# EVALUATION OF POTATO (*Solanum tuberosum*) CULTIVARS FOR YIELD AND CHIP COLOR BY HARVEST AND STORAGE DATES

by 3235

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# INTRODUCTION

The Irish or White potato, Solanum tuberosum, is one of the world's chief food plants, especially in Europe and America. It is the most important of all vegetables. When compared to other foods on a dry weight basis it is an excellent source of many vitamins and minerals, proteins and carbohydrates. The potato can be held under relatively crude storage conditions for rather long periods of time and still maintain much of its nutritive value (22). Potatoes are grown in nearly every country in the world. Production of potatoes in the world's major producing countries totaled more than 5.5 billion hundred weight. In the United States, Idaho was the leading state in potato production in 1969, with nearly 53 million hundred weight, followed by Maine, California, Washington, New York and North Dakota (22).

Mercer et al. (24) reported that manufacturers of potato chips used a little more than 43 percent of all potatoes sold for food processing. MacFarland (22) stated that 33 percent of the total crop of 1967 was processed into potato chips or French fries.

Potato cultivars differ greatly in size, color, maturity, storage ability and total solids contents. Cultivars of potatoes for fresh use may be different from those for processing. Chip processors prefer potatoes with high percentage of solids.

The potato is a shallow-rooted crop, and it will respond to irrigation in many areas. Dry periods of 2-3 weeks may reduce the yield. Excessive irrigation after the tubers are formed may reduce the yield because of rotting of the tubers (40). Lyman and Mackey (21) found

that high soil moisture by heavy rainfall or late irrigation, especially late in the season, resulted in lower specific gravity tubers. Low specific gravity tubers normally do not produce light chip color, particularly after storage and reconditioning.

The potato is a cool-season crop, moderately tolerant of frost. Werner (43) conducted a series of studies on the effect of temperature and photoperiod on tuber production and vegetative growth. He concluded that the growth of the top was favored by high temperatures and long days, but early tuberization was favored by low temperatures and short days.

Color is one of the most important factors that contribute to potato chip quality. A light color after cooking is a primary requirement. The dark color of potato chips made from tubers stored at low temperatures has long been recognized as a problem of the Potato Chip Industry (10).

Several researchers reported that the total yield of potatoes, production of U. S. No. 1 size tubers and potato chip color, can be influenced by several factors; such as date of harvest, cultivar planted and irrigation when approximately 50 percent of available soil moisture was depleted on light textured soil (3, 13, 14).

The objectives of this study were:

1. To evaluate four potato cultivars harvested at different dates for yield and quality characteristics.
2. To study the effect of different soil moisture regimes on yield and specific gravity of four cultivars.
3. To determine the chip color after one and two weeks storage of tubers of different cultivars harvested at different intervals.

# REVIEW OF LITERATURE

Sweetman (37) reported that the higher the sugar content of tubers, the browner were the chips made from them. Low sugar content appears to be associated with lightness of color. He also found that size of tuber did not significantly affect chip color after different conditions of storage.

Patton (28) indicated that it was the presence of free amino acids and reducing sugars that caused discoloration of potato chips and not reducing sugars alone.

Fitzpatrick and Porter (12) found that a Maillard Reaction between reducing sugars and amino acids plays a major role in the browning of potato chips.

Russell and Shaw (30) stated that the accumulation of reducing sugars in potato tubers exposed to low temperature occurs with concomitant formation of invertase enzyme.

Stewart and Couey (36) found that storage temperature before chipping is one of the most important factors influencing subsequent chip color of potatoes.

Barbarin and Bonner (2) reported that higher storage temperature results in an accumulation of reserve carbohydrates in the form of starch.

Hyde and Walkof (15) showed that potatoes stored at 40° F. for seven months produced good chip color without any period of conditioning.

Clegg and Chapman (7) obtained lighter color from potatoes stored at 70° F., especially early in the harvest season when potatoes were immature.

Lyman and Mackey (21) found that specific gravity influenced potato chip color. Tubers of high specific gravity produced chips of lighter color than did tubers of low specific gravity.

Salankhe et al. (31) indicated that there was significant correlation between specific gravity and chip color through cultivars.

Cunningham and Stevenson (8) stated that chip color and specific gravity were not associated.

Widstoe and Merill (44) reported that application of about three inches of water per application produced the best yield and quality.

Smith (33) found that cultivars of irrigated potato produced lighter chip color than those not irrigated.

Motes (25) concluded that chip color after storage was lighter with supplemental irrigation one of two years.

Prince and Blood (29) stated that irrigation increased the yield of U. S. No. 1 size tubers, however, at high application rates, the yield was greatly reduced.

Struchtmeyer (35) found that amount of water available to the potato plant is quite critical during certain periods in its life cycle. The amount of water can affect the size and number of tubers as well as their quality.

Jacob et al. (16) reported that by over irrigation even in dry years, the result was reduction in the yield.

Bradley and Pratt (4) pointed out that the major effect of moisture level upon tuber set seemed to be upon the earliness of set rather than upon the total number of tubers set.

Yamagouchi et al. (45) found that the darkest chips are from potatoes from soils of lowest temperatures.

Jacob et al. (16) indicated that irrigation would possibly increase tuber specific gravity.

Smith (33) stated that there is a good relationship between soil and air temperature and chip color. Air temperature ranged from 50° to 70° F. for a week preceding harvest produced chips of very light color.

Lorenz (20) found that the higher the air temperatures, the higher the soil temperatures.

Stewart and Couey (36) indicated that low soil temperature before harvest of potatoes had a darkening effect on chips subsequently made from them.

Recently Motes and Greig (26), on a series of field studies, found that when the air temperatures were higher, the irrigation requirements were greatest. They also concluded that irrigated plots differed significantly from non-irrigated plots when irrigation both increased yields and lowered soil temperatures. They suggested that both specific gravity and yield are inversely related to temperature.

Jones and Johnson (17) reported that higher yields resulted if potatoes were irrigated when soil moisture tension reached 0.3 atmosphere than at higher tension levels.

Cykler (9) stated that high yields of potatoes can be obtained by keeping the water content of the soil at a high level throughout the irrigation season and never letting the moisture content fall down.

Ware (42) reported that irrigation may be of greater value to the fall potato crop than the spring crop in the Southern regions because

rainfall during the fall is usually low and temperatures are high.

Hopes et al. (14) indicated that mature tubers produced chips of lighter color than immature tubers. The effect of maturity on chip color appeared to be due to higher reducing sugar content in immature tubers.

Shallenberger and Smith (32) also obtained lighter color of chips from mature potatoes than from immature potatoes of the same cultivar.

Appleman and Miller (1) reported that total sugars were lower in more mature tubers but after storage total sugars were equal from harvest of immature and mature potatoes.

Smith and Nash (34) pointed out that more mature tubers were higher in specific gravity and also lower temperatures during the latter part of the growing season produced tubers of higher specific gravity.

Terman et al. (39) found that specific gravity increased in tubers harvested from green vines due to rain preceding this harvest date.

