GOVERNMENT OF WESTERN AUSTRALIA

BOTANIC GARDENS & PARKS AUTHORITY

Wanggalili Project Report

Seed Collection and Propagation Trial

August 2019

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Executive Summary

Kings Park and Botanic Garden was engaged to conduct seed collection and training on Yindjibarndi country and a plant propagation trial in the Kings Park nursery, as part of the Wanggalili Project. The project works form part of a feasibility study to inform a business case for a commercially viable and sustainable agricultural and manufacturing business, in which local Yindjibarndi plants are propagated and grown, harvested by local Aboriginal people then manufactured into products for commercial sale.

Three field trips by Kings Park staff to Yindjibarndi country were undertaken for seed collection and training purposes in August 2018, November 2018 and January 2019. Seven target species were collected for the propagation trials:

- *Capparis lasiantha* (Jirrwirliny)
- *Capparis spinosa* (Bajila)
- *Capparis umbonata* (Gayawayi)
- *Cynanchum floribundum* (Wajurru)
- *Ficus aculeata* (Tharburi)
- *Ficus brachypoda* (Winyarrangu)
- *Santalum lanceolatum* (Burdardu).

Seeds were transferred to Kings Park for processing and the following tests and trials were undertaken:

1. **Seed viability testing**: random samples of pure seeds were x-rayed using specialised equipment to give estimates of the presence of endosperm and viable embryos within the seed.
2. **Nursery propagation trials**: seeds were sown into forestry tubes with Kings Park standard growth media for native plants. Propagation was conducted in a controlled environment glasshouse providing warm protected conditions. A range of seed treatments were applied to determine the most effective pre-treatment to improve germination.
3. **Laboratory germination testing**: sterilised seeds of each species were placed in a grid pattern on water based agar germination plates, which were then placed in incubator cabinets under a controlled temperature regime. Temperatures for this trial ranged from of 25–35°C. A range of seed treatments were also applied to determine the most effective pre-treatment to improve germination.

The results are summarised in Table 1.

Results from these trials have been used to prepare preliminary protocols for each species to inform future plant production (Appendix A). Plants from the trials were dispatched to the Pilbara for planting on Yindjibarndi country. In the longer term, planned later stages will potentially further advance the knowledge base relating to the local regionally important species, broadening the palette of species beyond those targeted in stage one, and reflecting the great utility of the flora as understood by the Yindjibarndi people.
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Table 1: Summary of results from Nursery and Laboratory propagation trials

Species Name	Yindjibarndi name	Common name	Estimated viability	Nursery propagation trial		Laboratory Germination Trial	
				Best seed treatment	Germination %	Best seed treatment	Germination %
Capparis lasiantha	Jirrwirliny	Split Jack	95%	Nicking + GA	95.00%	Nil @ 30°C	95.00%
Capparis spinosa	Bajila	Caper Bush	95%	Nil	67.50%	H2SO4	12.00%
Capparis umbonata	Gayawayi	Wild orange/Mango	60%	Nil	17.50%	Nil @ 25°C	15.00%
Cynanchum floribundum	Wajurru	Native Pear	< 1%	Nil	0.42%	Nil @ 25°C	6.00%
Ficus aculeata	Tharburi	Sandpaper Fig	51%*	Nil	53.33%	NA	NA
Ficus brachypoda	Winyarrangu	Rock Fig	45%*	Nil	52.50%	NA	NA
Santalum lanceolatum	Burdardu	Northern sandalwood	67%	Nicking + GA	70.83%	Nil or H2SO4 + GA	1.00%

*Estimated viability following an additional separation process to remove a large percentage of the unviable seed from the seed lot.

Plate 1: Yindjibarndi and Kings Park Team in the Field Collecting – August 2018

Plate 2: Kings Park and Yindjibarndi Team at Millstream – November 2018

1 Background

Following an initial site visit in late 2017 and discussions that followed by email, in June 2018, Kings Park and Botanic Garden was engaged to conduct seed collection and training on Yindjibarndi country and a plant propagation trial in the Kings Park nursery, as part of the Wanggalili Project.

The project works form part of a feasibility study to inform a business case for a commercially viable and sustainable agricultural and manufacturing business, in which local Yindjibarndi plants are propagated and grown, harvested by local Aboriginal people then manufactured into products for commercial sale.

A list of six local native plant species with potential for future commercial development were proposed and agreed as the initial target species for the trial.

2 Document Purpose

This report documents the collection, storage and testing methods of the nominated target species of seeds and the methods and results of the plant propagation trial. It also provides protocols for future seed storage and plant production and some recommendations for future seed collection.

