IRRIGATION AND NITROGEN EFFECTS ON THE FACTORS WHICH INFLUENCE THE YIELD OF A HILL OF POTATOES

Thesis for the Degree of M. S.

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Thomas H. Obourn

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IRRIGATION AND NITROGEN EFFECTS
ON THE FACTORS WHICH INFLUENCE THE YIELD
OF A HILL OF POTATOES

By

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AN ABSTRACT

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Approved ____________________

Thomas H. Obourn

Yield components of the potato consisting of tubers per stem, stems per hill and weight per tuber were studied at Lake City in 1961. Three varieties, Kennebec, Katahdin and Onaway, were evaluated under several combinations of irrigation and nitrogen.

When the data was arranged by number of stems per hill, the tuber number, the gross tuber weight and the weight of U.S. Number 1 fancy tubers increased as stems per hill increased. Added nitrogen increased tuber number per hill in the Katahdin variety but had no effect on the Kennebec variety. The most marked effect of nitrogen was in the increased weight per tuber of the Katahdin variety. Irrigation increased both tuber set and size for the Onaway variety.

Simple correlation coefficients between tubers to stems (T:S), weight to tubers (W:T) and weight to stems (W:S) revealed that for the most part they were correlated at above 1% level. Treatment of irrigation or nitrogen did not affect these relationships. The Kennebec variety was greater than either the Katahdin or the Onaway variety in (T:W).

It is proposed that yield components may be of value to both the potato breeder and production manager in evaluating varieties.

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INTRODUCTION

The potato industry is in a dynamic economic price-cost squeeze which makes it necessary for the potato producer to obtain high yields to realize the highest returns on his investments. Potatoes are marketed as fresh-market table stock, for processing, or as seed with each use having its particular requirements. Size is an important factor in the marketing of potatoes and most buyers are familiar with the U.S. Number 1 grade which is regulated by federal market grades and, in some states, by state marketing laws. Seed and processing potatoes have size standards of their own. The processors are not satisfied with the minimum quality standards of U.S. Number 1 and additional factors are required, such as dry matter and reducing sugars, which may affect the processed products.

The yield of a potato plant is the product of the number of tubers and the weight per tuber which may be considered as components of yield. When potato yield is considered on the unit of the hill, which is actually a grouping of individual plants, the number of stems per hill, the tubers per stem and the weight per tuber become the yield components. These components are governed by both environmental and hereditary influences. The yield potential of any variety is determined by the number of tubers set per plant and the potential tuber size, while actual yield is determined by environmental influences which may prevent full development of the tubers set.

It is the objective of this thesis to explore some of the environmental and hereditary differences between varieties on a component basis. With an understanding and use of yield components, a manager may adjust production practices for increased yield and the potato breeder may assess seedling populations.

REVIEW OF LITERATURE

Though the literature contains many references to the potato, little information is available on just how the potato plant reacts to hereditary and environmental factors which influence the yield.

Arthur (1), in 1891, was among the first to report any data pertaining to plant factors affecting yield of potatoes. He found that the number of tubers per hill is determined, within certain limits, by the number of stems per hill.

Claypool and Morris (8) reported the greatest yield of U.S. Number 1 tubers occurred with two to three stems per hill. The number of tubers per hill increased as the stems per hill increased. The hills with four stems offset the yield of those with one stem even though the latter had more tubers per stem and a higher average tuber weight. They concluded that potato size can be controlled either by seed piece or hill spacing.

Bushnell (6) showed that the number of stems varied from one to five per hill. The hills with the fewest stems produced the lowest yield. The hills with two to four stems gave the highest yield of potatoes over one and seven-eighths inches in diameter. He concluded that the number of stems per hill was not a factor affecting the yield of potatoes within the range of one to five stems.

Burton (4) found that the hills with more than one stem per hill produced more tubers than one stem hills, but this relationship was not an arithmetical progression.

Seed piece size has been reported by Bates (2) and Clark (9) to influence the number of stems. Clark (9) concluded that larger seed pieces generally have more eyes and therefore produce more stems. Greater stem number increased the tuber yield per hill.

Stem number by itself may be increased by some of the following practices: (1) Larger seed pieces generally have more eyes. Consequently, more stems per seed piece will be produced. Bates (2) and Clark (9). (2) Michener (17) treated the tubers forty-six days after harvest with ethylenechlorohydrin to break apical dominance. The non-treated tubers produced 1.6 stems while the treated tubers produced 4.7 stems per tuber. (3) Bushnell (6), working with Russet Rural tubers in Ohio, found that as the planting season progressed from April to June there was an increase in stem number. The stem increase was about one stem per tuber during this period. Bushnell (6) suggested that as the season progressed, wider spacing differences could be used. To take advantage of the increased stem number, 9 inch spacing for the early planting and 12 inch spacing for the later planting could be used.

Warren (19) cited many cases in which closer spacing produced a higher yield. In his investigations, 6 inch spacing consistently produced higher yields of 3 to 12 ounce tubers with smaller yields of tubers over 12 ounces; while a 12 inch spacing produced more tubers over 12 ounces and less of the 3 to 12 ounce class. These findings agree with Biship's (3) work. Bishop also reviewed the work of several other investigators whose conclusions supported his results.

Nitrogen and water are both essential for the production of a potato crop. If either is limited, the yield will be depressed; but when supplemental nitrogen or water is added, the yield may be increased. The influence of nitrogen or irrigation on the potato crop is a subject of much controversy in the earlier literature.

King (15), in 1886, stated that the percentage of large tubers was increased by irrigation and this increase in the tuber size added to the yield.

Clark (9), in studying the ontogeny of the potato tuber, declared that: (1) when irrigation was applied after tuber formation, there is only a size increase and (2) when applied before tuberization, there is both a set and size increase.

Fussing (11) worked with the Irish Cobbler variety in irrigation investigations. He found that this variety set 3.0 tubers per stem when supplemental irrigation was applied at 1.0 and 1.5 inch levels. Irrigation was applied after water had evaporated one inch from an open pan. A total of 12 inches was applied for the season. An average of 1.0 tuber per stem was set with no irrigation. Fussing concludes that added irrigation increased the tuber set, but it did not materially increase yield as not all the tubers increased in size.

Pratt, et al., (18) found that irrigation may increase the tuber set as well as the tuber size, but these results varied with location and season. Early-season irrigation in 1951 and 1952 produced 21 and 29 more tubers which were over 1.25 inches in diameter per 25 feet of row, respectively. In 1949 irrigation produced no increase in yield of the tubers over 2 inches in diameter. The irrigated potatoes averaged .41 of a pound, and the non-irrigated .42 of a pound per tuber.

Harris (13), working with flood irrigation, found that one inch of water per week for 12 weeks produced tubers averaging .22 of a pound. Treatments of 0, 2.5, 5 and 7.5 inches per week produced tubers weighing less. The 2.5 and 5.0 inch levels produced more tubers but the 1 inch level resulted in the highest yield. Early-season irrigation increased the tuber number while later applications increased the tuber size. Harris found the average yield per hill and per acre were very closely related to the application of supplemental water.

Bushnell (5) found that nitrogen, applied either in an organic form or as sodium nitrate, increased the tuber set; but it had no appreciable affect on the tuber size.

Martin (16) found the largest tubers were produced by mixtures of fertilizer containing large amounts of nitrogen and little or no potassium or phosphorous. When nitrogen was absent from the fertilizer, the yields were the lowest.

Bradley, et al., (7), investigating the influence of early-season irrigation and nitrogen application, concluded: (1) the greatest effect of moisture was earlier maturity rather than an increase in number of tubers set and (2) nitrogen was not effective in increasing tuber set.

The environmental factors over which man has some control have been discussed. Two factors over which he has little control are light and temperature. Hardenburg (12) states that the potato plant yields best in areas where the mean temperature of the warmest month of the growing season is not above 65° Fahrenheit. Intensity, quality, and duration of light are important. However, according to Hardenburg, these factors are not considered to be of any great consequence during the normal growing season.

MATERIALS AND METHODS

An experiment was set up at the Lake City Experiment Station in 1961, which was designed to measure the effect of irrigation and nitrogen levels on 3 different varieties of potatoes. Table 1 lists the materials used in this experiment. All varieties shown in Table 1 received combinations of irrigation and nitrogen. A split plot experimental design was used.

Table 1. Varieties used, nitrogen practices and irrigation treatments at Lake City Experiment Station. 1961.

Varieties	Elemental nitrogen pounds per acre	Irrigation applied at % field capacity
Kennebec	0	0
Katahdin	50 P.U.[1]	50%
Onaway	50 P.U. - 50 S.D.[2]	75%
	50 P.U. - 100 S.D.	
	150 P.U.	

[1]P.U. = Plow under.
[2]S.D. = Side dress - July 3.