Beenbaas (41) reported that immature tubers are of a poorer cooking quality than mature ones because they are not sufficiently floury. Furthermore, flavor deteriorates very quickly during storage.

## MATERIALS AND METHODS

A factorial experiment with completely randomized design comparing four potato cultivars, two soil moisture regimes and three harvest dates was conducted in the summer of 1969 at the Horticulture Farm at Kansas State University, on sarpy fine sandy loam soil. Block and irrigation treatments were confounded with moisture levels. Uniform seed pieces, approximately two ounces in weight, of Kennebec, Anoka, Irish Cobbler and Norchip cultivars were planted April 1, 1969. Seed pieces were planted twelve

inches apart in rows thirty-six inches apart. Fertilizer at 97 ∤ 42 ∤ 0 pounds per acre was banded beside the row on all plots on April 2. An additional 30 pounds nitrogen per acre was applied as a sidedressing on June 3. Irrigation treatments were as follows:

(a) Irrigated when tensiometers reached 0.30 atmospheres (referred to as irrigated).

(b) Rainfall (referred to as nonirrigated).

Tensiometers were placed at 6 and 12-inch depths to indicate soil moisture levels during the growing season. Moisture levels were recorded three days weekly and the soil moisture blocks were irrigated when the average 6 and 12-inch depths soil moisture tension readings were 0.30 atmosphere. Water was applied by an overhead sprinkler system that applied water at a rate of 0.17 inches per hour. Soil temperatures recorded four inches below the surface of the row are presented in Table 1 and Plate 1, Figure 1. Air temperatures and rainfall were recorded from thermograph and rain gauges located in the field. These records are listed in Table 2 and Plate 1, Figure 2. The cultivars were harvested at three different dates from each of the soil moisture levels: July 11, 22 and August 6.

Good management practices were followed to control insects, diseases and weeds. Twenty-four plots were harvested at ten-day intervals (dates of harvest). The fresh and dry weight of vines were recorded for each plot. Vines were cut off at soil surface and harvested immediately prior to harvesting the tubers. These weights indicated the relative quantity of foliage per cultivar at various irrigation levels as well as maturity of the plants at each harvest date. The tubers

were dug with a Champion Potato Digger. Total tuber weight and U. S. No. 1 (two inches in diameter and larger) tuber weight were recorded. Specific gravity was determined by the weight in air-weight in water method. Tubers were shipped via air express to Frito-Lay Research Laboratory, Inc., Irving, Texas, to determine the chip color of each treatment at harvest and after one and two weeks storage at 70° F. and 85 percent relative humidity. The potatoes were peeled in an abrasive type peeler and sliced at approximately 50 thousandths of an inch (.050"). The slices were fried in a Hotpoint Fryer (Model HK-3) in peanut oil. The normal starting temperature for frying was 350° F. and decreased to about 330° F. at the end of the frying operation which is determined by cessation of bubbles coming from the chips. Chips were ground so that they passed through an 8 mesh screen, then they were compressed. A Photovolt Model 610 Reflectance Meter was used to measure the reflectance of each compressed sample. A standard with a value of 31 was used as reference for chip color. A reading of 26 is normally the lowest commercially accepted color. High values indicate lighter color.

Table 1. Weekly average soil temperatures at 6-inch depth during growing season - May 30 to August 5, 1969.

| Date | Temperature | |
|---|---|---|
| | Irrigated | Nonirrigated |
| | °F | °F |
| May 30 | 61 | 61 |
| June 6 | 73 | 72 |
| June 13 | 66 | 66 |
| June 20 | 61 | 62 |
| June 27 | 70 | 70 |
| July 4 | 76 | 77 |
| July 11 | 77 | 76 |
| July 18 | 82 | 84 |
| July 25 | 80 | 80 |
| August 1 | 72 | 72 |
| August 5 | 76 | 78 |

## EXPLANATION OF PLATE I

Fig. 1. Soil temperature at 4-inch depth during the growing season for irrigated (0.30 SMT) and nonirrigated plots (rainfall).

Fig. 2. Weekly maximum, minimum and mean air temperatures during the growing season, records taken from the thermograph in the field.

PLATE I

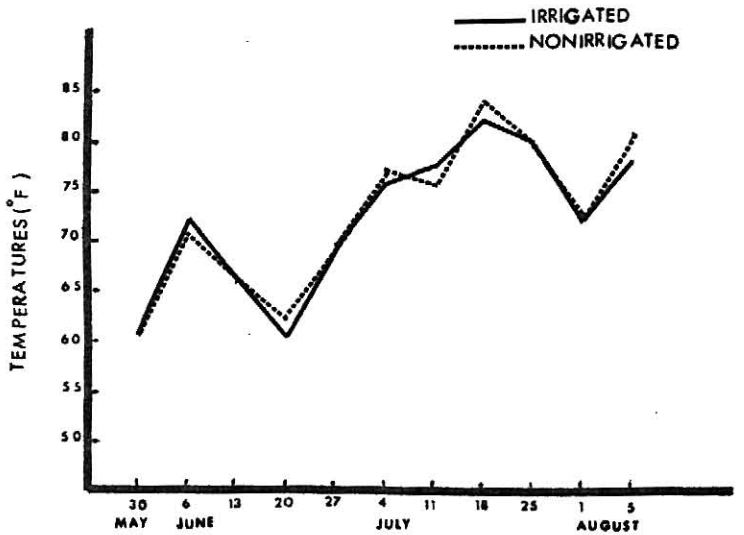


FIGURE 1

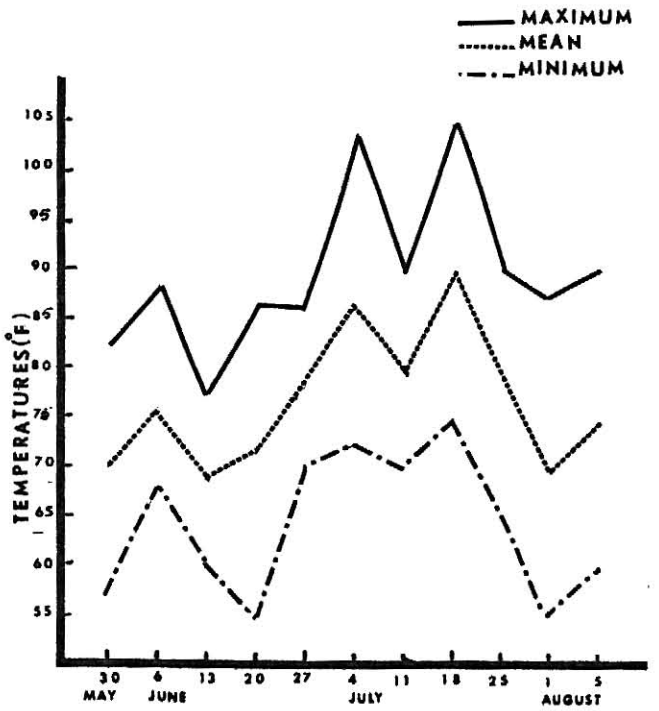


FIGURE 2

Table 2. Weekly average air temperatures and inches of rainfall during growing season from May 30 to August 5, 1969.