3 Seed Collection

Three field trips by Kings Park staff to Yindjibarndi country were undertaken for seed collection and training purposes in August 2018, November 2018 and January 2019. The first trip resulted in:

- Reconnaissance of the target areas, familiarisation with potential target species and their abundance, and establishment of the proposed collection sites.
- Training of ten Yindjibarndi participants in seed collection techniques, herbarium specimen collection and data recording.
- 28 herbarium collections of local species for confirmation of identification by the Kings Park botanist.
- Eight collections of seed from a range of plants, including some good quantities of *Solanum* species.

In addition, a positive and respectful working relationship was established with the Yindjibarndi people, including acknowledgement of the importance of their relationship with the land and the plants. Seed bags, secateurs, collection books and tags were left at the community centre for future collections to take place as more plants produced seed.

The November field trip was an opportunistic one as two Kings Park collecting staff were in the region for other purposes, funded by Kings Park. Outcomes of the second visit included:

- A meeting at Millstream Homestead with the Yindjibarndi collection team.
- Monitoring of the key target species for the project to determine collection dates.
- Tagging of several plants of target species while in flower for future seed collection, with specimens taken.

The third and final trip in January 2019 involved intensive collecting and meeting with project participants. Outcomes included:

- Good collections of five of the target species secured for the propagation trials, with one additional species (*Ficus brachypoda*, Winyarrangu/Rock Fig).
- Opportunity to meet with some of the project partners including City of Karratha.
- Meeting in Roebourne with key Yindjibarndi leaders.

Michael Woodley later delivered a good collection of the final target species to Kings Park, bringing the number of species included in the trial to seven.

All collections were assigned a seed lot number and Kings Park accession number and recorded in the horticultural database. (Table 2). The Kings Park Botanist confirmed species identification from herbarium specimens collected. Details of the four species collected but not included in the propagation trials are documented in Section 8.1 of this report.

Table 2: Target plant species details and reference numbers

Kings Park Accession Number	Kings Park Seed lot Number	Species Name	Yindjibarndi name	Common Name
20190112	17841	*Capparis lasiantha*	Jirrwirliny	Split Jack
20190114	17908	*Capparis spinosa*	Bajila	Caper Bush
20190113	17905	*Capparis umbonata*	Gayawayi	Wild orange/Mango
20190116	17915	*Cynanchum floribundum*	Wajurru	Native Pear
20190117	17919	*Ficus aculeata*	Tharburi	Sandpaper Fig
20190118	17920	*Ficus brachypoda*	Winyarrangu	Rock Fig
20190115	17914	*Santalum lanceolatum*	Burdardu	Northern sandalwood

Plate 3: Field training – August 2018

Plate 4: Collecting seed from Capparis spinosa

Interim reports on the seed collection and training trips were provided in August 2018 and March 2019.

4 Seed processing and viability testing

All seed was freshly collected within the four-month period before the trial was undertaken. Field collections were initially dried and cleaned to extract the pure seed from the fruits, using equipment and facilities in the Western Australian Seed Centre, Kings Park. Once cleaned, pure seed lots were placed in an environment controlled drying room with relative humidity of 15% to achieve optimum seed moisture content and stored at 18 °C prior to testing and sowing.

4.1 Seed Viability

Random samples of 100 pure seeds per species were counted out onto plates and x-rayed using specialised equipment to give initial estimates of the presence of endosperm and viable embryos within the seed. This x-ray process enables a quick, reasonably accurate and non-destructive estimation of the quality of a seed collection, or its viability.

Plate 5 shows an x-ray test plate image for target species *Capparis umbonata* as an example. Hollow (unviable) and filled (viable) seed are indicated on the plate. Careful interpretation and calibration for each species tested is required for accurate estimates.

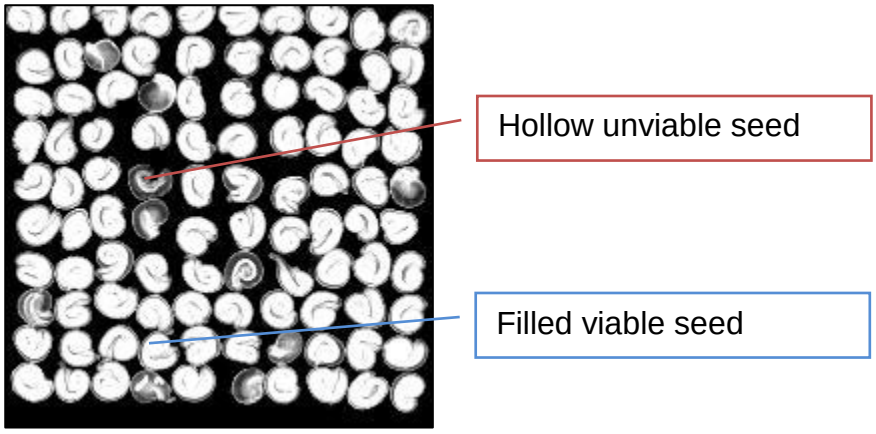

Plate 5: Example x-ray image of viable and non-viable seeds (Capparis umbonata)

Adjusted viability estimates for each of the trial species are presented in Table 3. The resulting viability estimates for the candidate species were typical for wild collected seed. The *Ficus* species were typified by very low viability and high seed numbers. The *Capparis* species exhibited a high estimated viability while *Santalum lanceolatum* was estimated at 67% viability. *Cynanchum floribundum* was estimated at very low viability with test interpretations suggesting aborted development within the seed. Subsequent germination testing confirmed this low viability estimate.

