

IncrEdibles: a festival of food, making the connection between crops and wild plant diversity

By Morvah George, Crop Wild Relatives Project Assistant, MSBP

This summer and autumn, Kew celebrates the amazing bounty of the plant world, inviting visitors to experience first-hand a selection of the 12,000 species we can feast on. This festival has been named "IncrEdibles: a voyage through surprising edible plants".

The festival will showcase the sheer number of edible plants growing in the Gardens. Visitors will be inspired to broaden their relationship with what they eat, by taking part in or observing the banquet of offerings that make up this fantastic festival. Whether they want to be part of a giant fruit salad installation by hiring a fruit inspired boat, stroll around a floating pineapple on the Palm House Pond, travel the globe in our global kitchen garden, join a tea party with a twist, bask in a picnic garden, or attend incrEdibly interesting talks and workshops, there is something for the whole family to get their teeth into.

Running until November 2013, the festival will comprise a range of activities and horticultural displays that will engage visitors with the world of edible plant diversity. Highlights include:

- The Tutti Frutti Boating Lake Kew's Palm House Pond has been transformed into a giant fruit salad boating lake and participatory artwork, the centre piece of which is a floating pineapple island, a symbol of Kew's extensive bromeliad collection. The installation explores the possibilities of edible fruit and provokes people to think again about the food that they eat every day.
- The Global Kitchen Garden this garden features over 90 edible plants from every corner of the globe. Two semicircular inner beds are dedicated to herbs while five outer beds represent different regions of the world including South America, West Asia and Europe. Grapes, pomegranate and olive trees are planted in a circular design, and beautiful arches planted with climbers make this a stunning space to explore. Visitors can discover where some of our best-loved food plants have travelled from and be surprised by what they discover, and will also be introduced to some lesser known and slightly obscure ones!
- The plant family beds here visitors can discover the importance of the plant families, from which their food comes. Plants are arranged according to their relationships



The Tutti Frutti Boating Lake. PHOTO: RBG KEW

with one another. This illustrates the taxonomic relationships between a selection of food crops and their wild relatives.

- The Grass Garden displays some of the world's most economically important cereals and plants that are a regular feature at breakfast, lunch and dinner.
- The Princess of Wales Conservatory film room will be showing a short film highlighting the importance of conserving the wild relatives of some of our most important crop plants, and Kew's work through the Millennium Seed Bank Partnership to collect and save the seeds of this genetic store cupboard.

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Kew hope that visitors will enjoy the stories of edible plants and leave the festival with a new understanding of the food they eat, its origin and what the future of crops might be. We want to explain the importance of the work being carried out by Kew and our Partners in conserving these plants for the future and the relevance that this area of plant genetic resource conservation has for global food security.

One of the topics being highlighted is the Adapting Agriculture to Climate Change project, a 10 year project in which the Millennium Seed Bank is co-ordinating a worldwide collection of the wild relatives of the 29 major food crops listed under Annex 1 of the International Treaty for Plant Genetic Resources of Food and Agriculture. Supported by the government of Norway, this project is a collaboration with the Global Crop Diversity Trust in which the wild relatives of the world's most important crops for food security are being collected for safekeeping and to provide much needed diversity to plant breeders. So far, the wild relatives have been identified, and the current state of the wild relative genetic resources in gene banks worldwide has been assessed. This summer sees the start of the collecting effort where, over the next few years, Kew will work with national project partners to fill the gaps in the wild genetic resources with new collections. These valuable collections will be stored at Kew's Millennium Seed Bank, with duplicate collections to be stored in the country of origin, and also in the Svalbard Global Seed Vault. The subsequent phase of the project will involve the evaluation of the new collections for useful traits and preparation of the material through pre-breeding, with an aim of giving a wider array of options to tackle the adaption requirements in agriculture. Crop wild relatives have already been proven to be useful to crop breeders. For example, a wild relative of rice, Oryza rufipogon Griff., was successfully crossed with the domesticated species Oryza sativa L. leading to a 10-20% increase in yield (Yuan, 1993) and resistance to wheat stem rust has also been found in wheat wild relatives and used effectively in modern wheat varieties (Rouse & Jin, 2011)



The Grass Garden displays some of the world's most economically important cereals PHOTO: RBG KEW

The Adapting Agriculture to Climate Change project team participated at the IncrEdibles planning workshops, brain-storming ideas for the festival. Through this the team contributed to the species list of IncrEdibles plants. The IncrEdibles festival provides an opportunity to inform the public about the narrow genetic bases of our modern crops, and the problem this may pose in terms of our ability to adapt to climate change, whilst highlighting the solutions that may be found in the conservation and use of crop wild relatives.

References

Rouse, M. N., Jin, Y. (2011) Stem rust resistance in A-genome diploid relatives of wheat. *Plant Disease* 95 (8): 941-944.

Yuan L.P. (1993) Advantages and constraints to the use of hybrid rice varieties. In: Wilson KJ, ed. *Proceedings of the International Workshop on Apomixis in Rice*. The Rockefeller Foundation and China National Center for Biotechnology Development, New York and Beijing: pp 1-4.