Cut potato seed pieces of 1.5 ounces were planted on May 16 and 17. The seed pieces were planted in 36 inch rows spaced 9 inches apart in the row. The initial fertilizer rate of 1000 pounds per acre of 0-10-40 was broadcast before plowing. Three-hundred pounds of 5-10-20 was applied in bands at planting. Additional nitrogen was incorporated as reported in Table 1. The soil type on which the potatoes were grown is classed as a Montcalm loamy sand. The pH of the plow layer was variable throughout the area but averaged 5.5. Fertilizer requirements were determined by soil tests.

Irrigation was applied from July 5 until harvest, with soil moisture determinations governing the application of water. When soil moisture decreased to 50% or 75% of field capacity, irrigation was applied. Yield data from irrigation were evaluated by comparison with plots receiving only normal precipitation.

Weather data from the U.S. Weather Bureau recording station on the Lake City Experiment Station are shown in Figs. 1 and 2. Temperatures during the May to September growing season were favorable for the growth of the potato plant. Rainfall was well distributed over the entire growing season.

Data were collected from plots of the Onaway, Kennebec and Katahdin varieties. The data for the Onaway variety were taken from 0 and 75% irrigation levels with nitrogen treatments of 50 and 50 plus 100 pounds nitrogen per acre. The data from the Kennebec and Katahdin varieties were obtained from 50% and 75% irrigation levels with all five levels of nitrogen.

The early variety, Onaway, was harvested on August 16, at which time the tops showed signs of maturity. Fifteen

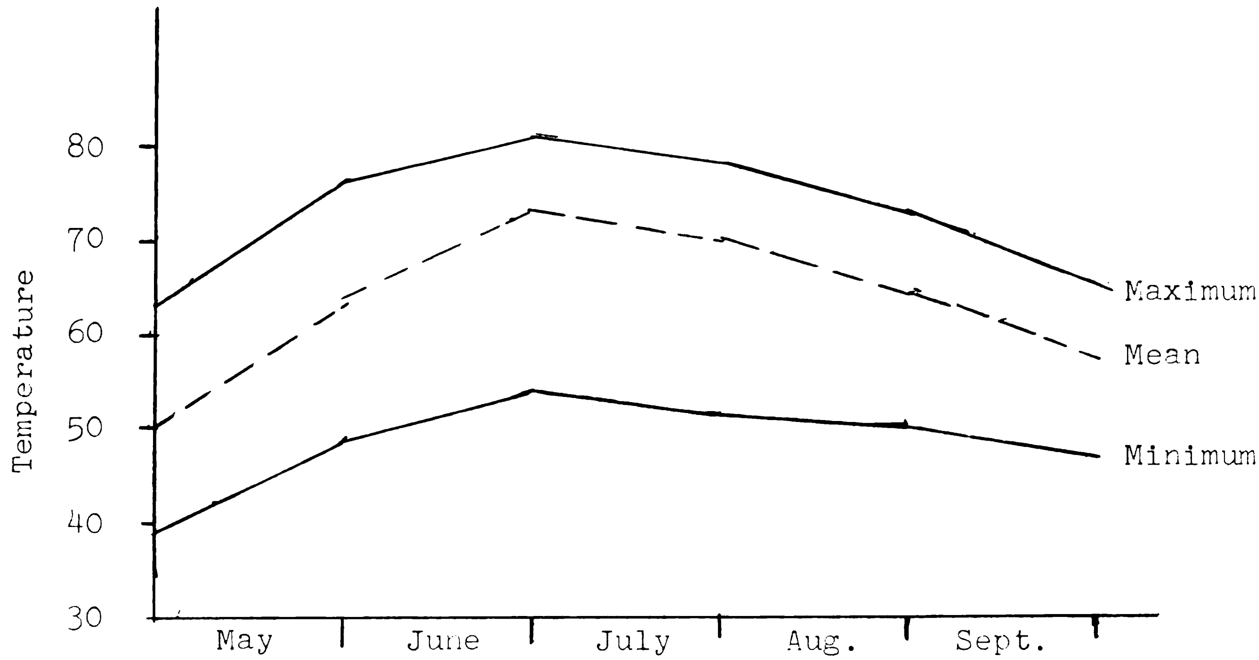

Fig. 1. Growing Season Temperature, Lake City Experimental Station May to Sept., 1961

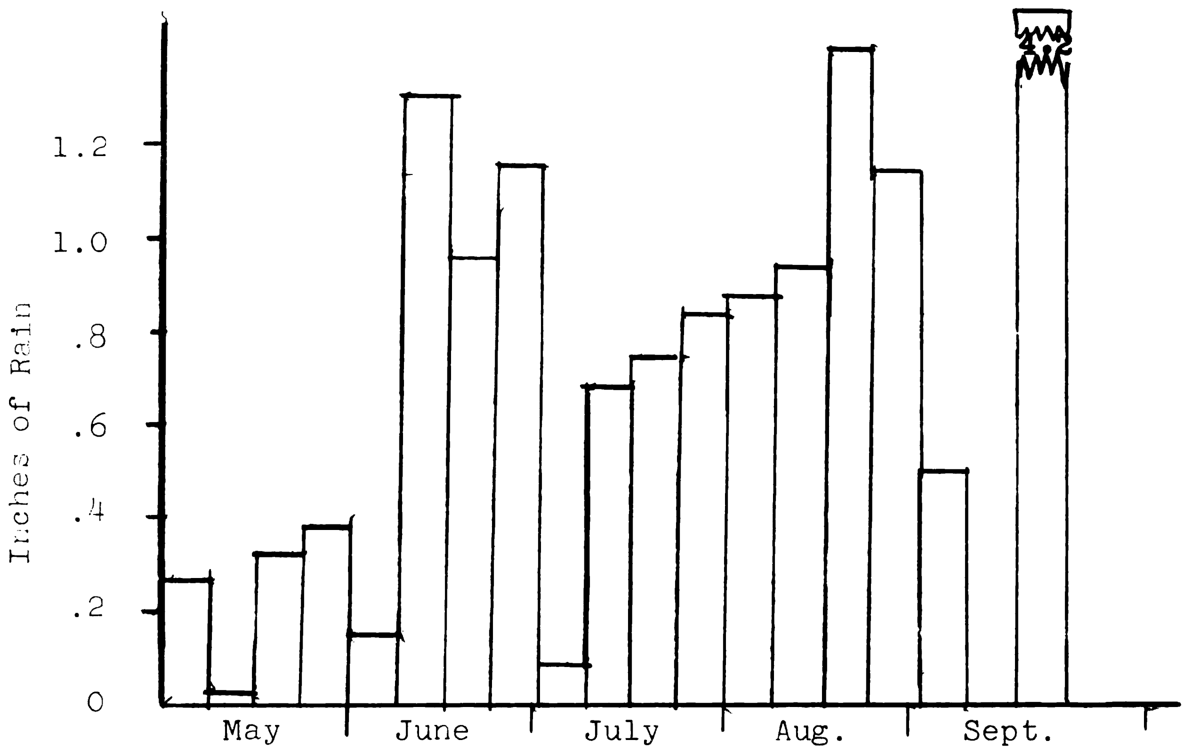

Fig. 2. Rainfall Inches Per Week, Lake City Experimental Station May to Sept., 1961

hills, each individually bagged, were harvested from each of three replications. The Kennebec and Katahdin varieties were harvested on September 14 and 15. Ten hills were harvested from each of three replications. Stem number was recorded on each bag containing a single hill sample. All bags were placed in 40° Fahrenheit storage until washed, dried and weighed. All tuber weights over one gram were individually recorded. One month after harvest all the tubers had been weighed and recorded.

Additional yield data were obtained from another experiment adjacent to the irrigation and nitrogen tests. It was a spacing trial of the Kennebec variety in which the seed pieces were spaced at 7.5, 9, 12, and 15 inches. This experiment received the same cultural practices as applied to the first experiment except that the nitrogen fertilization rate was 50 pounds per acre plowed under. All plots received irrigation. Data on stem number, number of tubers per hill and weight per tuber were recorded as in the nitrogen-irrigation experiment.

The nitrogen and the irrigation data were analyzed for analysis of variance using the Michigan State binary digital computer with program P 10. Simple correlation coefficients using hill data were run between the number of stems and the number of tubers (S:T); the weight of tubers and the number of stems (W:S) and the weight and number of tubers (W:T) for the irrigation and nitrogen replication. The data from the Kennebec, Katahdin, and Onaway varieties were divided into classes by tuber weight and number. Classes were constructed so that they would approximate useful market grades in potato marketing channels. These market classes are as follows: (1) tubers under 50 grams which equals a B size or whole size seed tuber, (2) tubers weighing between 50 and 300 grams which is a U.S. Number 1 fancy grade, and (3) the tubers over 300 grams which are used for processing, such as, french fries.