Table 3: Adjusted viability estimates for the seven candidate species

Seed lot Number	Species Name	Yindjibarndi name	Estimated number of seed in lot	Estimated viability by X-Ray
17841	*Capparis lasiantha*	Jirrwirliny	4325	95%
17908	*Capparis spinosa*	Bajila	27,287	95%
17905	*Capparis umbonata*	Gayawayi	1280	60%
17915	*Cynanchum floribundum*	Wajurru	1722	< 1%
17919	*Ficus aculeata*	Tharburi	37,850	< 0.025%
17920	*Ficus brachypoda*	Winyarrangu	30,750	< 1%
17914	*Santalum lanceolatum*	Burdardu	910	67%

4.2 Seed Separation Techniques

The very low viability estimates for each *Ficus* species was not considered practical or commercially viable for direct sowing techniques, which led to the use of novel seed-separation techniques on each of the *Ficus* seed lots to further separate the unviable seed by weight. The fine, uniform seed was separated using a zigzag separator, which separates seed batches by specific gravity into two types – heavy and light. This process removed a large percentage of the unviable seed, which was subsequently discarded. A random sample of the remaining seed was plated out and x-rayed to test whether the batch viability had increased to a more practical percentage. The results of this process showed an increased estimated viability of 45 - 51% (Table 4).

Table 4: Adjusted viability estimates for the Ficus species seed lots after processing with the specific gravity separator

Seed lot Number	Species Name	Yindjibarndi name	Pre-separation estimated viability	Post-separation viability
17919	*Ficus aculeata*	Tharburi	< 0.025%	51%
17920	*Ficus brachypoda*	Winyarrangu	< 1%	45%

Given the success of this technique for separating viable *Ficus* seed from very low viability seed lots it offers potential for processing bulk seed collections for storage and or direct sowing programs. Germination in subsequent nursery sowings confirmed the effectiveness of this technique with resulting germination percentage occurring at around 50%.

5 Nursery propagation trials

A series of nursery propagation trials were undertaken at the Kings Park Nursery from February to April 2019.

5.1 Methodology

5.1.1 Seed treatments

A range of seed treatments were applied to determine the most effective pre-treatment in improving germination results. Treatments included nicking of the seed coat, application of gibberellic acid (GA) or a combination of both these treatments. Descriptions of these treatments appear in Table 5.

Table 5: Seed treatment descriptions

Treatment Number	Descriptor	Description
1	Nil	Seed sown without any treatment (control)
2	Nicking	Nicking the seed coat (testa). Nicking is a quick and effective seed treatment used on some hard seeded medium to large seed where physical dormancy in the seed coat is suspected. Fine, side-cutting pliers are an effective tool for nicking some seed types. For smaller seeds a scalpel, forceps and a stereo microscope may be required. Plate 6 shows an example of seed nicking treatments.
3	Gibberellic acid treatment (GA)	Treatment of the seed with gibberellic acid by infusing the seed for 1 hour in a 100 ppm solution of GA3

Plate 6: Seed coat nicking technique on Capparis umbonata using side cutting electrician's pliers (from left); nicked seed ready for sowing (right). Photos: Dave Blumer.

Treatments were selected using the available knowledge for each species to produce the best germination outcomes in nursery soil based trials. Untreated seed of each species was sown as an experimental control. Table 6 shows the matrix of treatments for each species.

A total of 120 seeds were sown in each treatment group per species, representing three replicates of 40 seeds per treatment.

Table 6: Seed treatments for each species in the nursery, soil based propagation trial.

