SEED STORIES

Special Seed Edition

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"Agricultural skill is primary to a healthy society, and seed production is basic to agriculture"
Rob Johnston Jr., Founder, Johnny's Seeds

Seeds are so vital to agriculture and the growing of food, yet we take seeds for granted. We drive to a store, grab a packet of seed, plop down some money, and we head home to sow them, just as easy as that. Sometimes we leave them around for a while before sowing them, degrading seeds in the packet, because we fail to realize seeds are living organisms.

Not all seed are created equal. Some seeds were chosen from a field of plants by someone two thousand years ago, and may have traveled by camel or horseback in the pockets of someone taking a long journey over more than one continent to get here. Some took centuries to refine, removing all its bad habits, before it was truly domesticated. Others have been going in circles for a long time before it stopped here.

Some seeds were stolen, and carried in a totally different direction from their intended destination. For some valuable seeds, wars were started, with many paying the price with their blood. Some seed were left on the wayside, waiting for water that never came, and only one was left to carry on. Some seeds were lost forever, never to benefit mankind.

Seeds have traveled wherever man traveled from the time he ended his nomadic existence hanging out in trees, and settled down to a piece of land. We do know that all the seed of food crops grown in Hawaii came from somewhere else, and needed some assistance to get here. Just like us, each seed is an individual with a story to tell; how it endured trials and survived. Yes, not all seed are created equal as we'll learn in this special seed issue.

Getting here can take some twists and turns, as this story tells. A British ship attacked a French frigate on its way to Mauritius in the Indian Ocean. On the ship were a number of mango plants destined for planting on the island. The British, noticing that the plants were distinct cultivars, assigned each one a number. The British took the mango plants on a totally different direction, to the Caribbean. There are no records of the others, but Number 11 fruited and spread through the

Caribbean where it found its way to Florida in the 1800's, finally reaching Hawaii in the early to mid-1800's.
Today we call it the Common Mango, one of the most prolific mangoes known for their off-season fruiting habit in Kaunakakai, and its unique cluster of fruits. It's used as one of the main rootstocks to graft mangoes, along with Chinese or Pake mango. There's some who believe that the Chinese or Pake mango is Number 9, but we'll probably never know because not all seeds or plants travel with their name tags on.

I still remember a Filipino man who shared a story of how he brought this special pumpkin to Hawaii with him when he emigrated from the Philippines. He stuck them between his toes to hide them, and brought only four seeds. These kinds of stories are not far-fetched. For many people, seeds are so precious to them that they would do anything to have them, grow them, and keep them growing. These are real stories of how far people will go to grow and keep the best seed.

Eliot Coleman is author of the book, The New Organic Grower, and a real down-to-earth, common sense kind of farmer and farm tool inventor. This is what he says about seeds. *"I doubt if anyone will dispute the importance of good seed. Without high-quality seed, all the other activities are moot."* He goes on to say, *"The vigor and viability of seed grown under the careful cultural practices of this (organic) production system will far excel seeds that are purchased… I doubt that the direction of present-day seed breeding, selection, and genetic manipulation is favorable to the producer of high quality vegetables…Seeds are the spark of the operation, and the more control the grower can exert, the more dependable the system will be."*

I couldn't convey these thoughts any better, which is why I grow some of my own seed, and try to add a few crops to my growing list each year. Right now, I save daikon, lettuce, broccoli, okra, green onion, eggplant, tomato, Hawaiian shallot (akakai) bulbs, and more recently carrots and broccoli. I dry them, process them, and store them away for the next season, and even share them with others so in the unfortunate case that happen to lose them, I can fall back on them.

The weather is so unique in Hawaii, and there are few places in the world that have the same climate as us. Matching the seed with the climate is the key, but that means testing seed from around the globe, and also predicting which seed from what area of the world will do best here. Seeds keep traveling until they find a good place to settle down, and put down some roots. They become adapted to Hawaii through natural selection; the local environment will favor certain characteristics over another, and this will be expressed by the plant under certain conditions. By growing these seeds for generations, they will slowly adapt to our specific location and environmental conditions.

