EFFECT OF PLANTING DATES ON YIELD, INTERNAL BROWN SPOT AND OTHER CHARACTERISTICS IN POTATOES

by

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A Thesis Submitted to the Faculty

of Agricultural Sciences in Partial Fulfillment of

The Requirements for the Degree of

MASTER OF SCIENCE IN AGRICULTURE

Major: Horticulture - Agronomy

Minor: Soil Science

Approved:

In Charge of Major Work

Chairman, Graduate Committee

American University of Beirut

1963

CULTURAL STUDIES IN POTATOES

CHAUDHRY

ACKNOWLEDGEMENTS

The writer wishes to express his sincere gratitude to Dr. K.W. Hanson for suggesting the topic and for his invaluable advice in carrying out the work.

My sincerest thanks are due to Dr. Wallace W. Worzella for his advice, help and valuable suggestions in correcting the manuscript.

Thanks are extended to Mr. Fouad M. Malouf for his assistance in field work and to Miss Sira Guvlakdjian for typing the manuscript of this thesis.

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ABSTRACT

A study was conducted during the year 1962 at the University Farm in Lebanon to determine the effect of four planting dates, using four varieties, on the germination, plant height, flowering, yield and occurrence of internal brown spot in potato tubers.

The June planting gave the lowest germination. The flowering and the plant height for the March planting were significantly less as compared with later planting-dates. The maximum flowering was observed in the variety Arran Banner. Variety Climax produced maximum number of large tubers. The crop planted in June gave significantly lower yields of marketable tubers than that obtained from the earlier plantings.

The varieties Bintje and Climax were found to be completely resistant to internal brown spot. The intensity of internal brown spot in the varieties Arran Banner and Asoka decreased as the planting was delayed. Large potato tubers showed greater infestation by the internal brown spot disease than did the small tubers.

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INTRODUCTION

Potatoes (Solanum tuberosum) are one of the major food crops of the world. They produce more food per unit area than is obtained from the cereal crops. Therefore, by producing potatoes a greater number of people can be fed in overpopulated areas under conditions of food scarcity.

Potatoes are utilized in various ways such as for culinary purposes, starch, potato chips, dehydrated potatoes and canned potatoes.

Potato cultivation under good management results in very large monetary returns. Some 24.8 million hectares of potatoes are planted throughout the world, with an annual production of 276 million metric tons (5).

In Lebanon an area of some 5000 hectares is planted to potatoes which produce about 45000 metric tons of tubers annually (5). Potatoes rank first in area and production among the vegetable crops in Lebanon. According to Mankush (25), the potato area is distributed in three regions in Lebanon. About 70 percent of the crop is produced in the Beqa'a plain and the rest, 30 percent, is grown in the coastal plains and the mountain regions.

The potato crop in the Beqa'a plain is planted from

February to the end of June. Harvesting is usually completed by the end of October. Arran Banner and Up-To-Date are the commercial varieties generally planted by the growers. Early plantings of Arran Banner are severely affected by internal brown spot disease, which ruins the crop as far as the consumptive value of tubers is concerned. In most cases, the affected tubers show no external symptoms of the disease. Upon cutting a tuber one can see the isolated and brownish areas spread over the cut surface.

The term, internal brown spot, has a wide variety of synonyms throughout the world. In Lebanon the term "internal brown spot" or"chocolate spot" is used. The terms "sprain", "Streak" and"necrosis"have also been used (7,23,24). The disease is considered to be physiological in origin. Numerous workers (2,14,17,31) have presented evidence that physiological responses to weather and cultural practices may strongly influence both varietal susceptibility and the pattern of injury which develops.

The present studies were conducted during the year 1962 at the University Farm. The purpose of the trials was to determine the effects of time of planting on speed of germination, plant height, flowering, yield and the occurrence of internal brown spot in susceptible and resistant varieties. Two promising internal brown spot resistant varieties, viz., Bintje and Climax, with two susceptible varieties, viz., Arran Banner and Asoka, were used.

REVIEW OF LITERATURE

The effect of temperature, length of day and planting-date on speed of germination, plant height, flowering and yield in potatoes.

Climate plays an important role in potato production. Potatoes thrive best under cool climatic conditions but are sensitive to frost. The yield of potato tubers is greatly influenced by the temperature during the growing season. The optimum temperature for maximum yield is between 60 and 65°F (28). Richards (27) found that the young sprouts made the most rapid development at a constant temperature of about 75°F but later growth was best at approximately 64°F. Bushnell (9) found a decrease in tuber production at a constant temperature above 68°F and complete inhibition at 84°F.

