THE EFFECT OF PLANTING DATE, FERTILIZER RATE, AND HARVEST DATE ON THE YIELD, CULINARY QUALITY AND PROCESSING QUALITY OF RUSSET BURBANK POTATOES IN THE COLUMBIA BASIN OF WASHINGTON

R. Kunkel

The State of Washington ranks 4th as a potato producer. High acre yields in the Columbia Basin are responsible for the large production. Not only are the acre yields the highest in the nation, but the dry matter content of the potatoes is also among the highest produced anywhere. If this situation can be maintained, Washington, over the long pull, should remain in a competitive position in both the fresh market and in the processing industry.

Potatoes are planted continuously from about mid March until June, and harvested almost continuously from early July until mid November. Obviously, no one fertilizer recommendation will adequately provide the needs of potato crops with such long differences in the possible length of the growing period.

Although large potato yields enhance Washington's competative position, the quality of the potatoes produced is also of importance. A high percentage of No.1 grade tubers is always desirable, but very high specific gravity of the tubers is desirable only for most forms of potato processing. But even for processing, the value of high specific gravity must be balanced against the cost of other factors involved, such as hand labor for paring blackspots at a trimming table.

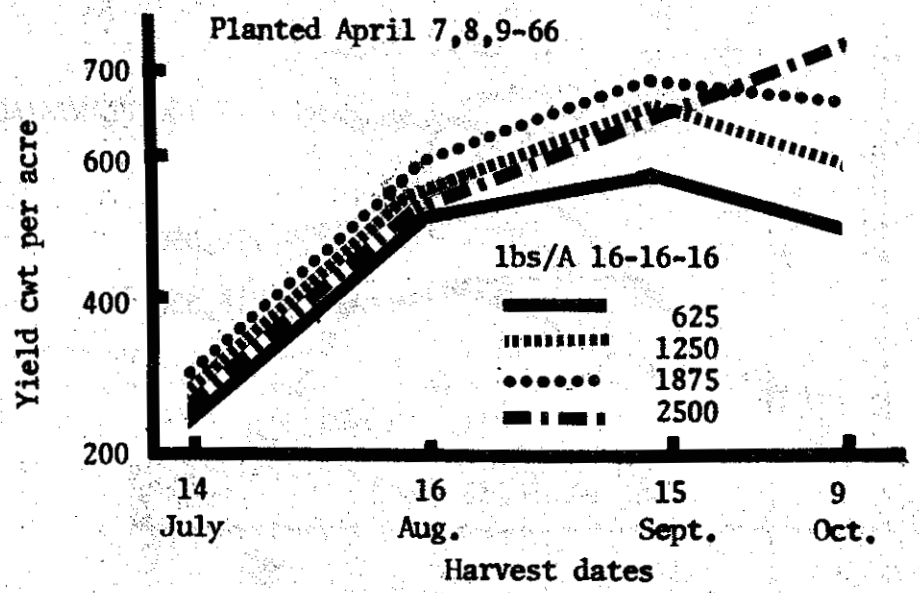
High specific gravity potatoes are desirable for most forms of processing, baking, and mashing, but the potatoes slough, and fall apart when boiled, making them less of a general purpose potato and to a degree increasing the dissatisfaction of the housewife.

It was the custom in the past to think of a fertilizer response only in terms of saleable potatoes. In the future, a fertilizer response would also be considered in terms of satisfaction to the fresh consumer, reduction in price adjustments from blackspot, and elimination of hand labor at the trimming tables in a processing plant.

It should never be forgotten that maximum yields of high quality potatoes are the result of the integration of at least 17 factors and not the result of one factor alone. Of the 17 factors, 10 can be more or less grower controlled. In our experimental work we endeavor to provide optimum conditions for growth by manipulation of the controlable factors.

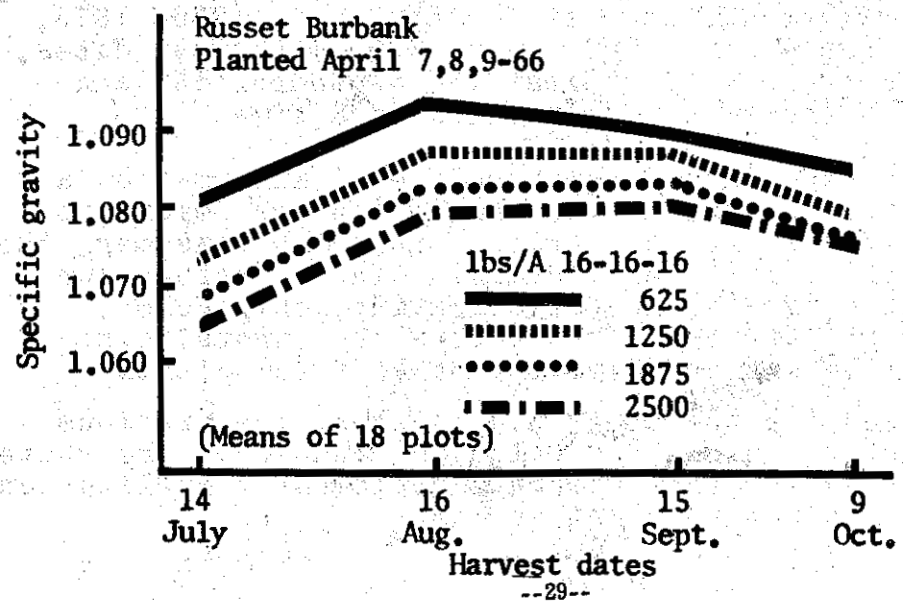
In 1966 it was shown that the most economical amount of fertilizer to use was dependant upon the time of harvest [Fig. 1]. Early crops of potatoes were smaller than late harvested crops of potatoes and therefore required less fertilizer.

Fig. 1--Yield of potatoes and amount of plant nutrients required are related to the length of the growing season.