| Date | Air Temperature | | | Rainfall |
|---|---|---|---|---|
| | Maximum | Minimum | Mean | |
| | F° | F° | F° | in |
| May 30 | 83 | 56 | 70 | 0.12 |
| June 6 | 89 | 63 | 76 | 0.07 |
| June 13 | 77 | 60 | 69 | 1.90 |
| June 20 | 88 | 55 | 71 | 1.20 |
| June 27 | 88 | 70 | 79 | 1.69 |
| July 4 | 104 | 72 | 88 | 0.45 |
| July 11 | 90 | 70 | 80 | 2.43 |
| July 18 | 105 | 75 | 90 | 0.93 |
| July 25 | 90 | 65 | 78 | 2.46 |
| August 1 | 85 | 55 | 70 | 0.08 |
| August 5 | 90 | 60 | 75 | 0 |

# EXPERIMENTAL RESULTS

Characteristics of potatoes studied in this experiment were: vine dry weight, total weight of tubers, total weight of the U.S. No. 1 tubers, specific gravity and chip color after one and two weeks storage.

Vine dry weight. Results were significantly different among cultivars (Table 3). Significantly greater vine dry weight was produced by Kennebec cultivar; whereas Anoka cultivar produced significantly lower vine dry weight. Significant differences occurred for vine dry weight among the three different harvest dates. Vine dry weight was significantly larger from the first and second harvests than from the third harvest. Significant differences did not occur between the first and second harvests in vine dry weight. Significant differences occurred in vine dry weight between different soil moisture treatments. Significantly higher vine dry weight occurred with irrigated than from nonirrigated plots. A significant interaction in vine dry weight occurred between harvest dates and cultivars. Kennebec cultivar had significantly greater vine dry weight at first, second and third harvests, respectively, than any other cultivar. The Anoka cultivar produced significantly lower vine dry weight at the three harvest dates than Kennebec, Irish Cobbler and Norchip cultivars.

Kennebec cultivar had significantly higher vine dry weight at first harvest than at third harvest. A significant interaction occurred between harvest dates and irrigation treatments. The first harvest with irrigation produced significantly greater vine dry weight than the first harvest

Table 3. Vine dry weight (pounds per ten plants) of four potato cultivars harvested at ten day intervals as influenced by soil moisture regimes.

| Cultivar | Irrigated | | | | Nonirrigated | | | | Cultivar Means | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Harvest* | | | | Harvest* | | | | Harvest* | | | |
| | First | Second | Third | Mean | First | Second | Third | Mean | First | Second | Third | Grand Mean |
| Anoka | 0.99 7/ | 0.56 | 0.48 | 0.68 5/ | 0.64 7/ | 0.89 | 0.35 | 0.63 5/ | 0.81 4/ | 0.73 | 0.42 | 0.65 1/ |
| Kennebec | 3.23 | 2.92 | 2.98 | 3.04 5/ | 3.29 | 2.93 | 1.47 | 2.56 5/ | 3.26 | 2.93 | 2.23 | 2.80 1/ |
| Irish Cobbler | 1.30 | 0.77 | 1.06 | 1.04 5/ | 0.87 | 1.11 | 0.58 | 0.85 5/ | 1.09 | 0.94 | 0.82 | 0.95 1/ |
| Norchip | 1.33 | 1.11 | 1.64 | 1.36 5/ | 1.06 | 1.54 | 0.79 | 1.13 5/ | 1.20 | 1.33 | 1.22 | 1.25 1/ |
| Mean | 1.71 6/ | 1.34 6/ | 1.54 6/ | 1.53 3/ | 1.47 6/ | 1.62 6/ | 0.80 6/ | 1.29 3/ | 1.59 2/ | 1.48 2/ | 1.17 2/ | 1.41 |

LSD = 0.05

* Harvest dates: July 11, 22 and Aug. 6

1/ Cultivar = 0.24

2/ Harvest = 0.20

3/ Irrigation= 0.02

4/ Cult. x Har. = .40

5/ Cult. x Irr. = NS

6/ Har. x Irr. = .20

7/ Cult. x Har. x Irr. = NS

with no irrigation treatment. The second harvest with no irrigation produced significantly higher vine dry weight than second harvest with irrigation.

Total weight of tubers. Significant differences occurred in total weight of tubers between cultivars. Kennebec, Irish Cobbler and Norchip cultivars produced significantly higher yield than Anoka cultivar (Table 4). Significant differences did not occur among Kennebec, Irish Cobbler and Norchip cultivars in the total weight of tubers.

Total weight of tubers was significantly different due to different harvest dates. Second and third harvests yielded significantly more tubers than first harvest. Yield was not significantly influenced by irrigation. A significant interaction occurred between harvests and cultivars. Anoka cultivar had significantly lower total weight of tubers at the three harvest dates than Kennebec, Irish Cobbler and Norchip cultivars. The total weight of tubers did not significantly differ among Kennebec, Irish Cobbler and Norchip cultivars at the three harvest dates.

A significant interaction occurred between irrigation treatments and harvests. Irrigated plots yielded significantly higher at third harvest than at first and second harvests. Total yield from nonirrigated plots was significantly higher at second harvest than at first and third harvests. A significant interaction occurred between irrigation and cultivars.

Anoka cultivar had significantly lower total weight of tubers than the other cultivars at both irrigated and nonirrigated plots. Significant differences did not occur among Kennebec, Irish Cobbler and Norchip

Table 4. Total weight of tubers (pounds per plot) of four potato cultivars, harvested at ten-day intervals, as influenced by soil moisture regimes.

| Cultivar | Irrigated | | | | Nonirrigated | | | | Cultivar Means | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Harvest* | | | | Harvest* | | | | Harvest* | | | |
| | First | Second | Third | Mean | First | Second | Third | Mean | First | Second | Third | Grand Mean |
| Anoka | 19.0 7/ | 14.1 | 13.4 7/ | 15.5 5/ | 15.6 7/ | 25.7 | 19.1 | 20.1 5/ | 17.3 4/ | 19.9 | 16.3 | 17.8 1/ |
| Kennebec | 22.1 | 29.6 | 37.9 | 29.9 5/ | 20.2 | 28.9 | 35.1 | 28.7 5/ | 21.2 | 29.3 | 36.5 | 29.0 1/ |
| Irish Cobbler | 23.9 | 26.3 | 39.8 | 30.0 5/ | 21.6 | 31.8 | 28.0 | 27.1 5/ | 22.8 | 29.1 | 33.9 | 28.6 1/ |
| Norchip | 23.3 | 28.4 | 41.6 | 31.3 5/ | 17.2 | 37.9 | 24.9 | 26.6 5/ | 20.4 | 33.2 | 33.3 | 28.9 1/ |
| Mean | 22.1 6/ | 24.6 6/ | 33.2 6/ | 26.6 3/ | 18.7 6/ | 31.1 6/ | 26.8 6/ | 25.5 3/ | 20.4 2/ | 27.9 2/ | 30.0 2/ | 26.1 |

LSD = 0.05

* Harvest dates: July 11, 22 and Aug. 6

1/ Cultivar = 3.3

2/ Harvest = 2.9

3/ Irrigation = NS

4/ Cult. x Har. = 5.7

5/ Cult. x Irr. = 4.7

6/ Har. x Irr. = 4.0

7/ Har. x Cult. x Irr. = 8.0

cultivars on either irrigated or nonirrigated plots in total weight of tubers.

