GROWTH AND DEVELOPMENT OF RUSSET BURBANK POTATOES

by

B. B. Dean, R. E. Thornton, N. M. Holstad

The production of potatoes in the Pacific Northwest contributes significantly to the economy. Per acre production costs in Washington are the lowest in the nation, however, transportation costs are rendering the total costs of production and delivery less favorable compared to the other production regions. Because of climatological advantages, Washington will continue to produce the highest quality processing potatoes with the highest per acre yields in the nation. In order for the industry to progress and to continue to compete favorably with other growing regions, we must be aware of input costs and manage them appropriately.

This paper describes a study initiated in 1979 (funded by the Washington State Potato Commission) which was designed to document the growth of the potato crop in the Columbia Basin of Washington so that management decisions could be made in a timely fashion.

EMERGENCE AND EARLY GROWTH

Germination and emergence of the potato crop is dependent on the soil temperature following planting. Yamaguchi (1) found that temperatures must be above 50°F. for reasonable growth of the White Rose potato variety. The temperature for germination of Russet Burbank potatoes had not been satisfactorily identified prior to this study. We therefore, constructed a temperature gradient apparatus in which germination temperature could be closely regulated (Fig. 1).

The results of this experiment indicated that reasonable growth (measurable difference over 2-3 days) occurred only above 50° F. and that optimum growth occurs at 69° - 75°F. (Table 1).

This data indicates that soils should be above 50°F before planting for reasonable growth to occur.

VINE GROWTH

Last year at this conference data was presented that showed optimum dry matter production occurs at temperatures between 68°F and 78°F (2). It may be concluded from that study, that optimum growth and subsequently potato tuber production occurs in that temperature range. In order to test the hypothesis that growth was maximal between 68° and 78°F and is reduced at temperatures higher or lower than this range, growth data were obtained weekly from 3 sites (in Washington) over 2 growing seasons (1980 and 1981). Vine weights (fresh and dry) tuber weights (fresh and dry) and compositional changes were recorded. Vine growth is rapid at first, levels off during the majority of the season and then decreases at the end (Fig. 2).

Although new leaves are continually being formed, older leaves are falling off, and therefore, no net increase in vine weight occurs during the mid portion of the season. As vines age and leaves begin to senesce, a decrease in vine weight occurs. This is also demonstrated in the fact that late in the season an increase in % vine dry weight occurs (Fig. 3). This is indicative of leaves drying while attached to the vines, but having not yet senesced.

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VINE COMPOSITION

The composition of vines changes markedly during the season. These changes have historically been utilized to estimate the fertility status of the plant (3,4). Petiole samples have been collected and NO_3^- content determined in order to predict fertilizer needs for the next growth period or to determine if adequate nitrogen levels are present in the soil.

During the 1980 and 1981 seasons, vine NO_3^- and other mineral content changes were determined weekly. To assess what physiological significance the foliage nutrient content had, the vine weight, tuber weight and nutrient content of each plant was analyzed individually.

The NO_3^- content of the foliage followed the typical pattern described by others (3,4) in the 1980 Othello plot. The relationship between vine growth, tuber growth and NO_3^- content in the 1980 Northern plot and the 1981 Southern plot show a different curve as illustrated by the 1981 Southern plot (Fig. 4).

Nitrogen is needed by the plant to manufacture proteins which are the workhorses in cells. They are responsible for manufacturing starch, carrying out basic cell functions and are stored in the tubers. NO_3^- is taken up by the plant in proportion to the rate of evaporation of water from the leaf surface. It is utilized by the plant as it is needed for the formation of proteins and other nitrogen containing compounds. The control mechanism for NO_3^- utilization is complex and beyond the scope of this discussion, however, it is important for the reader to understand that the amount of NO_3^- found in the plant will be related to the rate of uptake versus the rate of utilization. From a practicle standpoint, we need to understand how the NO_3^- content of the foliage relates to the yield of tubers on that plant. To determine this relationship, a regression analysis of foliage NO_3^- versus tuber yield was performed.

