Article by Alison Cooper

I am not a geneticist or plant scientist, with no knowledge of Mandarin or Taiwanese, so a visit to the World Vegetable Centre (AVRDC) home for the World's largest public vegetable gene bank, in Taiwan, tested my skills of interpretation and translation to the limit.

Working especially with farmer's co-operatives across Asia, India and Africa, AVRDC supplies crop seeds, adapted to survive whatever misfortunes an increasingly fickle climate and trails of over breeding and overcrowding throw at them.

Headquarters for the World Vegetable Centre, an international Non Governmental Organisation is located in the region of the old Taiwan capital, Tainan County. The centre attracts scientists across the world, while retaining strong ties to the local community of Shan Hua, a town with a long established agricultural tradition.
Providing the roots for the Centre's activities, Dr Andreus Ebert from Germany and Taiwanese Mr Whan share responsibility for curating Gene Bank's the vast collection. I had the chance to glimpse inside the heart of this real life archive and out in the fields, speak to researchers using the records to conserve rare indigenous vegetables and create hardy new varieties of familiar favourites like tomatoes.

Approaching the bank my steps fall into the sifting rhythm, transmitted from a circle of people in conical straw hats, crouching among the trees, shifting and shaking pans of seeds. Like most things in Taiwan it was important to move beyond first impressions. **I was soon to learn that this was more than a musical accompaniment, and in fact an ingrediant of the scientific process of sorting and selecting seeds for preservation in the gene bank vaults.**

Changing into slippers so that I don't carry spores, viruses or other plant pests in on my shoes, I accompany Dr Ebert on a guided tour of the bank.

1. **Processing** – Within the walls, genetic inheritance information from over 56,000 global varieties, collected over 30 years, is identified, coded and stored. Records in this unusual library are in the form of germplasm, the genetic information that allows plants to reproduce. While most is seeds, there is also an alium store for onions, shallots and garlic and tubors like potatoes as their structure and high moisture content needs different treatment.

   Shuffling into the first space, we see seeds being processed, extracted and cleaned, mostly by hand. Seeds are selected, bad seeds, very small seeds damaged seeds or those not confirming to the standards are removed. For long term preservation, temperature and humidity must come down. In this short term storage and processing area the temperature is cooled from the average 25-30 °C outside to 15°C.

2. **Storage** – The door of the cavernous chamber for medium term storage, clunked shut behind us. Here, temperature is reduced to 5°C like the inside of a domestic fridge, giant fans reducing the humidity to 45%. Different species require slightly different treatment to balance the temperature and humidity levels with the viability limits of the variety. Some seed surfaces will crack at lower temperatures, affecting their ability to grow outside. Coco seeds are not suitable for long term storage as they quickly loose viability, and coffee can only be stored for a few months.

   I was lucky enough to catch a rare glimpse inside the second chamber. The long term store can't be opened very often as this will increase the already enormous amount of energy needed to regulate its environment. The humm of fans and giant fridges became a roar as the door sealed. Temperature is below 0 °C, with humidity of -10 to 18%. Under these conditions seeds are expected to last between 50 and 70 years. They must not however, be forgotten, samples are grown outside at regular intervals. I am told that farmers would soon complain if the proportion of viable seeds is low and they regularly fail to germinate. First seeds must be mobilised by imbibing to take up water. Plants can then be grown outside, and their seeds harvested to maintain the variety. Wherever possible, it is best to use the originals, as each time seeds are grown outside they start to adapt to the conditions in Taiwan, losing their native characteristics.

   Care is taken to preserve indigenous crops, defined as those that are not immediately of major commercial importance world wide, in line with national programmes across the World. Examples include, egg plants, okra, loofah and bitter gourds, rich in antioxidants under investigation for treating diabetes. Older varieties may be more hardy with better resistance to disease than cultivated hybrids with desirable commercial characteristics and a narrow genetic basis.

   Dr Ebert tells me, small farmers need to use a risk management strategy of growing mixed crops together so they are less vulnerable to specialist insect attack. Failure to do this was responsible for totally wiping out coffee in Shri Lnaka which had to be replaced by tea. It was necessary to return to the origin of the crop in Etheopia to find older varieties with natural genetic resistance. The gene bank exists to help manage such eventualities.

3. **Conserving Indigenous Vegetables** – Out in the sunshine, heavily pregnant Mandy Ji La Lin took me on a tour of the indigenous vegetable garden. Here, lesser known

species with promising characteristics, either for commercial development or crossing with current popular varieties are grown. Tiny wild tomatoes gleam like holy berries, inedible for humans yet more hardy and resilient than their cultivated cousins. Creamy white African egg plant nestles among lush green and purple African cassava (sweet potato leaves) and, and I spot pink tarot popular in hotpots and markets across Taiwan. I am intrigued by the thorny coriander, popular in Thailand, exotic, pungent and aromatic for humans but far less attractive to insects than the commonly available round leafed type.

Mandy told me many of these vegetables are considered to have strong unpleasant tastes and smells making them less popular candidates for commercial development. She reminded me they have uses beyond food like washing skin and clothes and water purification. As well as climate resilience plants can also be selected for nutritional properties such as high antioxidant or beta carotene content (vitamins). This is often indicated by deep colour, greens, purples and yellows, and can help human immunity. Plants shelter in net cages to protect them from virus carrying Taiwanese whitefly and avoid cross pollination, maintaining the purity of the lines.

Transferring the information to records library helps prevent less immediately commercially attractive crops disappearing from existence, as farmers feel pressure to replace local varieties with high yield hybrids. Plants are measured, observed and photographed, recording days to flower and fruit, and fruit size and weight. I set out to discover how to identify which ones have the real X factor.