Weight of U. S. No. 1 tubers. Significant differences in weight of U. S. No. 1 size tubers occurred between cultivars (Table 5). Kennebec, Irish Cobbler and Norchip cultivars produced significantly greater weight of U. S. No. 1 tubers than Anoka cultivar.

Significant differences in weight of U. S. No. 1 tubers did not occur between Kennebec, Irish Cobbler and Norchip cultivars. Weight of U. S. No. 1 tubers differed significantly due to harvest dates. Yields from the second and third harvest were significantly higher than from the first harvest. Yield of U. S. No. 1 tubers did not significantly increase due to irrigation treatments. A significant interaction occurred between irrigation treatments and harvests. Plants from the irrigation treatments significantly produced greater weight of U. S. No. 1 tubers at third harvest than from first and second harvests. Plants from nonirrigation treatments produced significantly greater weight of U. S. No. 1 size tubers at second harvest than from first and third harvests. No significant differences occurred between first and second harvests of irrigated plots in the weight of U. S. No. 1 tubers.

Specific gravity of tubers. Specific gravity did not differ significantly due to irrigation treatments (Table 6). Significant differences in specific gravity occurred among cultivars. Irish Cobbler and Norchip tubers were significantly higher in specific gravity than either Kennebec or Anoka tubers. Ten days harvest intervals did not significantly influence tuber specific gravity. A significant interaction in

Table 5. Weight of U. S. No. 1 size tubers (pounds per plot) of four potato cultivars, harvested at ten-day intervals, as influenced by soil moisture regimes.

| Cultivar | Irrigated | | | | Nonirrigated | | | | Cultivar Means | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Harvest* | | | | Harvest* | | | | Harvest* | | | |
| | First | Second | Third | Mean | First | Second | Third | Mean | First | Second | Third | Grand Mean |
| Anoka | 13.0 [7] | 10.0 | 9.2 | 10.7 [5] | 10.9 [7] | 18.8 | 12.5 | 14.1 [5] | 12.0 [4] | 14.4 | 11.0 | 12.5 [1] |
| Kennebec | 15.0 | 20.2 | 26.5 | 20.6 [5] | 15.3 | 20.6 | 21.7 | 19.2 [5] | 15.1 | 20.4 | 24.1 | 19.9 [1] |
| Irish Cobbler | 17.7 | 18.4 | 27.1 | 21.1 [5] | 14.1 | 19.3 | 19.3 | 17.6 [5] | 15.9 | 18.8 | 23.2 | 19.3 [1] |
| Norchip | 15.7 | 21.1 | 29.5 | 22.1 [5] | 11.4 | 28.3 | 13.1 | 17.6 [5] | 13.5 | 24.7 | 21.3 | 19.8 [1] |
| Mean | 15.4 [6] | 17.4 [6] | 23.1 [6] | 18.6 [3] | 12.9 [6] | 21.8 [6] | 16.7 [6] | 17.1 [3] | 14.1 [2] | 19.6 [2] | 19.9 [2] | 17.9 |

LSD = 0.05

* Harvest dates: July 11, 22 and August 6

1/ Cultivar = 3.3

2/ Harvest = 2.8

3/ Irrigation = NS

4/ Cult. x Har. = NS

5/ Cult. x Irr. = NS

6/ Har. x Irr. = 4.0

7/ Cult. x Har. x Irr. = NS

Table 6. Specific gravity of four potato cultivars, harvested at ten-day intervals, as influenced by soil moisture levels.

| Cultivar | Irrigated | | | | Nonirrigated | | | | Cultivar Means | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Harvest* | | | | Harvest* | | | | Harvest* | | | |
| | First | Second | Third | Mean | First | Second | Third | Mean | First | Second | Third | Grand Mean |
| Anoka | 68 7/ | 59** | 60 | 62 | 74 7/ | 62 | 63 | 66 5/ | 71 4/ | 61 | 61 | 64 1/ |
| Kennebec | 53 | 60 | 63 | 59 5/ | 61 | 59 | | 62 5/ | 57 | 60 | 64 | 60 1/ |
| Irish Cobbler | 64 | 67 | 69 | 67 5/ | 72 | 63 | 65 | 67 5/ | 68 | 65 | 68 | 67 1/ |
| Norchip | 70 | 74 | 76 | 73 5/ | 74 | 74 | 67 | 71 5/ | 72 | 74 | 71 | 72 1/ |
| Mean | 64 6/ | 65 6/ | 67 6/ | 65 3/ | 70 6/ | 65 6/ | 66 6/ | 67 3/ | 67 2/ | 65 2/ | 66 2/ | 66 |

LSD = 0.05

1/ Cultivar = .003

2/ Harvest = NS

3/ Irrigation = NS

4/ Cult. x Har. = .005

5/ Cult. x Irr. = NS

6/ Har. x Irr. = .004

7/ Cult. x Har. x Irr. = NS

* Harvest dates: July 11, 22 and August 6

** 1.0 omitted in each specific gravity determination.

specific gravity occurred between irrigation treatments and harvests. Tubers at first harvest from nonirrigated plots were significantly higher in specific gravity than tubers at first and second harvests from irrigated plots. Significant differences in specific gravity did not occur between harvests from the irrigated plots.

A significant interaction in specific gravity occurred between cultivars and harvest dates. Norchip tubers were significantly higher in specific gravity at second harvest than the other cultivars. Significant differences did not occur in specific gravity of Norchip tubers at first, second and third harvests. Kennebec cultivar was significantly lower in specific gravity at first harvest than any other cultivar.

Chip color after one week storage. Chip color after one week storage varied significantly among cultivars (Table 7). Norchip tubers produced significantly higher chip color value (desirable) than the other cultivars.

Significant differences did not occur among Anoka, Kennebec and Irish Cobbler cultivars in chip color value.

Chip color after two weeks storage. Chip color did not differ significantly due to irrigation treatments (Table 8). Chip color varied significantly among cultivars. Norchip tubers produced significantly higher chip color value than the other cultivars. Anoka and Kennebec tubers had significantly lighter chip color than Irish cobbler. Harvest dates significantly influenced chip color. Significantly lighter chip color was produced at second harvest. Significant differences in chip color did not occur between first and third harvests.