RESULTS AND DISCUSSION

The analysis of variance, Table 2, reveals that there were significant differences between the Katahdin and the Kennebec varieties. There is also a significant difference due to supplemental nitrogen application. The greatest difference in the nitrogen treatments occurred between the 0 level and the other levels, being very close in their performance (Table 2). Soil moisture, maintained above 75% field capacity, though it gave the higher average yield, did not significantly increase the yield of potatoes over maintenance at 50% field capacity (Table 2). From these observations it was decided that the data could be combined by variety, no nitrogen and added nitrogen applications. The combining was done by the number of stems that occurred in a hill with all one stem hills in one group and all the hills with two stems, etc. until all the data were arranged in this manner.

Yield data for the Onaway variety were arranged by stem number per hill for no irrigation and high irrigation.

Potato hill yield, on a component basis, is a function of the following factors: (1) the number of stems per hill, (2) the number of tubers per stem and (3) the weight per tuber.

Table 2. Analysis of variance of hill yield of Kennebec and Katahdin varieties under treatments of five levels of nitrogen and two levels of irrigation.

	D.F.	Squares	Variance	F
Replication	2	991.6		
Irrigation (I)	1	3,175.5	3,175.5	3.0
Error (A)	2	2,094.8	1,047.4	
Nitrogen (N)	4	4,390.0	1,097.5	5.4**
I x N	4	2,135.5	533.9	2.6
Error (B)	16	3,239.7	202.5	
Varieties	1	2,951.2	2,951.2	12.7**
I x V	1	629.7	629.7	2.7
N x V	4	3,430.3	857.6	3.7*
I x V x N	4	702.7	175.7	0.8
Error (C)	20	4,657.1	232.9	
Total	59	28,398.1		

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

Treatment averages, grams per hill sample.

Irrigation		Nitrogen		Variety	
50% F.C.	1,214.7	0	1,119.8	Kennebec	1,358.6
75% F.C.	1,318.8	50	1,322.0	Katahdin	1,217.4
		50 + 50	1,301.4		
		50 + 100	1,339.2		
		150	1,352.7		

Stems per hill

The first component to be considered is the number of stems per hill. Botanically each stem in a hill, after it loses its attachment from the seed piece, is a separate plant. Hardenburg (12) states that each hill contains an organization of stems or plants that may vary from one to several.

The number of stems per hill and the total tubers per hill of the Kennebec, Katahdin and Onaway varieties are shown in Figs. 3, 4 and 5. There is a varietal response to stem number. The Katahdin variety produced up to five stems per hill, the Kennebec up to six stems per hill and the Onaway up to seven stems per hill (Table 3).

Table 3. The frequency of number of stems per hill by variety.

Varieties	Number of stems per hill 1	2	3	4	5	6	7
	Number of observations						
Kennebec	27	57	82	66	23	16	
Katahdin	47	89	82	55	22		
Onaway	11	29	50	43	26	14	8

It may be observed from Table 3 that there were more hills with 3 or 4 stems for the Kennebec variety than any other. Katahdin had the greatest number of hills with 2 or 3 stems and hills with 3 or 4 stems occurred more frequently in the Onaway variety. As the stems per hill increased above 4 there was a sharp decline in the number of hills represented.

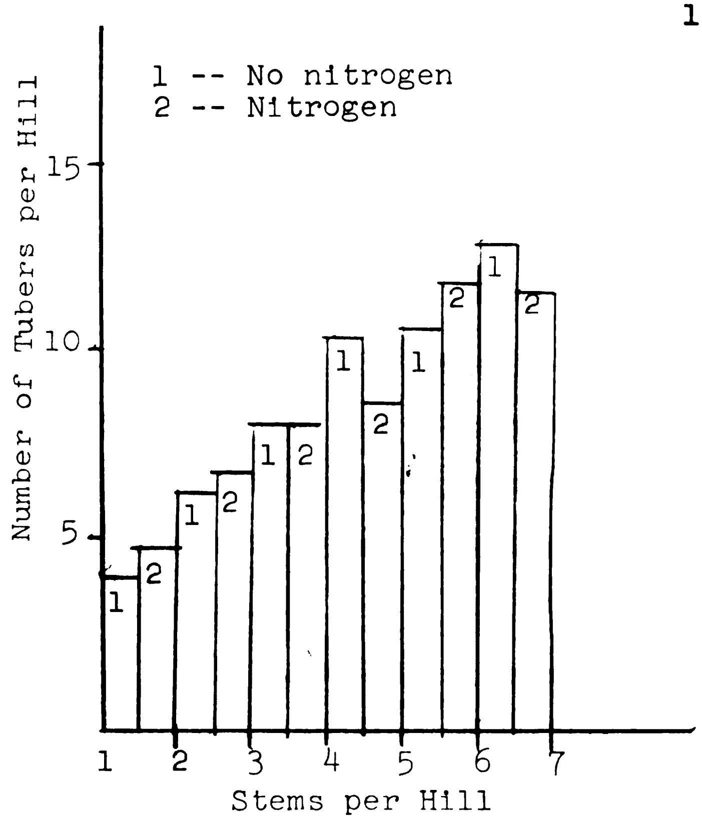

Fig. 3. Number of tubers of the Kennebec variety with treatments of No-nitrogen and nitrogen.

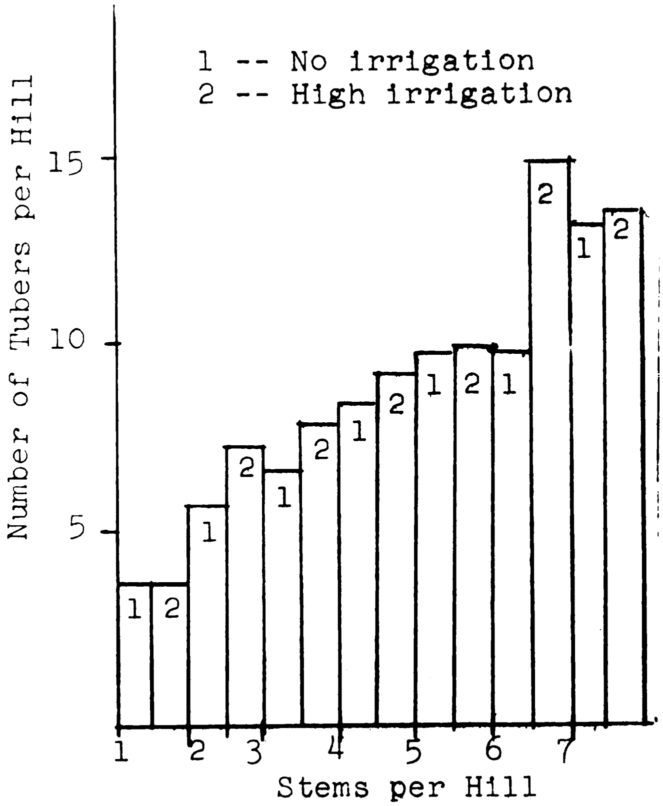

Fig. 4. Number of tubers of the Onaway variety with treatments of No-irrigation and high-irrigation.

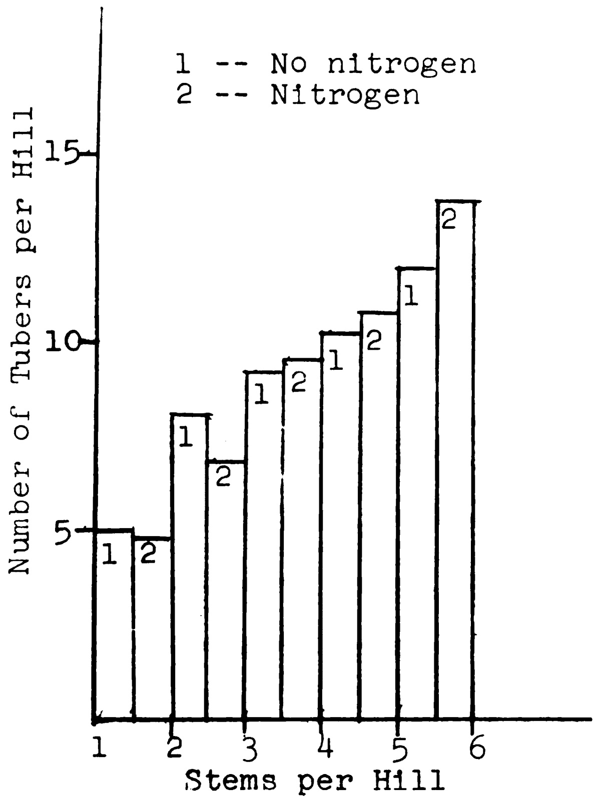

Fig. 5. Number of tubers of the Katahdin variety with treatments of No-nitrogen and nitrogen.

