GROWTH AND DEVELOPMENT OF SOLANUM TUBEROSUM CULTIVARS UNDER DIFFERENT SOIL MOISTURE LEVELS

by

JAMES EARL MOTES

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Approved by:

J. K. Greig
Major Professor

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INTRODUCTION

The white potato, Solanum tuberosum, is the most important vegetable crop in the United States. Although per capita consumption of fresh potatoes is decreasing total potato consumption is holding steady. Processing into potato chips and other dry and frozen products has curbed the decline in potato consumption.

Factors influencing potato yields and quality have been extensively studied (Akeley et al. 1, de Lis et al. 7, Hope et al. 11, Jacob et al. 12, Prince and Blood 19, Struchtemeyer 22 and Struchtemeyer et al. 23).

Limited work has been performed on growth and development and the chipping quality of potatoes grown in the Kansas River valley; however, both the potato chip industry and Kansas farmers are interested in increasing the potato acreage in Kansas, if cultivars and management practices can be determined that will consistently produce desirable chips. Akeley et al. (1), Hoover and Xander (9), Hope et al. (10), Lyman and Mackey (17), Smith (20), and Sweetman (24) have found various chemical and physical factors influencing the chipping quality of potatoes. Their studies were performed under climatic conditions where day length and temperature decreased prior to harvest, but under Kansas conditions for a Spring crop the reverse occurs.

Soil moisture level and maturity are factors which have been reported to effect chipping quality of potatoes (Akeley et al. 1, Hope et al. 10, Smith 20 and Sweetman 24). This study was designed to evaluate potato cultivars under both natural rainfall conditions and supplemental irrigation. The plots were harvested at weekly intervals throughout the growing season. Growth rate and development and chipping quality were studied.

The objectives of this study were: (1) to study the growth and development of three potato cultivars under different available soil moisture levels and (2) to evaluate the chipping quality of these cultivars at all stages of maturity when grown under different available soil moisture levels.

REVIEW OF LITERATURE

Struchtemeyer (22) reported that yield of tubers decreases as available soil moisture decreases. He observed that moisture stress produces more pronounced effects on tuber yield when it occurs in the last half of the growing season. Number of tubers formed was not consistent in its relation to per cent of available soil moisture but closely paralleled the trend in yield data when there were significant differences in number of tubers. He also reported that dry top weight followed the trend of tuber yield.

Struchtemeyer et al. (23) reported a significant increase in yield and number of tubers 3 of 4 years when Katahdin potatoes grown in Maine were irrigated when the available soil moisture level reached 50 per cent.

Prince and Blood (19) reported that irrigation may increase total yields of potatoes during dry years but may not always proportionately increase the yield of U. S. #1 potatoes. They also reported that irrigation per se may lower the specific gravity of potatoes, but probably not enough to seriously affect marketability.

Bradley and Pratt (5) reported that high soil moisture levels resulted in better top growth, earlier tuber set and a greater weight of tubers. They observed that greatest effect of soil moisture level seemed to be on earliness of tuber set rather than number of tubers set. They concluded that available soil moisture level should not fall below 50 per cent in the earlier part of growing season for maximum yield.

Jones and Johnson (14) reported that higher yields resulted when potatoes were irrigated when soil moisture tension reached .3 atmospheres than at higher tension levels. They also reported that droughts occurring early in the season were not as detrimental to yield as those occurring later.

De Lis et al. (7) reported that the most critical period concerning water requirement of the White Rose cultivar was the period of growth which begins with stolonization up to tuberization. They also reported that tubers reached a maximum weight 34 days after tuberization, but 43 days after tuberization tuber weight had decreased 19 per cent.

Blake et al. (2) reported that potato yields on Sassafras loam were equally good when available soil moisture was depleted between 33 and 67 per cent before irrigation.

Fulton and Findlay (8) reported that irrigation does not influence the dry matter content of tubers, but did increase total yield if adequate nutrient supply was available.

Jacob et al. (12) observed that exact optimum moisture level may vary from year to year but is in the neighborhood of 50 to 60 per cent of field capacity. They also observed that irrigation which gives a good increase in yield seldom reduces specific gravity but is more likely to increase it.

Bradley and Pratt (4) reported that potato yields are higher when irrigated before the available soil moisture dropped much below 50 per cent, especially on light textured soils. They reported an increase in number of tubers over 2 inches in diameter with irrigation in one growing season and only an increase in the average size of tubers over 2 inches in diameter the following growing season with irrigation.

Yamaguchi et al. (27) reported that foliar growth was optimum at soil temperatures of 70° to 75° F. and optimum soil temperature for tuber formation was between 60° and 75° F. They observed that many stolons initiate at soil temperatures of 50° to 55° F. but tuberization is delayed and long stolons developed. They also reported that soil temperatures below 60° F. and above 75° F. gave lower yield, specific gravity and starch content, however, sugar content was higher.

Clark (6) reported that tuber formation begins at about the end of the period of flower bud development with varietal variations directly related to earliness or lateness of maturity. He also reported that the entire crop of tubers are set at the beginning of the period of tuber development with a slight increase in number of tubers for a few weeks and a subsequent decrease later in the season. Evidence of shrinkage of small tubers toward end of the growing season was also reported.

Clark also reported that an early application of water, before tuber formation had started, resulted in an increase in the number and weight of tubers per hill and no increase in number of tubers due to irrigation after the period of tuber formation. Tubers which are small at the end of the season were not set later than large tubers but failed to grow.

Akeley et al. (1) reported that tubers from vines, which had been killed at successive periods in tuber development and dug at normal maturity date, showed significant increases in specific gravity as development proceeded 2 of 3 seasons.

Westover (26) reported from West Virginia that the greatest increase in U. S. #1 yield occurred at and in a period of 2 weeks after blossoming.

Johnson and Rowberry (13) reported that following the maximum solids content in tubers it generally leveled off or sometimes declined.

Terman et al. (25) reported that Katahdin cultivar tubers harvested weekly from green vines increased in specific gravity from 1.038 on July 15 to 1.073 August 24 but decreased at the September 7 harvest. He also reported that tubers from plots, which had the vines pulled weekly and all tubers dug at the end of the growing season, showed little difference in specific gravity for different dates of vine removal.

Murphy and Govens (18) reported that low soil moisture levels and high temperature adversely effect specific gravity while cultivars, fertilization practices and date of harvest will cause differences. Sweetman (24) found no significant difference in tuber size and chip color but found that tubers containing a high sugar content or tubers dug in the immature state produced darker and more uneven colored chips.

Box et al. (3) found that low soil moisture suction and minimum soil temperatures gave highest yields and quality of tubers in Texas. The value of irrigation in potato production depends on amount and distribution of rainfall was reported by Houghland et al. (11). Kehr et al. (15) reported that soil moisture greatly effects yield and quality of the potato crop.

Lyman and Mackey (17) reported that Russet Burbank cultivar tubers of high specific gravity consistently produced chips of lighter color than did tubers of low specific gravity.

Smith (20) observed that high soil moisture late in the growing season as a result of heavy rainfall or irrigation lowers specific gravity of tubers and results in darker chip colors made from tubers grown under those conditions.

Kushman et al. (16) reported that tuber size or shape had no correlation to chip color. He also reported that tubers dug in the immature state produced darker chips and uneven colored chips. He also reported that tubers containing a high sugar content produced dark chips.

Hoover and Xander (9) reported that only reducing sugars gave consistent evidence of correlation with the chipping color of tubers and that ascorbic acid, basic amino acids and specific enzyme systems were found to be inconsistently correlated with chipping color.

Hope et al. (10) reported that lighter chip colors were produced from more mature potatoes but the trend may be reduced by supplying excessive nitrogen.

MATERIALS AND METHODS

The experiment was conducted in the spring and summer of 1965 on the horticulture farm at Kansas State University. The sarpy fine sandy loam soil was prepared in good physical condition. Uniform seed pieces, approximately $1\frac{1}{2}$ ounces in weight, of certified or foundation seed stock of Kennebec, Irish Cobbler and Monona cultivars were planted March 31. Seed pieces were planted twelve inches apart in forty inch rows and covered four inches. Nitrogen at 72 pounds per acre and phosphate at 184 pounds per acre was banded beside the row.

Plants emerged April 21 but were killed to ground level April 28 by frost. A split-split plot design was used. Two treatments: irrigation to keep soil moisture level above 50 per cent at 6 inch depth; and natural rainfall as the only water source were replicated three times. Each replication contained sixteen random plots for each cultivar. Thirteen plots were harvested at

EXPLANATION OF PLATE I

Fig. 1. Amount and distribution of moisture during the growing season.

Fig. 2. Soil moisture levels at the 6 and 12 inch depth during the growing season on both irrigated and non-irrigated plots.

Fig. 3. Soil temperatures at the 4 inch depth during the growing season for both irrigated and non-irrigated plots.

Fig. 4. Mean weekly minimum and maximum air temperatures during the growing season, records taken at Kansas State University campus.