Werner (30) reported that a long day, high temperature and abundant external supply of nitrogen favor vegetative growth in all plant parts except tubers. Short days, low temperature and deficiency of nitrogen induce early tuberization. Days of intermediate length, low temperature and abundant supply of nitrogen, bring about maximum tuberization. Tubers are formed only when the carbohydrate content of the tops exceeds a certain level (21). An increase in the rate of respiration in the above ground parts of the plant, without a corresponding increase in photosynthesis results in a decrease

in the carbohydrate content and retardation of tuber growth. Boswell and Jones (8) reported a remarkable response of potato plant to length of day light. Other growth factors being favorable they found anincrease in aerial stem elongation with the increase in photoperiod.

Went (29) found that tuber production occurs with 12°C optimal night temperature. At high temperatures tuber formation is only possible with short days, whereas at lower temperatures tubers can be formed both in long and short days. Driver and Hawkes (11) found that short days (8 hours of light) with low night temperature gave good yield, while in long days (16 hours of light) with high night temperature, no tubers are formed. They concluded that the tuber formation in the potato can be controlled at will by the appropriate combination of light and temperature conditions. Gregory (18) grew one series of potato plants under tuber inductive conditions (20°C for 8 hours of day light followed by a dark period at 14°C for 16 hours.) and an other series under non-inductive conditions (26°C for 8 hours of day light followed by 8 hours of artificial light at 20°C and 8 hours of darkness at 20°C). Eighty four days after planting he observed that the plants under tuber inductive environments contained numerous underground tubers, while those grown under non-inductive conditions had none.

Grosch (19) conducted some pot experiments to study

the effects of date of planting (from March to June) and different rates of nitrogen application (One gram and three grams of N per pot) on tuber formation. He found that the short day effect at the time of emergence, produced by early planting, resulted in early tuber formation and rapid tuber development, while the top, remained short and died relatively early. The long day effect at the time of emergence, produced by late planting, resulted in tall branched tops. The tops of these plants continued assimilation over a longer period than those which emerged during short days. Consequently, they produced a tuber yield as high or even higher than those planted in March. In the plants which emerged in short days, nitrogen was used more for tuber development and in the long day plants it was used mostly for the tops.

Akely, Stevenson and Merriam (4) compared eight varieties and four dates of planting for three years in Maine and found that there was no significant difference between the three year means for the eight varieties planted on May 5 and May 15. However, the differences between the yield for these two dates of planting and the two later dates were highly significant. The highest yield occurred for the earliest date of planting and the yields decreased with delay in planting. They recommended that potatoes grown in northern Maine should be planted as early as possible to get the maximum yields.

Dyke (12) conducted a survey in England and Wales to ascertain the effects of planting date on the yield of

tubers. He found that the yields are decreased by delay in planting after April 11 at the rate of about 0.4 ton per acre per week. He also found that effects of dung, nitrogen and potash fell sharply when the planting was delayed from early to late April. He concluded that overall loss of yield in England and Wales due to delay in planting was approximately five percent.

Cunningham, Murphy, Goven and Akely (10) planted two varieties on four dates, viz., May 5, May 15, May 25, and June 4. They found that the delay in planting from May 5 to June 4 decreased the yield of Kennebec by 191 bushels per acre. However, the delay in the planting of the variety Kennebec from May 5 to May 15 decreased the yield of tubers only four bushels as compared with a 76 bushels decrease for the variety Katahdin during the same period. They have attributed the wide difference in yield between the Katahdin and Kennebec varieties to the shorter growing season required by the Kennebec variety to reach its maximum yield level. They also concluded that the early planting was more desirable particularly with late maturing varieties.

Hanson (21) conducted an experiment to find out the effects of planting and harvesting dates on potato yield in North Dakota. He found that the earliest planting made on May 1 and harvested on October 1 produced the highest yield. Khan (22) conducted some experiments in West Pakistan to find

out the best time of sowing. He found that early sowing gave significantly higher yield than late sowing and the yields decreased as the sowings were delayed.

Bosewell and Jones (8) have shown that long day (16 or 17 hours) accompanied by cool temperature and high relative humidity is desirable for flowering and seed set in potatoes.

The effect of climatic conditions, planting dates and varieties on the occurrence of internal brown spot in potatoes.

According to Atanasoff (7) the first report of brown spot in the literature seems to have been made by Horne in 1910. Horne distinguished two forms of this disease viz., "Internal disease" and "Sprain" or "streak" disease. Atanasoff (7) did not consider internal brown spot as a physiological disease. He reported that lack of moisture cannot be the cause of this disease, but sufficient moisture seems to be pre-requisite for the development of this disease in severe form. He found that this disease is not transmitted to fresh and healthy tubers by grafting portions of diseased tubers on them. He concluded that the cause of the disease is an organism which enters the tuber without bringing about distinct pathological changes at the point of entrance.