One strategy employed at the college is to conduct variety trials. We grow a bunch of different varieties of a specific crop and collect data on the different characteristics, whereby farmers can decide what variety of grow. The problem is there are so many varieties of a certain crop, and so many variables to evaluate, such as seasons, different input levels, and different irrigation levels, etc. This is only a starting point, and farmers must do their own testing to determine what variety best suits their farming system.

What About Garlic?

I get a lot of inquiries about what variety of garlic grows well in Hawaii. Choosing the best adapted garlic variety for Hawaii is a crap shoot, but understanding origins of garlic and where it migrated may provide some ideas on which ones would do best in Hawaii. Garlic is native to Middle Asia, in a crescent encompassing the mountainous foothills of three mountain ranges from Iran to China, the southern parts of the former Russian republics of Turkmenistan, Uzbekistan, Tajikistan, and Kyrgyztan, and also Afghanistan, Pakistan, and India. From there, garlic was carried in all directions and evolved into many different land races or varieties. Like humans, plants can adapt and acclimate themselves to different environments through selection and breeding.

Knowing this, I would select garlic that migrated south, such as the Mediterranean, including Italy and Spain, one of the areas where garlic was domesticated, as well as tropical areas of India, Africa, and Southeast Asia. I hope to conduct some trials to find which garlic is adapted to Hawaii. The Philippines has some strains of garlic, but knowing the history of that place, that garlic probably came from Spain. These varieties have done well in Hawaii, and are very potent, but have small cloves.

Carrot seed flower, called an umbel. Summer 2013

New Seed Crops

Carrots, under most temperate conditions, take two years before going to seed. I believe that due to the cool spring we had in Hoolehua the past spring, carrots planted in February are going to seed in August! These are some of the idiosyncrasies of growing certain vegetable varieties in Hawaii, and you never know until you try it for yourself. You could be capitalizing on a great competitive advantage. Selecting seed usually takes a large enough set of plants, say 50 to 100 plants to see differences in each plant.

Breeders will prioritize their breeding program, selecting for specific characteristics. In the mainland, earliness and cold-tolerance are two high priorities. In Hawaii, characteristics such heat tolerance, disease resistance, and adaptability to short days and hot humid conditions are all

important priorities. Hot days with warm nights are climatic conditions unique to the tropics, and many seeds bred for temperate conditions have a hard time thriving and even surviving in these conditions, but some of their ancestors may have had these traits.

It's only through growing, and also selfing plants or crossing them with themselves or a sibling that can we see what's in the background or in the bloodline of that plant. This is one step in creating new varieties for Hawaii. Having the right seed for your conditions can mean the difference between success and failure in farm production, and it starts with screening seeds for your specific conditions.

Hidden Treasure

Kauwela (far right) taking on the competition from Oregon – Summer 2012

Nana I Ke Kumu (Look to the Source)

At one time, the University of Hawaii College of Tropical Agriculture and Human Resources were the world leaders in the development of tropical vegetable seed varieties, and I was fortunate to work with one of the movers and shakers in this area of research. Some people you meet can inspire you beyond your greatest imaginations, and it was a chance meeting in a hallway of St. John Hall at UH Manoa that changed my life, by a teacher who happened to be a world-renown expert in his craft, and that was in breeding vegetables.

As I walked down the hall between classes, I heard this voice calling me, "Hey you, come here! I stopped, turned around, and walked toward him. He asked me, "What's your name?" I told him my name, and his next question was, "What high school did you go to?", and I told him, "Kamehameha." His reply was, "You're gonna be working with me." I was kind of dumbstruck, but I decided to go along with him because he was sincere and serious, and I didn't know where all of this was leading to. He was an older person, lean and weathered, but in good physical condition.

I could have said, "Get lost!" and be on my way, but I didn't. Besides, I didn't know who he was, but I figured he was probably a college professor. He told me to sit on a chair in his lab and read all these research papers on the table. I started reading this one foot tall stack of research papers that day, and all of them had something to do with tomatoes- diseases, insects, breeding, chromesomes, and on and on.

I found out that day that he was Dr. James Gilbert, a vegetable breeder, and a former teacher at Kamehameha. When I met him, he was almost 70 years old, but he was extremely knowledgeable and had lots of friends in high places of the seed world. You could tell he was the real thing, a gruff old man with over a half century of experience, unassuming, never caught up in himself, and very committed to what he was working on. After reading most of the research papers he assigned to me, my first project was to identify tomato quality characteristics of 93 tomato selections in a large field at the Poamoho Research Station on the North Shore of Oahu, not far from the town of Wahiawa.