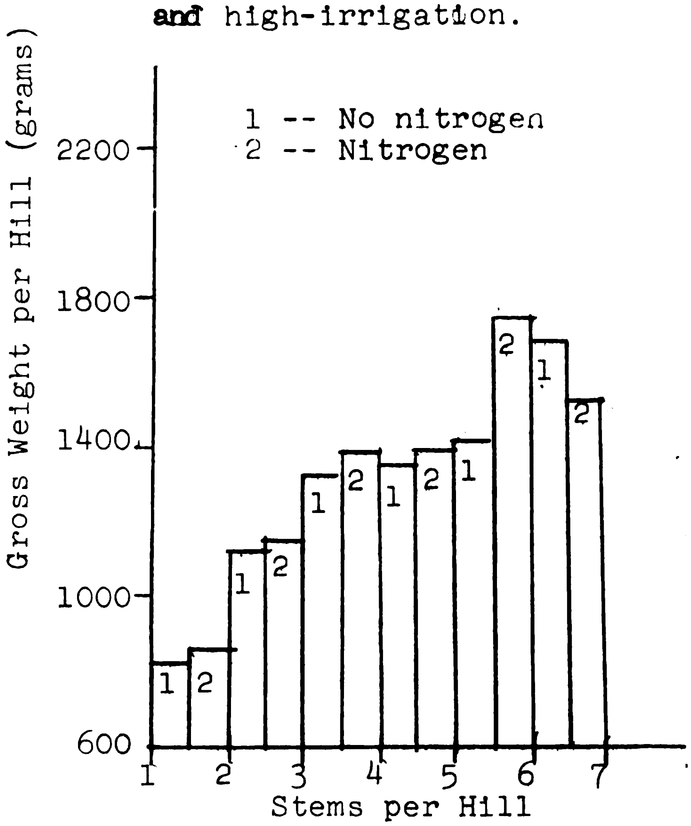

Fig. 6. Gross weight per hill of the Kennebec variety with treatments of No-nitrogen and nitrogen.

The total tuber number per hill increased as the stem number for each variety increased. The Katahdin variety did not have as many stems per hill as either the Kennebec or the Onaway varieties, but produced more tubers per hill. Nitrogen fertilization resulted in little difference in the number of tubers set by the Kennebec variety. When added nitrogen was applied to the Katahdin variety about .5 of an additional tuber was set per hill (Figs. 3 and 5).

Irrigation increased the tuber number per hill at every stem level above one per hill for the Onaway variety. As the number of stems per hill increased from one to seven, the number of tubers increased (Fig. 4).

Stem number and gross weight

The yield was very much increased when supplemental nitrogen was applied to the Katahdin variety. Kennebec, with no added nitrogen, produced a higher yield than the Katahdin variety with no added nitrogen (Figs. 6 and 7). Where added nitrogen was applied, both Kennebec and Katahdin varieties produced similarly in terms of gross weight (Figs. 6 and 7). The Kennebec variety responded very little to the application of added nitrogen except at the 5 stem level. At the 5 stem level, the hill yield of the Kennebec was 1751 grams and for the Katahdin, 1595 grams with supplemental nitrogen and without supplemental nitrogen, 1414 and 1377 grams respectively.

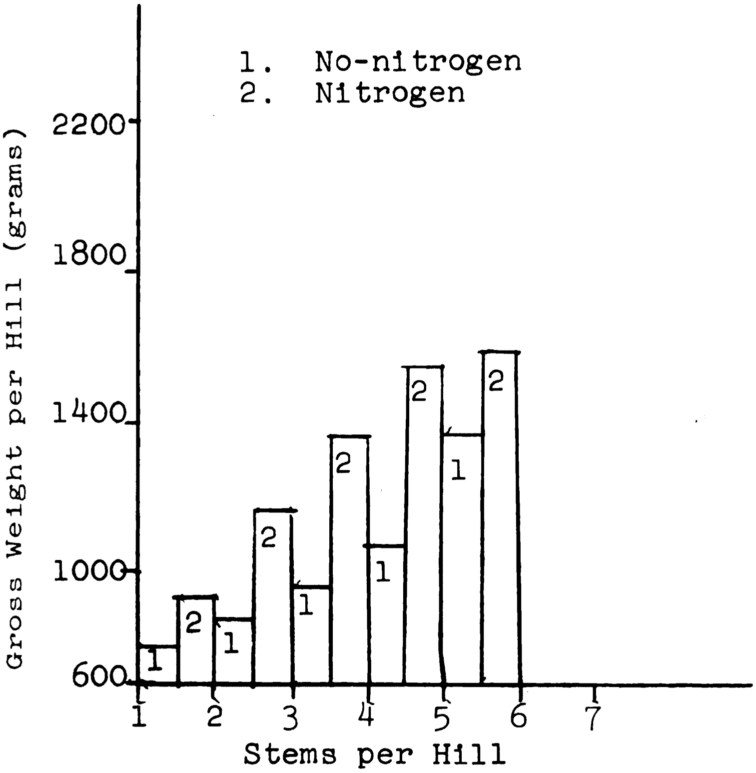

Fig. 7. Gross weight per hill of the Katahdin variety with treatments of No-nitrogen and nitrogen.

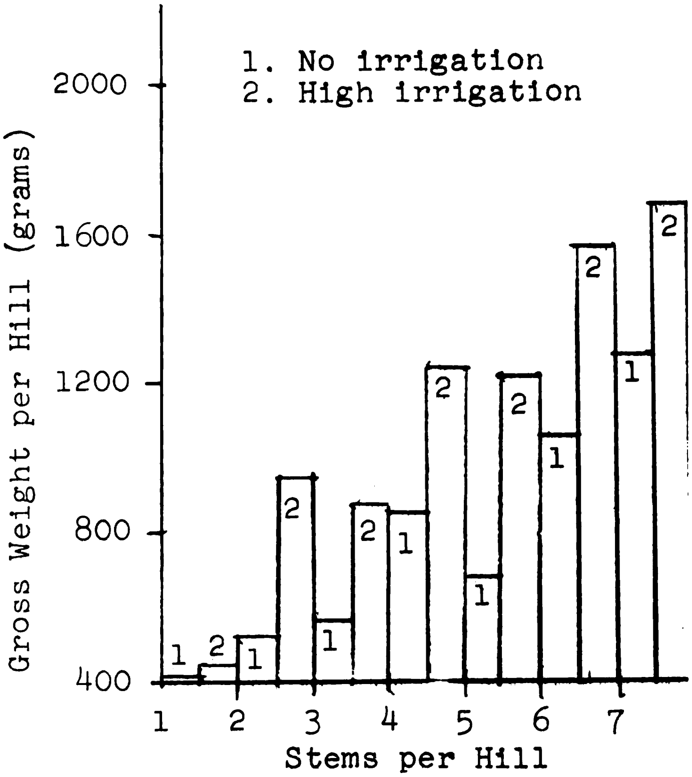

Fig. 8. Gross weight per hill of the Onaway variety with treatments of no-irrigation and high irrigation.

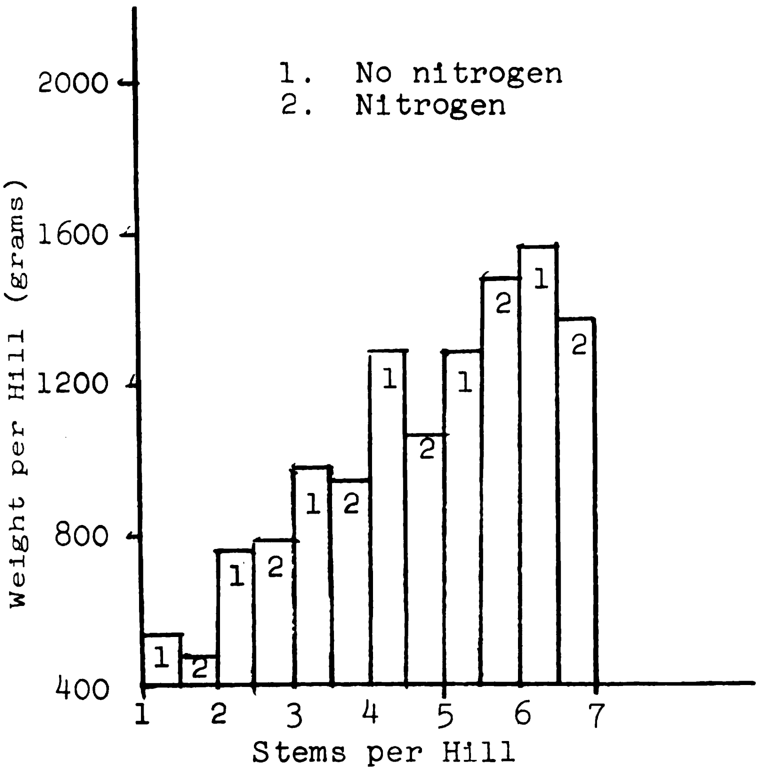

Fig. 9. Weight per hill of tubers between 50 to 300 grams of the Kennebec variety under treatments of No-nitrogen and nitrogen.