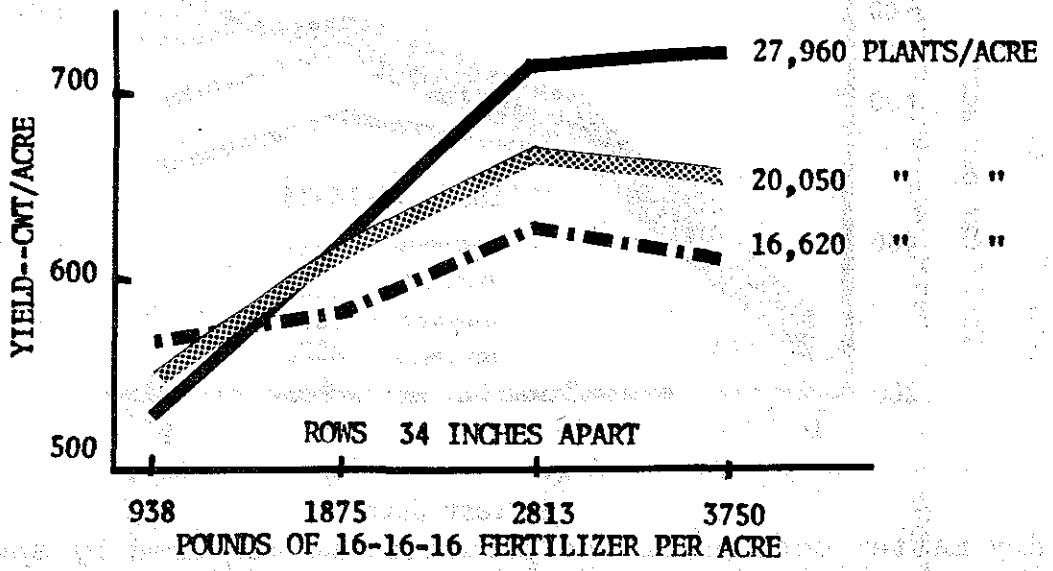
The dry matter content of the potatoes, as measured by specific gravity, was highest when the least amount of fertilizer was used, but the size of the difference found depended somewhat on the date of harvest [Fig. 2].

Fig. 2--Specific gravity of potatoes is a transient quality which varies with the time of harvest. Low fertilization results in potatoes with the highest specific gravities.



Other studies with the Russet Burbank have shown that the amount of fertilizer which can be profitably used was at least in part, dependant upon the number of plants [Fig. 3].

Fig. 3--The number of plants and not the number of acres to fertilize should determine the amount of plant nutrients required.



In still other studies, it was shown that high rates of fertilizer application produced maximum yields without appreciably decreasing the grade, the specific gravity, or impairing the quality of the chips [Fig. 4]. These results are in contrast to many of the reports published on the subject.

A comprehensive study was undertaken in 1967 to determine the conditions under which high fertilization was beneficial for high yields without serious detrimental effects on tuber grade or quality. In this study there were 4 planting dates, each 2 weeks apart [March 30, April 15, April 30, and May 15]. A 16-16-16 fertilizer was used at 5 rates--625, 1250, 1875, 2800, and 3125 pounds per acre. There were 4 harvest dates, each a month apart--July 15, August 15, September 15, and October 15. Each treatment was replicated 8 times.

To make the experiment as productive of information as possible, data were taken on 9 factors which are important directly or indirectly to the farmer, the fresh consumer, the processor, and the fertilizer industry. The 9 factors considered were yield, grade, specific gravity, chip color, blackspot, mineral nutrients in the tops and tubers, size of plant, number of tubers and time of death of the plants.

The land used for the study was in wheat the previous year, but most of the straw was baled and removed. The state of fertility was so low that without supplement fertilization, there was almost no potato plant growth.

Fig. 4--Large quantities of fertilizer can produce maximum yields of potatoes without seriously affecting the yield, grade, specific gravity of color of chips.

