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Stem Number & Tuber Set Relationships for Russet Burbank, Ranger & Umatilla Russet Potatoes in the Columbia Basin

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Variation in plant growth and yield potential among seed-lots of the same cultivar is often attributed to differences in physiological age of seed. Physiological age is a widely used term that, as yet, has never been defined biochemically. Seed-tuber age equates to the physiological status of seed at any point in time, which in turn is determined by complex interactions among agronomic and environmental factors of the production and post harvest environments. Differences in the physiological age of tubers may in fact be responsible for the so-called 'Northern Vigor' phenomenon, wherein seed produced in more northerly latitudes is purported to be more productive than that produced in more southerly latitudes. There is no doubt that variation in age among seed lots affects tuber set and yield potential. A method for quantifying age, however, is lacking.

While the age of seed can be manipulated in storage, the resulting effects on yield and grade depend in large part on cultivar and length of the growing season. A major research effort is underway in my lab to develop techniques to predict and manage the yield potential of seed potatoes. From a commercial production standpoint, the key questions are: **How do we quantify seed age at harvest? Or how can we assess tuber setting potential (i.e. potential productivity) before planting? Then if we can do this, how do we manipulate either physiological age (prior to planting) or agronomic management (after planting) so that tuber set and size development can be controlled within an optimum range for a particular market?** Knowing the relative age of a particular seed lot would allow for an adjustment of in-season management practices to optimize yield and grade from that seed, given the climatic constraints of a particular growing region. Research support from the Washington State Potato Commission has enabled us to make good progress in addressing these questions.

The objectives of the ongoing project are to:

(1) Determine the relative responsiveness of Ranger Russet, Umatilla Russet and Russet Burbank seed-tubers to physiological age.

(2) Identify potential biochemical/physiological marker(s) of seed age and evaluate their efficacy for predicting age-induced differences in plant growth, tuber set, yield and grade.

(3) Develop predictive models based on markers of physiological age that can be used by industry to estimate the relative differences in yield potential among seed lots prior to, or after planting.

To accomplish these objectives, Ranger, Umatilla Russet and Russet Burbank seed-tubers were acquired at harvest from northern (54^{o}N latitude) and southern (47^{o}N latitude) growing regions. The seed-tubers were stored under different temperature regimes over a 200-day storage period to create seven physiological ages with different productive potentials. Seed was analyzed at planting to identify promising biochemical markers of age. The relationships among seed biochemical markers, stem numbers, tuber set, final yield and grade were then modeled extensively, resulting in a program that growers and consultants can use to estimate the relative productivity of seed prior to planting (from seed biochemical markers), or an established crop prior to row closure (from stem numbers). A brief summary of our results over the past three years appears below.

Regardless of cultivar, plant emergence from southern-grown Ranger and Russet Burbank seed was faster than that from northern seed (Table 1), reflecting a physiological difference attributable to growing region. Seed source affected the yield profiles (tuber size distribution) but, contrary to 'Northern Vigor' claims, had no effect on total and U.S. No. 1 yields, which averaged 31.3 and 24.9 T/A, respectively, for Russet Burbank, and 34.2 and 29.2 T/A, respectively, for Ranger Russet. For both cultivars, plants from southern-grown seed set more tubers per hill than those from northern seed, resulting in a greater number of smaller U.S. No. 1 tubers per acre from the southern seed (Table 1). Specifically, 17 to 23% of the U.S. No. 1 yield of plants from northern seed consisted of oversize (>14 oz) tubers. In contrast, only 8 to 12% of the U.S. No. 1 tuber yield from southern-grown seed consisted of >14 oz tubers and a correspondingly higher percentage fell into the 4- to 14-oz size range compared with northern seed. Hence, northern and southern-grown Ranger and Russet Burbank seed produce different yield profiles in the Columbia Basin. This knowledge provides an opportunity to customize in-season management practices to the seed source, in order to achieve maximum productivity with respect to market requirements.

