Aging of Seed Potatoes
Physiological Process & Consequences for Production

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Exposing seed tubers to temperatures greater than 39°F (i.e. heat-unit accumulation) increases respiration and accelerates physiological aging. Apical dominance, tuber set, tuber size distribution, and economic return can be greatly affected by differences in the physiological age of seed (Knowles and Knowles, 2006). The degree of apical dominance (number of stems per seedpiece) is a good indicator of physiological age. As seed age advances, apical dominance decreases, resulting in more stems per plant. While cultivars vary in the extent of their response to seed age, in general, tuber set per plant increases with stems, resulting in a decrease in average tuber size.

Tuber set and size distribution can be optimized for a particular market by increasing or decreasing the average number of stems per seedpiece, without affecting overall yield (Knowles and Knowles, 2006). The values of seed, fresh-market, and processing potatoes are dictated in part by the specific array of tuber size classes; therefore, manipulating tuber size profiles by varying the physiological age of seed lots can significantly affect crop value. The extent of aging induced by a given period of high temperature exposure and the target stem number for a particular size distribution are cultivar-dependent.

The relationships among stem numbers, tuber set, tuber size distributions, and crop value have been determined for many mainstream long-russet cultivars (e.g. Ranger Russet, Russet Burbank, Russet Norkotah) (see Knowles and Knowles, 2006; Knowles et al., 2008). An example of these relationships is shown for Russet Norkotah CO strain 3 in Fig. 1.

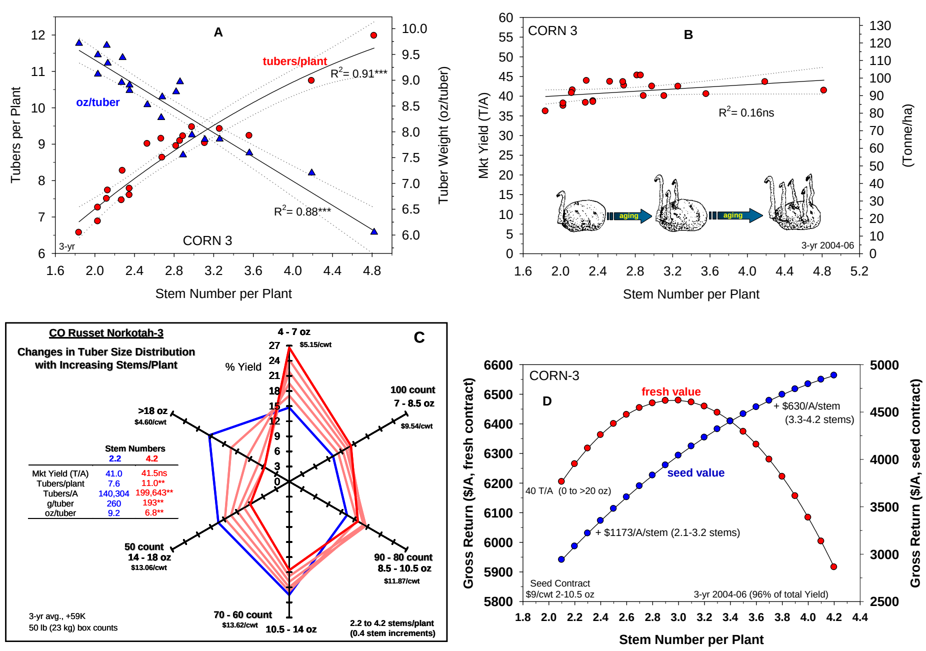

Fig. 1. Changes in tuber set and average tuber size (A), marketable yield (B), tuber size distribution (C) and economic values (fresh and seed contracts) (D) of Russent Norkotah (Colorado strain 3, CORN 3) in the Columbia Basin. Data are averaged over the 2004, 2005 and 2006 growing seasons (Knowles et al., 2008).

Development of techniques to predict, manipulate and better manage the physiological age and yield potential of seed potatoes is a core area of research in the potato postharvest program at WSU. The more we learn about the physiological process of aging, the better equipped the industry will be to understand how management practices can alter tuber physiology to affect the aging process. Recent work has suggested that tuber respiration is the 'pacemaker' of aging. Aging is an oxidative process that affects the hormonal regulation of apical dominance (Kumar and Knowles 1996a; 1996b; 1993). Preliminary studies (Knowles, unpublished) have indicated that seed tubers exposed to relatively brief periods (e.g. 10-20 days) of high temperature initially in storage, followed by holding at 39°F for the remainder of a 200-day storage interval, have a higher basal metabolic (respiration) rate at the end of storage compared with tubers stored the entire season at 39°F (Fig. 2).