For further information contact m.george@kew.org or r.eastwood@kew.org



The rose garden tea party table. PHOTO: RBG KEW

A **message** from Paul Smith



Millennium Seed Bank Partnership Leader

Edible plants comprise a significant component of the plant diversity that the Millennium Seed Bank Partnership seeks to conserve and promote the use of. We are therefore delighted to join the rest of Kew in celebrating this summer the huge diversity of edible plants. FAO estimate that there are at least 12,000

species of plants that people eat regularly. If we include famine foods, this figure may go as high as 30,000 species. Despite this, most people regularly eat perhaps a dozen plant species, including the big three – wheat, rice and maize. Through our Adapting Agriculture to Climate Change Project (see page 1–2) we are supporting the continued diversification of our main staples by providing plant breeders with crop wild relatives that include

useful traits such as disease resistance and drought tolerance. Through our Useful Plants Project (see page 4) we are helping to domesticate and increase the use of some of those more obscure food plants that most of us have never heard of. With my background in Africa, I have tasted the fruits of the mahobohobo (*Uapaca kirkiana*) and the equally delicious mobola plum (*Parinari curatellifolia*) but I have no idea what the chempedak (*Artocarpus integer*) or langsat (*Lansium domesticum*) taste like. The common denominator for those of us working in plant conservation is 'diversity'. As in most walks of life, diversity equals resilience, and it keeps things interesting. Imagine a world in which this diversity of choice is diminished or even lost altogether. Not an attractive proposition, nor tenable for our species in the long-term.

Israel Plant Gene Bank, activities and co-operation with the Millennium Seed Bank Partnership

by Rivka Hadas, Head of the Israel Gene Bank





Israel is home to a stunning array of 2,600 plant species. As part of the Fertile Crescent, the ancient land of Israel has played a major role in the development of civilisation, being at the cradle of agriculture and the origin of early domesticated crops. This region is characterised by geographic and climatic diversity and serves as a unique and rich centre of genetic diversity of major crop wild relatives (CWRs) such as cereals (wheat, barley, oats), legumes (pea, lentil, chickpea), fruit trees (plum, pear, almond, date), vegetables (onion, carrot, cabbage), aromatic plants (sage, fennel, oregano), and forage plants (clover, alfalfa), among others.

In the face of an increasing threat of genetic erosion and the need for immediate action to preserve local plant genetic resources, the main purpose of the Israel Plant Gene Bank (IGB) is to conserve representative gene pools of species of untapped economic, agricultural and socio-cultural significance. In addition, we pay attention to rare, endangered and endemic species.

A team of expert botanists is working to collect plant material according to a prioritised list of species and habitats, and detailed collection guidelines, which are reassessed each year. Each habitat visited by IGB's scientists is extensively documented, and the distribution patterns of native plant populations are monitored country-wide.



IGB team PHOTO: ISRAEL GENE BANK

Once a seed collection arrives at the Gene Bank, it is labelled and documented in a designated database. The sample is then reduced by means of cleaning, drying and viability testing, to a viable germplasm unit, which is in turn divided into short-term (for research and periodical monitoring) and long-term storage. A backup duplicate sample is sent for storage at the MSB. Each accession includes a dried specimen of an intact plant, which is deposited as a reference herbarium voucher at the Hebrew University of Jerusalem Herbarium.

Each year around 600–900 new samples are deposited in the IGB storage rooms. The IGB team is responsible for collecting, cleaning, and monitoring seed viability. The field experiment site, located in the vicinity of the IGB, is used for growing plants and to increase seed collections (as in the case of old accessions that have lost viability, or rare species with small sample sizes).

During the last five years we have collected about 4,500 samples, representing 990 different species. This collection is open to the scientific community worldwide as an accessible source of plant material for applied research. For more detailed information, please visit our web site: http://igb.agri.gov.il.

For further information contact Rivka Hadas (rihadas@volcani.agri.gov) or Ruth Eastwood (r.eastwood@kew.org)

Conserving indigenous food plants in Botswana – the case of the morama bean

By Kebadire Mogotsi (MSBP-UPP Co-ordinator in Botswana) & Tiziana Ulian (UPP International Co-ordinator, MSBP)



Tylosema esculentum (Burch.) Schreiber, the morama bean PHOTO: K. MOGOTSI

In Botswana, Kew's Project MGU – Useful Plants Project (UPP) strives to conserve indigenous plants which are important to rural communities. The project is delivered by the Botswana College of Agriculture (BCA) through seed conservation and propagation activities, planting in community gardens, and promotion and sustainable use of plants in marketable products.

The rural communities involved in Botswana since the first phase of the Project (2007-2010) are from Tsetseng and Pilikwe villages. More recently, two new communities have joined the Project: Shaikarawe and New Xadi, whilst four others have been involved in some of the activities.

Of the target list of around 170 species compiled in collaboration with local communities, 70% are food plants and among these, *Tylosema esculentum* (Burch.) Schreiber, the morama bean, has been prioritised by all communities for its high nutritional value.

The morama bean is highly prized by the people of the Kalahari Desert (Botswana, Namibia and South Africa), where it occurs naturally in grassland and open woodland. Seeds are usually roasted, resembling roasted cashews or chestnuts. The extracted oil is similar to almond oil and is suitable for domestic purposes, having a pleasant nutty flavour, although with a slightly bitter aftertaste. Morama beans are also boiled with maize meal, or ground and pounded to a powder, for making porridge or a cocoa-like beverage. In some areas small tubers and young stems are also roasted and eaten, having a pleasant flavour.