Table 7. Chip color (after one week storage) of four potato cultivars, harvested at ten-day intervals, as influenced by soil moisture levels (higher readings indicate a lighter colored chip).

| Cultivar | Irrigated | | | | Nonirrigated | | | | Cultivar Means | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Harvest* | | | | Harvest* | | | | Harvest* | | | |
| | First | Second | Third | Mean | First | Second | Third | Mean | First | Second | Third | Grand Mean |
| Anoka | 21.3 7/ | 26.3 | 26.0 | 24.5 5/ | 22.0 7/ | 20.7 | 24.0 | 22.1 5/ | 21.6 4/ | 23.3 | 25.0 | 23.3 1/ |
| Kennebec | 21.0 | 22.0 | 25. | 22.7 5/ | 23.0 | 18.7 | 23.3 | 21.7 5/ | 22.0 | 20.4 | 24.2 | 22.2 1/ |
| Irish Cobbler | 22.7 | 25.0 | 22.7 | 23.1 5/ | 19.7 | 18.0 | 18.7 | 18.8 5/ | 21.2 | 21.0 | 20.7 | 21.0 1/ |
| Norchip | 26.3 | 25.4 | 25.0 | 25.2 5/ | 24.0 | 29.7 | 27.7 | 27.1 5/ | 25.2 | 27.0 | 26.4 | 26.2 1/ |
| Mean | 22.8 6/ | 24.2 6/ | 24.7 6/ | 23.9 3/ | 22.2 6/ | 21.7 6/ | 23.4 6/ | 22.4 3/ | 22.5 2/ | 23.0 2/ | 24.1 2/ | 23.2 |

LSD = 0.05

1/ Cultivars = 2.6

2/ Harvest = NS

3/ Irrigation = NS

4/ Cult. x Har. = NS

5/ Cult. x Irr. = NS

6/ Har. x Irr. = NS

7/ Cult. x Har. x Irr. = NS

* Harvest dates: July 11, 22 and August 6.

Table 8. Chip color (after two weeks storage) of four potato cultivars, harvested at ten-day intervals, as influenced by soil moisture levels (higher readings indicate a lighter colored chip).

| | Irrigated | | | | Nonirrigated | | | | Cultivar Means | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Harvest* | | | | Harvest* | | | | Harvest* | | | |
| | First | Second | Third | Mean | First | Second | Third | Mean | First | Second | Third | Grand Mean |
| Anoka | 18.0 7/ | 28.3 | 20.3 | 22.2 5/ | 21.3 7/ | 24.0 | 23.7 | 23.0 | 19.6 4/ | 26.2 | 22.0 | 22.6 1/ |
| Kennebec | 19.7 | 23.3 | 22.7 | 21.9 5/ | 20.3 | 21.3 | 20.7 | 20.8 5/ | 20.0 | 22.3 | 21.7 | 21.3 1/ |
| Irish Cobbler | 19.0 | 22.0 | 17.7 | 19.6 5/ | 17.7 | 18.7 | 14.7 | 17.0 5/ | 18.4 | 20.4 | 16.2 | 18.3 1/ |
| Norchip | 25.3 | 29.0 | 26.7 | 27.0 5/ | 25.0 | 31.3 | 21.0 | 25.8 5/ | 25.2 | 30.2 | 24.0 | 26.5 1/ |
| Mean | 20.5 6/ | 25.7 6/ | 21.9 6/ | 22.7 3/ | 21.1 6/ | 23.8 6/ | 20.0 6/ | 21.6 3/ | 20.8 2/ | 24.8 2/ | 21.0 2/ | 22.2 |

LSD = 0.05

1/ Cultivar = 2.2

2/ Harvest = 2.0

3/ Irrigation = NS

4/ Cult. x Har. = NS

5/ Cult. x Irr. = NS

6/ Har. x Irr. = NS

7/ Cult. x Har. x Irr. = NS

* Harvest dates: July 11, 22 and August 6.

## DISCUSSION OF RESULTS

The results of this experiment indicated that harvest dates, irrigation treatments and cultivars influenced vine dry weight, total weight of tubers, yield of U. S. No. 1 size tubers, specific gravity and chip color.

Vine dry weight. The first harvest produced significantly greater vine dry weight than second and third harvest (Table 3). This was probably due to loss of foliage and senescence with later harvests. The Kennebec cultivar had greater vine dry weight than the other cultivars. This agrees with Bukhari (5) who reported that the Kennebec cultivar produced the highest vine dry weight of the cultivars studied. Kennebec had greater vine dry weight than the other cultivars at the first harvest and then decreased later in the season. However, vine weight was still higher than the maximum of the other cultivars. The small vines produced by the Anoka cultivar may be responsible for lack of yield. The Kennebec cultivar produced several times more vine weight than Anoka. Larger vine dry weight occurred from the irrigated plots than from nonirrigated plots. This agrees with the findings of Bradley and Pratt (4) that maintaining a high moisture level resulted in better top growth, earlier tuber set and greater weight of tubers.

Total weight of tubers. Kennebec cultivar significantly produced greater total tuber weight than the other cultivars (Table 4). Anoka cultivar significantly produced lower total weight of tubers. Motes (25) indicated that Irish Cobbler cultivar produced significantly greater total tuber yield in 1966, but no difference between cultivars occurred in 1967. Total tuber weight significantly increased at the

second and third harvests. This agrees with McGoldrick and Smith (23) who reported that yield was usually lowest with early harvest (Plate II, Fig. 3). The Kennebec cultivar vines remained green longer and total tuber weight increased until the third harvest. This possibly was due to the later maturity of the Kennebec cultivar allowing it to increase its tuber size and therefore its tuber weight increased after the senescence of the other cultivars. These results agree with Clark (16) who stated that variation of cultivars is directly related to earliness or lateness of maturity. He observed 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. A comparison of total weight of tubers with vine dry weight indicates that these two factors had a similar pattern for all varieties studied except Kennebec. Irrigation treatments did not significantly increase the total weight of tubers. This contradicts with results of Motes (25) who indicated that irrigation significantly produced greater total weight of tubers. Differences in response to irrigation varies between seasons because of differences in amount and distribution of rainfall.

Weight of U. S. No. 1 tubers. The first harvest was significantly lower in weight of U. S. No. 1 size tubers than the second and third harvests (Table 5 and Plate II, Fig. 4). The tubers at this harvest had not reached maximum size, therefore yield was less than at later harvest dates. The foliage was still green, so increased size of tubers occurred for later harvests. In early summer producing regions, immature potatoes are frequently harvested for the potato chip trade before

## EXPLANATION OF PLATE II

Fig. 3. Mean total weight of tubers per plot of four cultivars at ten-day harvest intervals.

Fig. 4. Mean weights of tubers per plots greater than two inches in diameter (U.S. No. 1) of four cultivars at ten-day harvest intervals.