As expected, storage aging treatments increased stem numbers and tubers per acre, resulting in smaller-size tubers at harvest. Tuber set and size development can be estimated with a high degree of accuracy early in the season from plant mainstem numbers for all three cultivars (e.g. Ranger Russet, Table 2), providing an underlying basis for yield prediction and thus the opportunity to adjust in-season management practices to optimize productivity relative to market requirements. While Ranger is presented as the example in Table 2, the stem number/tuber set algorithms for each cultivar and seed source have been incorporated into an interactive website (Fig. 1) for growers and consultants. By plugging in early-season stem counts, our results can be reproduced for estimating the relative differences in yield profiles of two or more seed lots growing under the same management conditions in the Central Columbia Basin. We are continuously updating this website with additional data as it emerges from the study.

Another remarkable finding from the seed productivity research was that the concentration of a potential age marker, 2-methyl-butanol, was higher in seed stored at higher temperatures. The level of this compound was measured in the seed prior to planting, and correlated well with stem numbers (and thus tuber set and yield) from different ages of Ranger and Russet Burbank seed. Hence, seed butanol content predicts average stem number per plant, from which the potential yield profile for a particular seed lot can be estimated (as in Table 2 and from our website). We are continuing to develop 2-m-butanol as a biochemical marker of the relative yield potential of seed prior to planting. The seed butanol results from this year's trials will be added to the multiyear data already incorporated into the website. This marker shows promise in enabling prediction of stem numbers and thus yield potential of seed prior to planting.

In summary, our research has shown that:

- Aging seed in storage affects the productivity of Russet Burbank, Ranger Russet and Umatilla Russet seed-tubers primarily by altering stem number/tuber set (source-sink) relationships, which can result in substantial shifts in tuber size distribution.
- Within limits, manipulating seed storage temperature can effectively change tuber size distribution to satisfy certain market requirements without affecting total yield.
- Umatilla was the most sensitive to aging treatments for a shift in tuber size distribution and a decline in productivity, followed by Ranger and Russet Burbank. This underscores the need for good temperature management of Umatilla seed after harvest.
- 'Northern vigor' was nonexistent in Russet Burbank and Ranger seed (total, U.S. No. 1 and marketable yields were equivalent for northern and southern seed). However, the size distribution of U.S. No. 1 tubers was affected by seed source; northern seed produced more oversize (>14 oz) tubers than southern seed.
- Stem number can be estimated from seed butanol content prior to planting in Ranger and Russet Burbank seed.
- Tuber set, size development and yield can be predicted from plant mainstem number for Russet Burbank, Ranger and Umatilla Russet potatoes grown in the Columbia Basin.

Table 1. Differences in productivity of northern- and southern-grown Russet Burbank and Ranger Russet seed in the Central Columbia Basin of WA. Seed-tubers were acquired at harvest, wound-healed at 54°F for 10 days and stored at 39°F for the remainder of the 200-day storage period. Data are averages of 2 and 3 years of field research for Ranger and Russet Burbank, respectively.

	Russet Burbank Seed Source		Ranger Russet Seed Source	
Yield Components	**54° N Lat.**	**47° N Lat.**	**54° N Lat.**	**47° N Lat.**
% Plant Emerg. (28 DAP)[a]	47.8	86.0**	79.2	95.8**
Stem No./plant	3.4	3.8 ns	2.7	3.0 ns
Total Yld (T/A)	31.2	31.5 ns	35.2	33.2 ns
Mkt Yld (T/A)[b]	28.6	30.3 ns	33.7	32.7 ns
U.S. No. 1 (T/A)	25.1	24.7 ns	30.6	27.7 ns
< 4 oz (T/A)	3.58	5.63**	3.12	5.04**
4–6 oz (T/A)	5.15	8.01**	4.99	6.67**
6-10 oz (T/A)	9.49	10.8 ns	10.5	11.2 ns
10-12 oz (T/A)	3.81	2.49**	4.45	3.74 ns
12-14 oz (T/A)	2.30	1.54*	3.49	2.76 ns
> 14 oz (T/A)	4.32	1.94**	7.14	3.38**
Cull (T/A)	2.57	1.25*	1.50	0.46**
Tubers/plant	8.0	9.8*	8.0	9.3**
Ounces/tuber	6.6	5.5**	7.4	6.2**
Tubers/A	140,500	176,600**	146,100	171,100**

[a]DAP, Days after planting. [b]Mkt Yld (marketable yield) = total yield minus culls. *,**P≤0.05 or 0.01, respectively, for comparisons between seed sources within a cultivar (ns, not significant).