PLATE I

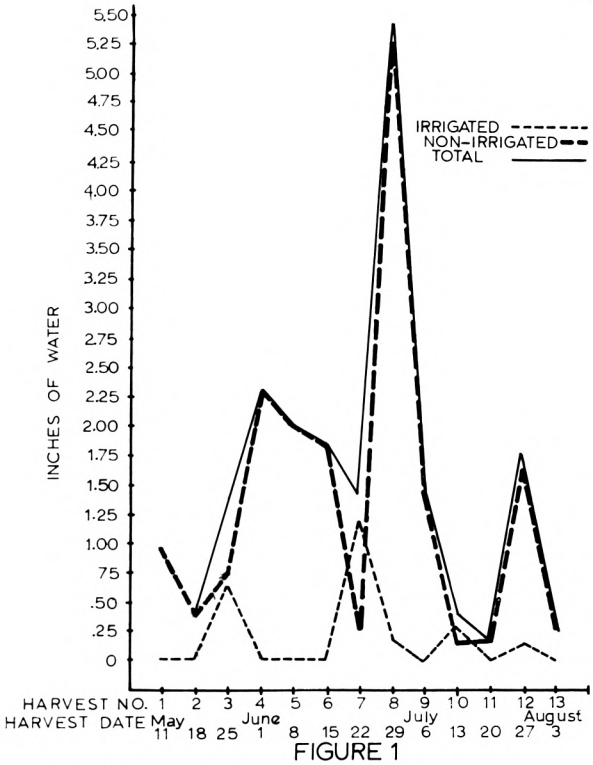


FIGURE 1

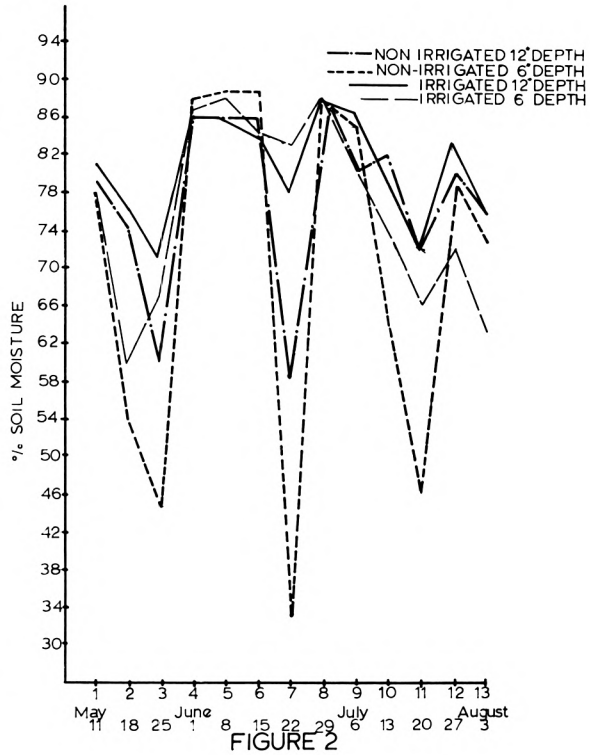


FIGURE 2

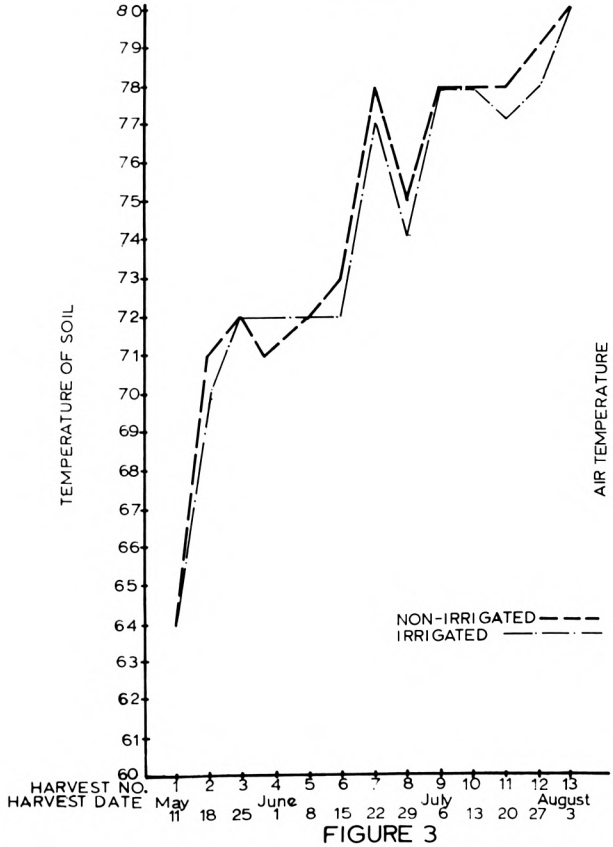


FIGURE 3

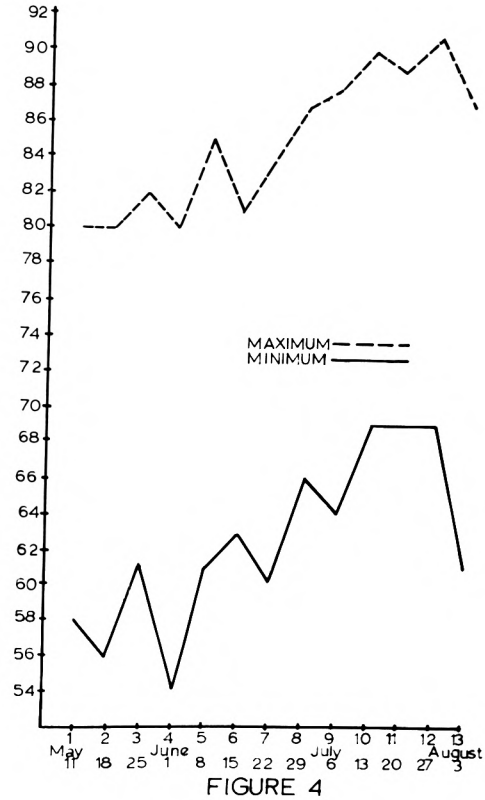


FIGURE 4

weekly intervals. Four plants of each cultivar comprised a replication. Seventy-two plants were harvested weekly beginning May 11 when plants were 2 to 3 inches tall.

Soil irrometers at 6 and 12 inch depths and thermometers at 4 inch depth were placed at four locations in each treatment block. Readings were recorded weekly; however, observations were made more frequently to determine moisture levels at all times (Plate I). A sprinkler irrigation system supplied .17 inch per hour uniformly over the irrigated block. Only 2.44 inches of irrigation water were required to maintain the desired soil moisture level. Rainfall for the 13 week growing period after plant emergence was 17.3 inches.

Height of plants were measured in inches weekly and the number of stems per hill were counted. Plant tops were removed weekly, placed in paper bags and oven dried at a temperature of 65° C. Dry weights of tops in grams per plant were obtained for each cultivar and treatment. Hills were then hand harvested. Number of stolons were counted per plant and all tubers larger than one-half inch in diameter were collected in paper bags. Tubers under one-half inch in diameter were counted as stolons. Total number and weight of tubers per plant was determined for each treatment and cultivar. Number and weight of tubers smaller and larger than 2 inches in diameter were determined per plant. All tubers weights were in grams per plant. Tubers larger than 2 inches in diameter were washed and air dried.

Specific gravity was determined using weight in air vs. weight in water method. The following day these tubers were chipped in a continuous batch fryer at the Frito-Lay Inc. plant in Topeka, Kansas. Chips were ground in a

Waring blender, screened through an 8 mesh screen, compressed in a chip compressor jig and then the reflectance measured with a Photovolt model 610 Reflectance Meter, using the tristimulus green filter and a white enamel plaque as a working standard. Readings of 28 or less were considered too dark for commercial potato chips.

All data were analyzed statistically according to Snedecor (21). The F tests for differences between treatment and cultivar means are expressed as probability for significance. L.S.D. values were determined to express differences in means.

EXPERIMENTAL RESULTS

Characteristics studied were: plant height, vine dry weight, number of stems, number of stolons; number, weight and specific gravity of tubers; and chip color by treatments and cultivars at weekly intervals.

Plant height did not differ significantly due to treatment (Table 1); however, significant differences occurred in plant height between cultivars. Kennebec and Irish Cobbler cultivars were significantly taller than Monona; and Kennebec was significantly taller than Irish Cobbler. Plant height was influenced significantly between weekly harvests. Significant weekly growth in height occurred until harvest number 7. Plants in harvest 8 were significantly taller than plants from all previous harvests. Plants harvested the ninth and tenth week were significantly shorter than plants from harvest 8. Plants harvested in week 11 were significantly taller than plants in all harvests except 8 and 9.

Vine dry weight did not differ significantly due to treatment (Table 2); however, significant differences in vine dry weight occurred between cultivars.

Table 1. Plant height (in inches) of three potato cultivars harvested at weekly intervals as influenced by soil moisture level.