PLATE 11

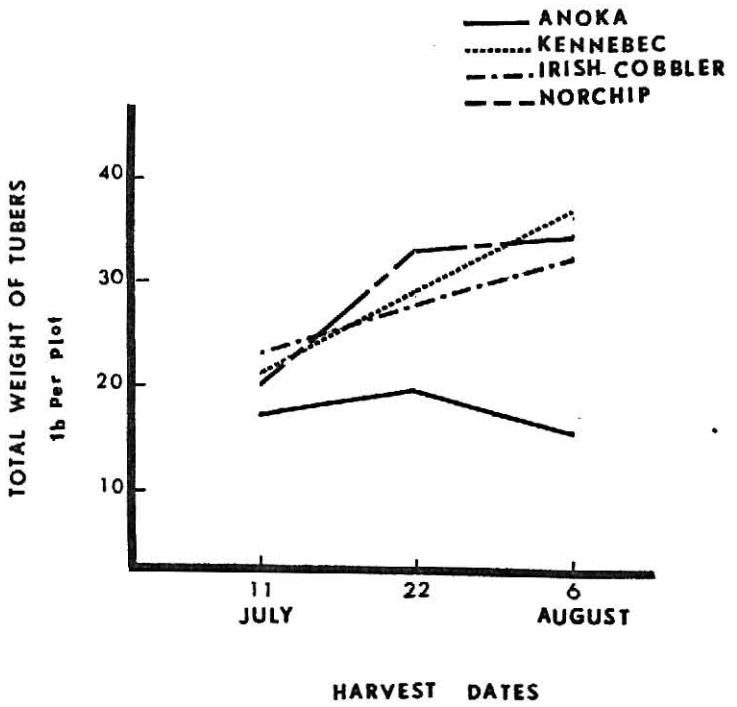


FIGURE 3

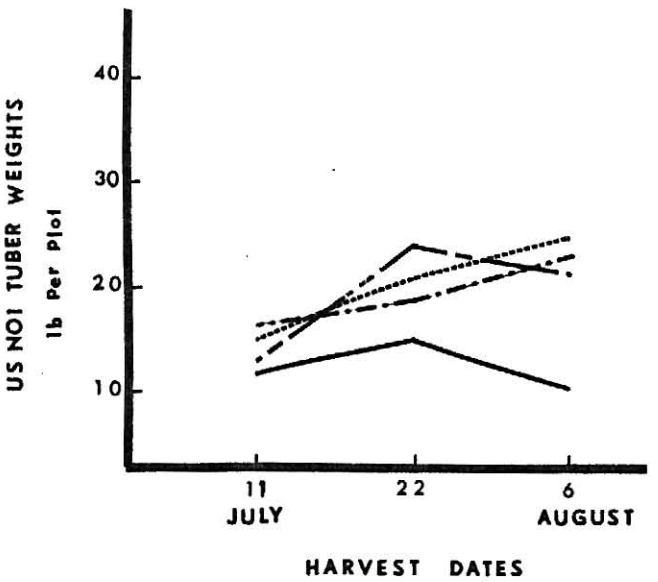


FIGURE 4

they have made maximum growth, because the price is higher per bag. Plants from irrigated plots produced larger weight of U. S. No. 1 tubers at their harvest than those from nonirrigated plots at the third harvest. Bradley and Pratt (4), Clark (6) and Edmundson (11) reported that an earlier set and more rapid tuber development occurred with higher soil moisture earlier in the growing season. Irrigation did not significantly influence weight of U. S. No. 1 size tubers. This agrees with Motes and Greig (26) who indicated that yield of U. S. No. 1 tubers was not affected by irrigation two of three years.

Specific gravity of tubers. Norchip cultivar had higher specific quality than any other cultivar. Kennebec tubers were significantly lower in specific gravity than any other cultivar (Table 6). Nash (27) reported that fairly large and constant differences were found in specific gravity between varieties. Specific gravity did not differ with irrigation levels. Jacob et al. (16) found no significant differences in specific gravity with different soil moisture levels. Harvest dates did not influence specific gravity of tubers. Kennebec cultivar increased in specific gravity as the season progressed. This was probably due to late maturing of this cultivar. Anoka cultivar decreased sharply in specific gravity at second harvest and remained constant at third harvest. This may have been due to higher temperatures prior to harvest of second and third harvests. Respiration rate would have increased and therefore a lower specific gravity, particularly since little additional photosynthesis was taking place for this cultivar.

Kehr et al. (18) reported that temperature above 70° F. increases respiration of the plants which in turn reduces the accumulation of

carbohydrates in the tubers.

An interaction between irrigation levels and harvests revealed that irrigated plots produced higher specific gravity at the end of the season than nonirrigated plots. This agrees with Bukhari (5) who reported that tubers from 0.30 SMT/Atm. (high irrigated plots) were significantly higher in specific gravity at third harvest than tubers from either 0.60 SMT/Atm. (low irrigated plots) or nonirrigation treatments (rainfall).

Chip color after one week storage. After one week storage at 70° F. Norchip tubers produced significantly lighter colored chips than all other cultivars studied. Irrigation did not significantly influence chip color of tubers after one week storage. Talbert and Smith (38) indicated if rainfall plus irrigation amounts to more moisture than plants can utilize for maximum growth, it may result in potatoes of low specific gravity and chips of dark color.

Chip color after two weeks storage. Norchip tubers produced lighter colored chips after two weeks storage than any other cultivar. This possibly was because the Norchip cultivar was higher in specific gravity than the other cultivars. This agrees with Lyman and Mackey (21) who stated that specific gravity influenced chip color. They observed that tubers of high specific gravity produced lighter chip color. Kunkel et al. (19) reported that the higher the specific gravity, the lighter the color of chips. Irish Cobbler tubers produced darker chip color after two weeks storage than the other cultivars. This conflicted with Clegg and Chapman (7) who found that the color of chips from the early maturing variety (Cobbler) from tubers stored at 50° F. was considerably darker than those stored at 70° F. This indicates that the choice of

EXPLANATION OF PLATE III

Fig. 5. Mean specific gravity of tubers of four cultivars at ten-day harvest intervals.

Fig. 6. Mean chip color of four cultivars after two weeks storage at 70° F. and 85 percent relative humidity at ten-day harvest intervals.