Yindjibarndi name	Species	Treatment	Total No. Seed Sown	Number of repeats	No. seed per repeat	Notes
Jirrwirliny	*Capparis lasiantha*	Nil	120	3	40	
Jirrwirliny	*Capparis lasiantha*	Nicking	120	3	40	
Jirrwirliny	*Capparis lasiantha*	Nicking + GA	120	3	40	
Bajila	*Capparis spinosa*	Nil	120	3	40	
Bajila	*Capparis spinosa*	Nicking	120	3	40	Small seed - difficult to nick
Bajila	*Capparis spinosa*	Nicking + GA	120	3	40	Small seed - difficult to nick
Gayawayi	*Capparis umbonata*	Nil	120	3	40	
Gayawayi	*Capparis umbonata*	Nicking	120	3	40	Evidence of a loose seed coat on many seeds when nicking- possible sign of aborted development.
Gayawayi	*Capparis umbonata*	Nicking + GA	120	3	40	Evidence of a loose seed coat on many seeds when nicking- possible sign of aborted development.
Wajurru	*Cynanchum floribundum*	Nil	120	3	40	
Tharburi	*Ficus aculeata*	Nil	120	3	40	All remainder seed batch sown into nursery trays to increased propagule numbers.
Winyarrangu	*Ficus brachypoda*	Nil	120	3	40	All remainder seed batch sown into nursery trays to increased propagule numbers
Burdardu	*Santalum lanceolatum*	Nil	120	3	40	
Burdardu	*Santalum lanceolatum*	Nicking	120	3	40	Hard seed coat – nicking effective exposing underlying endosperm
Burdardu	*Santalum lanceolatum*	Nicking + GA	120	3	40	Hard seed coat – nicking effective exposing underlying endosperm

5.1.2 Sowing

Seed propagation was conducted in a controlled environment glasshouse providing warm protected conditions (Plate 7). The estimated average air temperature in the dedicated propagation glasshouse ranged from 26–40°C.

Sowing occurred on 20 February 2019 with regular germination monitoring occurring until 24 April 2019. All seeds were sown into 50 mm square forestry tubes. The propagation mix was Kings Park standard growth media for native plants. Seeds were covered with a fine layer of 5 mm vermiculite.

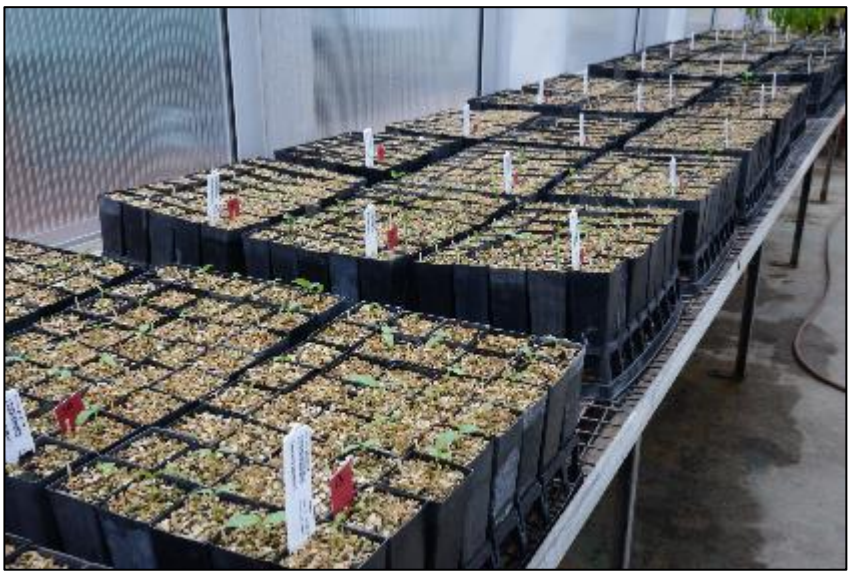

Plate 7: Nursery propagation trial - Glasshouse 6 Kings Park and Botanic Garden, 7 March 2019. Photo: Dave Blumer

5.2 Results and Discussion

The trial produced some interesting results from the range of treatments for each species ranging from 0.42% germination for the *Cynanchum floribundum*, through to the highest rate for *Capparis lasiantha* of 95% germination. The results are described in detail for each species below and summarised in Table 7. Results are also graphed in Figure 1 and Figure 2.

5.2.1 *Capparis lasiantha*

Capparis lasiantha was estimated to be highly viable seed (95%) from the x-ray process and proved to be highly germinable, with above 90% germination for all treatments. A slight increase in germination occurred with the seed treatments of nicking and nicking + GA, however the increase was not significant. Given the additional work required for pre-treatments and the insignificant increase in germination rates, standard sowing without treatment is recommended for this species. Germination rates of above 90% make it a viable method for production.

5.2.2 *Capparis spinosa*

Capparis spinosa was estimated to be highly viable seed (95%) from the x-ray process but germinated at 67% under standard sowing without treatment. The additional seed pre-treatments of nicking and nicking + GA proved to have a negative effect on germination,

reducing the results to 23–24% germination. The most likely cause of this is the small seed size making it difficult to nick the seed without damaging the endosperm and or embryo within the seed. Standard sowing without treatment is recommended for this species. Germination rates of 67% make it a viable method of production.