The composition and nutritional value of the seed competes with that of common cultivated leguminous plants (for example, pigeon peas and cow peas) as it is rich in oil and protein: protein content is around 36%. The bean also contains significant amounts of vitamins (A, B₃, B₆, folic acid, B₁₂ and E) and minerals (iodine, iron and zinc) (Müseler & Schönfeldt, 2006). It is also reported to be a potential source of phytonutrients, which have been shown to contribute to health (Jackson et al., 2010). Some village

elders proclaim to use this species to cure or prevent some illnesses such as diarrhoea, headaches, and women's reproductive system problems. Through the UPP, different ecotypes of the morama bean have been collected, banked and tested. Communities are involved in the collection of beans for cultivation, consumption, sale and processing into numerous marketable products. The Tsetseng community, through their community trust, have become leading innovators in marketable morama products. They collect and buy dry morama beans from other communities to process and sell in various forms.

The UPP has triggered another project, the Morama Bean Project, which is led by BCA in collaboration with other organisations in Botswana and Namibia. This project aims to increase awareness of indigenous grain utilisation for nutritional security and improved livelihoods, and therefore complements the UPP.

The Tsetseng community has hosted workshops throughout Botswana on cultivation and adding value to the morama bean. Practical sessions provide experience in processing the bean into various products. Research on plant physiology, involving both undergraduate and Masters students, is being conducted to find the best conditions to introduce the morama as a potential crop. It has potential commercial value both as a cash crop and in value-added products, particularly in the semi-arid lands where it is found (Jackson et al., 2010). Together, the UPP and the Morama Bean Project are contributing to the cultivation and promotion of the morama bean and are setting the stage for a global market.

For more information please contact:

Dr Kebadire Mogotsi (MSBP-UPP and Morama Bean Coordinator in Botswana): kmogotsi@bca.bw

Dr Tiziana Ulian (UPP International Coordinator): t.ulian@kew.org

References

Fox, F.W. & Norwood-Young, M.E. (1982) *Food from the veld*. Delta Books, Johannesburg.

Jackson, J.C.; Duodu, K.G.; Holse, M.; Lima de Faria, M.D.; Jordaan, D.; Chingwaru, W.; Hansen A.; Cencic, A.; Kandawa-Schultz, M.; Mpotokwane, S.M.; Chimwamurombe, P.; de Kock, H.L.; and Minnaar, A. (2010) The morama bean (*Tylosema esculentum*): a potential crop for southern Africa. *Advances in Food and Nutrition Research*. 61: 187-239.

Müseler, D. L. & Schönfeldt, H.C. (2006) The nutrient content of the marama bean (*Tylosema esculentum*) an underutilized legume from southern Africa. *Agricola16*: 7-13.



Products developed from the morama bean PHOTO: T. ULIAN

Desiccation tolerance in mature seeds of tea (*Camellia sinensis* L.) from China

By Charlotte Seal (MSB) and Hongying Chen (Kunming Institute of Botany)



Cup of tea Photo: L. FAN (CREATIVE COMMONS ATTRIBUTION-SHARE ALIKE 2.0 GENERIC LICENCE)

Camellia is the largest (> 200 species) and economically most important genus in the family Theaceae, with a centre of diversity in China (Cao et al., 2005). *Camellia sinensis* (L.), or tea, is the most widely consumed beverage plant in the world with commercial production yielding around 3.6 million tonnes of tea leaves annually. China was one of the earliest countries to widely produce and use tea, possibly as early as 2750 BC. The Yunnan Province has been producing tea for 1,700 years and plantations from the Ming Dynasty (1368 – 1644 AD) and the Qing Dynasty (1644 – 1912 AD) are still found today in the regions of Lincang and Puer. In addition to the leaves being rich in nutritious chemicals such as amino acids, flavonoids and vitamins, several species produce seeds with edible oils, that are used extensively in China for cooking and *Camellia* has global popularity as an ornamental plant (Cao et al., 2005).

Because wild species possess traits desirable for plant breeding, it is important to conserve these genetic resources for future exploitation. In the *Camellia* genus, 11 species were classified as at risk by the IUCN in 2011 (www.iucnredlist.org). However, the seed storage biology is unknown for many species and for those where it has been assessed, there is little consensus on the degree of desiccation tolerance or sensitivity. As the

environmental conditions during seed development can influence seed storage behaviour, we set out to assess the desiccation response of mature tea seeds at three sites (Kunming, Lincang and Puer) in the Yunnan Province with different environmental conditions. The project was a collaboration between Hongying Chen, Weiqi Li and Shixiong Yang of the Kunming Institute of Botany, and Ilse Kranner, Hugh W. Pritchard, Charlotte Seal and Jayanthi Nadarajan of the MSBP.

We found that desiccation tolerance was greatest in seeds from Kunming, the driest and coolest environment, followed by Puer and Lincang. Kunming seeds tolerated drying to 8 % moisture content (MC) or ~0.5 water activity (a_w). Such tolerance was observed in Lincang seeds only when hydrogen peroxide was applied to stimulate germination. Puer seeds tolerated drying to 16 % MC (~0.7 a_w). Therefore, all three seed lots demonstrated non-recalcitrant behaviour (i.e. were not desiccation sensitive) which was further supported by the length of the dry season after dispersal and the high ratio of seed coat to seed mass (>0.3).

We then considered whether desiccated seeds could be stored long-term at -20 °C, the international conventional temperature for seed banking. The seeds of many of the world's commodities, for example citrus, coffee and papaya, have limited storage potential at this temperature (Crane et al., 2006). We also found this to be true in tea, where even the most desiccation-tolerant Kunming seeds did not survive one month in storage. Data suggested that sensitivity to this specific low temperature is likely to be related to the lipid composition of the seed. Thus for long-term *ex situ* storage of tea seeds, cryopreservation should be considered.