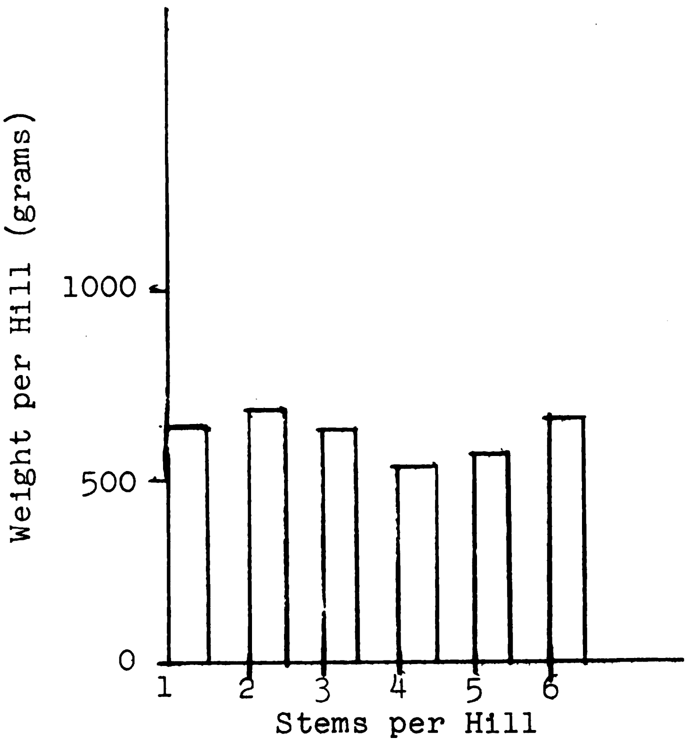

Fig. 10. Weight per hill of tubers weighing + 300 grams of the Kennebec variety with nitrogen treatment.

The gross weight of the Onaway variety increased at each stem level (Fig. 8). Irrigation added approximately 350-400 grams in gross weight per hill regardless of the stem number. The Onaway produced 1670 grams at the seven stem level with supplemental water and 1269 without.

Potato producers are not paid for the gross weight of the tubers they produce but for the tubers that meet certain specific market sizes. In order to examine the data more fully, the tubers were sorted into classes by tuber number and weight. The U.S. Number 1 fancy tubers of the Kennebec variety (Fig. 9) increased in weight per hill as the stem number increased from 1 to 6. The weight per hill of the large tuber weight classes of Kennebec did not change with the stem number (Fig. 10). Similar observations were made on the small class of Kennebec and the small and large classes of the Katahdin variety. The Katahdin and Onaway U.S. Number 1 fancy weight class increased as stem number increased (Figs. 11 and 12). The Onaway and Katahdin varieties exhibited the same relationship of small and large tuber classes as was noted for the Kennebec variety.

The effect of nitrogen on the yield of the Kennebec variety was slight (Fig. 13). Nitrogen applied to the Katahdin variety, much enhanced the weight per hill of U.S. Number 1 fancy tubers (Fig. 14).

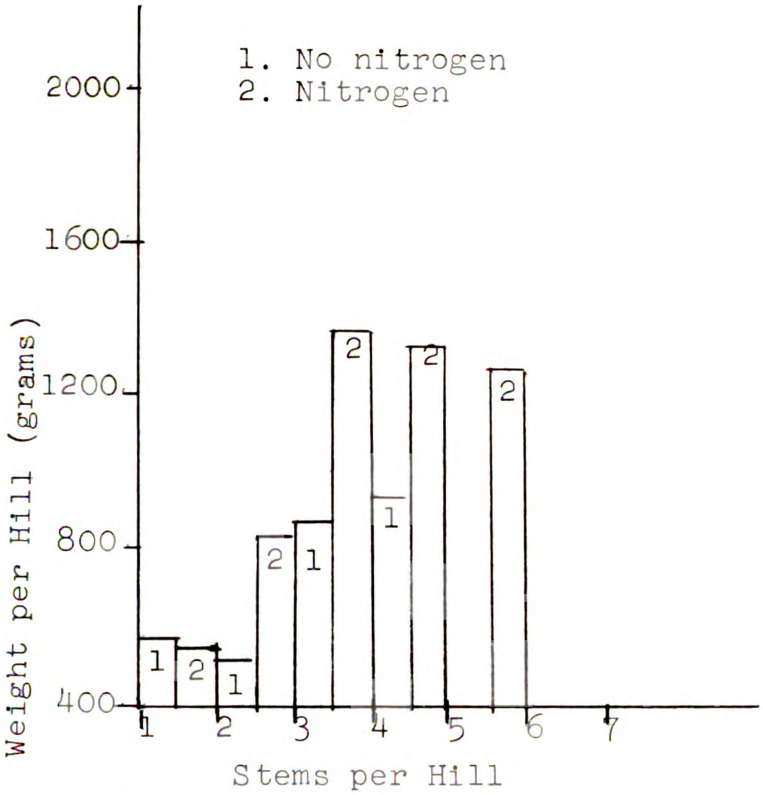

Fig. 11. Weight per hill of tubers between 50 and 300 grams of the Katahdin variety under treatments of No-nitrogen and nitrogen.

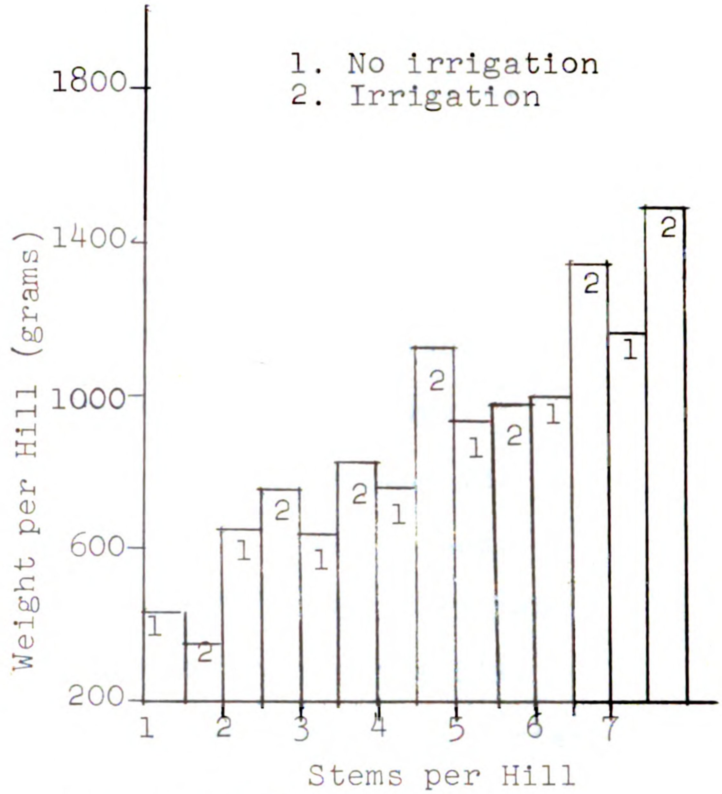

Fig. 12. Weight per hill of tubers between 50 and 300 of the Onaway variety under treatments of No-irrigation and irrigation.