5.2.3 *Capparis umbonata*

Capparis umbonata was estimated to be 60% viable from the x-ray process but germinated at 17.5% in nursery trials with standard sowing without treatment. No benefit to germination occurred from the additional seed treatments of nicking and nicking + GA, which proved to have a detrimental effect on germination. Standard sowing without treatment is the current recommendation for this species, however, further investigation is also recommended. Allowing for longer seed maturation before collection may be beneficial to enhance germination. Future collection programs should target multiple sites and later collections to investigate seed maturity as a factor to increase germination, along with trialling potential alternative processing and treatments.

5.2.4 *Cynanchum floribundum*

Cynanchum floribundum was estimated to be less than 1% viable in the x-ray process and seed germinated at 0.42% for standard sowing in the nursery trials without treatment. Only standard sowing was tested due to the very low seed viability estimate. Resulting germination was consistent with the viability estimate. The current low viability and associated germination rates suggest this species requires further investigation. Allowing for longer seed maturation before collection is likely to be required so future collection programs should target multiple sites and later collections to investigate seed maturity as a factor to increase seed batch viability.

5.2.5 *Ficus aculeata*

Ficus aculeata was estimated to be 54% viable in the x-ray process following specialised separation, and germinated at 53.3% for standard sowing without treatment. Only standard sowing was tested due to the low initial seed viability estimate and the low seed numbers after the seed separation process. As the nursery trials resulted in germination rates consistent with the estimated viability, standard sowing without treatment is the current best recommendation for this species. Note that seedling losses for *Ficus* species can occur due to pests and diseases and appropriate controls should be undertaken. Some small losses were experienced at the cotyledon stage in this trial due to white fly attack. Larger seed collections and the seed cleaning techniques developed in this trial should facilitate production of commercial numbers of plants for future programs.

5.2.6 *Ficus brachypoda*

Ficus brachypoda was estimated to be 45% viable from the x-ray process following specialised separation techniques, and germinated at 52.5% for standard sowing without treatment. Only standard sowing was tested due to the low initial seed viability estimate and the low seed numbers after the seed separation. As the resulting germination occurred at a higher rate than the viability estimate, standard sowing without treatment is the current best recommendation for this species. Note that seedling losses for *Ficus* species can occur due to pests and diseases and appropriate controls should be undertaken. As for the other *Ficus* species, some small losses were experienced at the cotyledon stage in this trial due to white fly attack. Larger seed collections and the seed cleaning techniques developed in this trial should allow for the production of commercial numbers of plants for future programs.

5.2.7 *Santalum lanceolatum*

Santalum lanceolatum was estimated at 67% viability in the x-ray process and germinated at 28.3% for standard sowing in the nursery without treatment. A significant increase in germination occurred with seed pre-treatments, with nicking plus gibberellic acid treatment resulting in the highest germination rate of 70.8%, just above the estimated viability. The results show that nicking is very effective in increasing germination rates (60%) over no treatment, and although the addition of gibberellic acid combined with nicking increased germination by a further 10%, it may not be warranted given the time and cost involved. The use of gibberellic acid can also increase the risk of elongating seedlings, which can in some cases result in inferior plants. Standard sowing with nicking is recommended for this species as germination rates of 60% make it a viable method of production.

Table 7: Germination results for the nursery, soil based propagation trial.

Yindjibarndi name	Species	Treatment	Germination Percentage	Notes
Jirrwirliny	*Capparis lasiantha*	Nil	90.83%	Highly germinable seed
Jirrwirliny	*Capparis lasiantha*	Nicking	93.33%	Slight but not significant improvement with nicking
Jirrwirliny	*Capparis lasiantha*	Nicking + GA	95.00%	Slight but not significant improvement with nicking + GA
Bajila	*Capparis spinosa*	Nil	67.50%	Good germination without treatment
Bajila	*Capparis spinosa*	Nicking	23.33%	Nicking is detrimental
Bajila	*Capparis spinosa*	Nicking + GA	24.17%	Nicking + GA is detrimental
Gayawayi	*Capparis umbonata*	Nil	17.50%	Germination data supports possible sign of aborted development evidenced by gaps between seed coat and endosperm.
Gayawayi	*Capparis umbonata*	Nicking	10.83%	Nicking is detrimental
Gayawayi	*Capparis umbonata*	Nicking + GA	5.00%	Nicking + GA is detrimental
Wajurru	*Cynanchum floribundum*	Nil	0.42%	Germination as per low viability estimate seed batch
Tharburi	*Ficus aculeata*	Nil	53.33%	Good germination resulting from improved seed lot quality through specialised separation process.
Winyarrangu	*Ficus brachypoda*	Nil	52.50%	Good germination resulting from improved seed lot quality through specialised separation process.
Burdardu	*Santalum lanceolatum*	Nil	28.33%	Very hard seed coat.
Burdardu	*Santalum lanceolatum*	Nicking	60.00%	Significant improvement in seed germination resulting from nicking
Burdardu	*Santalum lanceolatum*	Nicking + GA	70.83%	Significant improvement in seed germination resulting from nicking+ GA