Full article: Chen, H., Pritchard, H. W., Seal, C. E., Nadarajan, J., Li, W., Yang, S., & Kranner, I. (2012). Post desiccation germination of mature seeds of tea (*Camellia sinensis* L.) can be enhanced by pro-oxidant treatment, but partial desiccation tolerance does not ensure survival at –20° C. *Plant Science* 184 (March) 36-44.

For further information please contact Hugh Pritchard (h.pritchard@kew.org)

References

Cao, J., Parks, C.R., Du, Y.Q. (2005) *Collected species of the genus Camellia and illustrated outline*. Zhejiang Science and Technology Press, Zhejiang. Crane, J., Kovach, D., Gardner, C., Walters, C. (2006) Triacylglycerol phase and 'intermediate' seed storage physiology: a study of *Cuphea carthagenensis*. *Planta* 223 (5): 1081–1089.



Camellia sinensis in fruit PHOTO: H. CHEN



Tea (Camellia sinensis) flower PHOTO: RBG KEW

Thermal thresholds for seed dormancy loss and germination in Mediterranean wild fruits

By Efisio Mattana, Centro Conservazione Biodiversità, Università degli Studi di Cagliari and Kew Honorary Research Associate.

Investigating thermal thresholds for seed dormancy breaking and germination is crucial for a better understanding of plant ecological requirements. In particular, the identification of cardinal temperatures for germination allows the thermal niche for seed germination to be characterised. Seed germination occurs between a base (T_b) and a ceiling temperature (T_c) , with the highest germination rate occurring at an optimal temperature (T_o) . In addition, the temperature accumulation above T_b can be incorporated into the calculation of thermal time for germination (i.e. θ_g , expressed in °C days) which is a measure of species sensitivity to temperature (Garcia-Huidobro et al., 1982). Knowing the seed germination sensitivity of a species to temperature may help to understand and predict species responses to warming temperatures as a result of climate change, especially for wild species that have desirable traits for further development, the so-called neglected and under-utilised species (NUS).

Recently, we have investigated the thermal niches for seed germination of two Mediterranean wild fruits and NUS (*Ribes multiflorum* Kit *ex* Roem *et* Schult. subsp. *sandalioticum* Arrigoni, Grossulariaceae and *Vitis vinifera* L. subsp. *sylvestris* (C.C. Gmel.) Hegi, Vitaceae), one of which (*R. multiflorum* subsp. *sandalioticum*) is also endangered. This was within the framework of a collaboration between Efisio Mattana and Gianluigi Bacchetta of the Centro Conservazione Biodiversità (Università degli Studi di Cagliari, Sardinia - Italy), and Tiziana Ulian and Hugh Pritchard of the MSBP.

Ribes sandalioticum is a rare mountain shrub, endemic to Sardinia. The embryos are small at dispersal and they have to grow three times in length before the seed can germinate. Warm stratification (25° C for 3 months) followed by low incubation temperatures (< 15° C) enhances embryo growth rate and subsequent seed germination. After radicle emergence, epicotyl emergence is delayed for around two months and positively affected by GA₃ treatment. Seeds of this species showed epicotyl morphophysiological dormancy, highly synchronised with the Mediterranean seasonality (Mattana et al., 2012).



Ribes sandalioticum population in a wood with Quercus ilex L. and Sambucus nigra L. in Monte Novo San Giovanni, Orgosolo (NU – CE Sardinia). PHOTO: E. MATTANA

Vitis vinifera subsp. *sylvestris* is a vine with a distribution from North Africa to central Europe. Seed germination has been assessed in four Sardinian populations and modelled according to the present climate conditions and two simulated climate change scenarios (IPCC, 2007). The non-dormant, cold-stratified seeds have T_b of $9.0 - 11.3^{\circ}$ C and a thermal time requirement for 50% germination (θ_{50}) ranging from 33.6° C days to 68.6° C days, allowing prediction of a field emergence from March to May under the present climatic conditions. The detected T_b and θ_{50} values identified an altitude-related risk from climate warming, with lowland populations being more threatened due to a compromised seed dormancy release and a narrowed seed germination window (Orrù et al., 2012).

Both NUS showed complex combinations of thermal requirements for dormancy release and germination that limit their distribution to microhabitats around mountain streams or northern mountain slopes and highlight potential threats to natural regeneration from seed, from projected climate changes. The *ex situ* conservation of these species is urgent and is being progressed within the Millennium Seed Bank Partnership and the "Banca del Germoplasma della Sardegna" (BG-SAR) in Sardinia, in order to ensure the survival of the particular genetic pool of these threatened populations.

For further information, contact Hugh Pritchard (h.pritchard@kew.org) or Efisio Mattana (Mattana.efisio@gmail.com)

References

Garcia-Huidobro, J., Monteith, J.L., Squire, G.R. (1982) Time, temperature and germination of pearl millet (*Pennisetum typhoides* S. & H.) I. Constant temperature. *Journal of Experimental Botany* 33(133): 288-296.

IPCC(2007) *Climate change 2007: synthesis report.* (eds Pachauri RK, Reiginger A) Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Geneva, Switzerland: IPCC.

Mattana, E., Pritchard, H.W., Porceddu, M., Stuppy, W.H., Bacchetta, G. (2012) Interchangeable effects of gibberellic acid and temperature on embryo growth, seed germination and epicotyl emergence in *Ribes multiflorum* ssp. *sandalioticum* (Grossulariaceae). *Plant Biology* 14(1): 77-87.