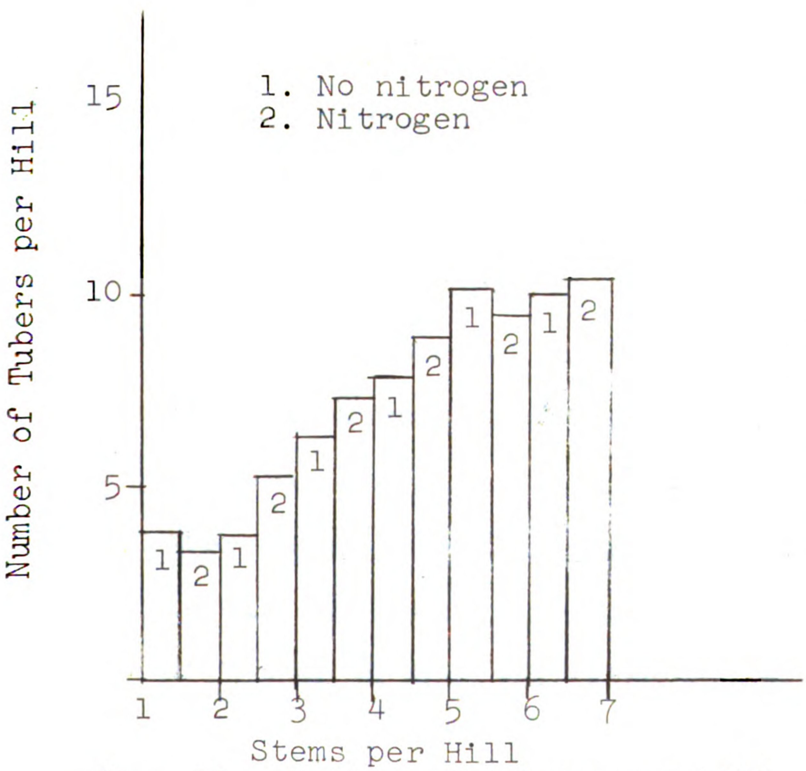

Fig. 13. Number of tubers per hill weighing between 50 and 300 grams of the Kennebec variety under treatments of No-nitrogen and

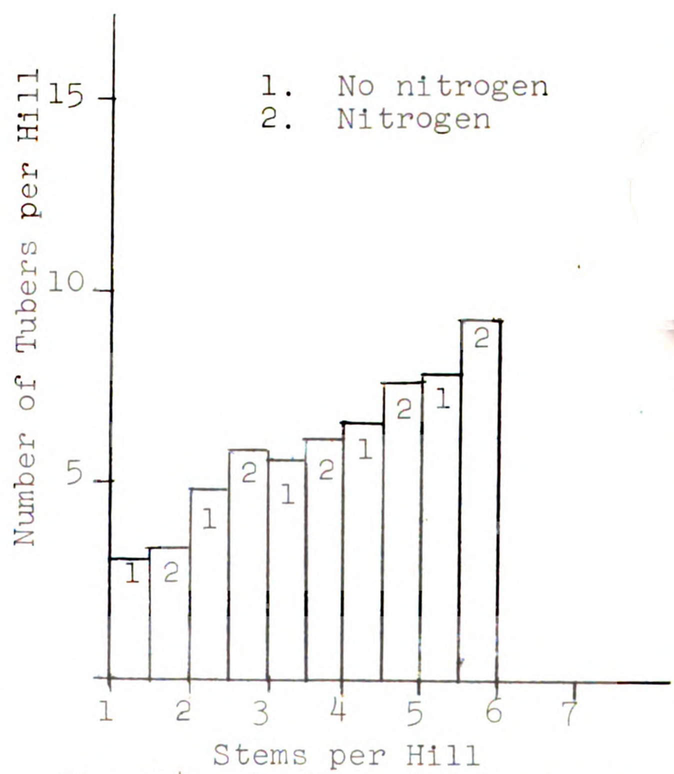

Fig. 14. Number of tubers per hill weighing between 50 and 300 grams of the Katahdin variety under treatments of

Irrigation resulted in additional weight per hill of the U.S. Number 1 fancy tubers in the Onaway variety (Fig. 12). The under 50 gram class and the over 300 gram class were similar to that of Kennebec and Katahdin.

The highest yields per hill of U.S. Number 1 fancy tubers for Kennebec, Katahdin and Onaway are as follows: (1) Kennebec, 1570 grams; (2) Katahdin, 1670 grams and (3) Onaway, 1490 grams. It was assumed that the Kennebec and Katahdin varieties would out-yield the Onaway since they had a month longer growing season. The largest weight per hill of the U.S. Number 1 fancy class was produced in all varieties in hills having the most stems.

When stem number increased for the Kennebec, Katahdin and Onaway varieties, the tuber number (Figs. 3, 4 and 5) and gross weight (Figs. 6, 7 and 8) increased. It was also shown that the weight of the U.S. Number 1 fancy grade also increased (Figs. 9, 11 and 12).

Tuber number

Table 4 presents the relationship of the average tuber number per stem of the Kennebec, Katahdin and Onaway varieties. Neither nitrogen nor irrigation affected the average tuber number. The hills with one stem consistently had the highest average tuber number per stem. At the one stem per hill level, the Onaway variety averaged about one tuber less per hill than either the Katahdin or the Kennebec. The average tuber number per stem decreased as the stem number per hill increased, but this was not a sharp decline.

Table 4. Average tubers per stem of the Kennebec and Katahdin varieties with treatments of no nitrogen and nitrogen and the Onaway variety with treatments of no irrigation and irrigation.

Stems	Kennebec		Katahdin		Onaway	
	No N	N	No N	N	No Irrig.	Irrig.
	No. tubers		No. tubers		No. tubers	
1	4.0	5.0	5.0	4.7	3.5	3.5
2	3.3	3.1	3.0	3.4	2.8	3.6
3	2.6	2.5	3.0	3.1	2.1	2.6
4	2.5	2.3	2.6	2.7	2.1	2.3
5	2.1	2.3	2.6	2.8	1.9	1.9
6	2.2	1.9			1.6	2.6
7					2.0	2.0

Figs. 3, 4 and 5 reveal that as the stem number increased the tuber number increased. The tuber number in itself does not express yield. The gross weight in itself is insufficient to express the economic yields. Weight and tuber number, must be compared, if a true picture is to be gained. Figs. 9, 11 and 12 present the data of the weight of the U.S. Number 1 fancy class of tubers between 50 and 300 grams. To give a more meaningful picture of the yield, the tuber number for the U.S. Number 1 fancy class is presented in Figs. 13, 14 and 15. The tuber number of the U.S. Number 1 fancy class increases as the stem number per hill increases just as in Figs. 3, 4 and 5.

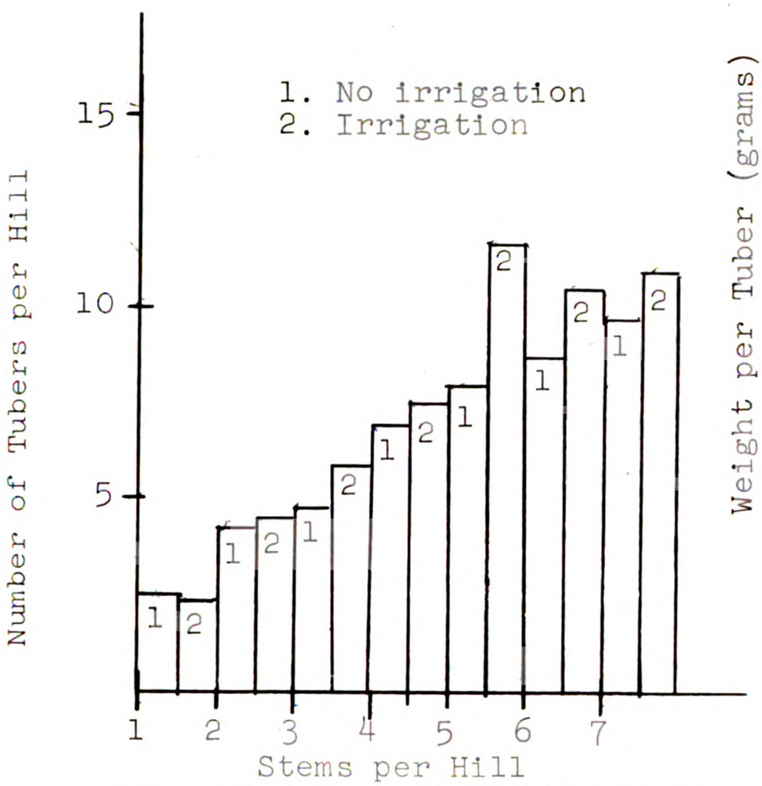

Fig. 15. Number of tubers per hill weighing between 50 and 300 grams of the Onaway variety with treatments of No-irrigation and irrigation.