Harvest number	Treatments: 50% soil moisture level				Treatments: Rainfall only				Cultivar means			
	Kennebec	Irish Cobbler	Monona	Mean	Kennebec	Irish Cobbler	Monona	Mean	Kennebec	Irish Cobbler	Monona	Grand mean
1	2.3	3.3	1.7	2.4	2.7	3.3	2.0	2.7	2.5	3.3	1.8	2.6
2	7.0	8.0	4.3	6.4	6.0	7.7	4.3	6.0	6.5	7.8	4.3	6.2
3	9.7	13.3	7.7	10.2	10.0	11.7	8.3	10.0	9.8	12.5	8.0	10.1
4	16.3	17.7	12.0	15.3	15.3	15.3	11.3	14.0	15.8	16.5	11.7	14.7
5	18.7	19.0	14.3	17.3	17.7	17.0	13.7	16.1	18.2	18.0	14.0	16.7
6	19.7	18.7	15.3	17.9	21.3	18.7	15.7	18.6	20.5	18.7	15.5	18.2
7	21.3	18.0	15.0	18.1	21.0	17.0	15.7	17.9	21.2	17.5	15.3	18.0
8	24.0	22.7	18.7	21.8	26.3	20.3	17.7	21.4	25.2	21.5	18.2	21.6
9	24.7	19.3	16.7	20.2	24.3	21.0	15.7	20.3	24.5	20.2	16.2	20.3
10	20.7	18.3	15.7	18.2	25.3	18.3	16.7	20.1	23.0	18.3	16.2	19.2
11	22.7	20.3	18.3	20.4	24.7	20.7	17.3	20.9	23.7	20.5	17.8	20.7
Grand mean	17.0	16.2	12.7	15.3	17.7	15.5	12.6	15.3	17.3	15.9	12.6	15.3

LSD 5% T ns C 0.6 C x T ns H 1.3 H x T ns H x C ns H x C x T ns

Table 2. Vine dry weight (in grams per plant) of three potato cultivars harvested at weekly intervals as influenced by soil moisture level.

Harvest number	Treatments: 50% soil moisture level				Treatments: Rainfall only				Cultivar means			
	Kennebec	Irish Cobbler	Monona	Mean	Kennebec	Irish Cobbler	Monona	Mean	Kennebec	Irish Cobbler	Monona	Grand mean
1	3	4	1	3	3	5	1	3	3	5	1	3
2	12	12	6	10	10	12	5	9	11	12	5	9
3	14	21	10	15	12	16	9	12	13	18	10	14
4	48	46	32	42	34	38	24	32	41	42	28	37
5	63	66	50	60	48	46	28	41	55	56	39	50
6	51	46	36	45	58	44	36	46	54	45	36	45
7	58	47	37	47	53	42	40	45	55	44	39	46
8	81	82	46	70	73	54	44	56	77	68	45	63
9	64	42	37	48	70	48	41	53	67	45	39	50
10	54	26	20	33	62	35	29	42	58	31	24	38
11	55	27	22	35	77	30	32	46	66	29	27	41
Grand mean	46	38	27	37	45	34	26	35	46	36	27	36

LSD 5% T ns C 3 C x T ns H 7 H x T 10 H x C 23 H x C x T ns

Dry weight of Kennebec was significantly greater than Irish Cobbler and Monona; and Irish Cobbler was significantly greater than Monona. Significant differences occurred in vine dry weights between weekly harvests. Plants from harvests 4, 5 and 8 had significant increases in dry weight. Vine weight of plants at harvests 9 and 10 significantly decreased. Plants from harvest 8 were significantly heavier than plants from all other harvests. No significant weekly differences in vine weight occurred at harvests 2, 3, 6, 7 or 11.

A significant interaction in vine weight occurred between dates and treatments. Plants from harvests 4, 5 and 8 had significantly greater vine weight with supplemental irrigation. Vine weight from the natural rainfall treatment was significantly greater in harvest 11. No significant differences in vine dry weight occurred between other weekly harvests.

A significant interaction in vine weight occurred between dates and cultivars. Kennebec and Irish Cobbler cultivars had significantly greater vine weight than Monona at harvest 8. Vine weight of Kennebec was significantly greater than Monona at harvests 9, 10 and 11; and significantly greater than Irish Cobbler at harvest 11. Vine weight between cultivars was not influenced significantly at harvests 1 through 7.

Number of stems per plant did not differ significantly due to treatment or weekly harvests (Table 3); however, significant differences in number of stems were influenced by cultivars. Irish Cobbler had significantly more stems per plant than Kennebec; and Kennebec significantly more than Monona.

Number of stolons per plant did not differ significantly due to treatment (Table 4). Significant differences in number of stolons were influenced

Table 3. Number of stems per plant of three potato cultivars harvested at weekly intervals as influenced by soil moisture level.

Harvest number	Treatments: 50% soil moisture level				Treatments: Rainfall only				Cultivar means			
	Kennebec	Irish Cobbler	Monona	Mean	Kennebec	Irish Cobbler	Monona	Mean	Kennebec	Irish Cobbler	Monona	Grand mean
1	3.3	4.1	1.8	3.1	2.8	3.7	2.2	2.9	3.1	3.9	2.0	3.0
2	3.9	3.9	2.1	3.3	3.4	3.6	1.8	2.9	3.7	3.8	1.9	3.1
3	3.1	4.5	2.2	3.2	2.6	3.9	2.3	2.9	2.8	4.2	2.2	3.1
4	2.6	4.2	1.8	2.9	2.8	4.1	2.0	3.0	2.7	4.2	1.9	2.9
5	3.7	4.3	2.2	3.4	3.2	4.7	2.0	3.3	3.4	4.5	2.1	3.3
6	3.7	4.5	2.5	3.6	3.3	3.5	1.8	2.9	3.5	4.0	2.2	3.2
7	3.5	3.8	1.8	3.1	3.7	4.3	2.5	3.5	3.6	4.1	2.2	3.3
8	3.3	2.7	1.7	2.6	3.3	3.3	2.0	2.9	3.3	3.0	1.8	2.7
9	3.2	3.7	2.2	3.0	3.5	4.0	1.7	3.1	3.3	3.8	1.9	3.0
10	3.0	4.7	3.0	3.6	3.3	4.7	2.2	3.4	3.2	4.7	2.6	3.5
11	3.7	4.7	2.3	3.6	3.3	5.0	1.8	3.4	3.5	4.8	2.1	3.5
12	3.3	4.2	1.3	2.9	2.3	4.0	1.8	2.7	2.8	4.1	1.6	2.8
Grand mean	3.4	4.1	2.1	3.2	3.1	4.1	2.0	3.1	3.2	4.1	2.0	3.1

LSD 5% T ns C 0.2 C x T ns H ns H x T ns H x C ns H x C x T ns

Table 4. Number of stolons per plant of three potato cultivars harvested at weekly intervals as influenced by soil moisture level.

Harvest number	Treatments: 50% soil moisture level				Treatments: Rainfall only				Cultivar means			
	Kennebec	Irish Cobbler	Monona	Mean	Kennebec	Irish Cobbler	Monona	Mean	Kennebec	Irish Cobbler	Monona	Grand mean
1	3.3	3.7	0.0	2.3	4.0	5.3	2.7	4.0	3.7	4.5	1.3	3.2
2	11.0	15.7	6.7	11.1	10.0	12.7	5.3	9.3	10.5	14.2	6.0	10.2
3	10.0	15.7	9.3	11.7	7.0	12.3	11.7	10.3	8.5	14.0	10.5	11.0
4	10.0	11.7	10.0	10.6	10.0	12.7	9.0	10.6	10.0	12.2	9.5	10.6
5	4.7	10.3	6.7	7.2	6.0	7.0	5.7	6.2	5.3	8.7	6.2	6.7
6	4.0	5.3	6.7	5.3	3.3	4.3	3.7	3.8	3.7	4.8	5.2	4.6
7	4.0	4.7	7.0	5.2	4.0	7.0	6.0	5.7	4.0	5.8	6.5	5.4
8	4.3	6.0	2.7	4.3	4.0	3.7	3.7	3.8	4.2	4.8	3.2	4.0
9	2.7	5.7	3.7	4.0	6.3	5.0	4.0	5.1	4.5	5.3	3.8	4.6
10	5.0	4.3	4.3	4.6	4.0	5.0	6.0	5.0	4.5	4.7	5.2	4.8
11	4.0	2.7	4.0	3.6	4.0	2.3	3.0	2.8	4.0	2.5	3.0	3.2
Grand mean	5.7	7.8	5.5	6.4	5.7	7.0	5.4	6.0	5.7	7.4	5.5	6.2

LSD 5% T ns C 0.9 C x T ns H 1.7 H x T ns H x C 2.4 H x C x T ns

by cultivars. Irish Cobbler had significantly more stolons per plant than Kennebec and Monona. Number of stolons were influenced significantly by weekly harvests. Plants from harvests 2, 3 and 4 had significantly more stolons than all other harvests. Plants from harvests 5 and 6 had a significant decrease in number of stolons. No significant weekly difference in number of stolons per plant occurred after harvest 6.

A significant interaction occurred between weekly harvests and cultivars for stolon number. Irish Cobbler plants had significantly more stolons than Monona in harvests 1 through 5 and significantly more than Kennebec in harvests 2, 3 and 5. Kennebec plants had significantly more stolons than Monona in harvests 1 and 2; and Monona more than Kennebec in harvest 7. No significant interaction occurred at harvest 6 or harvests 8 through 11.