The amount of NO_3^- in the foliage was not consistently related to tuber yield at any given point during either the 1980 or 1981 season (Table 2). There are several reasons why these results may have been obtained; 1) The NO_3^- content in the foliage was not limiting tuber growth. 2) Tuber growth is independent of foliage NO_3^- content. 3) Tuber yield is dependent of foliage NO_3^- content during a critical stage of growth which could not be tested by the measurements made during this study.

Regardless of the reason for no consistent correlation being found between NO_3^-content of the foliage and tuber yield the previous suggestions that maintaining high levels of NO_3^- in the foliage will result in high tuber yield is questionable. There is no doubt that critical levels of nutrients must be maintained in the foliage in order to sustain high crop growth rates, however, there may be an over use of fertilizer, particularly nitrogen, as a result of attempting to maintain certain levels of nutrients in the foliage. There may actually be a detrimental effect of maintaining high levels of NO_3^- in the foliage as the partitioning of growth into vines rather than tubers may occur under those conditions.

TUBER GROWTH

The growing season (frost free days) for potatoes in Washington is a long one (150-200 days). It has been suggested that potato tubers will grow continuously during this long growing season if supplied with water and nutrients. Data collected during an optimal growing season (1980) and one which was less optimal, (1981) (according to our thermal growth model) indicates that frost free days may not be the only climatic conditions which limit growth (Fig. 5).

The potential for growth of the potato is dependent on the amount of sunlight it receives, the temperature of the air and the length of the growing season. It is apparent from the model illustrated in (Fig. 5) that the 1980 and 1981 season have different growth potentials. In this case, growth is responsive to temperature. High temperatures (+80°F) result in less growth then cooler temperatures. We demonstrated last year at this conference that this particular model predicts the average specific gravity (relatively) of a potato crop in Washington and that reasonably will predict the relative yield. Estimates of lower yields in 1981 compared to 1980 bring this fact out.

We have found that in two years of considerable difference in growth potential that the crop did not develop significantly past August 15 in the Central or Southern part of the Columbia Basin. Yields were increasing in the Northern region at the time of commercial harvest. The overall yield in any of the regions of Washington is dependent upon the duration and the rate of tuber growth. These factors are controlled by stress factors during crop growth. The stresses may be nutritional, water, climatological, pathological or a combination of these. Regardless of the cause for yield ceasation, it is important for the producer to know where on the growth profile the crop is so that appropriate management decisions can be made to maximize the effectiveness of production inputs or minimize product loss.

These dates can be used to estimate planting date, fertilizer application timing, vine killing dates and harvest dates. Further studies can refine the dates for a given location. However, in order for a grower to maximize his production capabilities he should develop his own set of production curves under his own conditions.

CONCLUSIONS

This study has demonstrated that tuber yield increases rapidly (0.4-0.8 tons per acre per day) between July 1 and August 1 in the Central and Southern parts of the Columbia Basin, or between July 15 and September 1 in the Northern regions. Planting dates and weather conditions can modify the dates and rates considerably. The ceasation of tuber bulking prior to frost indicates that disease, stress or some physiological signal limits further yield increases under our climatic situation. The resolution of which factor(s) is (are) responsible may lead to significant gains in productivity.

The use of analytic techniques for determining the growth status of a crop is valuable in modern agriculture. We should however, be careful not to apply the interpretation of test results from studies designed to provide a method for determining adequacy into a practice of suggesting that the tool can also be used to predict the optimum. In this case study, the use of nitrate analysis of foliage was used by plant scientists to determine whether or not a nutrient was limiting growth. The implication should not be drawn that higher amounts will be better or even optimum. Our study has shown that foliage nitrate levels do not correlate consistently with the weight of tubers produced by the plant at that time. There is much room for further work in this area.

REFERENCES

1. Yamaguchi, M. H. Timm and A. R. Spurr. 1960. Effects of soil temperature on growth and nutrition of potato plants and tuberization, composition and periderm structure of tubers. ASHS V. 84 pg. 412-423.
2. Dean, B. B., R. E. Thornton, and R. A. Kennedy. 1981. Effect of environment on dry matter of potato tubers. 20th annual Washington State Potato Conference and Trade Fair Proceedings. pg. 67-72.
3. Tyler, K. B., O. A. Lorenz and F. S. Fullmer. 1961. Plant and soil analysis as guides in potato nutrition.. University of California Agricultural Experiment Station Bulletin 781.
4. Jones, J. Preston, and Charles G. Painter. 1974. Tissue analysis; a guide to nitrogen fertilization of Idaho Russet Burbank potatoes. University of Idaho Current Information Series No. 240. June 1974.