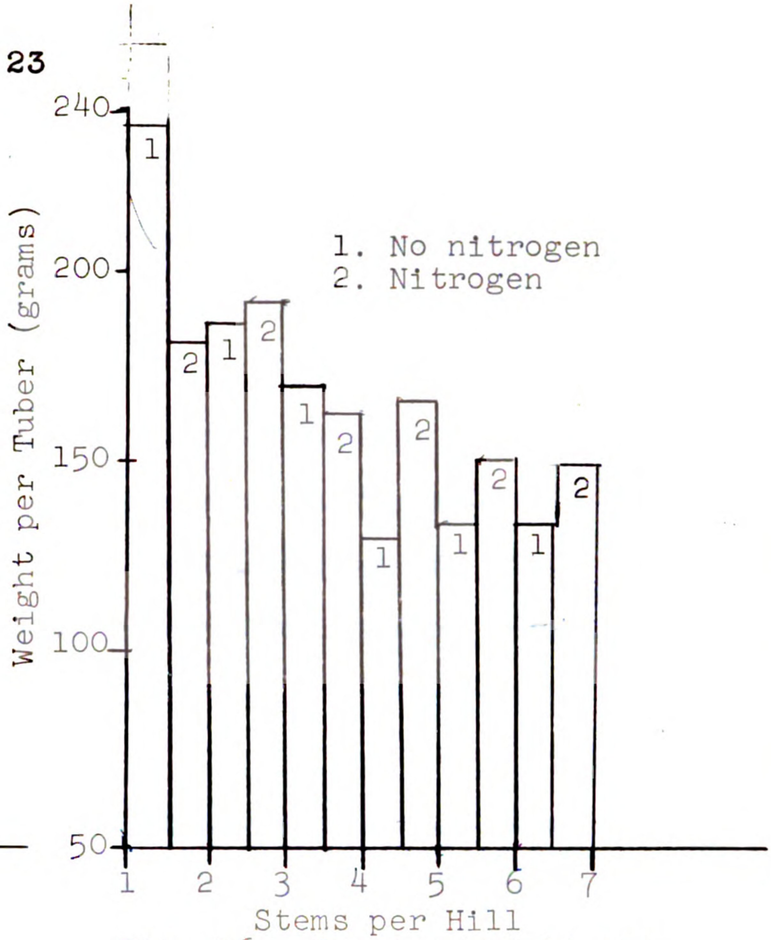

Fig. 16. Average weight per tuber of the Kennebec variety under treatments of No-nitrogen and nitrogen.

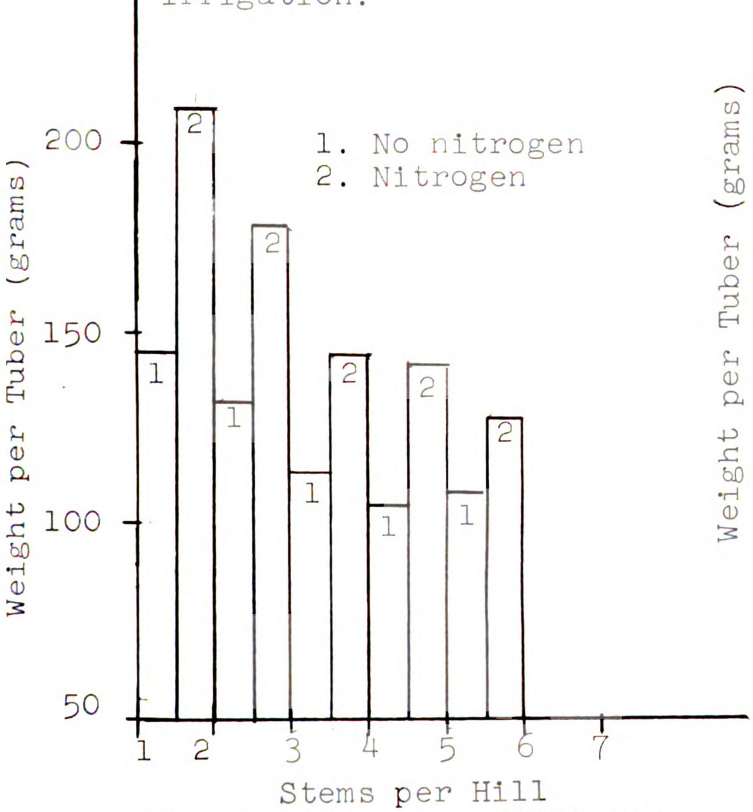

Fig. 17. Average weight per tuber of the Katahdin variety under treatments of No-nitrogen and nitrogen.

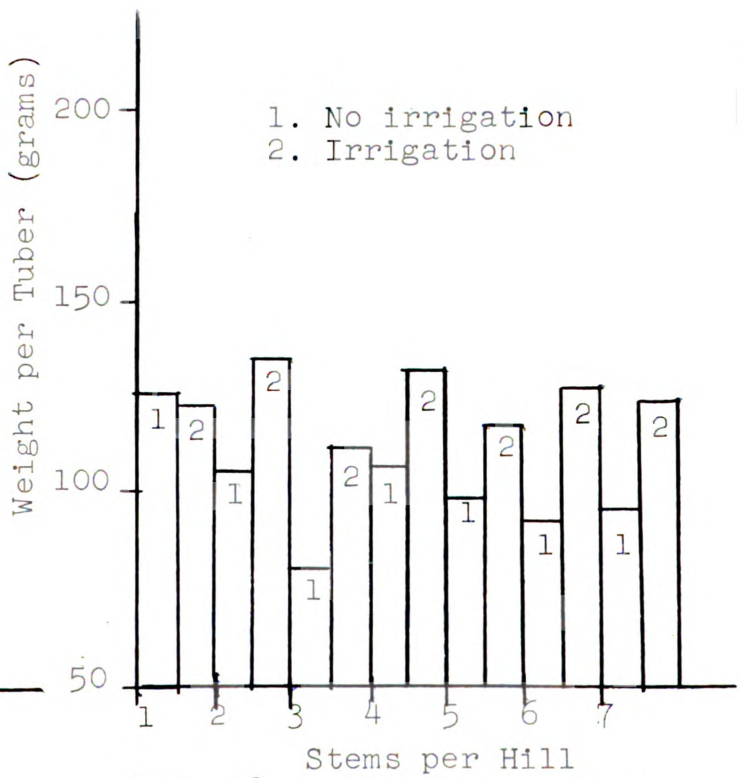

Fig. 18. Average weight per tuber of the Onaway variety under treatments of No-irrigation and irrigation.

The Kennebec variety (Fig. 13) responded very little to the application of nitrogen. In the Katahdin variety, (Fig. 14), nitrogen increased tuber number between one and four stems per hill.

The Onaway variety (Fig. 12) produced more U.S. Number 1 fancy tubers when irrigation was applied. As the stem number per hill increased, the tuber number increased. The maximum increase in tuber set took place at the 5 stem level. An average of one extra U.S. Number 1 fancy tuber was set per stem.

The tubers were divided into weight classes of less than 50, 50 to 300 and over 300 grams. The number of tubers occurring in each class were recorded. No observable trends were noted for any of the three varieties in the low or high tuber weight classes.

The yield of a hill may be influenced by a few large tubers or many small tubers. In processing the data, it was noted that some hills consisted of a few particularly large tubers while other hills had many small tubers. The two large tuber classes of the Kennebec variety are plotted in Figs. 9 and 10. Except for the U.S. Number 1 fancy tuber class there were no large differences in number of tubers or weight per hill within either of the other tuber classes. In this experiment the few large tubers or many small tubers per hill did not determine the yield. The only observable trend was that noted in Figs. 9, 11 and 12. As stem number increased the weight per hill of the U.S. Number 1 fancy grade increased.

The spacing trial of the Kennebec variety (Table 5) presents additional evidence of the effect of seed piece spacing on tuber size. The Kennebec seed pieces were planted at 4 spacings:--7.5, 9, 12 and 15 inches. When the harvested tubers were divided into classes, no observable differences were noted between the small and large tuber classes. The data expressed in Table 5 consist of the average tuber number in each of the 3 classes, but they are representative of the gross weight. The increase in weight per hill of the U.S. Number 1 fancy tubers occurred in each of the 4 spacings. When the spacing increased from 7.5 to 15 inches and the stem number increased from 1 to 5 stems per hill, the average number of U.S. Number 1 fancy tubers per stem increased.

Hougland and Akeley (14) working with the spacing of the Kennebec and the Merrimack varieties at seed piece spacings of 6, 9 and 12 inches concluded that: (1) as spacing became closer, tubers decreased in weight and (2) the Kennebec needed closer spacing to avoid over-size tubers.

Some of the relationships observed in the tuber classes are contrary to many reports in the literature. It is commonly believed that the hills with few stems produce large tubers and often over-size tubers; that the hills containing many stems produce many tubers with a low-average weight per tuber. Bates (2), and Claypool and Morris (8) found that the largest number of U.S. Number 1 tubers was produced in the hills having 2 to 3 stems; and that the tuber number and the tuber weight increased with the stem number.

Table 5. Number of tubers per hill in different weight classes of under 50 grams, 50 to 300 grams and over 300 grams. Data taken from spacing trial of the Kennebec variety spaced at 7.5, 9, 12 and 15 inches.

	Under 50 grams							50 to 300 grams							Over 300 grams						
Stem number	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Spacing																					
7.5 in.			1.6	1.0					3.0	4.5	5.1						1.3				
9 in.				2.2	1.0	3.0			5.0	8.3	6.3	7.0	9.0								
12 in.		1.5	1.4	1.5			3.5	4.0	5.0	6.3	8.3	10.6					1.3				
15 in.		1.7	2.0	1.8	2.3			5.5	5.0	5.7	13.0	11.6			1.5	1.5					

Fingey and Stewart (10) found that as the number of stems increased, the number of tubers per stem increased; but the yield of the marketable tubers decreased. The stem number, Bushnell (5) concluded, is a factor that can act much the same as seed piece spacing. A potato hill with many stems may produce the same effect as seed pieces spaced at intervals of approximately 6 inches. A potato hill with 2 to 3 stems is much the same as wide spacing, for instance 12 to 15 inches between seed pieces. Warren (19), and Bishop and Wright (3) have documented these facts.