Larson and Albert (23) described internal browning and stated that it is more prevalent in Wisconsin on sandy

gravelly soils during seasons in which temperatures are above normal and precipitation below normal. They started harvesting tubers, 73 days after planting, at weekly intervals and noticed a considerable increase in the amount and severity of necrosis in the tubers as the season advanced. They found that in general the small sized tubers (1 7/8") showed considerably less necrosis than tubers of U.S. No. 1 size. They stored the harvested tubers at 40°F for eight months and found no increase in the amount or severity of internal necrosis during the period of storage. In another experiment, they found that the tubers with two inches or more of soil cover were much less affected than those lightly covered. They also compared mulching treatments to create soil temperature differences around the growing tubers. They found that two inches of rye straw mulch consistently reduced internal tuber necrosis. They tried different macro and micro elements like lime, sulfur, salts of boron, copper, iron, magnesium, manganese and zinc alone or incorporated in the complete fertilizers and found no reduction in the incidence of disease with these treatments.

Larson and Albert (24) tested American and British varieties from 1944 to 1949 and found that the differences in varietal susceptibility to internal tuber necrosis in the British varieties were as great as those found in the American varieties.

Friedman (16) observed that the number of potato

tubers affected and the severity of internal brown spot increased with the increase in tuber size. He observed no change during storage in the number of tubers having internal brown spot or in the severity of the disorder.

Edmundson, Schaal and Landis (13) described this disease as dry brown spots scattered through the flesh of the tuber. These spots are dead cells, free from bacteria and fungi. They found no definite foliage symptoms associated with this disease. They recommended that tubers affected with internal brown spot should not be used for seed as they do not produce strong plants.

Ellison and Jacob (15) conducted a factorial experiment involving varieties, planting dates, vine killing treatments, harvest dates, irrigation and storage after harvest. They found that planting in May 1948 and in April and early May in 1949 resulted in more brown spots in the tubers as compared with the later dates of planting. The general level of internal browning decreased during storage in both years, but this was influenced by cultural practices.

Ellison (14) tested 36 varieties of potato for four years and concluded that varieties fell into three general groups viz., (1) those which were consistently resistant to internal browning (2) those which were consistently susceptible and (3) those which varied greatly from year to year. He emphasized the importance of testing varieties for several years before drawing any conclusions.

Friedman (17) reported the prevalence of internal brown spot in Long Island and New Jersey grown potato tubers during the growing seasons of 1948, 1949 and 1953 and its absence during 1950, 1951 and 1952. The prevalence of internal brown spot during the years 1948, 1949 and 1953 was associated with the occurrence of a heat wave followed by only a little rainfall. There was no heat wave in 1950 and 1951, but in 1952 a heat wave was followed by a considerable rainfall.

Wolcott and Ellis (31) compared 20 potato varieties using different cultural practices. They correlated variations in internal browning with variations in growth and tuberization phenomena which is influenced by photo-period and temperature. Internal browning was found to develop under conditions of fluctuating vine and tuber growth that are known to give rise to resorption of stored material from the tubers. During the years 1953 and 1954, symptoms identical with or closely resembling two or more of four types of browning (internal brown spot, corky ring spot, canker type and rust spot) were frequently found together in lots of potatoes and individual hills. From these observations they concluded that all these types are related in origin but differ in pattern, as a result of the different physiological age of tuber tissues at the time when injury occurs.

Ahmadi, Mobarak and Osgothorpe (3), and Hanson, Saad and Daouk (20) conducted experiments in Lebanon to study the effects of planting time on the occurrence of internal brown

spot in the potato variety, Arran Banner. They concluded that the intensity of internal brown spot in harvested tubers decreased with delay in planting date. They recommended the planting of resistant varieties for early plantings.

Potato varieties introduced from U.S.A., Ireland and Holland were tested at the University farm Lebanon during 1957-58 by Ahmadi (2). He recommended the varieties Bintje and Climax on the basis of yield, cooking quality and freedom from internal brown spot.

MATERIALS AND METHODS

The studies were conducted at the University Farm during the year 1962. The soil on which the experiment was conducted is a clay type, calcareous, low in organic matter and available phosphorus and with a pH of about 8.0.

A fertilizer consisting of 12 Kg. of nitrogen in ammonium sulfo nitrate and 24 kg. of P_2O5 in superphosphate was applied per dunum by a Gandy spreader during November 1961. A good seed bed was prepared during March 1962 when the soil was in the proper moisture conditions.