PLATE III

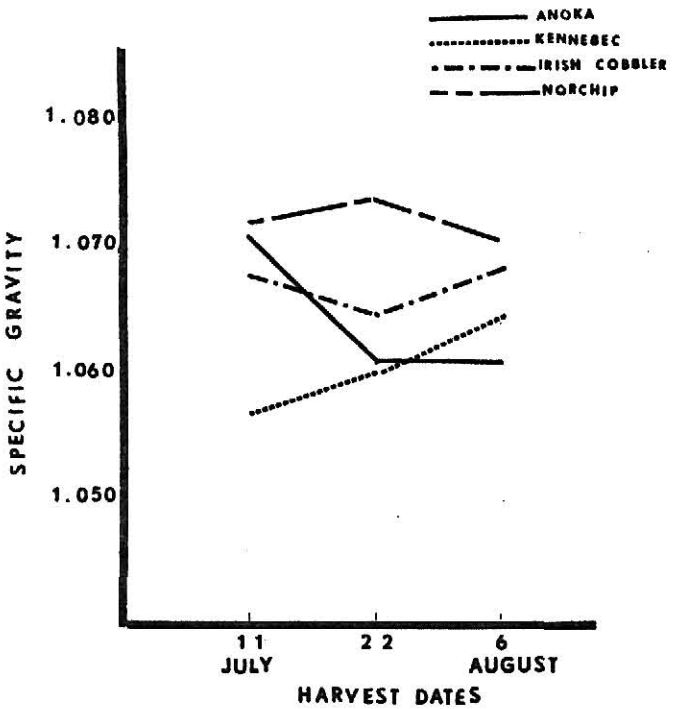


FIGURE 5

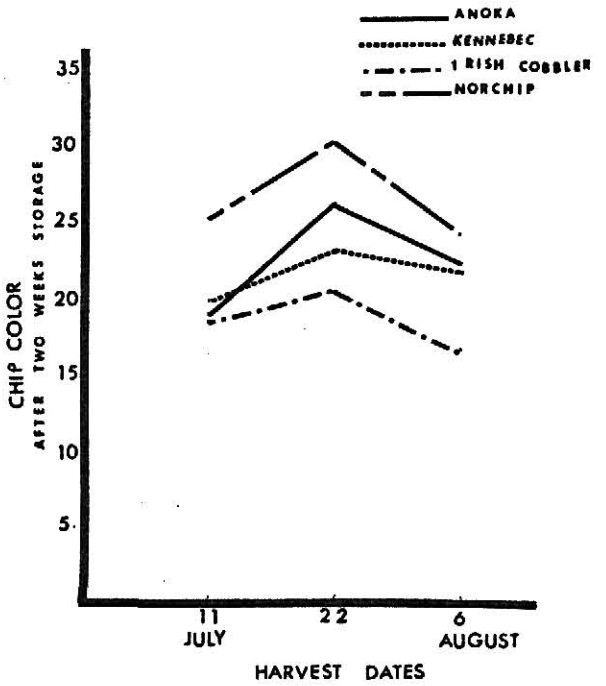


FIGURE 6

cultivars is essential to good storage management. Some cultivars chip very good from storage, such as Norchip cultivar, and some others chip very poorly from short time storage such as Irish Cobbler in this study. Shallenberger and Smith (32) reported that not only was storage temperatures the main factor influencing potato chip color, but cultivar, length of storage and maturity were also significant.

## SUMMARY

### Vine Dry Weight

Kennebec cultivar produced significantly greater vine dry weight than any other cultivar. Irish Cobbler and Norchip cultivars produced more vine dry weight than Anoka cultivar. Greater vine dry weight was produced from irrigated than from nonirrigated plots. The first harvest significantly produced greater vine dry weight than third harvest.

### Total Tuber Weight and Weight of U. S. No. 1 Tubers

Kennebec cultivar produced significantly higher total weight of tubers and weight of U. S. No. 1 size tubers than the other cultivars. Lower total weight of tubers and weight of U. S. No. 1 size tubers was obtained from Anoka cultivar.

The third harvest was significantly higher in total tuber weight and weight of U. S. No. 1 tubers than first and second harvests. Irrigation treatments did not affect significantly either the total weight of tubers or weight of U. S. No. 1 tubers. Irrigation treatments significantly affected both total weight of tubers and weight

of U. S. No. 1 tubers when interacted with harvests. The third harvest of irrigated plots produced significantly greater weight of U. S. No. 1 tubers and total weight of tubers than first and second harvests.

## Specific Gravity of Tubers

Norchip tubers were significantly greater in specific gravity than the other cultivars. Tuber specific gravity was not significantly influenced by irrigation treatments.

Kennebec cultivar increased in specific gravity as the season progressed. Norchip tubers were significantly higher in specific gravity at second harvest than any other cultivar. Tubers from the third harvest of irrigated plots had a higher specific gravity than those from non-irrigated plots. However, tubers from the first harvest of the nonirrigated plots were greater in specific gravity.

## Chip Color

After one and two weeks storage at 70° F. and 85 percent relative humidity, Norchip tubers produced significantly lighter chips than any other cultivar. Anoka cultivar produced significantly lighter chips than Irish Cobbler cultivar.

After one week storage, harvest dates did not significantly influence potato chip color. After two weeks storage, second harvest produced tubers significantly lighter in chip color than first or third harvests. Irrigation treatments did not influence significantly the color of chips after one and two weeks storage.

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# LITERATURE CITED


1. Appleman, C. O., and E. V. Miller. 1926.
A chemical and physical study of maturity in potatoes. U. S. Dept. Agr. Res. J. 33: 569-577.

2. Barbarin, A. L., and J. Bonner. 1948.
Experiments on sucrose formation by potato tubers as influenced by temperature. Plant Phys. 24: 720-738.

3. Blake, G. R., G. D. Grill and J. C. Campbell. 1955.
Studies on supplemental irrigation of potatoes in New Jersey. Amer. Potato J. 32: 327-331.

4. Bradley, G. A., and A. J. Pratt. 1955.
The effect of different combinations of soil moisture and nitrogen levels on early plant development and tuber set of potatoes. Amer. Potato J. 32: 254-258.

5. Bukhari, A. 1969.
Response of potato (Solanum tuberosum) cultivar to irrigation levels and harvest dates. Master's Thesis, Unpublished data, Dept. of Horticulture and Forestry, Kansas State University, Manhattan.

6. Clark, C. F. 1921.
Development of tubers in potato. U. S. Dept. Agr. Bull. 958.

7. Clegg, M. D., and H. W. Chapman. 1961.
Post harvest discoloration of chips from early summer potato. Amer. Potato J. 39: 176-184.

8. Cunningham, C. E., and F. J. Stevenson. 1963.
Inheritance of factors affecting potato chip color and their association with specific gravity. Amer. Potato J. 40: 253-265.

9. Cykler, J. F. 1946.
Effect of variation of available soil water on yield and quality of potato. Agr. Engin. 27: 363-365.

10. Denney, F. E., and N. C. Thornton. 1940.
Factors for color in the production of potato chips. Boyce Thompson Inst. Contrib. 11: 291-303.

11. Edmundson, W. C. 1940.
Potato production in the Western States. U.S.D.A. Farmers Bull. 1843, p. 27.

12. Fitzpatrick, T. J., and W. L. Porter. 1965.
Changes in the sugars and amino acids in chips made from fresh, stored and reconditioned potatoes. Amer. Potato J. 43: 238-248.

13. Fulton, J. M., and H. W. Murwin. 1955.
The relationship between available moisture levels and potato yields. Can. J. Agr. Sci. 35: 552-556.

14. Hopes, G. W., D. C. Mackey and L. R. Townsend. 1959.
The effect of harvest date and rate of nitrogen fertilization on the maturity, yield and chipping quality of potatoes. Amer. Potato J. 37: 28-33.

15. Hyde, R. B., and C. Walkof. 1962.
A potato seedlings that chips from cold storage without conditioning. Amer. Potato J. 39: 266-270.

16. Jacob, W. C., M. B. Russell, A. Klute, G. Levine and R. Grossman. 1952.
The influence of irrigation on the yield and quality of potatoes on Long Island. Amer. Potato J. 29: 292-296.

17. Jones, S. T., and W. A. Johnson. 1958.
Effect of irrigation at different minimum levels of soil moisture and of imposed droughts on yield of onions and potatoes. Proc. Amer. Soc. Hort. Sci. 71: 440-445.