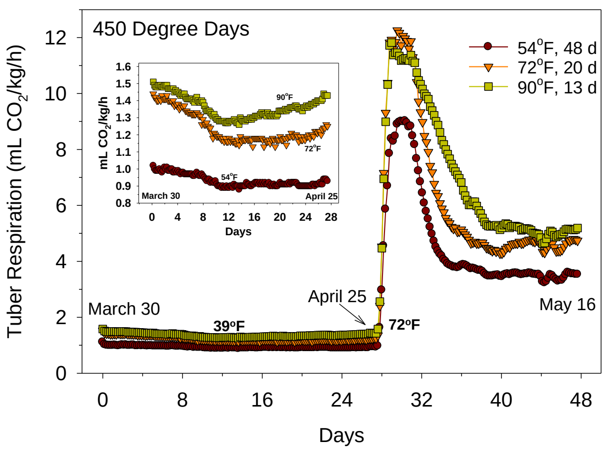

Fig. 2. Effects of high temperature aging treatments at the beginning of storage on respiration rates of Russet Burbank tubers at the end of storage. Seed-tubers accumulated 450 degree days at 54, 72 and 90°F in storage directly following harvest (late September). The tubers were then stored at 39°F until April 25. Respiration rates were compared from March 30 to April 25 at 39°F (inset). Note that tubers aged at higher temperatures at the beginning of storage had higher respiration rates at the end of storage. The storage temperature was increased to 72°F on April 25 to compare respiration rates during the early stages of sprouting. Tubers aged at 72 and 90°F had 37 and 49% higher rates of respiration than those aged at 54°F during sprouting.

These results imply that tubers 'remembered' the brief high temperature accelerated aging treatment, as indicated by their elevated respiration rates at the end of storage. An accurate but somewhat impractical measure of the physiological age of tubers may therefore be the total respiratory output from vine kill through storage to planting. Tuber respiration appears to be the pacemaker that dictates the rate of aging and production and storage conditions that affect respiration may, in effect, 'set the clock speed' that will ultimately determine the physiological age of seed at planting.

Controlled atmosphere storage studies are providing evidence of the importance of tuber respiration rate in the aging process. Seed subjected to a brief high-temperature (age priming) treatment at the beginning of storage was subsequently stored at 3.5% O_2 and 39°F until planting. The low O_2 atmosphere reduced the respiration rate of the primed seed relative to seed stored under conventional 21% O_2, and partly negated the effect of the high temperature aging treatment on stem numbers, tuber set, and tuber size distribution in the ensuing crop (Table 1, Fig. 3).

These results suggest that respiration is indeed the pacemaker that controls and reflects the rate of aging and **management practices that alter the basal metabolic rates of tubers, even for short periods, have the potential of producing tubers of different physiological age.** Physiological age may thus be the respiration rate of the tuber over a set period (e.g. from vine kill to planting). And the higher that is and the longer respiration 'ticks' at that rate, the older the seed lot will be. Knowing this, we can begin to design treatments that will set the respiration rate at different levels to control the aging process. The work is relevant to how seed is managed from maturation through storage to planting.

Seed Age*	Oxygen	2008 Trial Ranger	2008 Trial Burbank
		Stems per seedpiece	
Young	21%	2.7	2.3
	3.5%	2.2	1.8
Old	21%	5.0	5.4
	3.5%	3.8	3.7
	Age	**	**
	O_2	**	**
	Age x O_2	**	**

*80 and 600 degree-days. **P<0.01.

Table 1. Effects of seed age and oxygen concentrations during storage on stem numbers from Ranger and Russet Burbank seed-tubers. Seed-tubers were initially wound-healed at 54°F for 10 days following harvest. A seed sample was then incubated (aged) at 90°F (95% RH) for 21 days and then transferred to 39°F for the remainder of a 200-day storage period (Old = 600 deg-day seed). Young seed was stored continuously at 39°F following wound healing (Young = 80 deg-day seed). Seed was cut and planted at Othello, WA in mid April. Stems were counted approximately 55 days after planting. The effects of seed age and O_2 concentration on tuber size distributions are summarized in Fig. 3.

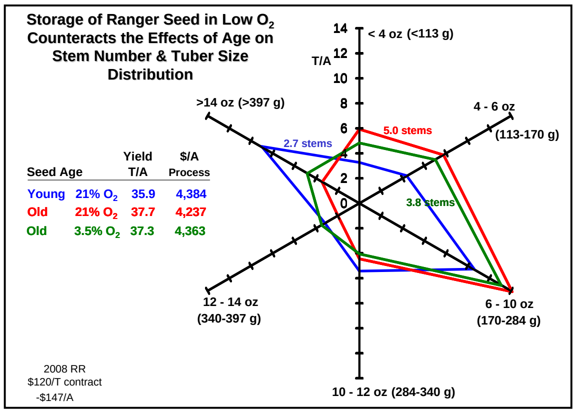

Fig. 3. Storage of Ranger Russet seed-tubers in 3.5% O_2 mitigates the effects of advanced seed age (high temperature induced) on stem numbers and shifts the tuber size distribution toward that characteristic of younger seed, which has low stem numbers.