Four varieties, i.e., two internal brown spot susceptible viz., Arran Banner and Asoka and two resistant varieties viz., Bintje and Climax were planted. The planting was done on four dates starting from the March 15 and ending on June 7 at four week intervals.

A four by four latin square was used as the experimental design. Dates of planting and replications were put in main plots and varieties were randomized in the subplots. A single subplot consisted of four rows, each five meters long and 0.75 meter apart. Seventeen tubers, spaced 30 cm. apart, were planted per row. The tubers were covered with 12 to 15 cm. of earth after planting. The seed pieces ranged in weight from 40 to 50 grams.

Standard cultural practices for the area were followed. The earthing-up was done on the completion of germination. The crop was irrigated every week during the growing season. Sprinkler system of irrigation was used until the middle of June and furrow irrigation was used during the latter part of the season. The crop was regularly sprayed at 3 week intervals against the attack of the potato tuber moth.

Meteorological data, regarding average monthly air and soil temperature and rainfall for the 1962 growing season of the potato crop at the University farm are given in Table I. (1).

Table 1. Average monthly air and soil temperature in degrees C and rainfall in m.m. at the University farm from March to September 1962.

	March	April	May	June	July	August	Sept.
(a) Air Temperature							
Mean Maximum	17.67	18.50	25.70	30.90	32.50	34.00	31.43
Mean Minimum	4.03	4.10	8.40	11.80	13.20	15.10	11.78
(b) Soil Temperature							
Sod 10 cm. deep	11.69	15.4	20.8	23.6	23.1	24.0	22.54
Bare earth 10 cm. deep	13.24	16.8	22.5	25.2	23.3	26.0	25.05
(c) Rainfall	10.50	43.3	3.7	--	--	--	--
(d) Relative Humidity %							
Mean Maximum	92.32	97.00	89.20	74.00	74.00	75.30	77.16
Mean Minimum	34.52	39.00	31.00	32.00	29.00	20.80	25.63

Germination data were collected at four day intervals for the first three plantings and at weekly intervals for the last planting to determine the speed of germination. Six plants were selected at random from the central two rows in each treatment for collecting data regarding plant height. Data regarding intensity of flowering were also recorded.

Marginal drying of leaves and appearance of black spots on them started in beginning of June in the varieties Climax and Asoka in March planting. Diseased leaves were sent to the plant pathologist for diagnosis and advice. It was reported that the black spots were not a pathological disease but a "natural dieback". Similar symptoms were noticed in the later plantings on these varieties.

The plants were allowed to grow until maturity. Harvesting was done on July 28, August 25, September 8 and 29, 1962. Four meters from the central two rows was harvested from each plot. The tubers were graded into 3 sizes viz., large (larger than 7 cm), medium (4-7 cm) and small (smaller than 4 cm). The number of tubers in each grade were counted and weighed.

Random samples, comprising of 30 tubers i.e. 10 tubers from each grade, were taken for determining the intensity of internal brown spot. The tubers were sliced into quarters longitudinally and all eight surfaces were examined carefully. Any discoloration which could be identified as internal brown spot was recorded. The results were compiled and analysed according to the method of analysis of variance (26). Comparisons of the varieties and dates of planting were made on the basis of the critical difference.

RESULTS AND DISCUSSION

An experiment was conducted during the year 1962 at the University farm to determine the effect of planting dates on four potato varieties as regards germination, plant height, number of flowers, yield of tubers and the occurrence of internal brown spot in the tubers. The results are presented in Tables 2 to 10. The analysis of variance for each character studied is given in Appendix. The results regarding the number and yield of large tubers and marketable tubers are discussed separatly. Marketable tubers include both large (7 cm. and above) and medium (4 to 7 cm.) tubers.

Germination.

Potato varieties planted in March, April and May do not differ significantly in germination as is shown in Table 2. In the June planting the variety Arran Banner has given significantly better germination than the other three varieties. The low germination in the varieties Asoka, Bintje and Climax for June planting can be attributed to the loss of viability in the tubers due to the sprouting in storage. The seed tubers were stored at room termperature during the year 1962. It was observed that the speed of germination was slow in the March and April plantings as compared with the crop planted in May and June. The slow rate of germination can be attributed to low soil temperature during that period. In the March and April plantings, the varieties Arran Banner and

Table 2. Effect of planting date and variety on germination percentage in potatoes during 1962 at the University farm.

