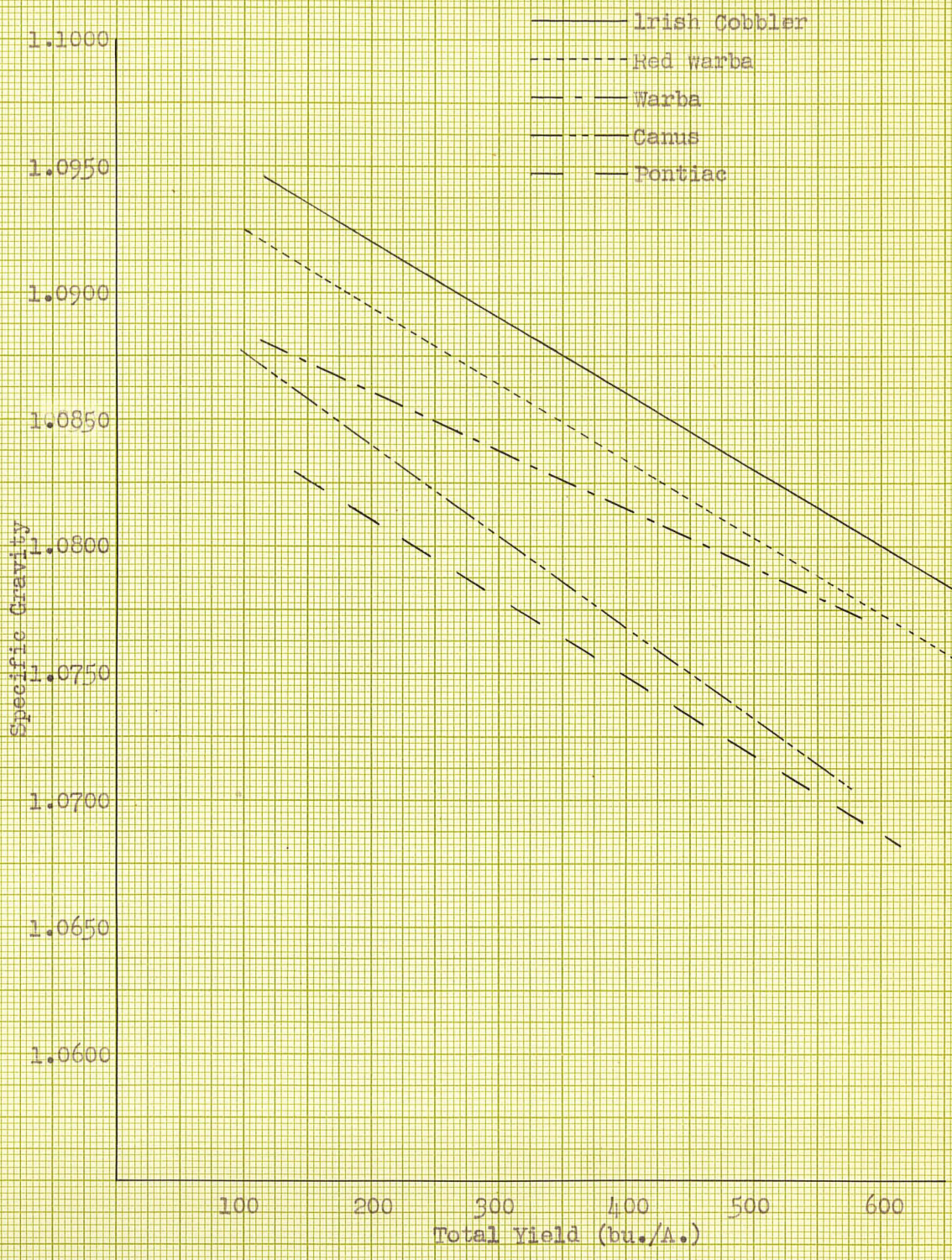

FIGURE 2. REGRESSION OF SPECIFIC GRAVITY ON TOTAL YIELD OF IRISH COBBLER, PONTIAC, CANUS, WARBA, AND RED WARBA

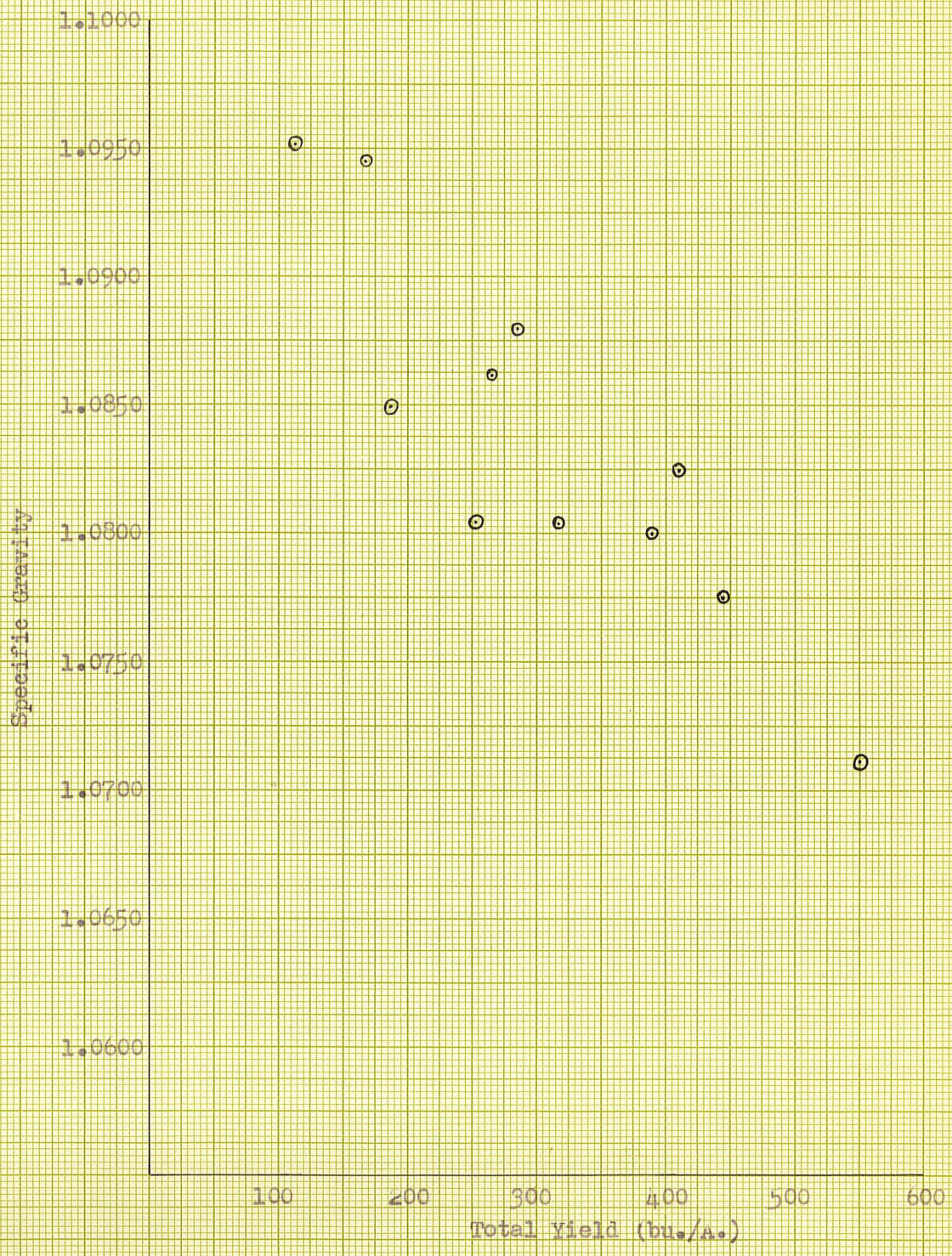

FIGURE 3. POINT DISTRIBUTION OF SPECIFIC GRAVITY IN RELATION TO STATION TOTAL YIELDS FOR 1946 - 1947 COMBINED

SUMMARY

Determinations were made of the specific gravity of the tubers of sixteen potato varieties and selections grown in eight areas of Manitoba during 1946 and 1947. Analyses of variance carried out on the data combined from all stations showed that, during each year, highly significant differences existed among the averages of the specific gravity produced by all varieties combined at each station.

Highly significant differences were present among the averages of the specific gravity of all varieties and selections. During 1946, the specific gravity of the tubers of ND-1 and Gold Nugget was significantly higher than that of the tubers of Irish Cobbler, while during 1947, the specific gravity of Irish Cobbler was exceeded by that of 148-99, Columbia Russet, 182-M16, and 134-19. During 1946, the specific gravity of Bovee and Minnesota 47.38; and during 1947, the specific gravity of 279-M3 and 148-84, did not differ significantly from the specific gravity of Irish Cobbler. In 1946, the following varieties and selections were significantly exceeded in specific gravity by Irish Cobbler; Red Warba, Warba, Pawnee, Kasota, Canus, Bliss Triumph, Pontiac, 134-19, 144-114, 279-M9, and 181-M7. In 1947, the following varieties and selections were significantly exceeded in specific gravity by Irish Cobbler; Red Warba, Warba, Canus, Pontiac, 144-114, 292-M2, 129-10, 279-M7, and 178-3. Highly significant interactions of variety by station were revealed which

indicated that varieties and selections which produced the highest level of specific gravity at certain stations would not necessarily produce the highest level at other stations.

The individual analyses of variance made on the data from each station showed that the varieties and selections differed in specific gravity by highly significant amounts at every station.

A negative correlation between total yield and specific gravity was found within the varieties, Irish Cobbler, Red warba, Warba, Canus, and Pontiac, and also between the rate of total yield at each station and the corresponding average specific gravity of potatoes produced at each station. The amount of change in specific gravity was found to vary from 0.00002 to 0.00005 units of specific gravity for every change in yield of one bushel of potatoes per acre.

The rate of change in specific gravity with change of yield did not vary from 1946 to 1947.

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