Number of tubers less than 2 inches in diameter was influenced significantly by treatment (Table 5). Plants from the supplemental irrigation treatment had significantly more tubers less than 2 inches in diameter. No significant difference in number of tubers less than 2 inches in diameter occurred between cultivars; however, significant differences did occur between weekly harvests. Plants from harvests 5 and 6 had significantly more tubers less than 2 inches in diameter than all later harvests. Plants from harvest 13 had significantly fewer tubers less than 2 inches in diameter than plants from all harvests except 7 and 12.

Number of tubers greater than 2 inches in diameter did not differ significantly due to treatment (Table 6); although, significant differences in number of tubers greater than 2 inches in diameter occurred between cultivars. Irish Cobbler plants had significantly more tubers greater than 2 inches

Table 5. Number of tubers per plant (less than two inches in diameter) of three potato cultivars harvested at weekly intervals as influenced by soil moisture level.

Harvest number	Treatments: 50% soil moisture level				Treatments: Rainfall only				Cultivar means			
	Kennebec	Irish Cobbler	Monona	Mean	Kennebec	Irish Cobbler	Monona	Mean	Kennebec	Irish Cobbler	Monona	Grand mean
5	6.5	6.4	5.2	6.0	4.3	4.6	4.7	4.5	5.4	5.5	4.9	5.3
6	5.1	4.8	6.2	5.3	2.8	3.0	4.4	3.4	4.0	3.9	5.3	4.4
7	3.0	3.1	2.5	2.9	2.2	2.5	2.0	2.2	2.6	2.8	2.2	2.5
8	2.2	4.0	3.2	3.1	1.9	1.7	2.3	2.0	2.1	2.8	2.8	2.6
9	2.9	3.1	3.0	3.0	2.6	2.2	3.2	2.7	2.8	2.7	3.1	2.8
10	3.0	2.5	2.7	2.7	2.2	3.2	2.0	2.4	2.6	2.8	2.3	2.6
11	2.1	2.7	2.4	2.4	2.6	4.8	2.0	3.1	2.3	3.7	2.2	2.8
12	2.3	5.9	1.2	3.1	1.2	2.2	.8	1.4	1.7	4.1	1.0	2.3
13	1.8	2.0	1.0	1.6	1.6	1.9	1.2	1.6	1.7	2.0	1.1	1.6
Grand mean	3.2	3.8	3.0	3.4	2.4	2.9	2.5	2.6	2.8	3.4	2.8	3.0

LSD 5% T 0.6 C ns C x T ns H 1.0 H x T ns H x C ns H x C x T ns

Table 6. Number of tubers per plant (greater than two inches in diameter) of three potato cultivars harvested at weekly intervals as influenced by soil moisture level.

Harvest number	Treatments: 50% soil moisture level				Treatments: Rainfall only				Cultivar means			
	Kennebec	Irish Cobbler	Monona	Mean	Kennebec	Irish Cobbler	Monona	Mean	Kennebec	Irish Cobbler	Monona	Grand mean
5	.1	.8	.6	.6	.2	.6	.3	.4	.2	.7	.5	.4
6	.8	2.2	1.1	1.3	1.7	2.3	.8	1.6	1.2	2.2	.9	1.5
7	2.7	3.2	2.2	2.7	2.2	3.2	2.0	2.5	2.4	3.2	2.1	2.6
8	3.9	4.7	2.6	3.7	2.8	4.6	3.2	3.5	3.4	4.6	2.9	3.6
9	3.2	4.7	3.4	3.8	3.4	4.8	2.4	3.6	3.3	4.8	2.9	3.7
10	3.7	4.6	3.1	3.8	4.2	4.7	3.1	4.0	3.9	4.6	3.1	3.9
11	4.7	4.3	3.3	4.1	4.3	4.7	2.7	3.9	4.5	4.5	3.0	4.0
12	5.2	4.6	4.2	4.7	4.8	4.7	4.8	4.8	5.0	4.6	4.5	4.7
13	5.3	5.2	2.2	4.3	4.8	4.2	3.3	4.1	5.0	4.8	2.8	4.2
Grand mean	3.3	3.8	2.5	3.2	3.2	3.8	2.5	3.1	3.2	3.8	2.5	3.2

LSD 5% T ns C 0.3 C x T ns H 0.5 H x T ns H x C 0.7 H x C x T ns

in diameter than Kennebec and Monona; and Kennebec plants had significantly more than Monona.

Number of tubers greater than 2 inches in diameter differed significantly due to weekly harvests. Plants from harvest 5 had significantly less and plants from harvest 12 significantly more tubers greater than 2 inches in diameter than all other harvests. A significant increase in number of tubers greater than 2 inches in diameter occurred weekly until harvest 9. Number of tubers per plant did not increase significantly between harvests 9, 10 and 11. A significant decrease in tubers greater than 2 inches in diameter per plant occurred between harvests 12 and 13.

A significant interaction occurred between weekly harvests and cultivars. Irish Cobbler plants had significantly more tubers greater than 2 inches in diameter than Monona at all harvests except 5 and 12; and more than Kennebec in harvests 6 through 10. Monona plants had fewer tubers less than 2 inches than Kennebec in harvests 10, 11 and 13.

Total number of tubers per plant did not differ significantly due to treatment or weekly harvests (Table 7); however, significant differences occurred in total number of tubers between cultivars. Irish Cobbler had significantly more tubers than Kennebec and Monona; and Kennebec had significantly more than Monona.

Weights of tubers less than 2 inches in diameter did not differ significantly due to treatment, cultivars or harvest periods (Table 8).

Weight of tubers greater than 2 inches in diameter did not differ significantly due to treatment (Table 9). Significant differences occurred in weight of tubers greater than 2 inches in diameter between cultivars. Kennebec and Irish Cobbler plants had significantly greater tuber weights than Monona.

Table 7. Total number of tubers per plant of three potato cultivars harvested at weekly intervals as influenced by soil moisture level.

Harvest number	Treatments: 50% soil moisture level				Treatments: Rainfall only				Cultivar means			
	Kennebec	Irish Cobbler	Monona	Mean	Kennebec	Irish Cobbler	Monona	Mean	Kennebec	Irish Cobbler	Monona	Grand mean
5	6.3	7.3	6.0	6.6	4.3	5.0	5.3	4.9	5.3	6.2	5.7	5.7
6	6.0	6.7	7.3	6.7	4.3	5.3	5.0	4.9	5.2	6.0	6.2	5.8
7	6.0	6.0	4.7	5.6	4.3	5.7	4.3	4.8	5.2	5.8	4.5	5.2
8	6.0	8.7	5.7	6.8	4.7	6.3	5.3	5.4	5.3	7.5	5.5	6.1
9	6.3	7.7	6.3	6.8	5.7	7.0	5.3	6.0	6.0	7.3	5.8	6.4
10	6.7	7.0	5.7	6.4	6.3	7.7	5.3	6.4	6.5	7.3	5.5	6.4
11	6.7	7.0	5.7	6.4	6.7	9.0	4.7	6.8	6.7	8.0	5.2	6.6
12	7.3	10.3	5.0	7.6	6.0	7.0	5.3	6.1	6.7	8.7	5.2	6.8
13	7.0	7.3	4.0	6.1	6.3	5.7	4.7	5.6	6.7	6.5	4.3	5.8
Grand mean	6.5	7.6	5.6	6.5	5.4	6.5	5.0	5.6	5.9	7.0	5.3	6.1
LSD 5%	T ns		C 0.5		C x T ns		H ns		H x T ns		H x C ns	H x C x T ns

Table 8. Weight of tubers (in grams) per plant (less than two inches in diameter) of three potato cultivars harvested at weekly intervals as influenced by soil moisture level.

Harvest number	Treatments: 50% soil moisture level				Treatments: Rainfall only				Cultivar means			
	Kennebec	Irish Cobbler	Monona	Mean	Kennebec	Irish Cobbler	Monona	Mean	Kennebec	Irish Cobbler	Monona	Grand mean
6	227	178	218	208	139	108	164	137	183	143	191	172
7	154	155	124	144	102	104	101	103	128	130	113	124
8	151	171	182	168	120	134	106	120	136	152	144	144
9	190	118	132	146	107	106	128	114	148	112	130	130
10	190	110	135	145	134	168	99	134	162	139	117	139
11	116	139	142	132	131	229	92	150	123	184	117	142
12	138	294	72	168	64	94	37	65	101	194	55	117
13	105	120	68	97	90	136	85	104	98	128	76	100
Grand mean	159	160	134	151	111	135	102	116	135	148	118	134
LSD 5%	T ns	C ns	C x T ns		H ns	H x T ns			H x C ns		H x C x T ns	

Table 9. Weight of tubers (in grams) per plant (greater than two inches in diameter) of three potato cultivars harvested at weekly intervals as influenced by soil moisture level.

