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Giant Pumpkins: Genetic and Cultural Breakthroughs

Jules Janick

The increasing record size of pumpkin has become an intriguing phenomenon over the past 150 years. The recent listing of winners in the *Guinness World Records* has provided incentive for hundreds of passionate growers worldwide to compete for financial rewards in prizes, returns on the sale of seed, and fame in the world of horticulture. A number of grower organizations are involved and the rules are wide open; nothing is prohibited except adding external weights, although there are careful regulations that require precision for the weighing procedure while rotting pumpkins are disqualified. Competition has become intense and in many ways the phenomenon is similar to sporting events involving racing animals (horses, dogs, camels, and humans) in which industries have been created and sums are wagered (Hill and Bünge, 2004). There are a number of other contests involving plants, e.g. fruit size (tomato, apple, lemon), plant size (sunflower, rose, amaranth), or crop performance (yield of maize and wheat), but none have caught the attention of the public as pumpkin fruit size. Competitors in the strange world of pumpkin size have been growers and plant fanciers with little interest shown up to now by the scientific community. The spectacular results being achieved have all been by empirical means suggesting that advanced degrees and science often take a backdoor to ingenuity achieved by ordinary folk.

HISTORY OF THE CONTEST

Interest in large pumpkins derives from exhibits from state agricultural fairs that became an important part of North American rural life in

Figure 1. William Warnock with his 403 pound Mammoth Giant Pumpkin and his medal from the French Exposition Universelle of 1900 (Connolly, 2006).



the 19th century. In 1900, William Warnock, a grower in Ontario, Canada received a special bronze medal from the French government for a 400 pound pumpkin exhibited at the Paris World's Fair (Fig. 1) and in 1904 provided tips for growers. Since then, a number of contests have been held regularly in the United States and at present pumpkin organizations include the Great Pumpkin Commonwealth (GPC), The New England Pumpkin Growers Association (NEPGA), and The World Pumpkin Confederation (WPC), whose pumpkin weigh off was established in 1983, along with the Riesen Kürbis Forum in Germany, and Giant Vegetable Growers of Ontario, Canada. Although the contests are international, most of the records have been achieved in New England located in the northeastern United States, where competition is fierce. The 2007 record (Fig. 2) is an astounding 1689 pounds (766.3 kg). The giant pumpkins have led to bizarre spinoffs including pumpkin cannons and pumpkin boat races (Fig. 3).

GENETIC MATERIAL

A number of cucurbit species have large fruit size including *Cucurbita pepo* and *Cucurbita maxima*. The contest now is centered on round orange or grey fruits of *C. maxima*, which has long been known to produce the largest fruit in the plant kingdom. The giant round orange phenotypes of *C. maxima* appear to be in a narrow gene pool out of 'Atlantic Giant' (oblong phenotypes are called 'Dill's Atlantic Giant' developed by William Dill, a Canadian from Nova Scotia, Canada). It is likely that the

'Atlantic Giant' and related huge show pumpkins trace their origin to the cultivar 'Mammoth,' recorded in the seed trade as far back as 1834 (Tapley et al., 1937). There has been continuous selection for size over a century with no evidence that the gains in record fruit weight, in absolute terms, are slowing down (Fig. 4). In fact, the 2007 record pumpkin exceeded the previous winner by 187 pounds. This large positive trend is suggestive of significant genetic change along with advances in cultivation techniques although definitive tests of trials with older germplasm have not been made. As the competition has increased, breeding and selection efforts have taken place with increasingly large sums paid for seeds of record winners (the record appears to be US\$850 for a single seed). Breeding systems have been empirical but recently pedigrees have been established for contest winners, similar to those found in horse racing.

CULTURAL PRACTICES

The cultural practices used to achieve fruit size include a number of standard practices in horticulture including improving soil tilth, good nutrition, pruning and fruit thinning, pest control, and season extension by using plastic covers in the spring (Langevin, 2003). Appropriate light and temperature is usually achieved by selection of locations favoring long days, cool nights, and warm sunny days without temperature extremes. Thus, there is clearly a latitude effect in record pumpkin size. There have been attempts to use misting to control day temperature, application of growth regulators, grafting to increase the number of root systems, and there are references to feeding of milk in the popular literature (my favorite is the chapter entitled Summer-Time in the classic 1933 book *Farmer Boy* by Laura Ingalls Wilder).

Figure 2. World record giant pumpkin, 2007 grown by Joe Jutras of North Scituate, Rhode Island, USA.