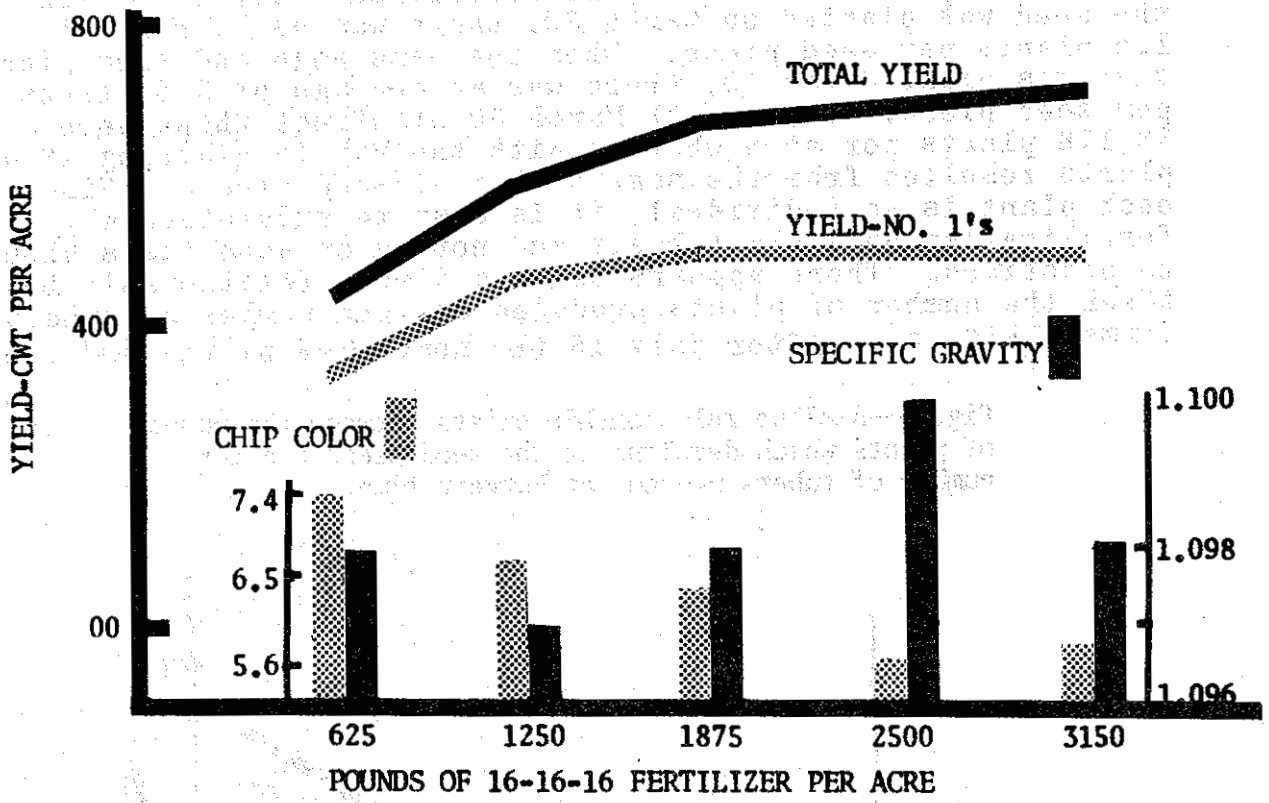
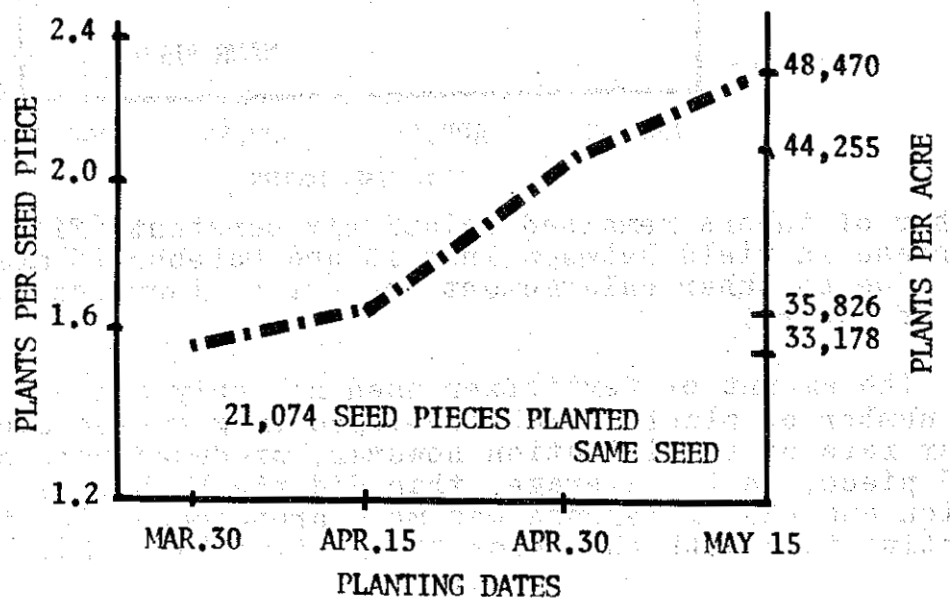
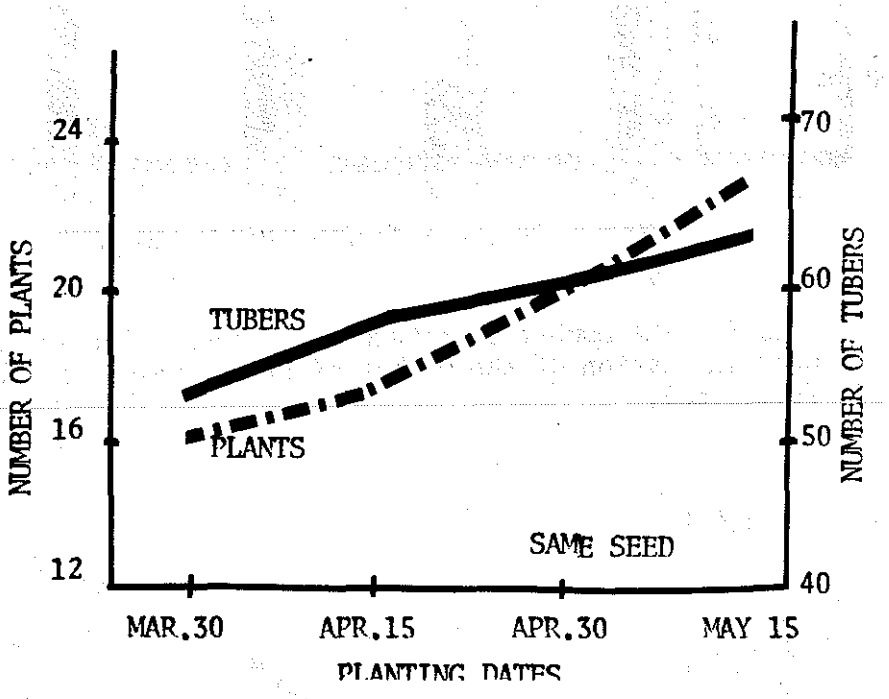


Fig. 5-- The number of potato seed pieces planted may be a poor indication of the number of plants which must be fertilized.



Plants per acre? Each plant which arises at the seed piece has its own tuber set and root system. The number of seed pieces planted is a poor indicator of the number of plants which must ultimately be fertilized [Fig. 5]. When the seed was planted on March 30, there was an average of 1.6 plants per seed piece. When the same seed and seed piece size was planted May 15, there was an average of 2.4 plants per seed piece. Thus, with March 30 plantings there were 33,178 plants per acre whereas with the May 15 planting 48,470 plants resulted from the same number of seed pieces. Since each plant is an individual, it is easy to understand why fertilization on a plant basis and not on an acre basis should be practiced. There appears to be a direct relationship between the number of plants produced and the number of tubers formed [Fig. 6]. After July 15 the number of plants and the

Fig. 6--A close relationship exists between the number of plants which develops at the seed piece and the number of tubers present at harvest time.



number of tubers remained relatively constant [Fig. 7]. Any increase in yield between July 15 and October 15 must have been due to tuber enlargement and not an increase in the number of tubers.

The amount of fertilizer used had only a minor effect on the number of plants which developed from a seed piece. The lower rate of fertilization however, produced more plants per seed piece, on the average, than did the high rate of fertilization and the difference was more pronounced with the May 15 planting than with the March 30 planting [Fig. 8].

Fig. 7--The number of plants which developed at the seed piece and the number of tubers present at each harvest date remained the same after July 15.