Harvest number	Treatments: 50% soil moisture level				Treatments: Rainfall only				Cultivar means			
	Kennebec	Irish Cobbler	Monona	Mean	Kennebec	Irish Cobbler	Monona	Mean	Kennebec	Irish Cobbler	Monona	Grand mean
6	87	255	107	150	181	262	94	179	134	259	101	164
7	364	495	298	386	282	385	256	308	323	440	277	347
8	612	658	375	548	470	668	419	519	541	663	397	534
9	554	706	529	596	552	743	414	570	553	724	471	583
10	603	786	443	611	720	732	515	656	661	759	479	633
11	984	769	547	767	903	752	554	737	944	761	551	752
12	1010	695	748	817	1000	858	807	889	1005	776	778	853
13	1204	831	567	867	1032	823	721	858	1118	827	644	863
Grand mean	677	649	452	593	643	653	472	589	660	651	462	591
LSD 5%	T ns	C 54	C x T ns		H 120	H x T ns			H x C 147		H x C x T ns	

Significant differences in weight of tubers greater than 2 inches in diameter occurred between weekly harvests. Significant increases occurred at harvests 7 and 8. Plants from harvests 12 and 13 had a significantly greater weight of tubers over 2 inches in diameter than all harvests except 11. A significant interaction occurred in tuber weights between weekly harvests and cultivars. Irish Cobbler had a significantly greater weight of tubers over 2 inches in diameter than Monona in all harvests except 12 and greater than Kennebec in harvest 9. Kennebec plants had a significantly greater weight of tubers over 2 inches in diameter than Monona in harvests after number 9 and Irish Cobbler after number 10.

Total weight of tubers did not differ significantly due to treatment (Table 10); although significant differences occurred in total weight of tubers between cultivars. Irish Cobbler and Kennebec cultivars had a significantly greater total weight of tubers than Monona. Tuber weight was influenced significantly by weekly harvests. Significant weekly increases in tuber weight per plant occurred at harvests 6, 8 and 11. Plants from harvests 11, 12 and 13 had significantly greater total tuber weights than all other harvests.

A significant interaction occurred in total tuber weight per plant between weekly harvests and cultivars. Irish Cobbler plants produced significantly greater total tuber weight than Monona plants for all harvests preceding number 6 and greater than Kennebec plants for harvests 7, 8 and 9. Kennebec plants produced significantly greater total tuber weight than Irish Cobbler plants for all harvests after number 10. No significant interaction occurred prior to harvest 7.

Table 10. Total weight of tubers (in grams per plant) of three potato cultivars harvested at weekly intervals as influenced by soil moisture level.

Harvest number	Treatments: 50% soil moisture level				Treatments: Rainfall only				Cultivar means			
	Kennebec	Irish Cobbler	Monona	Mean	Kennebec	Irish Cobbler	Monona	Mean	Kennebec	Irish Cobbler	Monona	Grand mean
3	0	20	1	7	1	14	3	6	0	17	2	6
4	57	115	47	73	22	97	30	50	40	106	38	61
5	156	267	168	197	120	177	147	148	138	222	158	172
6	314	432	432	392	321	371	259	317	317	401	345	355
7	518	650	422	530	384	489	357	410	451	570	390	470
8	762	829	557	716	591	802	558	650	677	815	558	683
9	744	823	661	742	660	846	542	683	702	834	602	713
10	792	896	578	756	839	900	614	784	816	898	596	770
11	1099	908	690	899	1034	981	646	887	1066	945	668	893
12	1147	989	786	974	1065	952	844	954	1106	971	815	964
13	1310	950	634	965	1122	959	806	962	1216	954	720	963
Grand mean	627	625	452	568	560	599	437	532	594	612	445	550

LSD 5% T ns C 34 C x T ns H 116 H x T ns H x C 107 H x C x T ns

Specific gravity of marketable tubers did not differ significantly due to treatment (Table 11); however, specific gravity was influenced significantly between cultivars. Irish Cobbler tubers were significantly higher in specific gravity than either Kennebec and Monona tubers. Weekly harvests influenced specific gravity significantly. Tubers from harvest 10 had a significantly higher specific gravity and tubers from harvest 13 had a significantly lower specific gravity than all other harvests. A significant increase in specific gravity occurred at harvest 10 and a significant decrease occurred at harvest 11. No significant change in specific gravity occurred prior to harvest 10 or at harvest 12.

Chip color did not differ significantly due to treatment (Table 12); however, chip color was influenced significantly by cultivars. Monona tubers had a significantly lighter chip color than either Kennebec and Irish Cobbler; and Kennebec was significantly lighter than Irish Cobbler. Significant differences in chip color occurred between weekly harvests. Significantly lighter chip colors occurred from tubers of harvests 7, 8 and 9 with no significant change preceding harvest 9. Tubers from harvest 6 had a significantly darker chip color than all other harvests.

A significant interaction occurred between weekly harvests and cultivars. Monona tubers had a significantly lighter chip color than Irish Cobbler tubers for all harvests except number 6 and significantly lighter than Kennebec tubers at harvests 9 and 11. Kennebec tubers had a significantly lighter chip color than Irish Cobbler for all harvests except number 6 and 9. No significant interaction in chip color occurred at harvest 6.

Table 11. Specific gravity of three potato cultivars harvested at weekly intervals as influenced by soil moisture level.

Harvest number	Treatments: 50% soil moisture level: Kennebec	Irish Cobbler	Monona	Mean	Rainfall only: Kennebec	Irish Cobbler	Monona	Mean	Cultivar means: Kennebec	Irish Cobbler	Monona	Grand mean
6	1.073	1.080	1.075	1.076	1.067	1.072	1.071	1.070	1.070	1.076	1.073	1.073
7	1.074	1.080	1.072	1.075	1.073	1.082	1.069	1.074	1.073	1.081	1.070	1.075
8	1.075	1.079	1.075	1.076	1.074	1.084	1.069	1.076	1.074	1.082	1.072	1.076
9	1.075	1.083	1.076	1.078	1.069	1.074	1.066	1.070	1.072	1.078	1.071	1.074
10	1.079	1.086	1.083	1.083	1.078	1.084	1.073	1.078	1.078	1.085	1.078	1.080
11	1.077	1.080	1.070	1.075	1.071	1.074	1.067	1.071	1.074	1.077	1.068	1.073
12	1.071	1.075	1.075	1.074	1.066	1.079	1.067	1.071	1.068	1.077	1.071	1.072
13	1.067	1.073	1.064	1.068	1.058	1.075	1.062	1.065	1.063	1.074	1.063	1.067
Grand mean	1.074	1.080	1.070	1.076	1.069	1.078	1.068	1.072	1.072	1.079	1.071	1.074

LSD 5% T ns C 0.002 C x T ns H 0.003 H x T ns H x C ns H x C x T ns

Table 12. Chip color values as determined on a Photo-volt Reflectance Meter for three potato cultivars harvested at weekly intervals as influenced by soil moisture level. (Higher readings indicate a lighter colored chip.)

Harvest number	Treatments: 50% soil moisture level				Treatments: Rainfall only				Cultivar means			
	Kennebec	Irish Cobbler	Monona	Mean	Kennebec	Irish Cobbler	Monona	Mean	Kennebec	Irish Cobbler	Monona	Grand mean
6	25.3	22.0	26.3	24.6	25.0	24.3	25.7	25.0	25.2	23.2	26.0	24.8
7	27.7	24.3	29.7	27.2	28.0	23.3	27.3	26.2	27.8	23.8	28.5	26.7
8	29.7	26.0	31.0	28.9	29.0	26.7	32.7	29.4	29.3	26.3	31.8	29.2
9	32.3	32.0	38.0	34.1	31.0	29.0	36.0	32.0	31.7	30.5	37.0	33.0
10	36.3	28.3	36.7	33.8	35.3	30.3	37.7	34.4	35.8	29.3	37.2	34.1
11	36.7	27.7	38.3	34.2	31.3	25.3	36.7	31.1	34.0	26.5	37.5	32.7
12	36.3	27.7	36.3	33.4	34.0	32.0	35.7	33.9	35.2	29.8	36.0	33.7
13	35.7	29.3	39.0	34.7	34.7	31.0	35.0	33.6	35.2	30.2	37.0	34.1
Grand mean	32.5	27.2	34.4	31.4	31.0	27.8	33.3	30.7	31.8	27.4	33.9	31.0

LSD 5% T ns C 1.7 C x T ns H 1.8 H x T ns H x C 2.9 H x C x T ns

DISCUSSION OF RESULTS

The results of this experiment revealed that only number of tubers less than 2 inches in diameter was effected by supplemental irrigation. High rainfall and soil moisture levels during the growing season was probably responsible (Plate I). Houghland et al. (11) reported that the value of irrigation in potato production depends upon the amount and distribution of rainfall. Struchtemeyer (7) found total number of tubers related to yield and inconsistently related to per cent available soil moisture.

Plant height and vine dry weight increased to a maximum at harvest 8 then decreased due to the beginning of plant senescence and abscission of older leaves (Plate II). Heavy rainfall also destroyed much of the older foliage. Number of stems per plant did not vary at weekly harvests. Number of stolons per plant were greatest at harvests 2, 3 and 4 and decreased at harvest 5 and 6 which were the harvest periods with the greatest number of tubers less than 2 inches in diameter. Number of tubers larger than 2 inches in diameter was greatest at harvest 12. Total number of tubers per plant and the weight of tubers less than 2 inches in diameter did not differ throughout the season; however, total number of tubers per plant tended to increase until late in the season and weight of tubers less than 2 inches tended to decrease at later harvests (Plate III). Clark (6) reported that number of tubers will increase slightly for a few weeks and then decrease later in the season. Greater weights of tubers over 2 inches in diameter occurred as the season progressed as would be expected (Plate IV). Total tuber weight increased until harvest 12 after which no increase occurred due to death of plants.

