PHYSIOLOGY OF TUBER BULKING

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The rate of tuber bulking for most cultivars is determined early in the growing season from both environmental and physiological factors. Environmental factors include planting date, temperatures at planting (both soil and air temperatures) and weather extremes. Physiological factors include cultivar, seed piece size, the resulting number of tubers produced per unit land area and physiological age of the seed (Fig. 1).

Physiological Factors Affecting Bulking Rate	Environmental Factors Affecting Bulking Rate
• Cultivar/Variety • Day Length • Number Tubers/ft2 • Seed Piece Size • Stem Numbers/Hill	• Planting Date • Early Season Temperature • Nutrition and Water Management • Mid-Season Temperatures >95 °F • Frost / Hail

Figure 1

A cool, wet spring will tend to produce fewer stems per plant and take longer for seed to emerge than a warm spring season. Because most cultivars have a consistent number of tubers on each stem, the stem numbers per seed piece play a strong role in determining the bulking rate. Larger seed pieces will tend to have more stems per hill and consequently, bulking rate can increase with increasing seed size when planted at the same spacing. Although the seed piece size is an important determinant of bulking rate, the physiological age of the seed lot is equally important to the growth rate of the tubers.

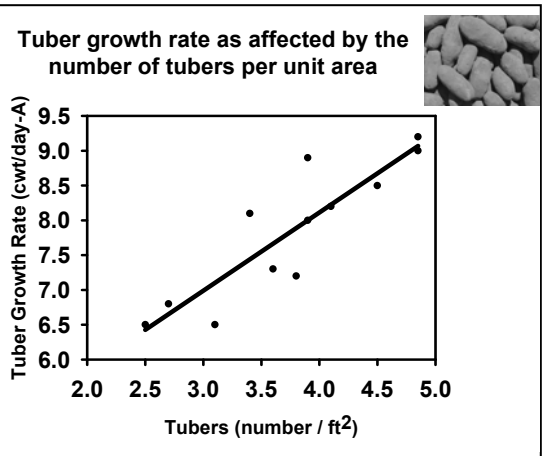

Figure 2.

During the tuber initiation growth stage, tubers are formed on stolons and the number of tubers carried to harvest is determined from environmental conditions during this growth stage. The number of harvested tubers will depend on the stem population as well as the environmental conditions during this initiation phase of growth. A good correlation of bulking rate versus tuber number per square foot is shown in Figure 2. For example, if you have an average of three stems per hill planted at 12 inch spacing on 36 inch rows and each stem has three tubers, the bulking rate could

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be determined from this graph. From this example, three tubers per square foot would show a bulking rate of about 700 pounds per acre per day or 7 cwt/A-day.

The tuber number per foot will vary with cultivar, seed size, seed physiological age and temperature during the tuber initiation stage of growth. For Russet Burbank potatoes, the average tuber number per stem is fairly consistent, but can depend on the degree of *Rhizoctonia solani* infection that may occur in any field or carried on the seed piece. Under average growing conditions the number of tubers per hill will determine the growth rate. Research data from 9 location-years has shown that Russet Burbank potatoes will have an average bulking rate of 6.5 cwt/A-day (Fig. 3).

The potential tuber number that can be successfully produced by a plant varies with the season as shown in Figure 4. During a ten to fourteen day period (tuber initiation phase) the number of developing tubers increases to about 15-20 maximum and then declines to some lower value that will be carried to harvest. Initiated tubers not carried to harvest will be re-adsorbed by the plant. As the plant adapts to the environmental conditions at tuber initiation, different number of tubers per hill will be seen during different growing seasons. Consequently, the bulking rate of any cultivar will be a function of the physiology of the plant and its environment. Maximum bulking rates of Russet Burbank potatoes have been recorded at 7-8 cwt/A-day. The maximum bulking rates obtained from published literature for several other cultivars are shown in Table 1.