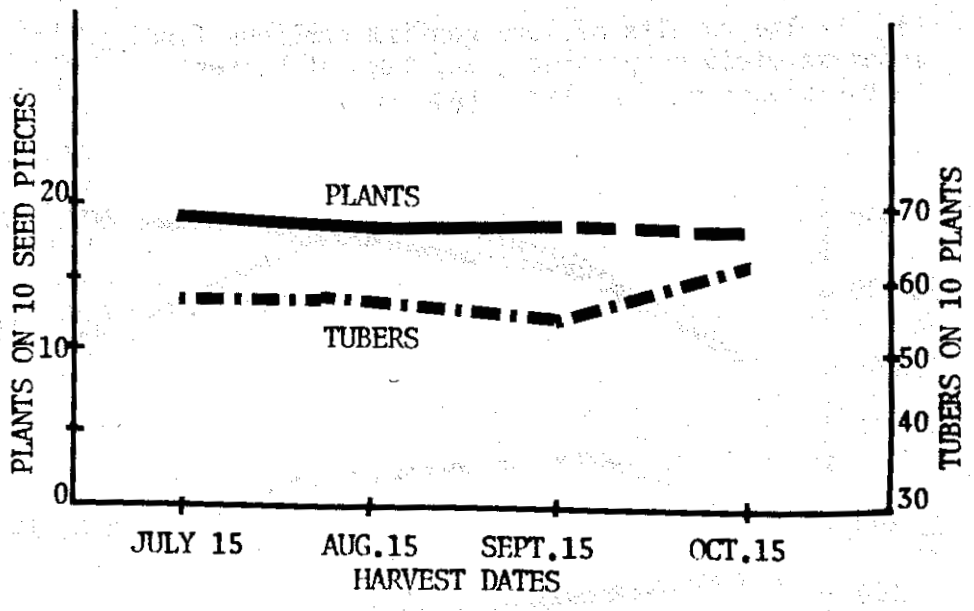
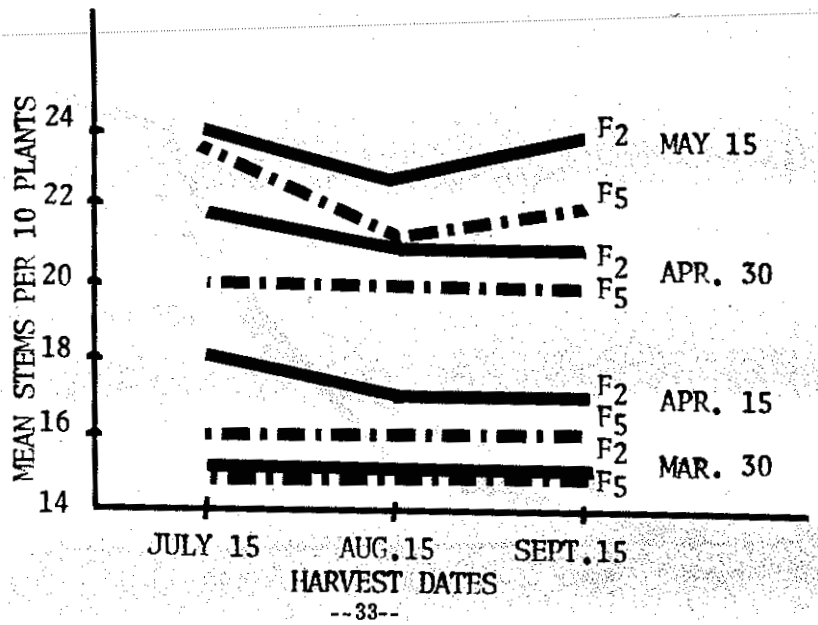


Fig. 8--The amount of fertilizer applied had only a minor effect on the number of plants which developed at the seed piece.



As in the study reported in Figure 1, when the potatoes were harvested in mid July they required less fertilizer than when harvesting was delayed until October. Potatoes for harvest between July and October required intermediate amounts of fertilizer [Fig. 9]. The 1967 growing season was extremely

Fig. 9--The results of 1967 confirm previous findings relating yield of potatoes, and time of harvest to the amount of fertilizer required.