Table 2. Predicted changes in yield profile, tuber set and size with increasing aboveground stems from northern-grown Ranger Russet seed-tubers planted in the Columbia Basin (regression models upon which these estimates are based were derived from two years of field data, 2001-2002). This data can be generated from the seed productivity website (see Fig. 1).

	Percent of Marketable Yield – northern RR seed						Tuber No.		Tuber Wt.		Tubers/A
Stems/Plant	**< 4 oz**	**4-6 oz**	**6-10 oz**	**10-12 oz**	**12-14 oz**	**>14 oz**	**per stem**	**per plant**	**g/tuber**	**oz/tuber**	**(1000's)**
2.6	9.9	14.1	29.8	11.8	9.7	24.6	3.0	7.7	215.3	7.6	140.5
2.8	10.9	14.9	30.4	11.6	9.5	22.9	2.9	8.0	208.7	7.4	145.6
3.0	11.9	15.6	31.0	11.4	9.2	21.3	2.8	8.2	202.5	7.1	150.5
3.2	12.7	16.3	31.4	11.1	8.9	19.7	2.7	8.5	196.7	6.9	155.2
3.4	13.6	17.0	31.8	10.9	8.7	18.3	2.7	8.7	191.4	6.8	159.6
3.6	14.3	17.7	32.2	10.7	8.4	17.0	2.6	8.9	186.5	6.6	163.7
3.8	15.1	18.4	32.4	10.4	8.1	15.8	2.5	9.1	182.0	6.4	167.6
4.0	15.7	19.2	32.6	10.2	7.8	14.8	2.4	9.3	177.9	6.3	171.3
4.2	16.3	19.9	32.8	10.0	7.6	13.8	2.3	9.5	174.2	6.1	174.7
4.4	16.8	20.6	32.8	9.7	7.3	13.0	2.3	9.7	171.0	6.0	177.9
4.6	17.3	21.3	32.8	9.5	7.0	12.2	2.2	9.8	168.2	5.9	180.8
4.8	17.7	22.0	32.7	9.3	6.8	11.6	2.1	10.0	165.9	5.9	183.5
5.0	18.0	22.8	32.5	9.0	6.5	11.0	2.0	10.1	164.0	5.8	185.9
5.2	18.3	23.5	32.3	8.8	6.2	10.6	1.9	10.2	162.4	5.7	188.1
5.4	18.5	24.2	32.0	8.6	6.0	10.3	1.9	10.3	161.4	5.7	190.0
Coeff of det (R^2)[a]	0.91**	0.99***	0.49	0.63*	0.78**	0.93**	0.97***	0.97**	0.98***	0.98***	0.98***
Std. Error of Est.[b]	1.4	0.5	1.8	1.1	0.9	2.0	0.1	0.2	3.9	0.1	4.1

[a]Values (x100) represent the percent variation explained by the models.
*,**,***Correlations were significant at the 0.05, 0.01 and 0.001 levels, respectively.
[b]Standard errors of the estimates of percent yield, tuber set and size from stem number per plant.

Fig. 1. Website to illustrate the effects of seed source and stem numbers on tuber set and size distribution of Ranger Russet, Russet Burbank and Umatilla Russet seed potatoes in the Columbia Basin of Washington. Seed was acquired from northern (54°N latitude) and southern (47°N latitude) growing areas. Estimates of tuber set and size distribution from stem numbers via the algorithms in this website are based on 2-3-year average yields from different physiological ages of seed tubers planted in replicated plots at Othello, WA. Spacing was 34 inches between rows and 10 inches between seedpieces (1.75-2.25-oz/seedpiece) within a row. Seedpieces were planted 8 inches deep. Stem number per plant inputs to the calculator should be the average over at least 100 ft of row. All crops were grown for an average of 160 days under a linear move irrigation system. The estimates of percentage tubers in each size category from stem numbers will vary with spacing.

Access this website directly at www.ionophore.com/seed or indirectly through the postharvest variety development website (www.wsu.edu/~fullern) and click on "Seed Productivity Website"