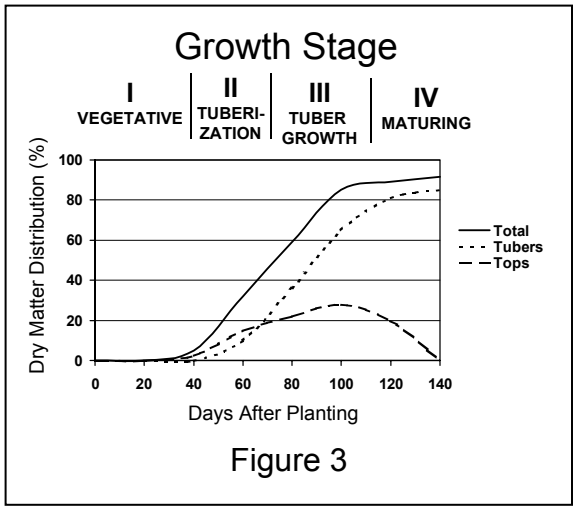

Figure 3

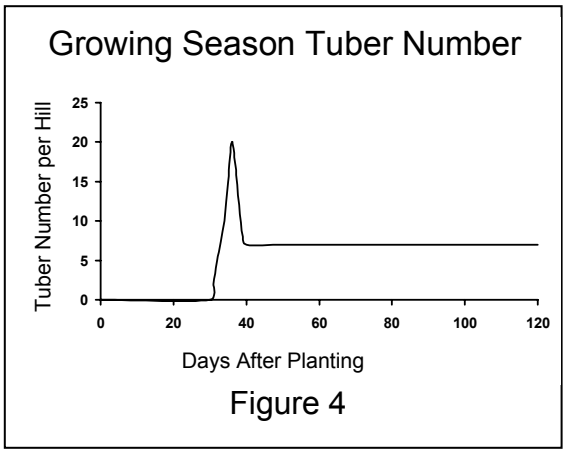

Figure 4

Maximum bulking rates for any individual cultivar and field will be determined by the physiology of the seed and the environmental conditions during tuber initiation. To obtain adequate bulking rates for most commercial cultivars requires proper

Table 1
Maximum tuber growth rates of six potato cultivars

Variety	Plant growth type	Growth rate cwt/A-day
Russet Burbank	Indeterminant	7.5 - 8.5
A66102-51	Indeterminant	7.8 – 9.1
Centennial Russet	Indeterminant	7.8 – 9.5
Norgold Russet	Determinant	10.5 – 11.5
Pioneer	Determinant	9.4 - 12.2

nutritional and production management. From this discussion it is clear that the grower has some control over the bulking rate through cultivar/seed lot selection and best management practices but has little control over annual environmental conditions during tuber initiation.

The growth and development of Russet Burbank potatoes versus growth stage is shown in Figure 3. Under optimum growing season conditions the rate of bulking is linear from just after tuber initiation until maturity or leaf senescence begins. Even though the bulking rate was predetermined during the tuber initiation growth stage, the seasonal tuber growth or yield is based on the number of days to maturity or length of the growing season. It is important to note the tuber bulking rate does not increase in late season nor does it change during the linear phase of growth. At maturity or late season, the bulking rate slows due to number of hours of daylight available for photosynthesis and the developing unfavorable day temperatures. Tuber enlargement continues as materials are translocated from the vines into the tubers. Approximately 10-15 percent of the total tuber weight can be obtained from the final stage of growth.

One study evaluated bulking rate of Russet Burbank potatoes at three nitrogen regimes, 1 = deficient N, 2 = adequate or recommended N and 3 = excessive N applied during the growing season. The amount of vine growth or leaf area was determined for each of the three nitrogen fertility regimes. Dry matter accumulation for total, tuber and tops was graphed versus time. Leaf area index (area of the leaf tissue versus the surface area of the ground) was also recorded. Figure 5 shows the seasonal development for the indeterminant cultivar, Russet Burbank. Figure 6 shows the corresponding seasonal development for a determinant cultivar, Russet Norkotah.