Figure 3. Race of the pumpkin boats.
Courtesy of Wayne Hackney.



Recent record results suggest that a combination of improved culture and genetic change is responsible for the enormous increases in fruit size in giant pumpkin.

As the contest progressed there were a number of goals that seemed unachievable but each has been surpassed with ease. The first goal was the 500 pound (187 kg) pumpkin, quickly followed by 1000 pound (373 kg) and 1500 pound (560 kg). The 2007 record yield of 1689 pounds points to a new goal of 2000 pounds (746 kg) and clearly the international scale of the conference will make 1000 kilos (2204 pounds) the goal in the near future.

THE PHYSIOLOGY AND GENETICS OF FRUIT SIZE

The accumulation of fruit size is a combination of physiology, environment, and genetics. The water content of pumpkin is about 88% and may be as high as 91 to 94% in giant pumpkins

(Culpepper and Moon, 1945). The fruit acts as a physiological sink and the combination of cell size and cell number determines final fruit size. In large-fruited pumpkin as compared to fruits of smaller cucurbits there is a more extended period of cell division and greater cells expansion after cell division ceases (Sinnott, 1939). In the larger show pumpkins the period from seeding to harvest is about 130 to 140 days while the period from pollination to harvest is about 60 to 80 days but the major growth phase is considerably shorter and must be under genetic control. As a practical matter, since pumpkin is grown outdoors there is a seasonal limit in temperate climates. The growth of fruit is under negative genetic control, thus in small fruited species a gene that stops fruit growth was first identified as *fw 2-2* in tomato and cloned (Liu et al., 2003). Mutations in this gene result in continuous fruit growth. Interesting enough, the physiology of fruit growth in pumpkin has not been extensively studied in relation to cell number and cell expansion. It is unclear when cell division ceases in *C. maxima* fruits or how large each cell can be. Weight estimates made in intervals throughout the season indicate that maximum daily gains can reach 50 pounds (18.7 kg) per day, as compared to about 3.5 pounds (1.3 kg) per day fresh weight with cattle.

SCIENTIFIC QUESTIONS

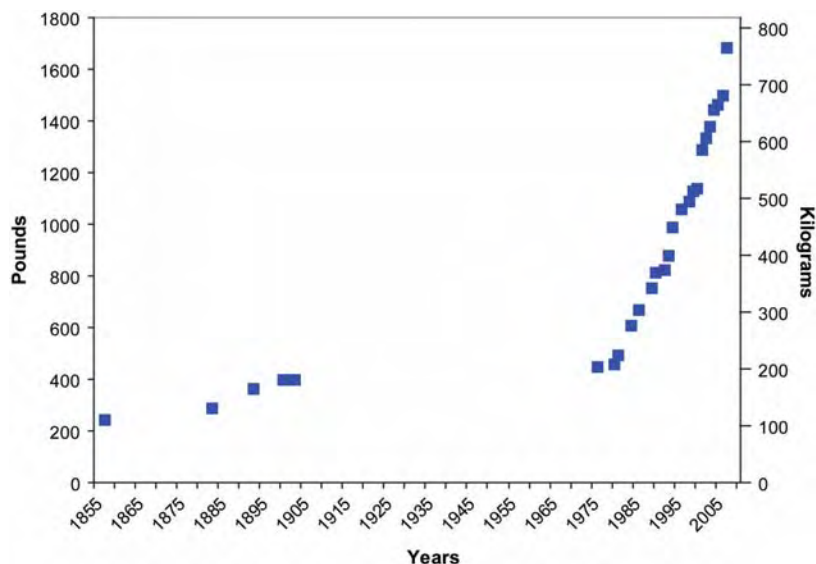
The success achieved in increasing the growth of pumpkin fruit is a challenge to horticultural science that has been ignored. An obvious question would be to determine the upper limit of fruit size; another would be to apportion the genetic, environmental, and physiological limits. Perhaps, there is no obvious limit and it might very well be possible to continually expand fruit growth if fruit senescence could be deferred or eliminated and increased cell number could be continued indefinitely. Clearly, answers to these questions are being approached empirically by

nonacademic horticulturists, and it is time for the academic community to get involved. Someone has accused academics in the agricultural arena of merely proving that the practices achieved by the best growers are correct. I suggest the academic and scientific community cooperate on this engaging problem for the delight of the public everywhere.

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Figure 4. World records of pumpkin fruit weight, 1857 to 2007.



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