Varieties	Date of Planting				Mean
	March 15	April 12	May 10	June 7	
Arran Banner	92.0	97.8	84.6	88.2	90.6
Asoka	95.6	95.6	90.4	66.2	86.9
Bintje	99.3	99.3	81.6	71.3	87.9
Climax	100.0	97.0	82.3	65.4	86.2
L.S.D at 5%	N.S	N.S	N.S	9.4	

Asoka were slow to germinate as compared with the varieties Bintje and Climax. In the May and June plantings there was not much difference in the speed of germination of the four varieties studied. Different requirement for the rest period in the different varieties may account for the differences in the speed of germination in the earlier plantings.

Plant Height.

Different planting dates had a significant effect on the plant height in potatoes. The crop planted on March 15 produced significantly shorter plants as compared with later plantings as is shown in Table 3. The smaller plants obtained from the earliest planting can be attributed to the short days and the low temperature during the development period of the crop. Under such conditions, tuberization starts early and plant growth is checked. Similar results were obtained by Grosch (19). He found that the short day effect at the time of emergence, produced by early planting, resulted in early tuber formation and rapid tuber development, while the top remained short and died relatively early. The results are also in agreement with those obtained by Werner (30), who found that a long day, high temperature and an abundant supply of nitrogen favor vegetative growth in all plant parts except the tubers.

Verieties also differ in their plant height. The variety Arran Banner produced significantly taller plants

Table 3. Effect of planting date and variety on plant height in cms. in potatoes during 1962 at the University farm.

Varieties	Date of planting				
	March 15	April 12	May 10	June 7	Mean
Arran Banner	44.1	59.9	62.4	57.9	56.1
Asoka	22.4	38.1	41.2	42.6	36.1
Bintje	34.7	54.9	60.4	56.2	51.4
Climax	20.6	39.6	42.9	47.2	37.6
Mean	30.5	48.1	51.7	51.0	

	L.S.D. (5%)	L.S.D. (1%)
Plantings	3.5	5.3
Varieties	1.6	2.2

Date of planting	May 10	June 7	April 12	March 15
Mean of planting	*51.7	51.0	48.1	30.5

Varieties	Arran Banner	Bintje	Climax	Asoka
Mean of varieties	56.1	51.4	*37.6	36.1

* Treatment means underlined by the same line do not differ significantly at the 5 percent level.

than the other three varieties. Asoka and Climax, produced the shortest plants, and Bintje intermediate with an average of 51.4 cms. in height. Short plants are usually associated with early maturing varieties (6). Tuber formation starts early in early maturing varieties with the result that the top growth is checked and the plants remain short.

Flowering.

Flowering in potatoes has been greatly influenced by different planting dates as can be seen from Table 4.. The plantings made in March produced significantly less flowers as compared with the other three dates of planting. The crop planted in May produced 68.2 percent, while that planted in March developed only 24.3 percent flowers. Different lengths of photoperiods, to which the different plantings were exposed during the growing period, can account for the differences in flowering. The long day (16 or 17 hours) is desirable for flowering in potatoes (8). The low intensity of flowering in the March planting was due to the short length of photoperiod during flowering time. In the May planting the days were the longest during flowering time, which resulted in maximum flowering.

Varieties also differ significantly from one another in flowering. Maximum flowering was observed in the variety Arran Banner, in which 85.0 percent of the plants produced flowers. Minimum flowering took place in variety Asoka where

Table 4. Effect of planting date and variety on percentage flowering in potatoes during 1962 at the University farm.

Varieties	Date of planting				Mean
	March 15	April 12	May 10	June 7	
Arran Banner	89.8	91.8	88.0	70.8	85.0
Asoka	0.0	44.0	32.5	37.0	28.4
Bintje	7.5	64.0	93.0	69.0	58.3
Climax	0.0	35.2	59.5	48.2	35.7
Mean	24.3	58.7	68.2	56.2	

	L.S.D. (5%)	L.S.D. (1%)
Plantings	9.7	14.8
Varieties	5.9	8.1

Varieties	Arran Banner	Bintje	Climax	Asoka
Mean of varieties	85.0	58.3	35.7	28.4
Plantings	May 10	April 12	June 7	March 15
Mean of plantings	*68.2	58.7	56.2	24.3

* Treatment means underlined by the same line do not differ significantly at the 5 per cent level.

only 28.4 percent of the plants produced flowers. The varietal difference in flowering is a genetic character which is influenced to some extent with the climatic conditions and the fertility status of the soils. No flowers were produced by the varieties Asoka and Climax when planted in March. In Bintje, the flowering was observed only on the more vigorous border plants, where the soil was more fertile. Arran Banner flowered very early with an average of 89.8 percent for March planting.

Number of Large Tubers.

The dates of planting had little influence on the total number of large tubers per dunum as is shown in Table 5.