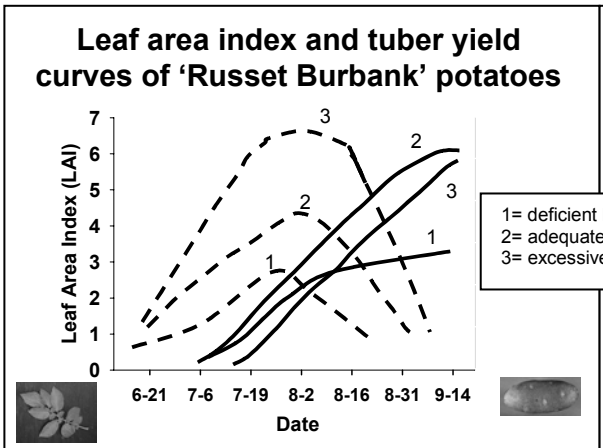

Figure 5

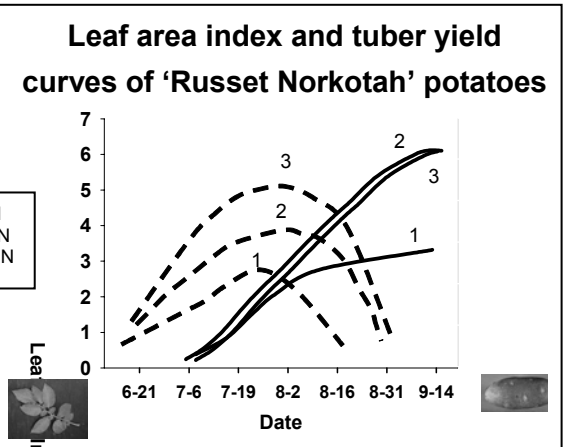

Figure 6

The effect of nitrogen nutrition and leaf area index clearly shows that nitrogen fertility in excess of the recommended rate increases the vine size above that necessary to maximize bulking rate. A leaf area index of 3 to 3.5 maximizes the interception of sunlight. In other words, any vine size that produces a leaf area greater than 3.5 is limited in growth rate by the available sunlight. Usually the initiation of tubers in high nitrogen programs is delayed by as much as 10 to 14 days. This delay can result in a loss of yield by as much as 90 cwt/A (6.5 cwt growth rate times 14 days = 91 cwt).

On determinant cultivars i.e., Russet Norkotah, the delay in tuber bulking may not be affected by nitrogen nutrition, as are indeterminant cultivars. The bulking rate is usually higher in short season cultivars but the linear phase of growth is also shortened. Cultivars such as Shepody and Russet Norkotah are determinant cultivars used primarily as early season processors or are used for the fresh pack industry.

An important consideration for the grower is to minimize the time to tuber initiation from emergence. This process prevents tuber bulking delay while the plant is producing excess vine and top growth. This delay, 10-14 days, is more critical in short growing seasons than in longer season areas.

The linear phase of tuber growth remains constant unless events occur that cause the plant to stop growing (high temperature above 95°F) or severe hail damage. Each event causes the tuber bulking rate to decline until the conditions are more favorable for growth. In seasons where there are 30 or more days above 95 F, the tuber growth (yield) may be severely reduced or quality of the crop may be compromised.

CONCLUSIONS

The bulking rate of potatoes is determined during tuber initiation phase of growth and depends on both environmental and physiological factors. After tubers are initiated the bulking rate is highly correlated to the tuber number per square foot and it continues in a linear mode until late season conditions limit the amount of sunlight available for growth.

The bulking rate does not increase during late season. In fact, the bulking rate may decline due to temperature, seasonal weather events and especially when early die symptoms are visible in the field. Late season growth, primarily from translocation out of the vines and into the tubers, can account for 10-15 percent of the final yield of the crop.

Conclusions

- Large canopy does not produce higher bulking rate.
- Late season nitrogen does not increase bulking rate.
- Bulking rate is not greater in August.
- Translocation from vine into tubers may account for 10-15% of final yield.

Application of late season nitrogen will not increase the bulking rate. The practice of applying excess nitrogen late season may reduce specific gravity and tuber quality. The best nitrogen management practice requires that a portion of the seasonal nitrogen be applied to indeterminant cultivars and the remainder after tuber initiation is complete. Nitrogen management for determinant cultivars is less critical since no delay in tuber growth due to excessive early season nitrogen occurs.

The production of large canopies in potato crops does not produce greater tuber bulking rates. Canopies with leaf areas greater than 3-3.5 are limited by sunlight duration and will not have greater bulking rates than crops with a normal range of leaf areas. The importance of best management practices for potato production is hereby emphasized.