Weight per tuber

The average tuber weight for the Kennebec, Katahdin and Onaway varieties is shown in Figs. 16, 17 and 18. When there was more than one stem per hill in the Kennebec and Katahdin variety, there was little decrease in the average tuber weight. The addition of nitrogen markedly increased the average tuber weight of the Katahdin variety (Fig. 17). In the Kennebec variety (Fig. 16) the relationship between nitrogen and no nitrogen and weight per tuber was not consistent; the nitrogen application producing little if any increase in the average tuber weight. Where nitrogen was applied to the Kennebec variety it generally had a higher average tuber weight than Katahdin. The Kennebec variety averaged approximately 25 grams more per tuber beyond the one stem level than did the Katahdin variety.

When observations were made on the Onaway variety, it may be noted that there was little difference between the one and seven stem level in the average weight per tuber. Irrigation produced a larger average tuber weight at all stem levels. With irrigation, the average tuber weight of the Onaway variety increased 25 grams.

Correlations

Simple correlation coefficients were determined between number of tubers and number of stems (T:S), gross weight per hill and number of tubers (W:T) and gross weight per hill and number of stems (W:S). (Tables 6 and 7). Ten hills were used for the analysis for each replication and the replication r values were averaged to obtain the values in the body of Table 6.

Of the 60 correlation coefficients shown under the Kennebec and Katahdin varieties for 5 levels of nitrogen and 2 levels of irrigation, 52 exceeded the 1% level, 4 exceeded the 5% level and 4 were not significant. The 4 that are not significant are under the W:S classification.

In the classification of T:S, of 20 correlation coefficients all but 2 exceed the 1% level and are greater than .500. This indicates a rather consistent relationship.

The correlation coefficients of W:T were fairly consistent with but one (.472) significant at only the 5% level.

The correlation coefficients of W:S, though for the most part significant at the 1% level, are somewhat less than the corresponding coefficients under T:S and W:T.

Table 6. The simple correlation coefficients between the number of tubers (T), number of stems (S) and weight per hill (W) for the Katahdin and Kennebec varieties grown at Lake City in 1961. Ten hills per plot were harvested from each of three replications. The correlation coefficients are the averages of the coefficient obtained from the three replications.

Nitrogen treatments	Irrigation high								
	Katahdin			Kennebec			Ave. nitrogen		
	T:S	W:T	W:S	T:S	W:T	W:S	T:S	W:T	W:S
0	.664	.635	.582	.746	.860	.662	.705	.747	.602
50	.444	.636	.514	.690	.728	.598	.567	.682	.556
50 + 50	.906	.695	.588	.771	.802	.542	.808	.748	.565
50 + 100	.793	.737	.488	.564	.745	.380	.678	.741	.434
150	.543	.576	.220	.763	.791	.189	.653	.683	.204
Ave. high irrigation	.666	.645	.478	.706	.785	.478	.686	.715	.478
	Irrigation low								
0	.656	.552	.454	.483	.729	.470	.569	.640	.462
50	.803	.807	.652	.708	.862	.709	.755	.834	.685
50 + 50	.810	.666	.623	.767	.634	.411	.788	.650	.527
50 + 100	.656	.786	.473	.779	.845	.591	.717	.825	.532
150	.621	.472	.365	.687	.697	.580	.654	.584	.472
Ave. low irrigation	.709	.656	.519	.685	.753	.552	.697	.704	.535
Average variety	.687	.650	.498	.695	.769	.515			
Average 0 nitrogen							.637	.693	.532
Average 50 nitrogen							.666	.758	.620
Average 50 + 50 nitrogen							.798	.699	.546
Average 50 + 100 nitrogen							.697	.783	.483
Average 150 nitrogen							.675	.633	.338
General average							.691	.709	.507

5% level 0.381
1% level 0.487

Harvest observations may give some insight into why these correlation coefficients are lower than the correlation coefficients of T:S and W:T. It was observed, when digging the hills, that some stems had a very few or no tubers while other stems might have many tubers.

The response is very similar for the Kennebec, Katahdin (Table 6) and Onaway (Table 7). All varieties had correlation coefficients of T:S, W:T and W:S that exceeded the 1% level in significance. Kennebec had a higher W:T correlation than Katahdin. The W:S relationship was lower for each variety but it again was not significantly lower than the other r values.

Irrigation by itself on the Kennebec and the Katahdin varieties is not significantly different in either case.

All nitrogen applications when viewed independently of variety or irrigation exceed the 1% level in significance except the 150 pound application in W:S (.338). The same general relationship exists in T:S, W:T and W:S for each nitrogen level as has been noted for variety and irrigation (Table 6).

In the Onaway variety (Table 7) the 0 level of irrigation gave higher correlation coefficient values than the high level of irrigation. However, this difference between 0 irrigation and high irrigation was not enough to be significantly different.

The coefficient of determination (r^2 x 100) gives another slant to the data in Tables 6 and 7. An example would be of .691 under general average for T:S which when squared and multiplied by 100 equals 47.7%. This means that 52.3% of the squared variability in number of tubers per hill is unaccounted for by the squared variability in stem number. Similarly, the coefficients of determination of squared variability in gross weight of tubers per hill due to variability in tuber number is 50.3% and in gross weight per hill due to variability in stem number is 25.7%. Many factors, such as, fertility, moisture, temperature, soil aeration, etc., could affect these relationships and must be studied further to get at the sources that influence the variabilities that affect the correlations.

Table 7. The simple correlation coefficients between the number of tubers (T), number of stems (S) and weight per hill (W) for the Onaway variety grown at Lake City, 1961. Fifteen hills per plot were harvested from each of three replications. The correlation coefficients are based on 45 hills.

Nitrogen treatment	Irrigation high			No irrigation			Ave. nitrogen		
	T:S	W:T	W:S	T:S	W:T	W:S	T:S	W:T	W:S
50 + 50	.530	.477	.495	.798	.745	.635	.664	.611	.565
50 + 100	.552	.746	.679	.774	.734	.496	.663	.740	.587
Irrigation	.541	.611	.587	.786	.739	.565			
General average							.663	.675	.576

5% level 0.381
1% level 0.487

SUMMARY

Data were taken from an experiment measuring irrigation and nitrogen responses of Katahdin, Kennebec and Onaway at the Lake City Experiment Station in 1961. Hill data were compiled on the number of stems per hill, the average number of tubers per stem and the weight per tuber per hill.

The investigations may be summarized under the following:

Stem and Tuber Number

1. As the stem number per hill increased, tuber number and gross weight per hill increased.
2. When the data were divided into classes, only numbers of the U.S. Number 1 fancy tubers (50-300 grams) increased with stem number. Tuber number classes for small (under 50 grams) and large tubers (over 300 grams) were inconsistent.

Tuber Weight

1. Average tuber weight decreased as the number of stems increased.

Correlations

1. Coefficients of correlations between T:S, W:T and W:S were, for the most part, statistically significant,

regardless of treatment.

2. The three relationships were somewhat stronger in Kennebec than in Katahdin on the average.
3. The W:S relation had the lowest r value of any of the relationships studied.

General

1. The component of yield hypothesis may be very useful to the potato breeder. Stem number, tuber number and tuber weight may be important considerations for the breeder in selecting new varieties. Any one of these factors or a combination may have a definite bearing on the marketable yield of a new seedling. Components of the tuber number and the tuber weight might be used to project the yield of a seedling from a few hills to an acre basis.
2. The potato producer may be able to predict yield in his fields early in the growing season. If yield expectancy is not up to par, he may be able to manipulate some factor, such as nitrogen fertilization or irrigation, to increase his yield by influencing one of the components.

There was a marked varietal response to nitrogen and irrigation for each of the three varieties. There is also a difference between varietal response to different components. A case in point is the Kennebec variety in its response to

added nitrogen. The Kennebec was not very responsive to any of the nitrogen levels applied during the growing season. It may be concluded from this that large applications of nitrogen are not beneficial when applied to the Kennebec variety. It was shown that the Onaway responded very well to irrigation in that it increased the tuber set and also increased the tuber size.

Some yield-influencing factors have been investigated and are reported in the literature, but many of these factors have not been investigated on the component basis.

When these component factors have been studied and the varietal responses are better known, recommendations may be made to manipulate the crop environment for the most beneficial yield. In this way blanket recommendations will not have to be made for all varieties in all locations, but they may be broken down by variety and by area.

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