Orrù, M., Mattana, E., Pritchard, H.W., Bacchetta, G. (2012) Thermal thresholds as predictors of seed dormancy release and germination timing: altitude-related risks from climate warming for the wild grapevine *Vitis vinifera* subsp. *sylvestris. Annals of Botany* 110 (8): 1651-1660.



Left: Fruits of *Ribes multiflorum* subsp. *sandalioticum* PHOTO: E. MATTANA Right: Grapes of *Vitis vinifera* subsp. *sylvestris*. PHOTO: G. BACCHETTA

Juniper – on the rocks?

By Stephanie Miles, UK Co-ordinator, MSBP

Common juniper, Juniperus communis PHOTO: RBG KEW



A glass of gin and tonic PHOTO: NOTFROMUTRECHT, CREATIVE COMMONS

At this time of the year in Europe, the thought of sitting outside on a warm evening with a gin and tonic is very welcome. Ice clinking against the long, cold glass with a couple of slices of lemon jauntily bobbing around at the surface...and to think that wouldn't be possible without the aromatic berries (or more correctly, cones) of the fabulous juniper bush.

Gin is derived from the juniper-flavoured and very alcoholic traditional liquor of the Netherlands and Belgium known as 'Jenever'. Originally used for medicinal purposes, its recreational properties soon caught on and it remains very popular today in dedicated Dutch and Belgian bars. Juniper is also used, particularly in Scandinavian cuisine, to flavour a wide variety of culinary dishes. Flavour and odour are at their strongest immediately after harvest and decline during drying and storage, and the cones are best lightly crushed before adding to your chosen dish. Having spent a couple of hours in a car with a freshly collected batch recently, I can vouch for the strength of the aroma. In vapour therapy, juniper oil can be used for the treatment of addictions, nervous tension, hangovers, over-indulgence of food and to stimulate the nervous system and bolster the spirit in challenging situations; a perfect remedy for seed-collectors!

The wildlife benefits of juniper are diverse. The fruits and shoots provide an important food source for wild birds and mammals, particularly during the winter months when other food sources are scarce. Juniper also supports a large number of invertebrates, fungi, bryophytes and lichens. However, the outlook for *Juniperus communis* in the UK is precarious. Populations are decreasing as bushes die of old age and natural regeneration is limited, either due to scrub encroachment, the shortage of viable seed or predation of seedlings by rabbits or livestock. The problem is particularly acute in lowland England on chalk or limestone substrates. Plantlife's practical management guide for lowland juniper (Wilkins and Duckworth, 2011) is a useful reference for understanding the issues of regeneration and reinforcement of populations (www.plantlife.org.uk/).

Juniperus communis is protected in the four regional biodiversity priority conservation lists in the UK, and populations on heaths or calcareous

grasslands are included in EC Habitats Directive Annex I. Unfortunately another threat has appeared in the UK in the form of an outbreak of the soil-borne fungal pathogen *Phytophthora austrocedrae* for which juniper is a host. Populations in the north of England and Scotland have been affected and the Forestry Commission is taking the lead on assessment and management.

Seed collections from several populations in England are being conserved in the MSB where seed quality is analysed and germination protocols developed. A further comprehensive collecting strategy is planned for populations as part of our UK National Tree Seed Project (see page 11). The *ex situ* conservation of this important species is a priority to allow further research and a resource for ongoing conservation programmes.

(Top tip from our Seed Cleaning team. In order to avoid a gooey mass when removing the seeds from cones, use wood ash to reduce the stickiness of the resin and the seeds can then be easily separated from the debris)

For further information, contact Stephanie Miles (s.miles@kew.org)

References

Wilkins, T.C. and Duckworth, J.C. (2011) *Breaking new ground for juniper – a management handbook for lowland England*. Plantlife, Salisbury.



Collecting Juniperus communis at Old Winchester Hill, Hampshire. PHOTO: S. MILES

Conservation of yams in Madagascar

By Tianjanahary Randriamboavonjy, Hélène Ralimanana, Paul Wilkin, Tim Harris and Stuart Cable





Harvesting *Dioscorea alata* in Ambalavao Fianarantsoa PHOTO: T. RANDRIAMBOAVONIY

Madagascar is one of the richest countries for yams with around 42 recorded species representing just over 7% of the global total. Of these, 37 species are native and 36 species are endemic to Madagascar. The endemic Madagascan species form a separate clade within the phylogeny of the genus and one of its main characteristics is that most species are edible either raw or following simple cooking.

Dr Paul Wilkin, Kew's Dioscoreaceae specialist, collaborates with staff of the Kew Madagascar Conservation Centre in Antananarivo (KMCC). So far 12 species have been assessed as 'threatened with extinction' using IUCN criteria. Many of the widespread species are increasingly threatened by overexploitation and deforestation. In Madagascar, 80% of the population rely on subsistence farming and 50-70% suffer seasonal malnourishment. Wild yams are an important component of the diets of rural people, especially during the "hungry months" between harvests of rice and other staple crops when food supplies are low. Increasing scarcity means that people have to search longer and further to find yams and they often harvest the tubers before maturity.

The government of Madagascar is developing a national strategy for yams to ensure food security for rural populations. The project is led by the Ministry of Agriculture in collaboration with a range of conservation, research and development organisations, such as KMCC. The national strategy will provide a framework to promote yams as a food crop and to improve sustainable production by small-scale farmers. It draws on the wide-ranging experience of the partner organisations that have worked with communities growing both high-yielding cultivars of introduced species as well as the wild native species.