Table 1.

Temperature °F	Days to 50% Emergence	Growth Rate cm/day
41.5	–	–
46.4	–	–
51.1	–	–
53.2	14.5	–
56.8	11.5	1.0
60.3	9.0	0.75
63.5	9.5	0.75
67.3	8.0	0.75
69.6	7.0	1.0
72.1	6.0	1.2
75.6	6.0	1.2
78.4	6.0	1.4

Table 2. Regression of vine NO_3 concentration on tuber yield to date.

1980				1981			
Field A Date	"r"	Field B Date	"r"	Field A Date	"r"	Field B Date	"r"
6/10	-.54						
6/17	-.51	6/16	.40	6/16	-.44	6/16	-.52
6/24	-.42	6/23	-.16	6/23	-.06	6/16	.00
7/01	-.80	7/01	-.61	6/30	.16	6/30	-.01
7/08	-.80	7/07	.04	7/07	.04	7/07	-.38
7/15	-.37	7/14	.22	7/14	.28	7/14	.11
7/22	-.31	7/21	.55	7/21	.26	7/21	-.34
7/29	-.31	7/28	.06	7/28	.06	7/28	-.26
8/05	-.82	8/04	.11	8/04	.13	8/04	-.25
8/12	-.28	8/11	.11	8/11	.02	8/11	.16
8/19	.55	8/18	-.65	8/18	-.21	8/18	.18
8/26	.07	8/25	-.74	8/25	.15	8/25	.21
9/02	-.17	9/01	-.29	9/01	-.02	9/01	.21

Figure 1. Water is pumped from each water bath to a chamber on one end or the other of the aluminum block. The block serves as a conductor of heat from one end and cold from the other. The conduction results in a linear temperature gradient along the block.