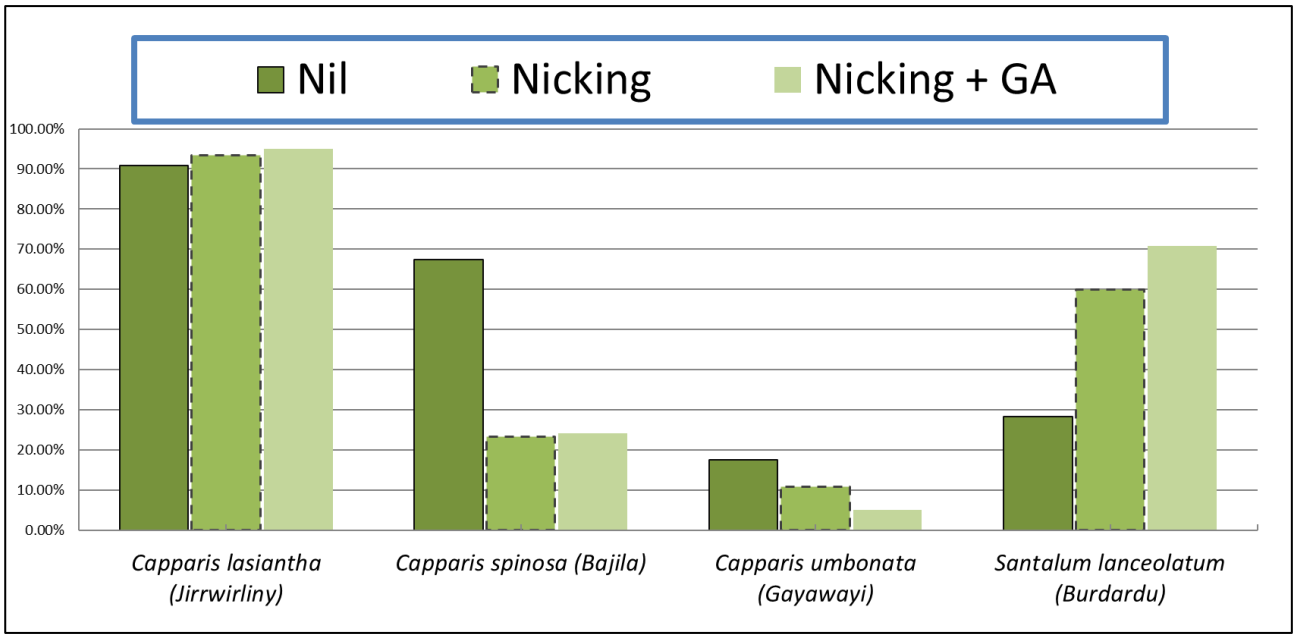

Figure 1: Average seed germination (%) of four candidate species trialed using nicking and gibberellic acid treatments