There were 92 selections, with 50 plants of each selection, and I would walk down each row and evaluate each selection, looking for plant differences within a selection, and collecting data on fruit shape and size, inside and outside color, size of the stem and blossom end scars, numbers of fruit in the clusters, and also any defective characters such as nipple tips, green gel around the seeds, green shoulder color, and cracking, both radial and concentric. I also had to taste each selection.

On the first day, I was ready to quit. My stomach was aching from eating too many tomatoes even before I got half-way through the selections. I told him, "Doc, I can't do this. My stomach is aching from eating all these tomatoes!" Then he tells me, "I didn't tell you to EAT the tomatoes, just TASTE 'em and SPIT 'em out!" After he clarified that, everything worked out alright and we worked together for a year.

Some selections came from other parts of the globe, and many were crosses with wild species from Central and South America. The wild ones have resistance to many of the common diseases of tomato, but they're small and some taste really bad and were even poisonous. Dr. Gilbert would also walk through and make his selections, and we would keep the fruits of the best selections, and process the seeds for the next season's trials. The challenge was to find the good tasting ones with a combination of quality characteristics and disease-resistance.

He would take the best selections and cross them with the large ones, and hopefully create a large tomato with good market characteristics and resistance to diseases. Easier said than done! For one thing, small fruit is a dominant genetic trait, and also there's a whole bunch of quality characteristics we were looking for. The other challenge was that some of the good genes were connected to bad genes such as root-knot nematode resistance with bad fruit cracking, so you had to find that individual plant that had the good character without the bad one.

Through his research, Dr. Gilbert accomplished just that. He found a large fruited selection with resistance to a bunch of diseases and it had dark red fruit, but sometimes it inherited bad habits from its wild relatives. It would take generations of growing to cull out the bad characteristics and refine the selection. Something like us, so we would clean it up by growing a large field of it

and selecting only the best ones for advanced selections. This is what vegetable breeding is all about. What I didn't realize at that time is that we were doing ground-breaking research that would benefit farmers and mankind for decades to come.

Dr. Gilbert wasn't just any vegetable breeder, he was one of the top tomato breeders in the world, and was involved in conventional breeding to develop disease-resistant tomatoes the old way, using Mendelian genetic principles. He had a special combination of skills because he was a plant pathologist or disease expert and also a plant breeder, a rare breed.
He was also part of an elite group of researchers with similar skills located across the US, in Florida, California, Oregon, Ohio, Michigan, North Carolina, Maryland, and other places, and they all collaborated with each other to breed these special disease-resistant tomatoes as part of a national consortium, the Southern Tomato Exchange Program (STEP). Dr. Gilbert was not only one of the ring leaders, but the top dog, a pacesetter because he was the only one who could breed tomatoes ***all year-round!*** The others had to deal with the challenges of winter. This is one of the advantages of conducting breeding programs in Hawaii, and it seems like others have finally figured this out.

All told, he had selected and bred tomato varieties with resistance to over 12 different tomato diseases in one plant, unheard of in plant breeding. He also collaborated with breeders in foreign countries, and seed packets would arrive from all parts of the world, and we would include some of them in our field trials. To me, this was so intriguing, and to have a walking library at my disposal was truly a gift. Everyone else had to attend classes to learn, but I had the class to myself.

Dr. Gilbert also taught a class in Vegetable Crops, and he worked with all the movers and shakers of the vegetable breeding world such as Henry Munger of Cornell and Tex Frazier of Oregon State, considered heavyweights in their part of the world. I could ask him almost any question about breeding and tomatoes, and about most vegetables, for that matter, and he would know the answer. He also bred lettuce, beans, peas, soybeans, cucumbers, eggplant, and others. That was in 1976, and the fruits of his work are still seen today.

In Florida, one of the main tomato growing states, a major disease is tomato bacterial wilt where whole plants would wilt when the bacteria attacked the root system. Once the disease is in the ground, it's hard to kill, so the only strategy is to breed resistant varieties. Resistance to this disease came out of a tomato selection from Hawaii, Hawaii 7996, from Dr. Gilbert's program. But the biggest mystery was where did this plant come from? Nobody knew and Dr. Gilbert's field notes didn't provide the answers.