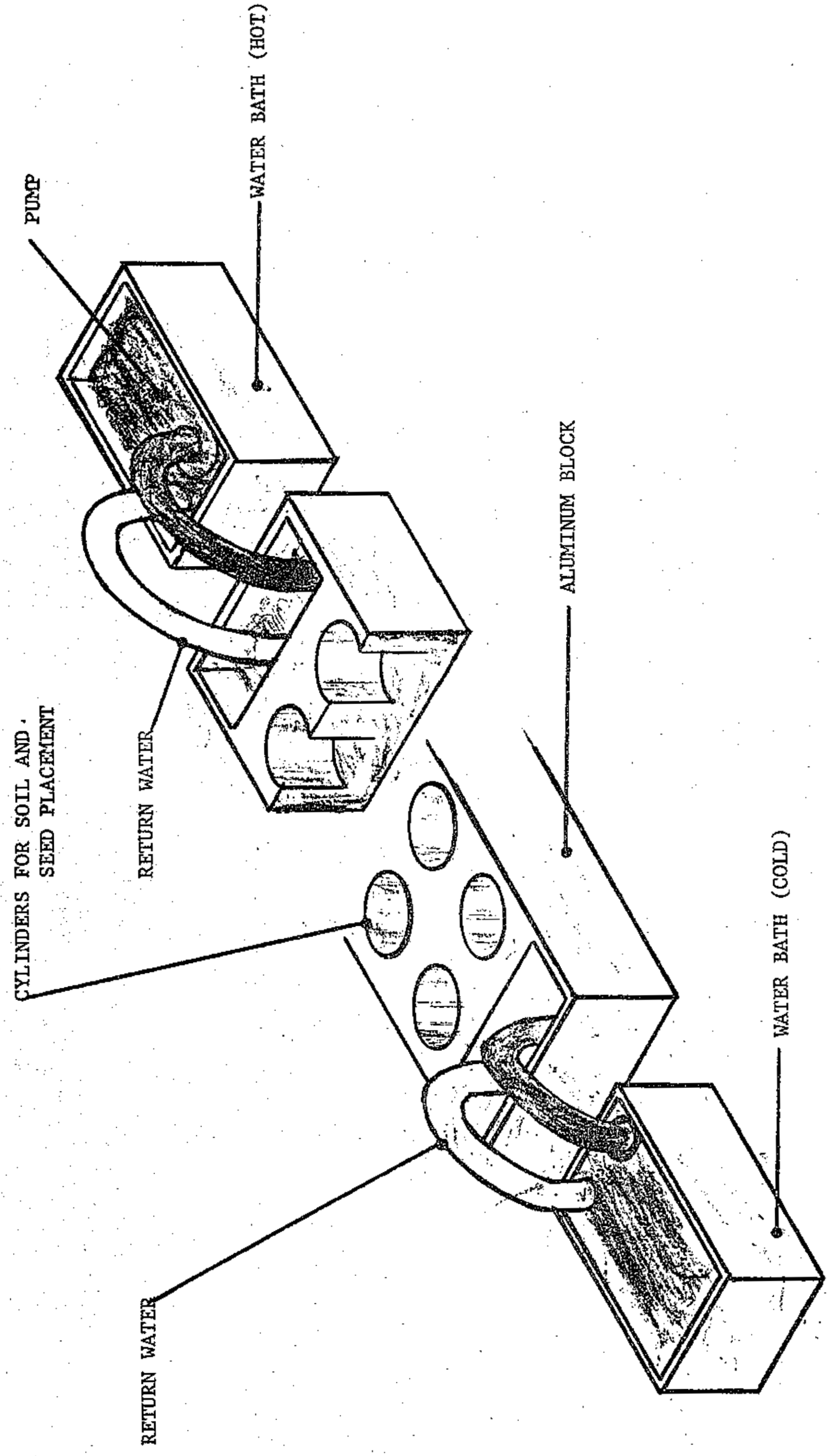

Figure 2. Fresh weight of tubers and vines and % NO_3 of Vine during growth of Russet Burbank Potatoes (1980 Northern Plot).

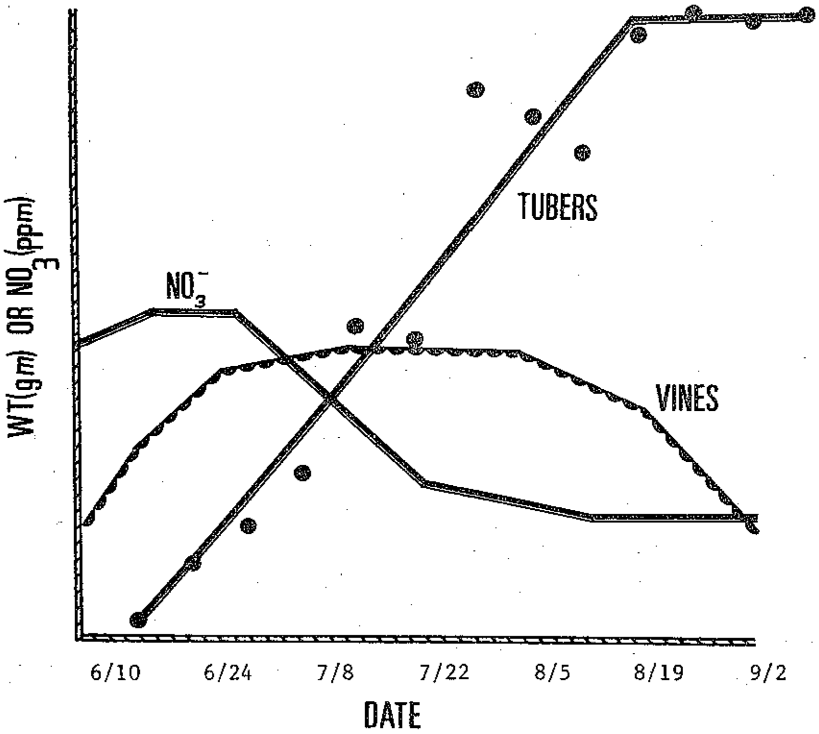

Figure 3. Change in fresh weight (FW) and % dry matter (DM) of Russet Burbank Potato Vines during growth.