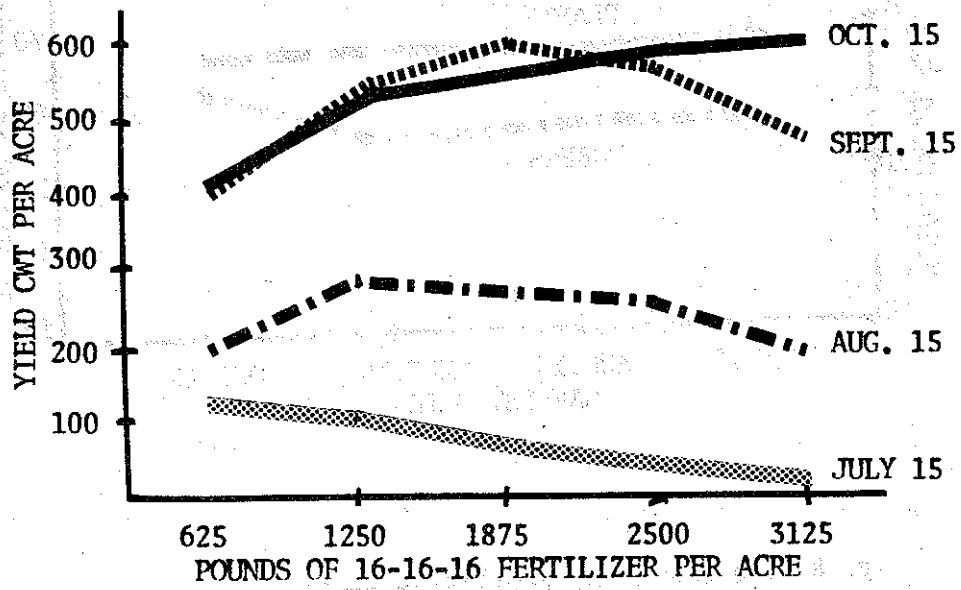
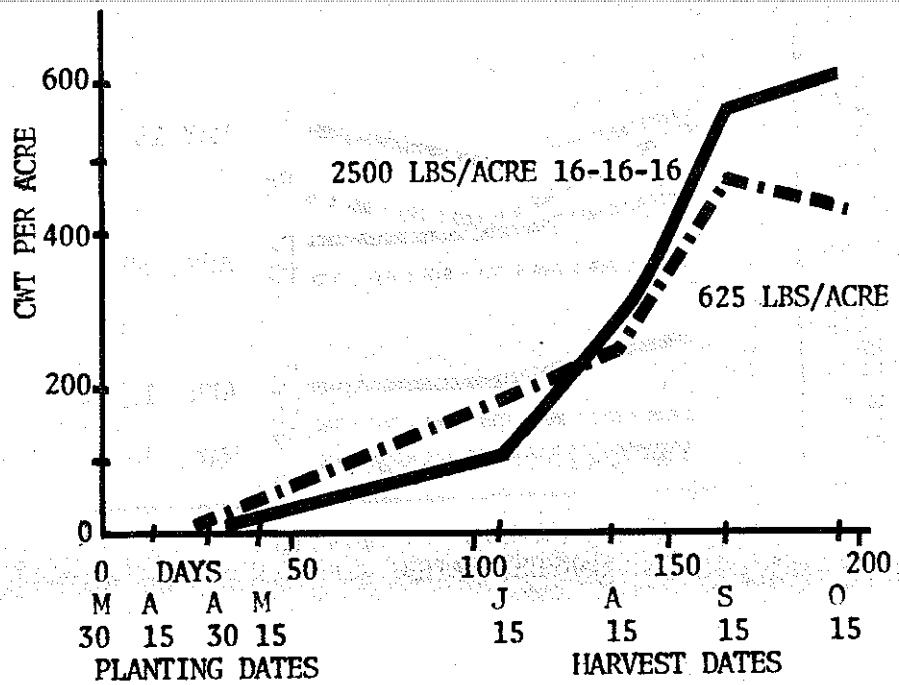
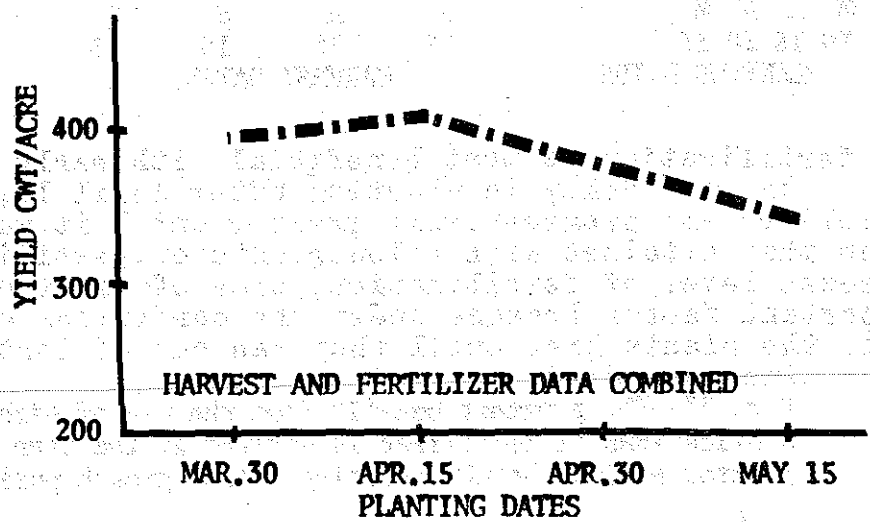


Fig. 10--High levels of fertility result in low early yields of potatoes but produce the largest yields if given a long growing season.



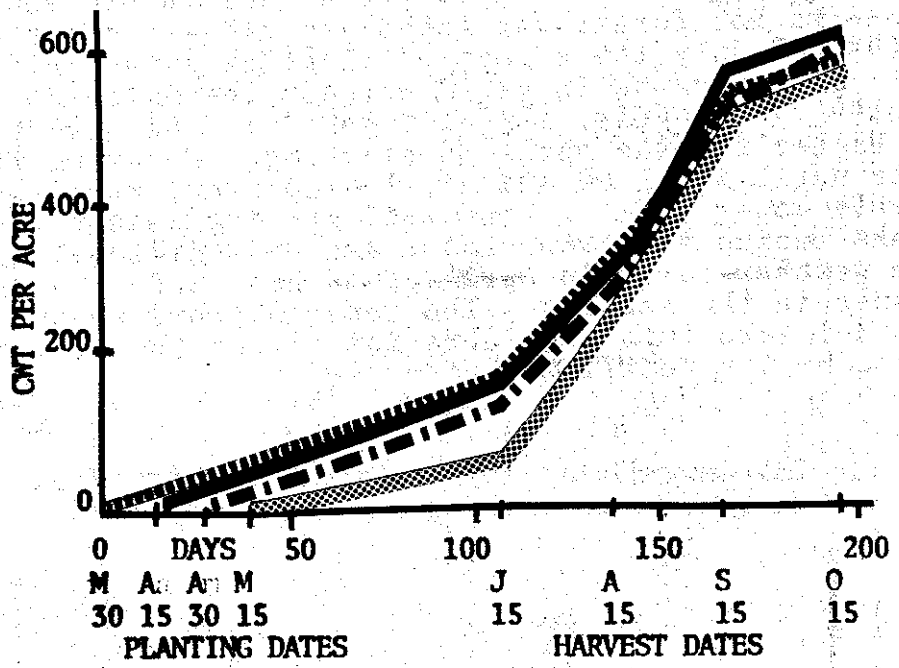
hot and the yields were lower than in 1966. The top yield in 1966 [Fig. 1], was over 700 CWT/acre, but in 1967 the maximum yield was only a little over 600 CWT/acre [Fig. 10]. The highest fertilizer rate produced the lowest yield early in the season, but the highest yield late in the season. When all the data for fertilizer rates and harvest dates are combined to show only the effect of planting dates on yield, there was little difference in yield between the March 30 and April 15 planting dates [Fig. 11]. In general, the yields were a little higher for the April 15 planting. Delaying the planting date until April 30 and May 15, however, resulted in progressively lower yields. The 1967 growing season was about two weeks behind the 1966 season and an additional two weeks of warm weather early in April could have made a substantial difference in the results. The general trend shown in Figure 11 does not take into consideration either the effect of harvest date or the fertilizer rate.