In 2007, KMCC and the NGO Ny Tanintsika initiated a pilot yams project with communities within a new protected area, the Ambositra-Vondrozo Forest Corridor (COFAV). This area of humid forest is a hotspot of biodiversity in eastern Madagascar but suffers deforestation due to slash and burn agriculture. The aim of the project is to take pressure off the overcollected wild species by introducing cultivation of high-yielding cultivars of the introduced Asian species *Ovibe (Dioscorea alata* L.) around the villages. This activity is supported by funding from the Innocent Foundation. In 2011, the 12 participating communities produced over 52 tonnes of yam tubers between 321 households. Yam cultivation has also been adopted in neighbouring communities without encouragement from the project. Tim Harris of Kew recently undertook a socio-economic survey for an MSc dissertation and found that the participating communities valued cultivated yams above wild yams, which require hard work to collect. The next stage of the project is to develop cultivation techniques for the native species and investigate the potential impact of climate change.

KMCC is continuing to undertake surveys of yams around Madagascar and recently rediscovered *Dioscorea decaryana* H.Perrier in the High Plateau. This species was thought to be extinct and was only known from two herbarium specimens, a male and female plant, collected 75 years ago. The team led by Dr Hélène Ralimanana of KMCC found the yams growing on rocky outcrops about 15 km from the town of Ambatofinandrahana. Current work includes further surveys of the extent of the population to determine the conservation status of the species and repeated seed collections for the Millennium Seed Bank Partnership (MSBP). The tubers will be screened for biochemical content and if the species is edible and tasty, or has potential for other valuable products, the team will try to cultivate the yam as part of the new Darwin-funded RBG Kew Madagascar Agroforestry Livelihoods Project.

Dr Paul Wilkin continues to work on the taxonomy of this important plant group in Madagascar and has published several new species in recent years. Kew has helped to support a PhD student at the University of Antananarivo, Mamy Tiana Rajaonah, who is studying the taxonomy of the economically important introduced species *Dioscorea alata* L. and *D. esculenta* L.. Information on Madagascan yams, both native and introduced, has been compiled for the Dioscoreaceae scratchpad (taxonomically focussed website) of the eMonocot Project by Tiana Randriamboavonjy of KMCC (http://dioscoreaceae.e-monocot.org/).

The MSBP, with local partner Silo National des Graines Forestières (SNGF), is making a significant contribution to yam conservation and food security by targeting this and other groups of useful plants. The team has so far made 34 collections representing 14 species of Madagascar's yams and most of the species known from the areas with lower rainfall.

For further information contact

Paul Wilkin (p.wilkin@kew.org) or Stuart Cable (s.cable@kew.org) or Tiana Randriamboavonjy (trandria.rbgkew@moov.mg)

The 'omics' of seed quality in response to climate

By Hugh W. Pritchard, MSBP

Each year massive economic losses are suffered by farmers and the seed trade alike due to poor seed quality. These losses are partly due to inadequate seed storage conditions, and are predicted to be exacerbated by climate change. Researchers at the MSBP have joined a team of 11 European participants to unravel how environmental stresses to the mother plant will impact upon seed quality, and if seed storage conditions prior to sowing can be improved to enhance seed quality. The \in 3 million project, "Impacts of Environmental Conditions on Seed Quality" (acronym "EcoSeed"), is funded by the 7th EU Framework Programme for Research and Innovation.

Every seed has a life of its own. Information received during its development on the mother plant determines its quality: how long a seed can be stored, if it will be dormant, if it will germinate readily after storage and if it will grow into a healthy, vigorous new plant. Seed quality is further influenced by storage conditions, and is vital to agriculture and industry. It has been estimated that yield loss from major cereals due to rising temperatures between 1981 and 2002 was \$5 billion per year. Importantly, seed wastage resulting from sub-optimal seed performance undermines food security and livelihoods. High-quality seeds and a capability to store them adequately are also pivotal to safeguard the seeds of wild plant species required for the conservation of plant diversity.

In this project, three crop species, barley, sunflower and cabbage, will be studied together with the model plant *Arabidopsis* to see how drought and elevated temperatures suffered by the mother plant impact upon seed quality. As a next step, the scientists want to find out how changes in temperature, humidity and oxygen concentrations during storage further affect seed viability, storability and seedling vigour. The teams will apply the most recent state-of-the-art "omics" (transcriptomics, proteomics and metabolomics) and "post-omics" techniques to unravel factors that determine seed quality on different levels: they will study how genes within the seed are affected by stress, and how this influences the production of proteins and smaller compounds required for a healthy metabolism. The knowledge gained from the detailed study of the above four plant species will then be validated for wild plant species to the benefit of conservation projects; research which is being led by Hugh W. Pritchard at the MSBP.

Four years in the planning, with significant advice from Defra (UK) and The European Plant Science Organisation, EcoSeed runs from 2013 to 2016. The project is coordinated by Prof. Ilse Kranner of the University of Innsbruck (Austria) and involves teams at the Royal Botanic Gardens, Kew (UK), Leibniz-Institut für Pflanzengenetik und Kulturpflanzenforschung, Gatersleben (Germany), Université Pierre et Marie Curie (France), Max Planck Institute for Plant Breeding Research (Germany), Warwick University (United Kingdom), Institute National de la Recherche Agronomique (France), University of Leeds (United Kingdom), Universidad de Salamanca (Spain), Commissariat à l'énergie atomique et aux énergies alternatives (France) and Limagrain Europe (France).