18. Kehr, A. E., R. V. Akeley and G. V. C. Hougland. 1964.
Commercial potato production. U. S. Dept. Agr. Handbook No. 267.

19. Kunkel, R., J. Gregory and A. M. Binkley. 1951.
Mechanical separation of potatoes into specific gravity groups shows promise for potato chip industry. Amer. Potato J. 28: 690-696.

20. Lorenz, O. A. 1950.
Air and soil temperature in potato fields, Kern County, California during spring and early summer. Amer. Potato J. 27: 396-407.

21. Lyman, S., and A. Mackey. 1961.
Effect of specific gravity, storage and conditioning on chip color. Amer. Potato J. 37:51-57.

22. MacFarland, C. S. 1969.
Potatoes, summer and fall crops and summary. 1969 Marketing Guides - World Potato Production. Amer. Potato Yearbook, Vol. 22, pp. 71 and 74.

23. McGoldrick, F., and O. Smith. 1948.
Killing potato vines. Amer. Soc. Hort. Sci. Proc. 51:401-405.

24. Mercer, R. L., I. C. Feustal and K. P. Bemis. 1966.
Potato Processing and Utilization Committee Report.
Potato Handbook, Vol. 11, p. 50.

25. Motes, J. 1969.
Soil moisture, maturity and fertility effects on potato (Solanum tuberosum) cultivars for chipping. Ph.D. dissertation, Dept. of Horticulture and Forestry, K.S.U., Manhattan, Kansas.

26. _____, and J. K. Greig. 1969.
Effect of irrigation on soil temperature, potato yield and specific gravity during early summer. J. Amer. Soc. Hort. Sci. 94:510-511.

27. Nash, L. B. 1941.
Relation of variety and evironmental conditions to partial composition and cooking quality. Amer. Potato J. 18:91-99.

28. Patton, A. R. 1948.
Process for controlling potato chip color.
U. S. Patent 2448152.

29. Prince, A. B., and P. T. Blood. 1962.
Some effects of irrigation and fertilization on the yield and quality of Kennebec potatoes. Amer. Potato J. 39:313-319.

30. Russell, P., and R. Shaw. 1966.
Effect of temperature on invertase inhibitor and sugars on potato tubers. Plant Phys. 41:1657-1661.

31. Salankhe, D. K., E. J. Wheeler and S. T. Dexter. 1953.
The effect of various environmental factors on the suitability of potatoes for chip making. Agron. J. 46:195.

32. Shallenberger, R. S., and O. Smith. 1955.
Browning reaction in potato chips. Amer. Potato J. 32:428-430.

33. Smith, O. 1960.
Factors affecting and determining potato chip quality.
Amer. Potato J. 38:265-271.

34. _____, and L. B. Nash. 1942.
Potato quality vs. relation of time of planting, time of harvest and fertilizer treatment to composition and cooking quality. J. Amer. Soc. Agron. 34:437-451.

35. Struchtmeyer, R. A. 1961.
Efficiency in the use of water by potatoes. Amer. Potato J. 38:22-24.

36. Stewart, J. K., and H. M. Couey. 1967.
Chip color of Kennebec potatoes influenced by yield and storage temperatures. J. Amer. Soc. Hort. Sci. 92:807-813.

37. Sweetman, M. D. 1930.
Color of potato chips as influenced by storage temperatures of the tubers and other factors. U. S. Dept. Agr. J. Agr. Res. 41:479-490.

38. Talbert, W. F., and O. Smith. 1967.
Potato Processing. Avi Publishing Co., Inc., West Port, Connecticut. pp. 262-290.

39. Terman, G. L., C. E. Cunningham, M. Goven and E. Lord. 1951.
Effect of harvest dates on yield, specific gravity and quality of potatoes. Maine Agr. Exp. Sta. Bull. 491.

40. Thompson, H. C., and W. C. Kelly. 1957.
Vegetable Crops, McGraw-Hill Book Company, Inc., Fifth ed. p. 372.

41. Veenbaas, A. 1954.
Verschiller in Consumptiek Waliteit tussen-Klei-enzaarda ppelen ende oorzaken, daarvan. Gestenc. Med. Cilo. No. 2, p. 39.

42. Ware, L. M. 1943.
The value of organic matter and irrigation in the production of potatoes in Alabama. Amer. Potato J. 20:12-23.

43. Werner, H. O. 1933.
Soil management experiments with vegetables. Neb. Agr. Exp. Sta. Bull. 278.

44. Widstoe, J. A., and L. A. Merill. 1912.
The yield of crops with different qualities of irrigation water. Utah Agr. Exp. Sta. Bull. 117.

45. Yamagouchi, M., B. J. Hoyle and F. W. Zink. 1959.
Effect of certain areas of production and storage on chipping quality, chemical compositions and specific gravity of California potatoes. Proc. Amer. Soc. Hort. Sci. 74:649-659.

# EVALUATION OF POTATO (*Solanum tuberosum*) CULTIVARS FOR YIELD AND CHIP COLOR BY HARVEST AND STORAGE DATES

by

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B. S. Cairo University, 1965

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AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

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MASTER OF SCIENCE

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1970

A factorial study was conducted in 1969 to examine the response of Anoka, Kennebec, Irish Cobbler and Norchip cultivars to various soil moisture treatments and different harvest and storage dates. Uniform seed pieces were planted April 1, 1969, on a Sarpy fine sandy loam soil. The soil moisture block was irrigated when the average 6 and 12-inch soil moisture tension readings were 0.30 atmosphere.

A completely randomized design was used. Twenty-four plots were harvested at 10 day intervals: July 11, 22, and August 6. Fresh and dry weights of vines from ten plants were recorded for each plot. Total weight and weight of U. S. No. 1 size tubers were recorded. Specific gravity of tubers was determined by the weight in air-weight in water method. Chip color was determined from tubers after one and two weeks storage at 70° F. and 85 percent relative humidity.

The result of this study revealed that total weight of tubers, U. S. No. 1 size tubers, vine dry weight and chip color, after two weeks storage were the factors influenced by the date of harvest. Total weight of tubers and U. S. No. 1 size tuber weight increased to a maximum at harvest 3 (last harvest) of the irrigated plots. Vine dry weight increased at second harvest then declined at third harvest of the nonirrigated plots. Greater vine dry weight was produced from irrigated than from nonirrigated plots.

Specific gravity was highest under the nonirrigated plots at the first harvest and then decreased as the tubers matured. The third harvest of irrigated plots produced significantly greater weight of U. S. No. 1 tubers and total weight of tubers than first and second harvests. Supplemental irrigation did not influence chip color of tubers after being stored one and two weeks.

It was concluded that the response of potatoes to various soil moisture levels and the influence of harvest dates differ among cultivars. Kennebec, Irish Cobbler and Norchip cultivars produced the greatest total weight of tubers and U. S. No. 1 tuber weight and Anoka produced the least. The highest specific gravity was produced by Norchip cultivar, and Kennebec cultivar had the lowest. Norchip cultivar produced lighter colored chips (after one and two weeks storage). Specific gravity did not appear to be correlated with chip color.