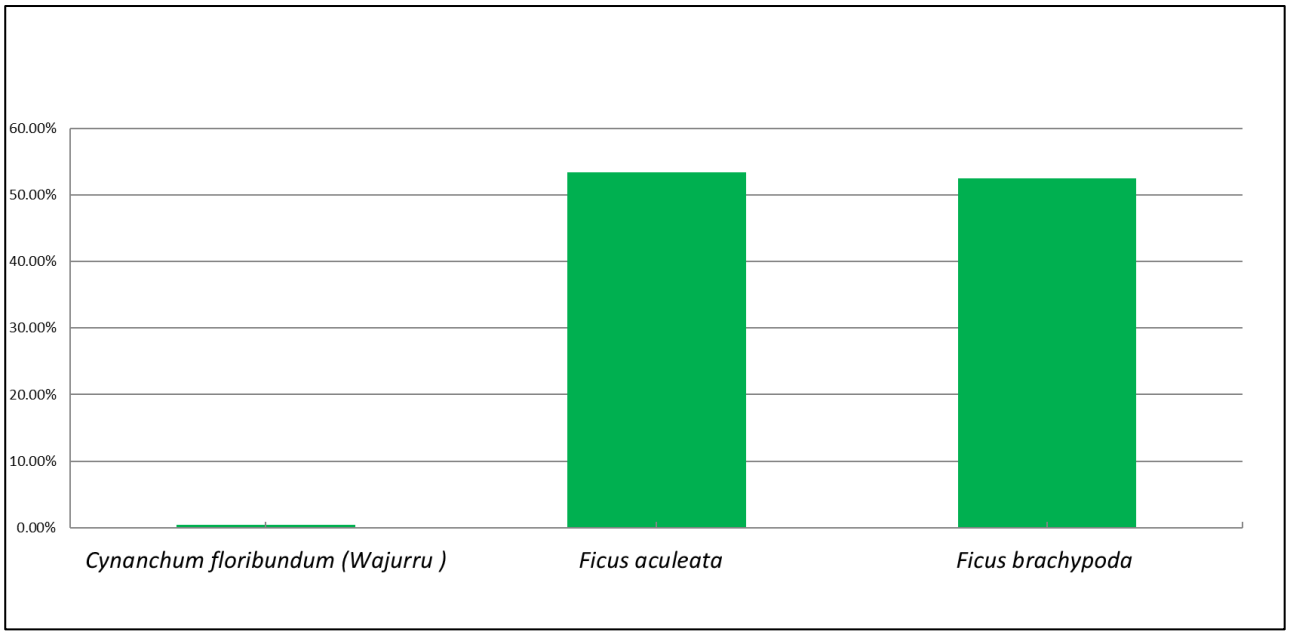

Figure 2: Average seed germination (%) of three candidate species sown without seed treatments

6 Laboratory germination testing

Laboratory germination testing is an important tool to provide base line data under controlled repeatable conditions. This is a key scientific metric for each seed batch and provides insight into likely germination under nursery conditions and how storage affects seed viability over time. It allows for a range of germination temperature regimes to be tested at any time of year and provides a mechanism for testing many dormancy-breaking treatments.

Laboratory based testing does not always match standard soil-based germination under nursery conditions (as is the case with the *Capparis spinosa* seed batch in this report). This usually means one or more determining factor was different between the two methods of germination. High levels of plate contamination can also adversely affect laboratory germination.

6.1 Methodology

Germination testing was undertaken in controlled laboratory conditions at the Biodiversity Conservation Centre in Kings Park during March 2019. This involved sterilised seed of each species placed in a grid pattern on water based agar germination plates (Plate 8), which were then placed in incubator cabinets under a controlled temperature regime. Temperatures for this trial ranged from of 25–35°C.

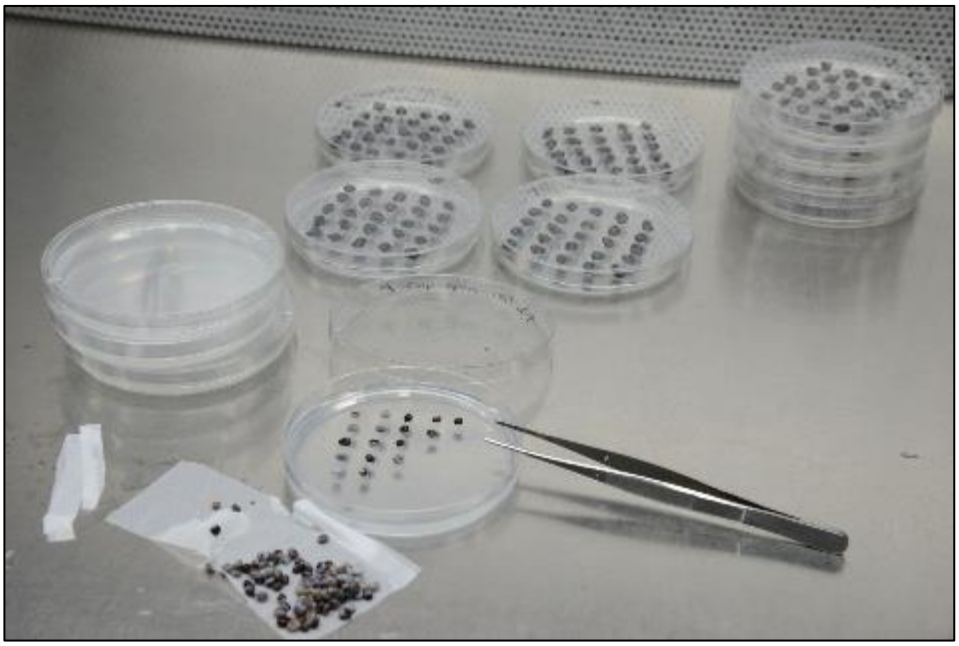

Plate 8: Laboratory germination test set up – Capparis spinosa seed. Photo: Dave Blumer

6.1.1 Seed treatments

A range of seed pre-treatments were applied as for the nursery trials with additional treatments tested to complement the nursery trials. These included seed nicking, gibberellic acid, acid scarification and combinations of these, plus different temperature regimes. All species included a control of untreated seed.

Treatments are described in Table 8 and a matrix of treatment combinations applied is provided in Table 9.

A total of 100 seeds were tested per treatment, representing four replicates of 25 seeds.

Table 8: Laboratory seed treatment descriptions

Treatment Number	Descriptor	Description
1	Nil	Seed sown without any treatment (control)
2	Nicking	Nicking the seed coat (testa)
3	GA	Gibberellic acid treatment. Treatment of the seed with gibberellic acid by infusing the seed for 1 hour in a 100 ppm solution of GA3
4	H2SO4	Acid scarification. Treatment of the seed with high concentration sulphuric acid (98% laboratory grade) by immersing the seed for varying periods to break physical dormancy within the seed coat.