4. **New Stress Resilient Varieties** – In the greenhouse scientist Rachael Symonds (UK), described how she combines indigenous genes with commercial varieties to improve survival in extreme conditions.
   'I have been working at an international research centre with an international community for the global public good'
   "Why we are doing the research is to help plants survive under stress, for example tomatoes with thicker skin may be more resilient. This is vital now as the climate is changing and the world is getting drier and hotter. Plants, especially vegetables won't be able to live where they do at the moment. We need to produce high value nutritious crops for areas most affected like Sub Saharan Africa."

   She told me, commercial varieties can be crossed with wild types that you can't eat to help their tolerance to stress. For example some types of inedible wild tomato growing naturally near the sea may be more resistant to drought and dehydration from salty soil by having a different type of cell membrane barrier structure. These can then be bred with some of the more commercial varieties to produce food crops better able to survive.

   "We've got a gene bank with thousands of varieties so we select types of interest, often going back to the wild type to cross them with cultivated varieties. Seeds that don't get selected for one experiment are returned to the bank for use at another time and place."

   Controlled experiments are used to test this out, comparing samples of tomatoes with known characteristics with the new varieties in controlled dry and wet conditions, artificially created in pots. Water and salt level are carefully measured and the

resulting crop yields dried and weighed to establish whether or not there is a significant advantage, and if so its extent.

" I can take many types of measurements to describe the plants and their interaction with the environment. A breeding programme for a new variety can take three years to produce vegetables to eat."

5. **Packing and Labelling** – Back inside the bank, Dr Ebert explained how packing and labelling is an essential step towards distribution of identified seeds. First, in the processing area, they are weighed and stored 20 – 30 in paper packages. A barcode system is used to identify the seeds and labels are placed on them by hand. Each time the packets are labelled there is a danger that two numbers could be exchanged and the barcode system is used to reduce errors.

   In the long term store, seeds are packed into vapour proof aluminium packets. Unlike the organic paper material this doesn't have the same interaction with moisture in the environment. Before putting in these final bags seed samples are tested for moisture content, comparing it with the baseline. Given even the slightest hint of moisture seeds could germinate, rendering them useless for storage and future planting and breeding. The aluminium packets are kept in sealed drums for future.

6. **Passport Data** – 'Integrated passport data' for seed lines is represented on a freely accessible database. This information includes, a unique number to identify the lines, and like your own birthday, their date and place of collection. Nutritional information is also stored and used to inform the breeding process, together with research information from other parts of the Centre, to produce a well documented profile. The computerised records are freely available for anyone interested enough to browse them.
7. **Safety Back Up** – When disaster strikes such as the 2004 Boxing Day Tsunami in Shri Lanka is, this preserved collection enabled the farmers to go back to the seeds and start production again. Just like backing up your hard drive, a safety back up is made in a secure sister site in Korea. This is reassuring given that Taiwan is prone to earthquakes, and like anywhere is not without is vulnerabilities to climate catastrophe as demonstrated by the landslides shortly after my visit in 2009. Unlike a computer the genetic information is stored in the seeds themselves. Even in long term storage viability beyond fifty to seventy years is precarious, requiring a considerable energy.
8. **Distribution** – There is a small charge for distribution of seeds from the gene bank, staggered according to means, lower for national programmes and higher for seed companies. Co-ordinating distribution flow is tricky, as the Rio conference on Biodiversity in 1992 gave countries of origin ownership of seeds and plant materials. They can choose whether or not to make it available to the bank, grant or refuse permission for countries beyond their own borders to use them, placing restrictions on the bank. Dr Ebert suggests the current legislation is complex to implement because plant species don't stick to international geographical and political boundary limits making it hard for any one country to prove which plants are native.

   "Co-operation and collaboration are needed to continue with the exchange to produce new varieties and feed a still growing world population with always less and less land which is more difficult with this legislation."

Balancing the need for movement with ecosystem preservation is a critical challenge. As sea levels rise in response to climate change, so does demand for heat, drought, flood and salt tolerance species, accelerating global redistribution of genes. At the same time, recognition of the importance of wild and domestic varieties is higher than ever, as farmers need to incorporate characteristics from wild types, more hardy to poor soil and extreme temperatures into the higher yielding varieties. Seeds are treated for pests before leaving the bank and quarantine encouraged in the receiving country.

9. **Consumer Choice** – World Wide, Who's to say what happens to the gene lines on leaving the bank, as on reaching their destination seeds will enter agricultural production as the farmers see fit exposing them to cross breeding at the discretion of local humans, animals, birds and insect behaviour. Despite best efforts, it is not possible for the gene bank to certify that seeds are virus and pest free. Post entry quarantine and growing out isolated samples in the destination country is required to check for disease that might be present but not show up in Taiwan. Success now, is dependent on local knowledge and expertise, and outcomes cannot be completely controlled.

   The gene bank is vital in countering the threat of a narrowing gene base as farmers select for specific traits, leaving commercially valuable crops with large juicy fruit crops that are both attractive to insects and vulnerable to devastation by viruses. The coffee crisis in Shri Lanka, demonstrated this threat is real. Today, thanks to consumer's preference for flavour, taste and colour, older stronger varieties are becoming more popular, despite having lower yields. This trend for quality has allowed niche markets for unusual varieties to develop, powerful encouragement for preserving the world's diverse genetic heritage.

For more information visit:
http://www.avrdc.org/index.php?id=13