For further information contact Hugh Pritchard (h.pritchard@kew.org)



the model plant *Arabidopsis*, before transferring knowledge to wild plant species

A message from Kew's new Director, Richard Deverell



As a former Trustee and now Director of the Royal Botanic Gardens, Kew, the vision and global impact of the Millennium Seed Bank Partnership has given me constant inspiration. The target of banking 25% of the world's plant species is ambitious, but with an active global network of MSB partners it can be achieved and we will be closer to safeguarding the remarkable diversity of plants on our planet. And yet the work of the MSBP doesn't stop at seed banking; applied conservation and restoration projects put the collections to practical use, demonstrating the real value of the seed bank when combined with expertise in seed research and conservation. The reach of the MSBP is truly global and it provides an essential contribution to Kew's ongoing mission to inspire and deliver plant-based conservation worldwide. In my role as Director I fully support and commend the work of the MSBP and look forward to welcoming new partners and to witnessing the real benefits that this remarkable initiative delivers as we face the challenges of a changing world.

Having previously worked for the BBC, Richard Deverell took up the post of Director of the Royal Botanic Gardens, Kew in September 2012.

Seed biology supporting *ex situ* conservation and the restoration ecology of Mediterranean temporary pools

By Angelino Carta, Department of Biology, Pisa University

In a recent joint study by researchers from the Tuscan seed bank at the University of Pisa and the MSBP, the germination and seed bank storage of species in Mediterranean temporary pools were studied. Mediterranean temporary pools are a very specialised, rare and threatened habitat found in Mediterranean-type climates worldwide.

Whilst the germination behaviour varied between species, the prevailing tendency was to favour germination at cool temperatures. Although seeds possessed orthodox storage behaviour (i.e. desiccation tolerance), slow or delayed drying treatments improved the quality of collections. We conclude that these species are adapted to the irregular presence of water with characteristics that are typical of neither truly aquatic nor wetland plants.

This study was undertaken under the auspices of the Tuscan Archipelago National Park, which is responsible for the *in situ* conservation of these habitats. Our results help understand the storage conditions required for these rare species and will ensure that seeds are available for use as starter material in the restoration of temporary wetlands.

Literature

Carta, A., Bedini, G., Müller, J.V. & Probert, R.J. (2013) Comparative seed dormancy and germination of eight annual species of ephemeral wetland vegetation in a Mediterranean climate. *Plant Ecology* 214 (2): 339-349.

Carta, A., Bedini, G., Foggi, B. & Probert, R.J. (2012) Laboratory germination and seed bank storage of *Ranunculus peltatus* susp. *baudotii* seeds from the Tuscan archipelago. *Seed Science and Technology* 40 (1): 11-20.

Tuckett R.E., Merritt D., Hay F.R., Hopper S.D., & Dixon K. W. (2010) Dormancy, germination and seed bank storage: a study in support of *ex situ* conservation of macrophytes of southwest Australian temporary pools. *Freshwater Biology* 55 (5):1118-1129.

For further information, please contact Angelino Carta (acarta@biologia.unipi.it) or Jonas Müller (j.mueller@kew.org).



Juncus capitatus (dwarf rush) flowers and fruits PHOTO: A. CARTA



Angelino Carta collecting seeds in a pool PHOTO: G. GESTRI

NEWS

Orchid Seed Science and Sustainable Use (OSSSU) – UK workshops on the conservation of orchid seed

In March this year, National Collection holders (Plant Heritage) and breeders of orchids attended workshops at the Millennium Seed Bank and the King Charles I school in Kidderminster. The workshops, sponsored by the Stanley Smith Horticultural Trust, were to demonstrate to growers the techniques they could use to conserve their own seed and provide an insurance for the future of their living collections. Also, to develop a 'Citizen Science' project, in which they will collect data on controlled pollinations and capsule ripening times, and share these with the OSSSU community through the network's website (www.osssu.org). In addition, there are opportunities for donations of seed for research and banking.



Learning about orchid seed conservation in the MSB PHOTO: S. LEGUIL

The MSBP's training programme

Sixteen participants, from Brazil, Colombia and Argentina, attended a five-day Seed Conservation Techniques training course, at Cenargen HQ in Nov 2012. Jointly organised and delivered by Kew and Cenargen, the course included key theory and practical sessions on topics from seed collecting through to seed longevity and storage. Participants spent a day at the EMBRAPA farm, making seed collections and preparing herbarium vouchers. The training course, one of the agreed joint activities under the Kew – EMBRAPA Memorandum of Understanding, signed in January 2011, was supported by the Sfumato Foundation, Kew and Cenargen. Another course is planned for 2014.

In a similar arrangement, a course, 'Plant Conservation Biology: Science and Practice', was held (1-14 March 2013) in New Delhi. This course was jointly organised and supported by the National Bureau for Plant Genetic Resources and Kew. It covered all aspects of *ex situ* conservation of plant genetic resources and was provided to 18 students from across Asia. This training course is one of the joint activities under the planned collaboration between Kew and the Indian Council for Agricultural Research.

UK National Tree Seed Project

With a host of new pests and diseases attacking the United Kingdom's native treescape, the MSBP is tackling the threat by establishing the country's first national collection of tree seeds – the UK National Tree Seed Project. At least one collection was made of most UK tree species under the MSBP UK Programme (1997-2000). However, the UK does not have comprehensive and genetically representative *ex situ* collections of native tree populations for research and use in practical conservation.