Fig. 11--Generally a delay in planting date beyond a certain period results in lower yields of potatoes.



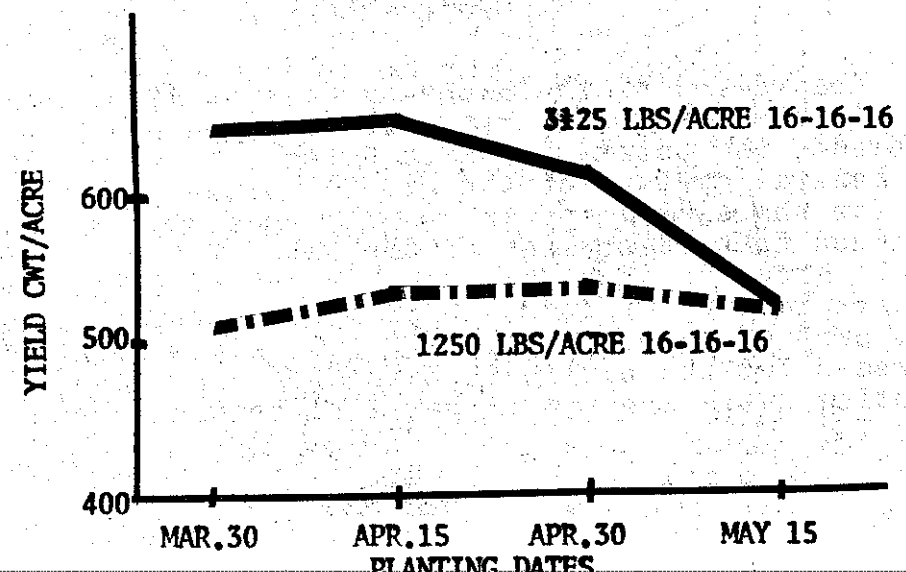
Regardless of the planting date in 1967, when the data for all the fertilizer rates for a given planting date are combined, the total yields on October 15 were similar, as was the general pattern of the growth curves [Fig. 12]. The reason for the similarity is readily understandable when it is realized that regardless of the rate of fertilizer used, the plants grew for about the same number of days. Note that the most rapid rate of increase in yield occurred during the hottest part of summer. Note that the lines representing yield increase for the earliest [March 30] and latest [May 15] planting dates are almost parallel between August 15 and October 15.

Fig. 12--The similarity between the final yield of potatoes obtained from the different planting dates seems to indicate the total length of life of the plants is more important in determining the yield than the time at which the seed was planted.



High fertilization is most beneficial with early planting [Fig. 13]. For each delay in planting after April 15, the loss in yield became progressively greater until it was no higher than that obtained with a lower rate of fertilization. With the lower level of fertilization, time of planting was not an important factor because under the conditions of the experiment, the plants grew until they ran out of fertilizer, after which time they died.

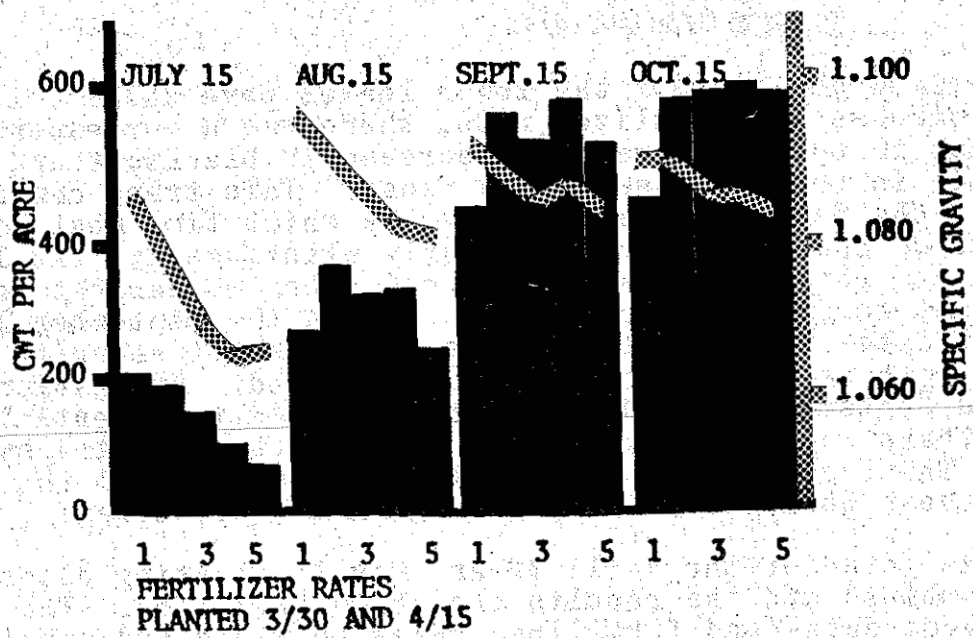
Fig. 13--The greatest benefit from the use of high applications of fertilizer is derived if the crop is planted early, thereby ensuring a long growth period.



Because of the similarity in yield between the March 30 and April 15 plantings, the data for these two dates were combined. Since there were 8 replications of each treatment, combining the data from the two planting dates resulted in means of 16 value in each and made them considerably more reliable. Figure 14 shows the relationship between the amount of fertilizer used, the resultant yield and the specific gravity of the tubers in relation to the date of harvest.

On the July 15 harvest date, the yield of tubers was the lowest and as the rate of fertilization increased, there was a progressive depression in yield and also in specific gravity of the tubers. The yield of potatoes was higher at each successive harvest date, but not with all fertilizer levels [Fig. 14]. The reduction in specific gravity of the potatoes from the use of high fertilizer rates was less late in the season than early in the season.