Specific gravity of tubers increased to a maximum at harvest 10 and declined the rest of the season as reported by Johnson and Rowberry (13). This probably was due to high soil moisture after physiological maturity (Plate I) as found by Murphy and Govens (18). Terman et al. (25) also found specific gravity to decrease after reaching a maximum. Chip color became lighter until harvest 10 with little variation after this harvest possibly due to physiological maturity as found by Hope et al. (10) and Sweetman (24).

The Kennebec cultivar was the tallest of the cultivars studied followed by Irish Cobbler and Monona. Vine dry weight had nearly an identical pattern with plant height. An interaction between cultivars and harvests reveals the vine dry weight of Kennebec plants to be greater than Irish Cobbler and Monona after harvest 8 indicating Kennebec to be later maturing for the foliage was retained much longer.

Number of stems (Plate II) were greatest on Irish Cobbler followed by Kennebec and Monona. Irish Cobbler also had more stolons than the other cultivars. At harvests 2 through 5 an interaction between harvests and cultivars showed that Irish Cobbler plants produced more stolons than the other cultivars early in the season. This could possibly be due to the greater number of stems per plant on the Irish Cobbler cultivar.

No differences in number or weight of tubers less than 2 inches in diameter occurred between cultivars. Differences in number of tubers greater than 2 inches in diameter did occur between cultivars (Plate III). Irish Cobbler plants produced more tubers greater than 2 inches in diameter than Kennebec which produced more than Monona. An interaction between harvests and cultivars showed Irish Cobbler plants to produce more tubers greater than 2 inches in diameter than other cultivars until harvest 11. Kennebec produced

an equal number of tubers over 2 inches in diameter to Irish Cobbler the last 3 harvests, which was probably due to the later maturity of the cultivar.

Irish Cobbler plants produced a greater total number of tubers than Kennebec which had more than Monona. This again was probably due to the greater number of stems and stolons per plant produced by the Irish Cobbler cultivar.

Kennebec and Irish Cobbler plants produced a greater weight of tubers larger than 2 inches in diameter than Monona (Plate IV). An interaction between harvests and cultivars revealed that Irish Cobbler plants produced a greater weight of tubers larger than 2 inches in diameter than other cultivars until harvest 11; Kennebec plants produced more than Irish Cobbler and Monona for the remainder of the harvests. This was due to the later maturity of the Kennebec cultivar allowing it to increase its tuber weight after the senescence of the other cultivars. This agrees with Struchtemeyer (22) that tuber yield follows the trend in dry vine weight.

Kennebec and Irish Cobbler plants produced a greater total tuber weight than Monona. An interaction between harvests and cultivars shows Irish Cobbler plants to have a greater total tuber weight than other cultivars from harvest 5 to 10. From harvest 11 to 13 Kennebec plants produced a greater total weight of tubers than other cultivars again due to later maturity. Monona plants produced less total tuber weight than other cultivars probably due to fewer stems per plant, smaller plant size and earlier maturity.

Irish Cobbler tubers were of higher specific gravity than other cultivars studied. Murphy and Govens (18) reported that cultivars differ in specific gravity. Interaction between harvests and cultivars indicated that Irish

Cobbler tubers had a higher specific gravity than Kennebec and Monona at all harvests and also showed Kennebec and Monona to be very similar in specific gravity at all harvests.

Monona tubers produced lighter colored chips than Kennebec which were lighter than Irish Cobbler. Irish Cobbler tubers did not produce chips of an acceptable color. No trend existed between specific gravity and chip color at the last 3 harvests. This disagrees with Lyman and Mackey (17) who reported that tubers of high specific gravity consistently produce chips of lighter color than tubers of low specific gravity of the same cultivar. Interaction between harvests and cultivars indicated that Irish Cobbler had darker colored chips than Kennebec and Monona at all harvests. Monona tubers produced lighter chips than Kennebec at harvests 9, 10 and 11. This may possibly be due to Monona reaching physiological maturity earlier than Kennebec. This agrees with both Kushman et al. (16) and Hope et al. (10) that lighter colored chips are produced from more mature tubers.

EXPLANATION OF PLATE II

Fig. 1. Mean plant heights of 3 cultivars at weekly harvest intervals.

Fig. 2. Mean vine dry weights of 3 cultivars at weekly harvest intervals.

Fig. 3. Mean number of stems per plant of 3 cultivars at weekly intervals.

Fig. 4. Mean number of stolons per plant of 3 cultivars at weekly intervals.