The four varieties differed significantly in the number of large tubers that each produced per dunum. The variety Climax produced the maximum number of large tubers, while Arran Banner produced the smallest number. The variety Arran Banner has a tendency to set a greater number of tubers. This creates competition for storage of food material with the result that most of the tubers can not attain a large size. The varieties Claimax and Asoka have a tendency to set fewer tubers with the result that more food is stored in each developed tuber.

Number of Marketable Tubers.

The mean number of marketable tubers per dunum is given in Table 6. The planting dates had a significant effect on the number of marketable tubers that are developed. The March

Table 5. Effect of planting date and variety on the number of large tubers per dunum in potatoes during 1962 at the University farm.

Varieties	Date of planting				Mean
	March 15	April 12	May 10	June 7	
Arran Banner	4958	3458	4833	2750	4000
Asoka	8000	9167	7292	6542	7750
Bintje	5125	5625	9625	6000	6594
Climax	9000	11583	7375	7750	8927
Mean	6771	7458	7281	5760	

	L.S.D. (5%)	L.S.D. (1%)
Plantings	Non Significant	
Varieties	882	1212

Varieties	Climax	Asoka	Bintje	Arran Banner
Mean of Varieties	8927	7750	6594	4000

Table 6. Effect of planting date and variety on the number of marketable tubers per dunum in potatoes during 1962 at the University farm.

Varieties	Date of planting				
	March 15	April 12	May 10	June 7	Mean
Arran Banner	30750	43583	22708	19333	29094
Asoka	27541	31542	26417	13083	24646
Bintje	39458	44583	25042	15375	30562
Climax	23500	26208	21625	16583	21979
Mean	32812	36479	23948	16094	

	L.S.D. (5%)	L.S.D. (1%)
Plantings	6980	10570
Varieties	2940	4045

Plantings	April 12	March 15	May 10	June 7
Mean of Plantings	* 36479	32812	23948	16094

Varieties	Bintje	Arran Banner	Asoka	Climax
Mean of Varieties	*30562	29094	24646	21979

* Treatment means underlined by the same line do not differ significantly at the 5 per-cent level.

and April plantings produced the greatest number of marketable tubers with an average of 32812 and 36479 per dunum, respectively. The planting made in June produced the least number of marketable tubers, or only 16094 per dunum.

The varieties Bintje and Arran Banner produced the greatest number of marketable tubers as compared with the varieties Asoka and Climax.

Yield of Large Tubers.

The yield of large tubers per dunum was not influenced by the different planting dates as is shown in Table 7.

The four varieties differe significantly for the yield of large tubers that each produced per dunum. The variety Climax produced the highest yield of large tubers when compared with other three varieties. The mean yield of variety Climax was 1279.0 Kg. per dunum, as compared with the variety Arran Banner which produced only 658.0 Kg. per dunum. Total tuber setting was low in the varieties Climax and Asoka as compared with Arran Banner and Bintje. This made more food material available for storage per tuber, with the result that a greater number of tubers attain a large size and the yield of large tubers is increased.

Yield of Marketable Tubers.

The mean yield of marketable tubers in Kg. per dunum is given in Table 8. The planting dates had a significant effect on the yield of marketable tubers. The highest yield

Table 7. Effect of planting date and variety on the yield of large tubers in Kg per dunam of potatoes during 1962 at the University farm.

Varieties	Date of planting				
	March 15	April 12	May 10	June 7	Mean
Arran Banner	798.8	485.0	921.7	426.7	658.0
Asoka	842.1	1185.0	1029.2	1070.0	1031.5
Bintje	561.2	658.3	1258.8	788.7	816.8
Climax	1157.9	1744.2	1150.0	1064.2	1279.0
Mean	840.0	1018.1	1089.9	837.4	

	L.S.D. (5%)	L.S.D. (1%)
Plantings	N.S.	N.S.
Varieties	127.3	174.5

Varieties	Climax	Asoka	Bintje	Arran Banner
Mean of varieties	1279.0	1031.5	816.8	658.0

Table 8. Effect of planting date and variety on the yield of marketable tubers in kgs. per dunum of potatoes during 1962 at the University farm.