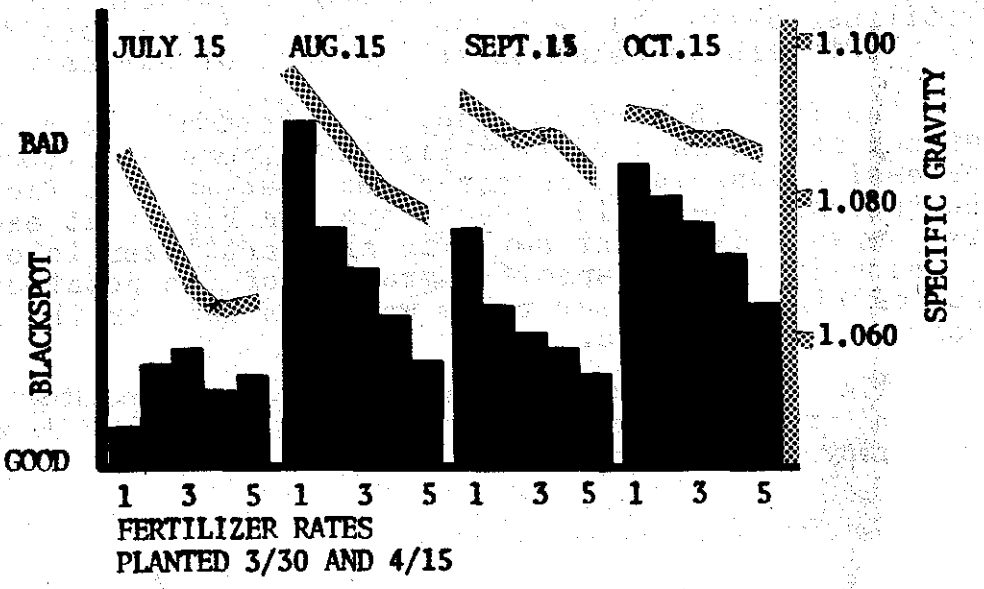
Fig. 14--The yield and specific gravity of the potatoes were affected by the amount of fertilizer used and the time the crops were harvested (last irrigation Sept. 13).



The relationship between harvest date, fertilizer rate, specific gravity and blackspot are shown in [Fig. 15]. On July 15, specific gravities of the tubers from the respective fertilizer rates were relatively low and the tubers were essentially blackspot resistant. The potato vines were green on July 15, but those receiving the lowest fertilizer rates were beginning to fade to a yellowish green color.

By August 15, which was a very hot period, the specific gravities of the tubers increased substantially at all 5 fertilizer levels, as did also the severity of the blackspot. By August 15 the vines growing on the lowest fertilizer rate

Fig. 15--There is a relationship among time of harvest, specific gravity of the potatoes and the susceptibility of the potatoes to blackspot when the potatoes are planted early in April (last irrigation Sept. 13).



were yellow and many of the lower leaves were dead. With each increase in fertilizer rate, there was a corresponding decrease in specific gravity, decrease in blackspot and an increase in the greeness of the vines. This trend continued through the September harvest date by which time most of the foliage on the plants from the early plantings and the lower fertilizer rates was dead. By the October 15 harvest date blackspot was more severe than it was on the September 15 harvest date, but the differences in blackspot severity due to the rate of fertilizer applied persisted. Irrigation was stopped September 13 and since the plants were essentially dead, there was very little loss of water through transpiration. The tubers which were left in the soil until the October harvest were essentially in high humidity storage.

The data for the April 30 and May 15 planting dates were also combined and the results are shown [Fig. 16]. The effect of harvest dates and fertilizer rates on yield and specific gravity of the potatoes are similar to those shown in Figure 14 for the average effects of the March 30 and April 15 planting dates--even the effects of the fertilizer rates on specific gravity and blackspot are similar for the first three harvest dates, but high rates of fertilization increased blackspot at a more rapid rate between the September and October harvest dates than did the low rates of fertilization. This was a change in fertilizer effect on blackspot.

Between the September and October harvest dates some factor other than fertilizer per se was influencing the degree of blackspot. The greenest vines are now associated with the most rapid rate of increase in blackspot [Fig. 17].

Fig. 16--As the time of harvest was delayed more fertilizer was needed for maximum yield of potatoes and the reduction in specific gravity resulting from the high fertilizer rates became less (last irrigation Sept. 13).

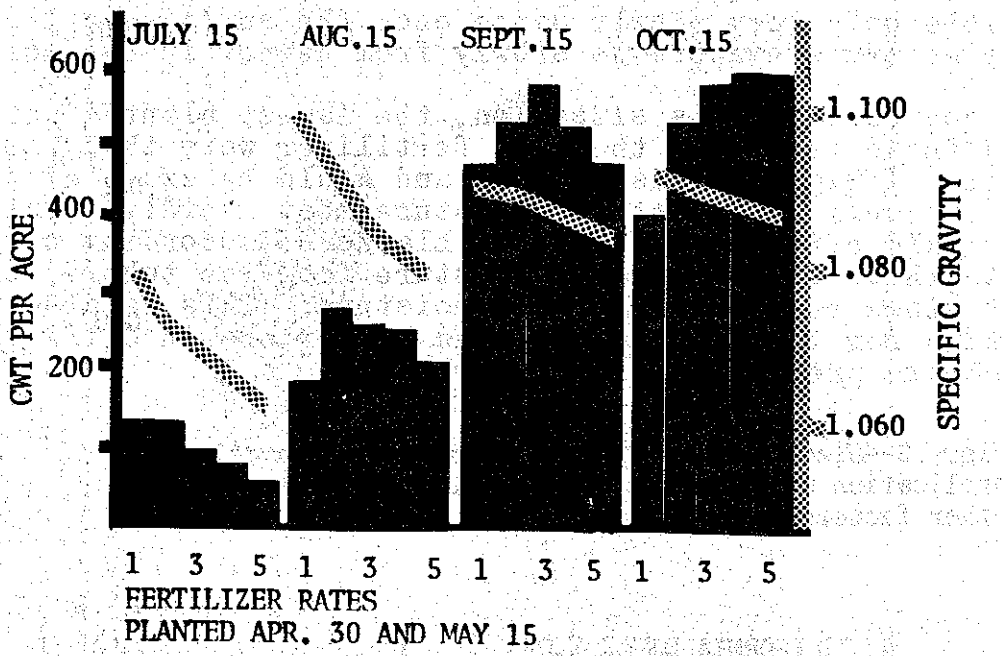
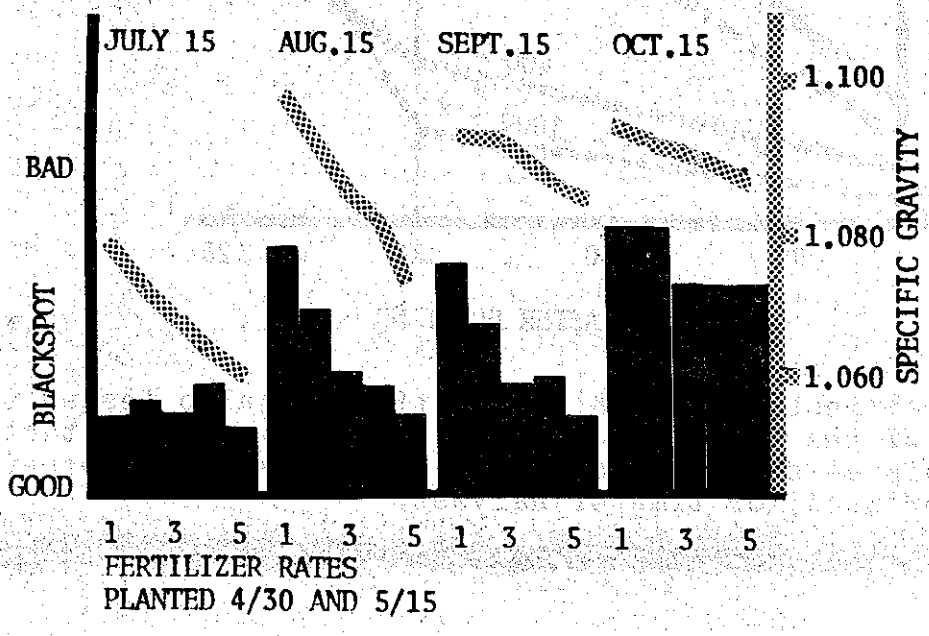