PLATE II

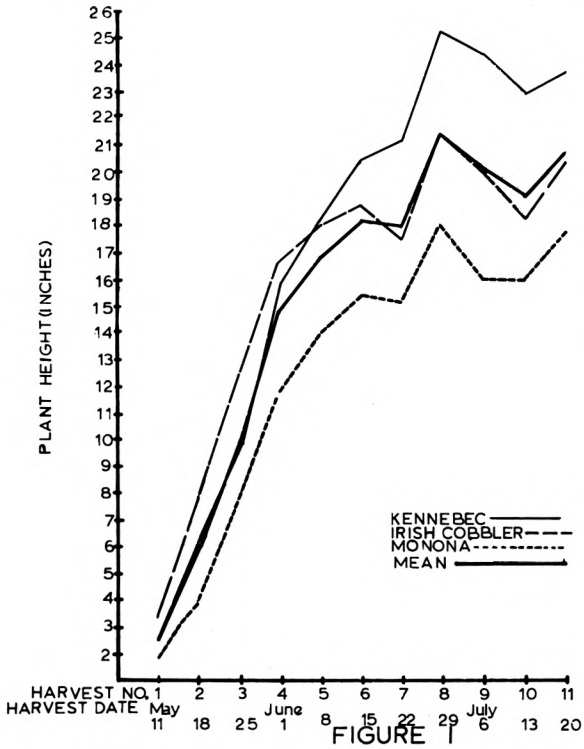


FIGURE 1

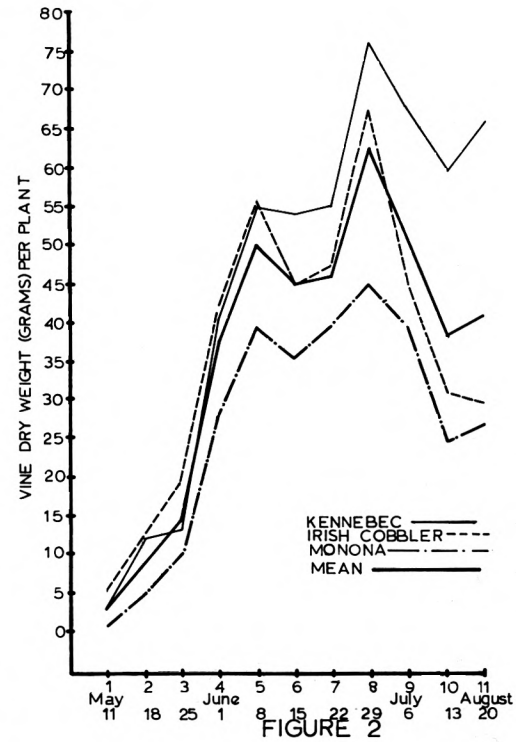


FIGURE 2

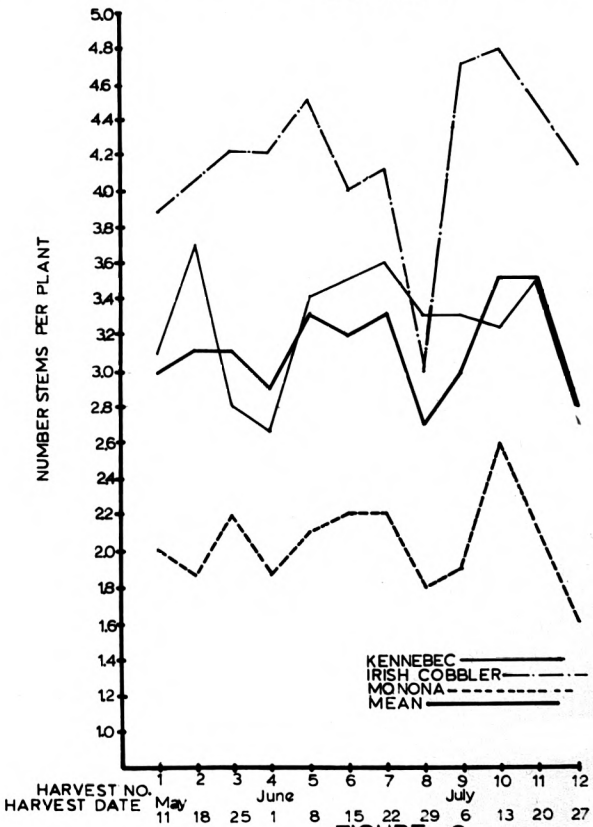


FIGURE 3

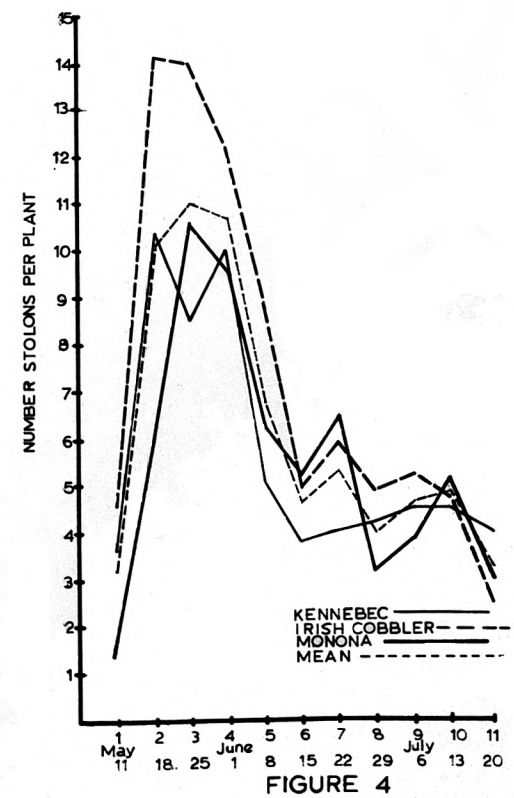


FIGURE 4

EXPLANATION OF PLATE III

Fig. 1. Mean number of tubers less than 2 inches in diameter of 3 cultivars at weekly intervals.

Fig. 2. Mean number of tubers greater than 2 inches in diameter of 3 cultivars at weekly intervals.

Fig. 3. Mean number of tubers per plant of 3 cultivars at weekly intervals.

Fig. 4. Mean weight of tubers per plant less than 2 inches in diameter of 3 cultivars at weekly intervals.

PLATE III

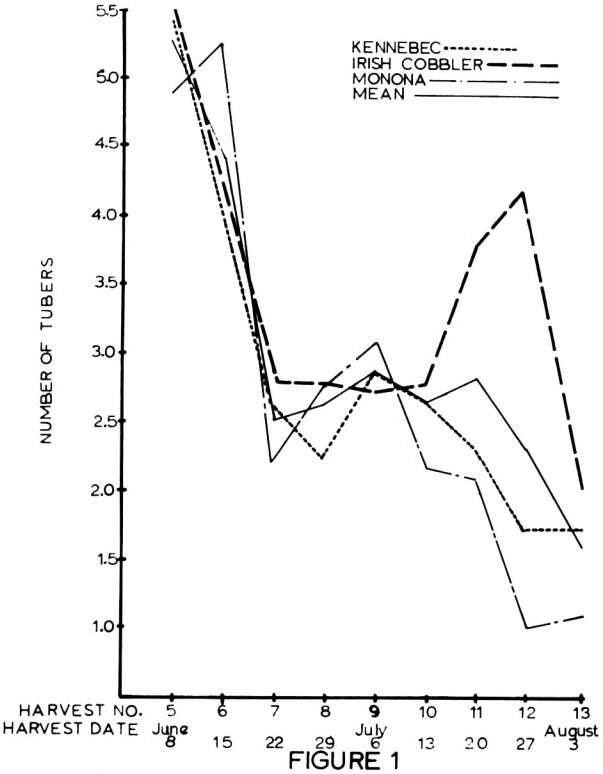


FIGURE 1

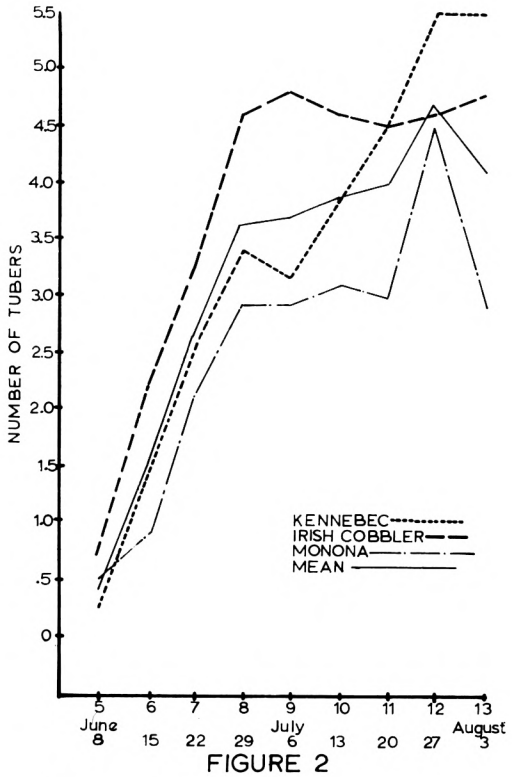
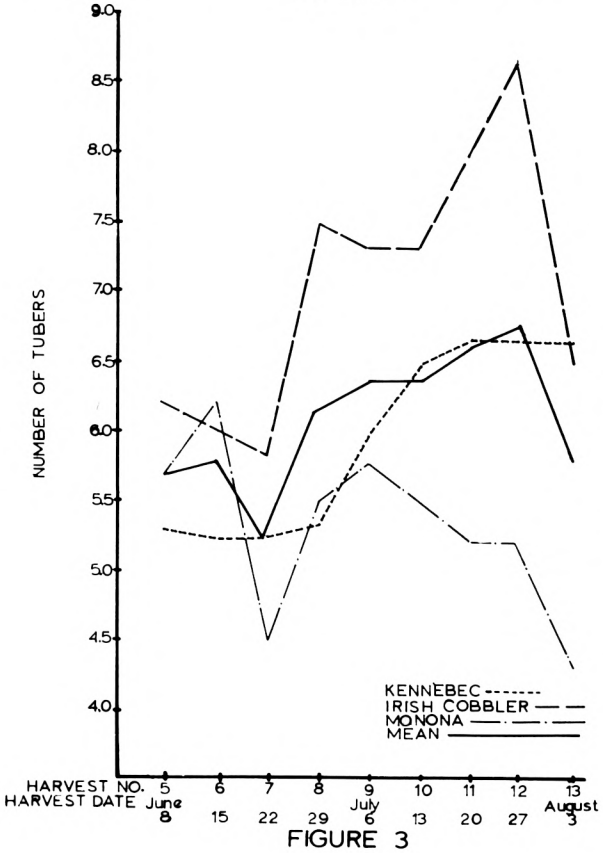


FIGURE 2



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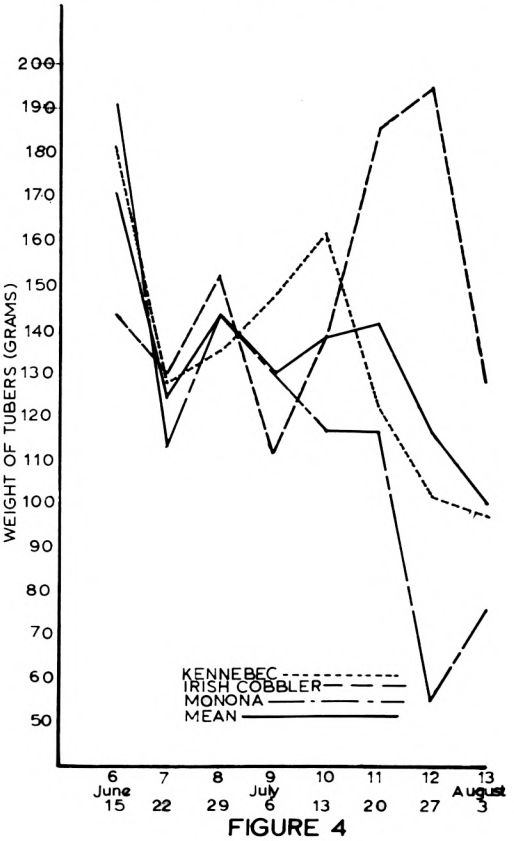

FIGURE 4

EXPLANATION OF PLATE IV

Fig. 1. Mean weight of tubers per plant greater than 2 inches in diameter of 3 cultivars at weekly intervals.

Fig. 2. Mean weight of tubers per plant of 3 cultivars at weekly intervals.

Fig. 3. Mean specific gravity of tubers of 3 cultivars at weekly intervals.

Fig. 4. Mean chip color of tubers of 3 cultivars at weekly intervals.