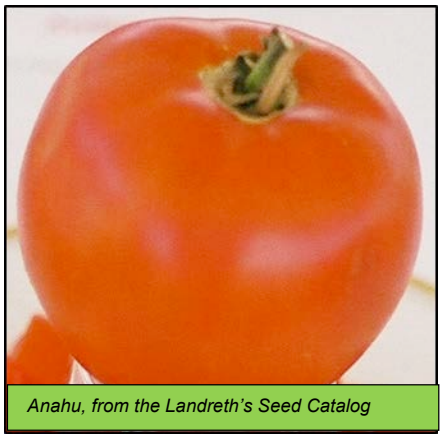
Pedigree is important for plant breeders because it may provide answers to future disease problems, and helps them predict which selections might be resistant to certain diseases in the future by performing a genetic map of each selection. Florida State University tomato breeder

Jay Scott used Dr. Gilbert's variety, UH 7996 to add bacterial wilt resistance to his tomato selections in order to create bacterial wilt resistant tomato varieties for Florida, and the U.S. Dr. Gilbert also created a tomato variety called Kewalo with resistance to this disease, and is grown in many Pacific islands where bacterial wilt is a problem.

You never know where the fruits of your labor will end up. In the 2010 report of the Tomato Genetics Cooperative, a world-wide consortium of tomato breeders, they acknowledged Dr. Gilbert's contribution to this work and in tracing the origins of this tomato thirty years after he retired, they quote, "*Breeding is an art as much as a science, and the exact pedigree of the most famous bacterial wilt resistant line, 'Hawaii 7996' will probably remain the secret of the breeding genius of the late J.C. Gilbert."* To have a mentor like him was unreal, and I just have to count my lucky stars for that chance meeting. There were other great mentors along the way, but Dr. J.C Gilbert was definitely *OUTSTANDING* in his field.

Anahu to You

Dr. Gilberts greatest claim to fame was the development of a tomato variety called Anahu. It was named after one of his students at Kamehameha. Bill Anahu was a pilot in the Korean War, and was killed in combat. Anahu was the star tomato with resistance to at least 6 diseases, and used to develop many of the commercial nematode-resistant tomatoes grown in the world. This variety would top many university tomato trials held by the Southern Tomato Exchange Program (STEP). The strategy was to cross Anahu with a high quality tomato developed in the respective states, and this strategy was able to accelerate tomato breeding tremendously in the U.S.



Anahu, from the Landreth's Seed Catalog

One of Anahu's progeny is Celebrity, an All-America Awards winner, who like its parent has resistance to many diseases and also root-knot nematodes, a major production challenge even on Molokai. Anahu was also used to develop indeterminate hybrid tomatoes for the tropics, and the most popular was a variety called N-52 developed by the University of Hawaii, planted throughout the tropics, in the Pacific and as far away as Israel. When a flood washed out the UH Seed Lab in Sherman Hall several years ago, the other parent of N-52 was lost. STEP 305 was a selection developed by Florida State University in the 1970's with both high quality characteristics and disease resistance, and was lost in the flood.

I have spent about three years trying to track down this variety in the US and in foreign countries, Canada, France, Belgium, and the Netherlands. Recently, I found it in Beltsville, Maryland and also at the Asian Vegetable Research and Development Center in Kaoshiung, Taiwan. Getting the seed is one thing, but getting it to germinate is another. The seed from Maryland failed to germinate, so I'm hoping the ones from Taiwan will be the bomb. We'll find

out in a month or two. This adventure has made me realize how easy seeds can be lost, and when they're lost, they're lost forever. This is how fragile some of our seeds really are, and we've seen the loss of Hawaii taro varieties just in the last 20 years.

The Right Variety

Having the right crop variety is another important piece of your production system, and I've been talking a lot about this because I see this as the Achille's heal in many farms. We don't have a lot of options, so we grow the best ones we can find, but it still doesn't fit. Even the papaya variety we grow could be improved because it ripens too fast during summer months. Many other crop varieties are developed for high input systems or for temperate regions.