Varieties	Date of planting				
	March 15b	April 12	May 10	June 7	Mean
Arran Banner	2501.2	2635.8	2257.9	1510.4	2226.3
Asoka	1856.7	2462.9	2238.7	1443.8	2000.5
Bintje	2214.2	2580.0	2180.0	1266.7	2060.2
Climax	2050.0	2714.6	2192.1	1562.1	2129.7
Mean	2155.5	2598.3	2217.2	1445.7	

	L.S.D. (5%)	L.S.D. (1%)
plantings	497.3	753.0
Varieties	N.S	N.S

Plantings April 12 May 10 March 15 June 7

Mean of plantings* 2598.3 2217.2 2155.5 1445.7

* Treatment means underlined by the same line do not differ significantly at the 5 per cent level.

of marketable tubers was obtained from plantings made in March, April and May with mean yield of 2155.5, 2598.3 and 2217.2 kg. per dunum, respectively. The crop planted in June gave significantly lower yield as compared with that obtained from the earlier plantings. The low yield obtained from the last planting can be attributed to the high temperature prevailing during the tuber setting period. The high temperature increased the rate of respiration in the above ground parts of the potato plants, without a corresponding increase in photosynthesis. This resulted in decreased carbohydrate content for storage in the tubers. The poorer germination in the last planting resulted in fewer plants which was also partly responsible for the lower yield. The results are in agreement with the results obtained by Cunningham, Murphy, Goven and Akely (10) and Hanson (21). They found that early plantings gave higher yield than late plantings and the yields decreased as the plantings were delayed.

The four varieties did not differ significantly in the yield of marketable tubers.

Internal Brown Spot.

After each harvest large, medium and small tubers were sliced for internal brown spot observations. The varieties Bintje and Climax were found to be completely resistant to internal brown spot, therefore, only the results of the susceptible varieties Arran Banner and Asoka are discussed.

The occurrence of internal brown spot in potatoes is greatly influenced by the planting dates as is shown in Table 9. Tubers from the June planting showed a low susceptibility to internal brown spot as compared with the earlier plantings. The mean intensity of internal brown spot was 63.2 percent for the March planting and it decreased to 31.5 per cent as the planting was delayed to June. The decrease in internal brown spot with delay in planting can be attributed to comparatively lower temperature during the maturing stages of the June plantings as compared with the earlier plantings. The data obtained agree with the results reported by Ellison and Jacob (15) and Ahmadi, Mobarak and Osgothorpe (3). They found that the intensity of internal brown spot decreased with the delay in planting. Arran Banner and Asoka were found to be equally susceptible to the incidence of internal brown spot.

The size of tubers had a great effect on the occurrence of internal brown spot in potatoes as can be seen from Table 10. Large tubers are more affected with internal brown spot as compared with small tubers. The mean incidence of internal brown spot in large, medium and small tubers was 74.2, 59.4 and 17.0 per cent, respectively. The occurrence of internal brown spot usually takes place in the maturing stages of the tuber development. The small tubers are physiologically immature at harvest time and consequently they are less

Table 9. Effect of planting date and variety on percentage incidence of internal brown spot in potatoes during 1962 at the University farm.

Varieties	Date of planting				Mean
	March 15	April 12	May 10	June 7	
Arran Banner	70.8	60.8	53.3	20.7	51.4
Asoka	55.5	49.1	47.5	42.4	48.6
Mean	63.2	54.9	50.4	31.5	

	L.S.D. (5%)	L.S.D. (1%)
Plantings	22.18	33.50
Varieties	N.S	N.S

Plantings	March 15	April 12	May 10	June 7
Mean of plantings *	63.2	54.9	50.4	31.5

* Treatment means underlined by the same line do not differ significantly at the 5 per cent level.

Table 10. Effect of tuber size and variety on percentage incidence of internal brown spot in potatoes during 1962 at the University farm.

Varieties	Size of tubers			Mean
	Large	Medium	Small	
Arran Banner	76.2	58.5	20.9	51.4
Asoka	72.2	60.4	13.1	48.6
Mean	74.2	59.4	17.0	

	L.S.D. (5%)	L.S.D. (1%)
Size of tuber	10.56	14.82
Variety	N.S	N.S

Size of tuber	Large	Medium	Small
Mean	74.2	59.4	17.0

susceptible to internal brown spot. These findings are in agreement with the results obtained by Friedman (16). He observed that the number of potato tubers, affected with internal brown spot, increased with the increase in tuber size. Larson and Albert (23) also found that in general the small tubers showed considerable less necrosis than tubers of U.S. No. 1 size.

SUMMARY AND CONCLUSIONS

The study was conducted during the year 1962 at the University Farm to determine the effect of four planting dates on the germination, plant height, flowering, number and yield of potato tubers and the occurrence of internal brown spot in the tubers of potatoes. The dates of planting were March 15, April 12, May 10 and June 7. The varieties Arran Banner, Asoka, Bintje and climax were used.

The potato varieties planted in March, April and May did not differ in germination, but in the June planting the variety Arran Banner gave significantly better germination than the other three varieties. The June planting gave the lowest germination.