The Project will ensure that the collection of UK tree seeds already protected in the MSB will grow and become more comprehensive, eventually representing the full genetic diversity of the UK's tree populations. These seeds will be available to research organisations working on solutions to the threats facing UK trees, such as the control of pests and diseases and environmental change. Ultimately, these seed collections can be used for restoring trees to the UK countryside and increasing tree cover. The Forestry Commission is a key partner, providing advice on target species and help with collecting seeds.

Clare Trivedi is the UK National Tree Seed Project Co-ordinator, and will manage this project alongside her MSBP international partnerships. A Project Officer has been appointed and will work full-time on this project from June.



Collecting ash (*Fraxinus excelsior*) seeds at Wakehurst Place PHOTO: RBG KEW



Fragmented Widdringtonia population on Mulanje PHOTO: R.CROFT

PhD award

Chanyenga, Tembo F. (2013) Effect of population size on viable seed output, seed rain and natural regeneration pattern of a tropical conifer Widdringtonia whytei Rendle in Malawi. PhD thesis, University of Stellenbosch, South Africa.

Widdringtonia whytei is a tropical endemic coniferous, fire-adapted pioneer tree species within natural fire-fragmented Afromontane forest patches in a very confined area on Mulanje Mountain in Malawi. Survival of the species is presumed to be threatened by natural and anthropogenic factors, including uncontrolled harvesting of mature trees for its valuable timber. Tembo's study investigated how fragmentation affects the reproductive biology of the species in three sites. The results show that viable seed output was not affected by population size, tree diameter and crown position, whilst seed rain was influenced by population size. The presence of many seed producing trees in large fragments promoted seed rain density. The number of dispersed seeds was generally very low and poorly dispersed because W. whytei cones are semi-serotinous and depend on moderate to severe fires for heavy seedfalls and wider dispersal (which did not occur during the study period). The seed readily germinates between 15 and 25°C with the optimum at approximately 20°C either under light or dark conditions. Fragment size did not influence seedling regeneration in W. whytei and regeneration density was clearly related to the seed rain pattern. Seedling mortality was mainly caused by regular fires during the dry hot seasons outside the forest patches and along the edges, while the presence of thick litter layers and shady conditions caused mortality inside forest patches. This study provides important information for the conservation and management of this important high-value conifer. It highlights some of the difficulties the species is experiencing in terms of viable seed production, seed dispersal and seedling regeneration in and around the forest patches. To secure adequate regeneration and subsequent population growth in W. whytei, there is a need to allow moderate to severe spotting fires at intervals to promote seed dispersal and exposed mineral soil for rapid seedling establishment.

This PhD was supervised by Prof. Coert Geldenhuys and Dr. Moctar Sacande (contact: m.sacande@kew.org).



Millennium Seed Bank Collection Figures 31 May 2013

Total collections	64508
Number of species	33037
Number of genera	5412
Number of families	331

Key science publications (October 2012 – April 2013)

- 1. Paulsen, T. R., Colville, L., Kranner, I., Daws, M. I., Hogstedt, G., Vandvik, V. & Thompson, K. (2013) Physical dormancy in seeds: a game of hide and seek? New Phytologist 198 (2): 496-503.
- 2. Colville, L., Bradley, E. L., Lloyd, A. S., Pritchard, H. W., Castle, L. & Kranner, I. (2012) Volatile fingerprints of seeds of four species indicate the involvement of alcoholic fermentation, lipid peroxidation, and Maillard reactions in seed deterioration during ageing and desiccation stress. Journal of Experimental Botany 63 (18): 6519-6530.
- 3. Newton, R.J., Hay, F.R. & Ellis, R.H. (2013) Seed development and maturation in early spring-flowering Galanthus nivalis and Narcissus pseudonarcissus continues post-shedding with little evidence of maturation in planta. Annals of Botany doi: 10.1093/ aob/mct051
- 4. Alhdad, G. M., Seal, C. E., Al-Azzawi, J. & Flowers, T. J. (2013) The effect of combined salinity and waterlogging on the halophyte Suaeda maritima: the role of antioxidants. Environmental and Experimental Botany 8 (March): 120-125.
- 5. Pérez, M., Bueno, M. A., Escalona, M., Toorop, P., Rodríguez, R., & Cañal, M. J. (2013). Temporary immersion systems (RITA®) for the improvement of cork oak somatic embryogenic culture proliferation and somatic embryo production. Trees, 1-8. doi: 10.1007/ s00468-013-0876-y

Correction

Our apologies to Michele Sanchez whose name was omitted from the article "Kew's horticulturalists pollinating for the future" which appeared in the last issue of Samara. She jointly wrote this article with Noelia Alvarez and should have been credited.

WE WANT TO HEAR FROM YOU! Samara is your newsletter, so send us news and articles about yourself and your work. Contact the editors Kay Pennick and Clare Trivedi Royal Botanic Gardens, Kew Wakehurst Place, Ardingly, West Sussex, RH17 6TN, UK Tel: +44 1444 894178 Fax: +44 1444 894100 Email: samara@kew.org Samara aims to provide information and inspiration for MSBP partners and a flavour of the successes of the Partnership for other interested recipients and is available as a PDF from the MSBP website at: www.kew.org/samara If you wish to receive notification of future editions of Samara, then you need to provide us with your name, organisation, email address, and postal address. Please send your email to samara@kew.org. We will hold your details for the purposes of

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