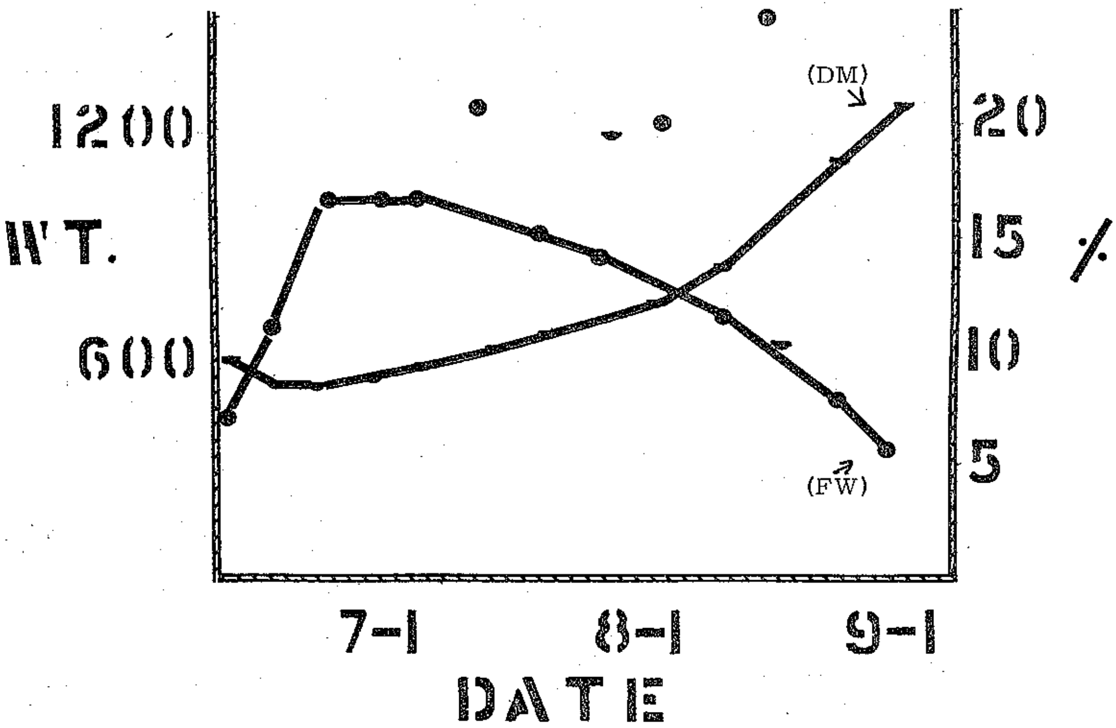

Figure 4. Fresh weight of tubers and vines and % NO_3 of vine during growth of Russet Burbank potatoes (1981 Southern Plot).

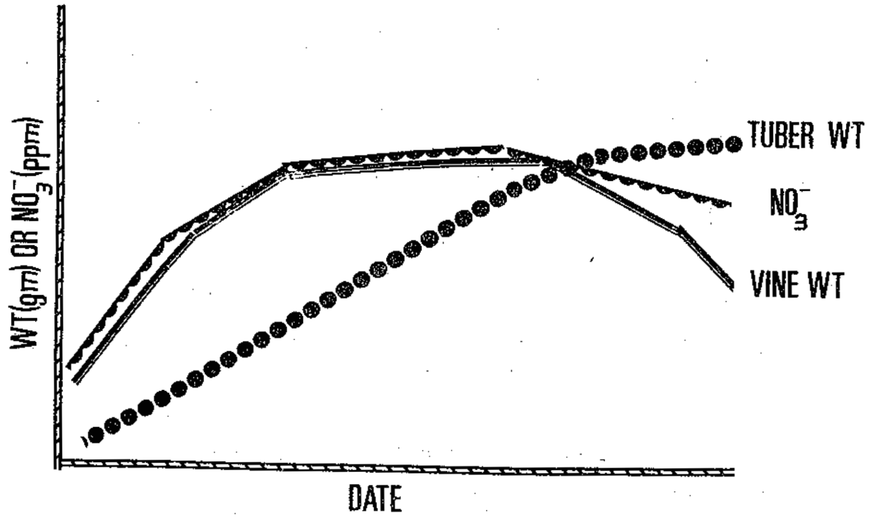

Figure 5. Thermal Growth Model comparison for two different years (Calculations made using model described in 1981 Conference Proceedings, page 67).