Matching the right variety with the farming system is the key; there are organic varieties, and these are usually the old heirloom varieties, and there are conventional, high-input varieties. Using varieties with 'wild blood' or ones developed in low input systems can make a world of difference in both organic and conventional agriculture, and I've seen it first-hand on Molokai. The best example of this was a simple observation trial I conducted on a farm. The farmer was Johnny 'Pineapple; Keohuloa, a great tomato grower and a great cooperator because we would agree to the plan, and he would implement it.

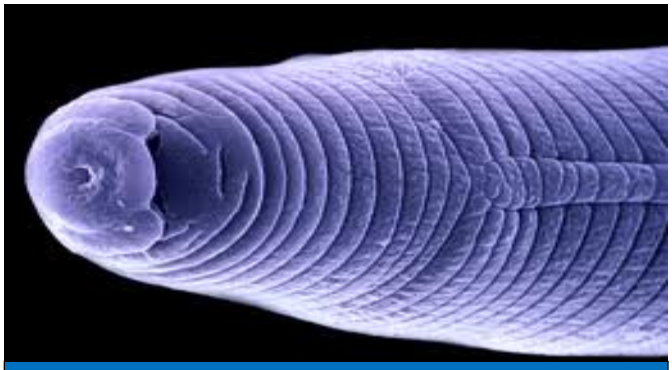
In a field trellis system, he grew two indeterminate tomato varieties, Hawaii N-52 and a new Goldsmith tomato variety. Goldsmith Seed tomatoes were the new kids on the block with a reputation for large, firm, bright red beefsteak tomatoes, but were they adapted to Molokai's conditions? Both varieties had large fruit, but Goldsmith was a little larger and darker red.

As the fruits were ripening on the vine, all the Goldsmiths had 'blossom end rot' (BER), a physiological problem where the bottom of the tomato turned black and was deemed unmarketable. The main cause of BER is a calcium deficiency, but it could be triggered in many ways, including too much nitrogen fertilizer, insufficient water, and even nematodes. But one tomato variety could also have a higher demand for calcium than the other variety. In other words, some tomatoes are more efficient in utilizing what nutrients they can get.

Turns out the Goldsmith tomatoes were bred and selected in Florida on calcareous soils, soils having high calcium content due to their sand and coral content. Under these breeding conditions, tomatoes grown in this place will be adapted to and selected for high calcium conditions. In other words, these tomatoes were being selected to grow well in Florida, and not in Hoolehua, Molokai. Our soil is naturally low in calcium, but there are varieties selected for our conditions. Also, some varieties are more efficient users of fertilizers, especially those with 'wild blood'.

Hawaii N-52, on the other hand, has lots of wild blood derived from tomato relatives such as Lycopersicon peruvianum and L. hirsutum in one of its parents, Anahu. Developed in Hawaii for Hawaiian conditions, including climate, diseases, and insects, these wild relatives carry special

genes for resistance to diseases and insects, and are adapted to extreme climatic conditions. This is only one variety of vegetable, and we need varieties of all vegetables adapted to the different farming system that we adopt. This is where variety trials come in, and if we don't find what we want or need, then we have to develop them. This sounds like a lot of work, but this is the first day of the rest of your life and once you've found it, then you have it.



Electromicrograph of Meliodogyne javanica

Nematode-Resistant Varieties

Hawaii was in the forefront of developing of nematode-resistant seed varieties. Nematodes are microscopic eelworms that cause root damage. The worst ones are the root-knot and reniform nematodes, both major pests on Molokai. Root-nematodes cause galls on roots and affect uptake of nutrients of water, and there are two species in the lowlands, *Meliodogyne incognita* and *Meliodogyne javanica*. Of these, the Javanica nematode is more difficult to control, and the most common species on Molokai of the two. The Reniform nematode, *Rotylenchus reniformis* will attack small feeder roots. They're usually antagonistic, so if you find one kind, you won't find the other.

Both have a wide host range. Reniform nematodes are major pests of pineapple, sweetpotatoes, heliconia, and many other crops. Root-knot nematodes attack beans, tomatoes, eggplant, okra, beets, carrots, radish, taro, papaya, peas, cucumbers, and many other crops. Control with pesticides is very costly, and many nematicides or nematode killers have been banned due to their impact on the environment and their toxicity. We don't know enough about reniform nematode resistant crops, so much research is needed.