The plant height for the March planting was significantly less as compared with later planting dates. The variety Arran Banner produced the tallest plants, while the varieties Asoka and Climax produced the shortest plants.

The flowering was less intense in the March planting as compared with the other three dates of planting. Maximum flowering was observed in the variety Arran Banner and the minimum flowering was observed in the variety Asoka.

No significant difference was found in the number of large tubers due to planting dates. Climax produced the

maximum number of large tubers, while the variety Arran Banner produced the minimum number of large tubers.

The March and April plantings produced the greatest number of marketable tubers. Bintje and Arran Banner produced a greater number of marketable tubers than the varieties Asoka and Climax.

The yield of large tubers per dunum was not influenced by the different planting dates. The planting dates had a significant effect on the yield of marketable tubers. The crop planted in June gave significantly lower yield as compared with that obtained from the earlier plantings. The variety Climax produced the highest yield of large tubers when compared with other three. However, the four varieties did not differ significantly in the yield of marketable tubers.

Tubers from the June planting showed a lower susceptibility to internal brown spot as compared with the earlier plantings. The varieties Bintje and Climax were found to be completely resistant to internal brown spot. A greater number of large potato tubers were affected with internal brown spot than the small tubers.

The results of the experiment indicate that the most practical method for preventing serious losses from internal brown spot is to use resistant varieties like

Bintje and Climax. The planting should be done as early in spring as the soil and weather conditions permit. The early planted crop can be harvested by the end of July and the land can be utilized for raising some other vegetable crop provided irrigation water is available during that period.

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APPENDIX

Table 11. Analysis of variance for percentage germination in potatoes

Source	D.F.	M.S. March 15	April 12	May 10	June 7
Replications	3	15.1	3.8	66.8	179.7*
Varieties	3	52.1	7.8	66.8	458.2**
Error	9	16.5	2.4	49.2	34.7

Table 12. Analysis of variance for plant height in potatoes

Source	D.F.	M.S.
Plantings	3	1607.30**
Rows	3	12.40
Columns	3	35.93
Error(a)	6	16.11
Varieties	3	1593.90**
Varieties x Plantings	9	27.33**
Varieties x Rows	9	4.88
Varieties x Columns	9	12.29
Error(b)	18	4.85

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* denotes F values significant at the 5% level.

** denote F values significant at the 1% level.

Table 13. Analysis of variance for flowering in potatoes.

Source	D.F.	M.S.
Plantings	3	274.7
Rows	3	236.0
Columns	3	5820.5**
Error(a)	6	127.2
Varieties	3	104233.0**
Varieties x Plantings	9	1318.1**
Varieties x Rows	9	109.3
Varieties x Columns	9	35.7
Error(b)	18	62.5

** denote F values significant at the 1% level.

Table 14. Analysis of variance for number of potato tubers per dunum.

Source	D.F.	M.S.(large tubers)	M.S. (Marketable tubers)
Plantings	3	335.1	43919.7**
Rows	3	82.7	1370.3
Columns	3	970.3*	367.3
Error(a)	6	193.7	2345.7
Varieties	3	2555.2**	9917.7**
Varieties x Plantings	9	379.5**	3385.3**
Varieties x Rows	9	32.7	473.4
Varieties x Columns	9	143.6*	124.3
Error(b)	18	50.9	565.7

* denotes F values significant at the 5% level.

** denote F values significant at the 1% level.

Table 15. Analysis of variance for yield of potato tubers per dunum.

Source	D.F.	M.S.(Large tubers)	M.S.(Marketable tubers)
Plantings	3	9.40	133.09**
Rows	3	2.81	5.10
Columns	3	19.72*	13.81
Error(a)	6	2.53	11.91
Varieties	3	41.83**	5.43
Varieties x Plantings	9	9.89**	3.17
Varieties x Rows	9	2.16	4.31
Varieties x Columns	9	3.06*	2.75
Error(b)	18	1.07	2.27

* denotes F values significant at the 5% level.

** denote F values significant at the 1% level.

Table 16. Analysis of variance for percentage internal brown spot in potatoes.

Source	D.F.	M.S.
Replication	3	44.8
Plantings	3	461.4*
Error(a)	6	54.7
Varieties	1	27.2
Varieties x Plantings	3	269.1**
Error(b)	12	11.9

Table 17. Analysis of variance for percentage internal brown spot in potatoes.

Source	D.F.	M.S.
Replication	3	37.1
Variety	1	45.7
Error(a)	3	15.2
Sizes	2	2601.1*
Variety x size	2	40.4
Error(b)	12	7.8

* denotes F values significant at the 5% level.

** denote F values significant at the 1% level.