If temperature-induced accelerated aging depends on permanently elevating the basal metabolic rates of tubers, it should be possible to demonstrate progressive attenuation of the effects of an age priming treatment on respiration over a 200-day storage period, and subsequently on stem numbers, tuber set and size distribution in the resulting crop. Preliminary studies have indicated that the sensitivity of seed potatoes to high temperature-induced accelerated aging decreases from vine kill through storage to planting (Fig. 4). However, the high temperature-induced increased respiration response was the same regardless of when the age-priming treatment was given during the storage season. These results underscore the importance of time in the aging process. Exposure of seed to a high temperature age priming treatment at the beginning or end of storage elevates respiration (the pacemaker) to the same degree; however, the timing of these treatments results in vastly different physiological ages. The only difference between these treatments is the time interval from treatment to planting. The longer the respiration rate of tubers remains at an elevated level, the greater their physiological age at planting. This research is fundamental to our understanding of the aging process and has practical relevance in contributing to recommendations for end-of-season handling and storage of both seed and processing potatoes.

Summary

- Seed age affects stem numbers & tuber size distribution in a predictable manner
- Manipulating seed age & stem numbers can alter crop value
- Aging is an oxidative process involving respiration, which responds directly to temperature
- Exposure of seed-tubers to high temperature advances physiological age

- ➢ Seed tubers ‘remember’ exposure to high temperature, which is indicated by elevated metabolic rate; respiration is likely the pacemaker of aging.
- ➢ Sensitivity of a seed lot to aging diminishes with time in storage (need to develop treatments that can ‘set the clock speed’ for aging)
- ➢ Physiological age appears to be the integration of respiration over time.

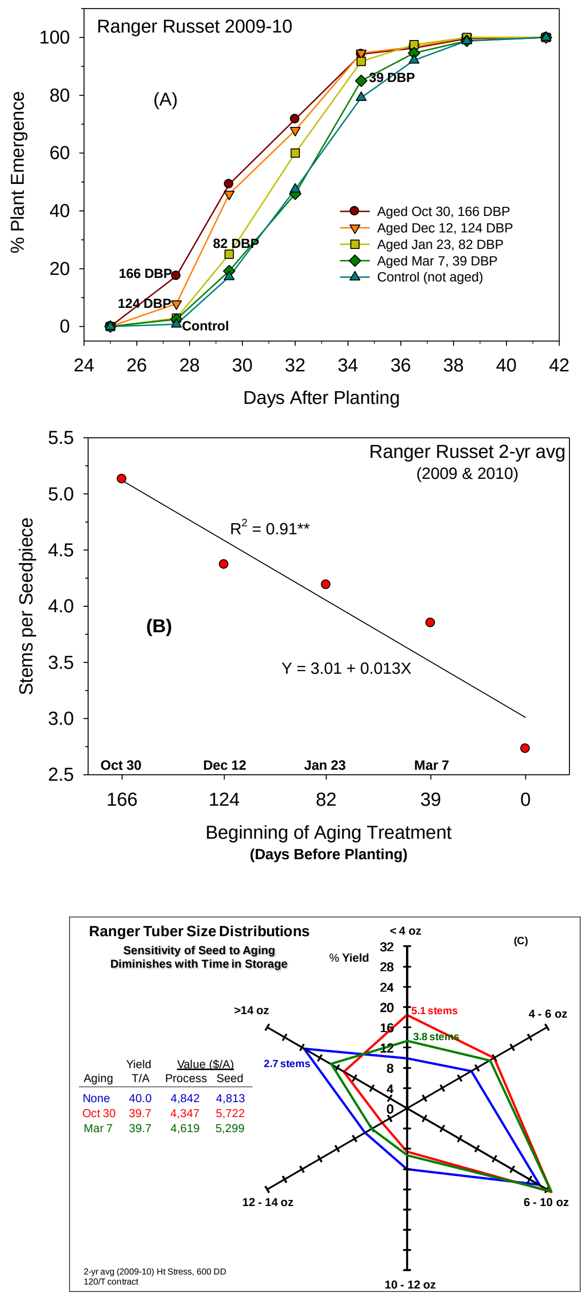

Fig. 4. Effects of seed age on plant emergence (A) stem number per seedpiece (B), and tuber size distribution (C) depend on the timing of an accelerated aging treatment (21 days at 90°F) during the storage season. Seed tubers are most sensitive to high temperature-induced accelerated aging at harvest and become progressively less receptive with time in storage. For these studies, seed-tubers were acquired at harvest and wound-healed at 54°F (95% RH) for 10 days. The seed was then stored at 39°F, except for brief (21-day) aging treatments at 90°F (95% RH) given to separate samples on Oct. 30 (166 days before planting, DBP), Dec. 12 (124 DBP), Jan 23 (82 DBP), and Mar. 7 (39 DBP). Control (non-aged) seed was stored the entire season at 39°F. The four aged seed lots had each accumulated 600 degree days (4°C base) at different times over the 200-day storage interval. Note that the greatest effect of the aging treatment on hastening plant emergence and increasing stem number occurred when given early (166 DBP). The effect of the age priming treatment diminished progressively when imposed later in the storage season. The age priming treatment sets the pacemaker of aging (tuber respiration) at a high rate and the longer the respiration is maintained at a high rate before planting, the greater the physiological age.

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