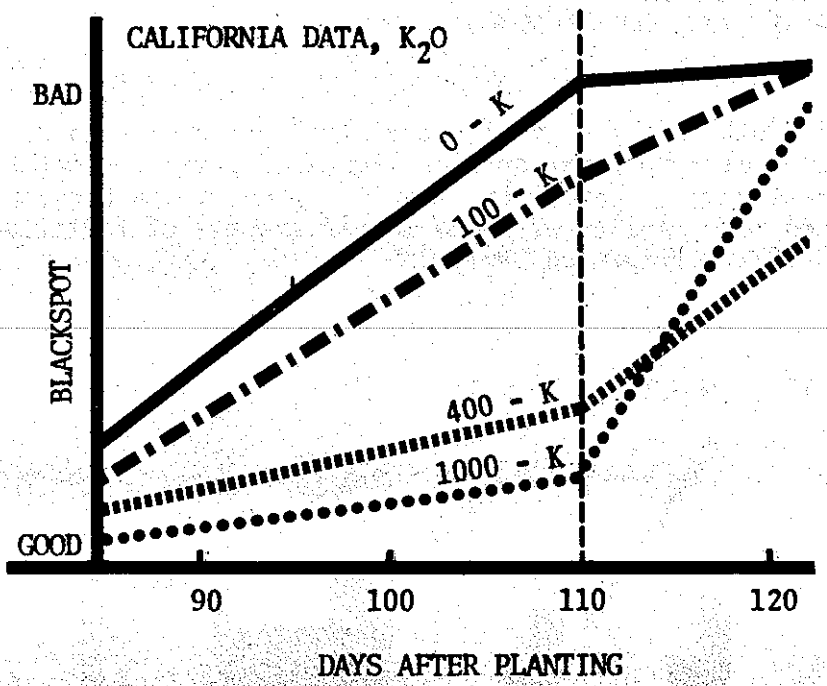
Fig. 17--Both specific gravity and blackspot decreased as the amount of fertilizer applied increased until the October 15 harvest date. Thereafter, specific gravity and blackspot increased more rapidly with the larger amounts of fertilizer applied (last irrigation Sept. 13)



The explanation is found in the fact that the water was turned off on September 13, at which time the vines from the early planted plots and those receiving the low fertilizer rates were essentially dead by September 15. Since water was applied until September 13 the ground was moist, and since the vines were dead the tubers were, essentially, in high humidity storage and would be expected to become more blackspot susceptible only very slowly since once the surface soil is dry, the moisture evaporates slowly from deeper in the soil.

In contrast to this situation, the latest planted potatoes and those receiving the most fertilizer were the greenest at the time irrigation was stopped and would be expected to deplete the soil of its stored moisture most rapidly. This in turn would effect the degree of blackspot according to the degree to which the vines drew moisture from the tubers, the greenest vines requiring the most moisture. This is also the explanation for the results obtained by workers in California and which are presented [Fig. 18].

Fig. 18--Blackspot was reduced by potassium fertilizer application until 110 days after planting, thereafter other factors dominated.



Each treatment from each replication was also tested for the effects of the treatments on chip color. No consistant effect on chip color was measured for planting date, amount of fertilizer used, or time of harvest.

SUMMARY

1. Potatoes which are planted for early July harvest need less fertilizer than those intended for late harvest. The amount of fertilizer needed depends not alone on the time of harvest, but also upon the plant population. The number of seed pieces planted may be a poor indicator of the number of plants which need feeding.

2. The specific gravity of potatoes can increase or decrease quite rapidly depending upon the changes in soil moisture, loss of water through transpiration and vigor of the plants. Potatoes harvested in July were generally low in specific gravity and excess fertilization depressed the specific gravity even more. The rate of increase in specific gravity of the potatoes growing at high levels of fertilization was enough faster than the low fertilizer rates to make the specific gravities about equal by the end of the growing season.

3. Blackspot was at a minimum as long as the vines were green and growing vigorously and ample water was provided to offset the losses due to transpiration.

Potatoes which had become badly blackspot susceptible became markedly less susceptible by leaving them in moist soil for a month. During this period, the tubers decreased in specific gravity due to a loss of dry matter from respiration and the absorption of water through the skins.

Potatoes on green vines became blackspot susceptible after irrigation was stopped and the soil dried out. Associated with the increase in blackspot was an increase in specific gravity.