PLATE IV

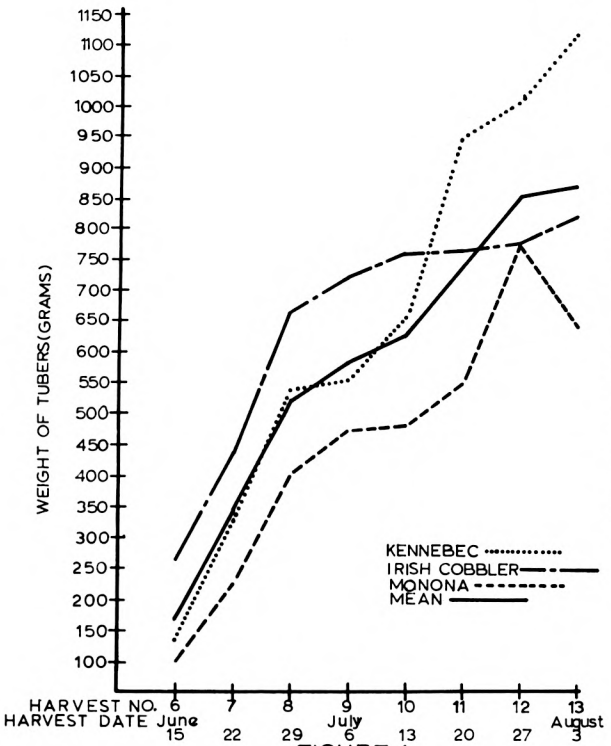

FIGURE 1

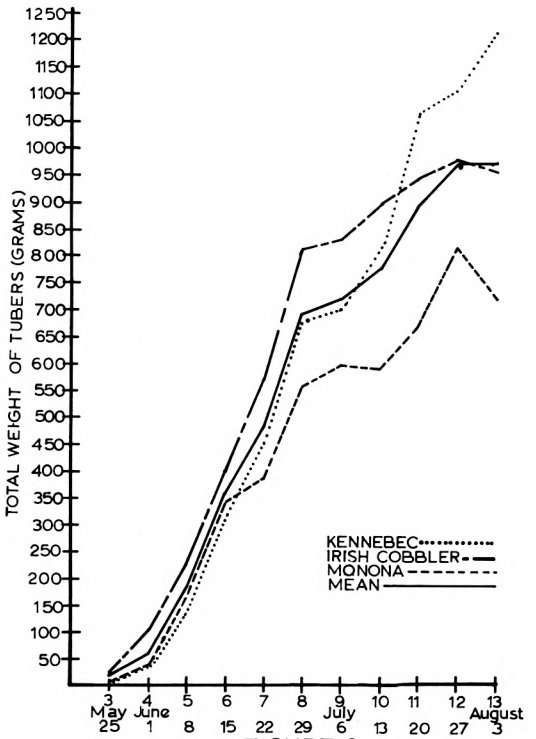

FIGURE 2

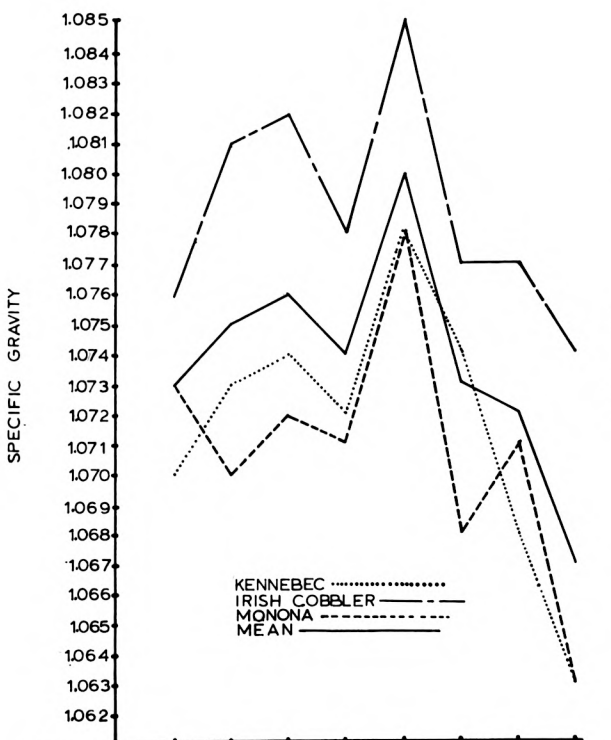

FIGURE 3

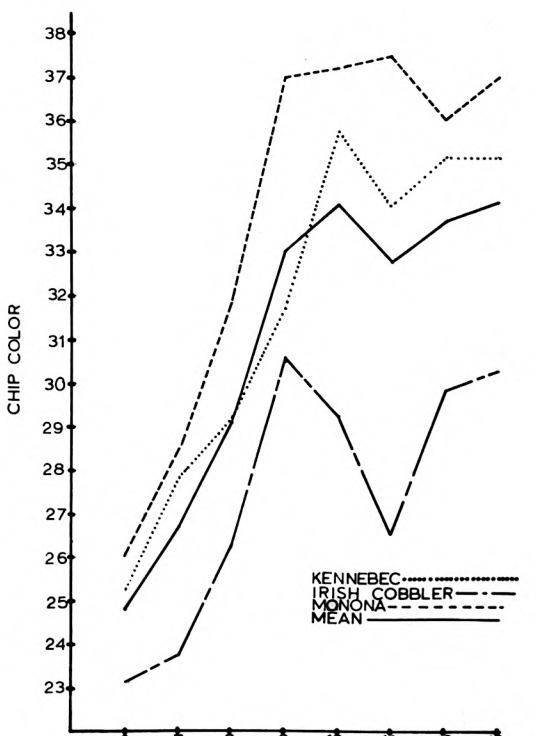

FIGURE 4

SUMMARY

1. Only the number of tubers less than 2 inches in diameter was influenced significantly by supplemental irrigation treatment during the 1965 growing season.
2. Plant height and dry weight were nearly parallel and significantly greater at harvest 8 than any other harvests.
3. Kennebec plants were significantly taller and produced greater dry weights of tops than Irish Cobbler and Monona plants.
4. Number of stems per plant remained constant throughout the season. Irish Cobbler had significantly more stems per plant than Kennebec which had significantly more than Monona.
5. Total number of tubers did not vary significantly throughout the season. Irish Cobbler produced significantly more stolons and tubers per plant than either Kennebec or Monona.
6. Kennebec produced a significantly greater total tuber weight than Irish Cobbler and this cultivar had significantly more than Monona.
7. Irish Cobbler had a significantly higher specific gravity than the other cultivars at all harvests.
8. Monona and Kennebec produced chips of acceptable color but Irish Cobbler did not.
9. Monona tubers produced chips of acceptable color at earlier harvests than Kennebec or Irish Cobbler.
10. Tubers of lower specific gravity of a cultivar did not produce darker colored chips.
11. Chips made from more mature tubers were lighter in color.

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GROWTH AND DEVELOPMENT OF *SOLANUM TUBEROSUM* CULTIVARS UNDER DIFFERENT SOIL MOISTURE LEVELS

by

JAMES EARL MOTES

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Only limited work has been performed on growth and development and the chipping quality of potatoes grown in the Kansas River Valley. Kansas farmers and the potato chip industry are interested in increasing the potato acreage in Kansas, if cultivars and management practices can be determined that will consistently produce marketable potato chips. The objectives of this study were: (1) to study the growth and development of 3 potato cultivars under different available soil moisture levels and (2) to evaluate the chipping quality of these cultivars at all stages of maturity when grown under different available soil moisture levels.

The experiment was conducted during the spring and summer of 1965. Uniform seed pieces of Kennebec, Irish Cobbler and Monona cultivars were planted March 31. A split-split plot design was used. Two treatments: irrigation to keep the soil moisture level above 50 per cent at 6 inch depth; and natural rainfall as the only water source were replicated three times. Only 2.44 inches of irrigation water were required to keep the soil moisture level above 50 per cent for 17.3 inches of rainfall fell during the 13 week growing period. One plot from each replication consisting of four plants of each cultivar was harvested at weekly intervals for 13 consecutive weeks beginning when the plants were 2 to 3 inches tall. The following data was recorded at each harvest: plant height; vine dry weight; number of stems and stolons per plant; number and weight of tubers smaller and larger than 2 inches in diameter; total number and total weight of tubers; specific gravity of tubers; and chip color.

The results of this study revealed that number of tubers less than 2 inches in diameter was the only factor influenced by supplemental irrigation due to the high amount of natural rainfall. Plant height and vine dry weight

increased to a maximum at harvest 8. Number of stems per plant did not vary at weekly harvests. Number of stolons per plant was greatest at early harvests. Number of tubers less than 2 inches in diameter was greatest at harvests 5 and 6. Number of tubers greater than 2 inches in diameter was greatest at harvest 12. Total number of tubers per plant did not differ throughout the growing season. Weight of tubers less than 2 inches in diameter did not differ throughout the growing season. Greater weights of tubers over 2 inches in diameter occurred as the growing season progressed. Total tuber weight increased until harvest 12. Specific gravity of tubers increased to a maximum at harvest 10 and declined the rest of the growing season. Chip color became lighter until harvest 10 with little variation at later harvests.

The Kennebec cultivar was the tallest of the cultivars studied followed by Irish Cobbler and Monona. Vine dry weight followed the pattern of plant height. Number of stems were greatest on Irish Cobbler followed by Kennebec and Monona. Irish Cobbler also had more stolons than other cultivars. No differences in number or weight of tubers less than 2 inches in diameter occurred between cultivars. Irish Cobbler cultivar produced more tubers greater than 2 inches in diameter and a greater total number of tubers than Kennebec which produced more than Monona. Kennebec and Irish Cobbler plants produced a greater weight of tubers larger than 2 inches in diameter and a greater total weight of tubers than Monona. Irish Cobbler cultivar tubers were of higher specific gravity than the other cultivars. Monona cultivar tubers produced lighter colored chips than Kennebec which were lighter than Irish Cobbler. Irish Cobbler cultivar tubers did not produce chips of an