Table 9: Seed treatments for the laboratory based germination testing

Yindjibarndi name	Species	Treatment	No. Seed Sown	Number of repeats	No. Seed per repeat	Temp °C
Jirrwirliny	*Capparis lasiantha*	Nil	100	4	25	30
Jirrwirliny	*Capparis lasiantha*	H2SO4 + GA	100	4	25	30
Bajila	*Capparis spinosa*	Nil	100	4	25	30
Bajila	*Capparis spinosa*	H2SO4 + GA	100	4	25	30
Bajila	*Capparis spinosa*	Nil	100	4	25	25
Bajila	*Capparis spinosa*	Nil	100	4	25	35
Bajila	*Capparis spinosa*	H2SO4	100	4	25	30
Gayawayi	*Capparis umbonata*	Nil	100	4	25	30
Gayawayi	*Capparis umbonata*	H2SO4 + GA	100	4	25	30
Gayawayi	*Capparis umbonata*	Nil	100	4	25	25
Gayawayi	*Capparis umbonata*	Nil	100	4	25	35
Wajurru	*Cynanchum floribundum*	Nil	100	4	25	30
Wajurru	*Cynanchum floribundum*	Nicking	100	4	25	30
Wajurru	*Cynanchum floribundum*	Nil	100	4	25	25
Wajurru	*Cynanchum floribundum*	Nil	100	4	25	35
Wajurru	*Cynanchum floribundum*	Nicking	100	4	25	25
Wajurru	*Cynanchum floribundum*	Nicking	100	4	25	35
Burdardu	*Santalum lanceolatum*	Nil	100	4	25	35
Burdardu	*Santalum lanceolatum*	H2SO4 + GA	100	4	25	35
Burdardu	*Santalum lanceolatum*	GA	100	4	25	35

6.2 Results and Discussion

Laboratory germination testing provided baseline data for the seed batches and was generally consistent with the results of the soil based nursery propagation trial. The exceptions to this were the *Capparis spinosa* seed batch that performed better in glasshouse trials, most likely due to a diurnal temperature change requirement, and the *Santalum lanceolatum* seed batch that suffered from high levels of contamination in the laboratory based tests. The results are discussed below and summarised in Table 10.

6.2.1 *Capparis lasiantha*

Capparis lasiantha recorded a germination rate of 95% for untreated seed, matching the estimated viability of the seed from x-ray. A significant decrease in germination occurred with pre-treatment with GA plus acid scarification.

6.2.2 *Capparis spinosa*

Capparis spinosa germinated at 12% or less for all treatments and temperatures, despite an estimated high viability rate (95%) from the x-ray process. There was no significant benefit to germination from any of the treatments with poor laboratory results most likely due to a diurnal temperature change requirement, as occurred in the nursery trial. Temperatures in the laboratory test were constant.

6.2.3 *Capparis umbonata*

Capparis umbonata was estimated to be 60% viable from the x-ray process but germinated at 15% without treatment at 25°C. This result was similar to the nursery trial with no benefit to germination derived from pre-treatments or higher temperatures. Further testing is required to identify potential dormancy within this species.

6.2.4 *Cynanchum floribundum*

Cynanchum floribundum had less than 1% estimated viability and the highest germination rate of 6% was through no pre-treatment at 25°C. Germination rates were lower at higher temperatures tested and nicking seed provided no benefit. The current low viability and associated germination rates indicate further investigation is needed.

6.2.5 *Santalum lanceolatum*

Santalum lanceolatum was affected by high contamination, possibly due to the sterilisation process being less effective on these seeds due to their very rough seed coat. Tests resulted in poor germination rates of 1%, much lower than the nursery trials, despite 67% estimated viability. Future laboratory testing for this species should include consideration of alternative seed coat sterilisation methods. Note, some species are inherently problematic in laboratory tests due to persistent infection arising from the seed coat.

Table 10: Germination results for the laboratory based germinability testing

Yindjibarndi name	Species	Treatment	Temp °C	Germination Percentage
Jirrwirliny	*Capparis lasiantha*	Nil	30	95.00%
Jirrwirliny	*Capparis lasiantha*	H2SO4 + GA	30	36.00%
Bajila	*Capparis spinosa*	Nil	30	7.00%
Bajila	*Capparis spinosa*	H2SO4 + GA	30	4.00%
Bajila	*Capparis spinosa*	Nil	25	3.00%
Bajila	*Capparis spinosa*	Nil	35	0.00%
Bajila	*Capparis spinosa*	H2SO4	30	12.00%
Gayawayi	*Capparis umbonata*	Nil	30	2.00%
Gayawayi	*Capparis umbonata*	H2SO4 + GA	30	1.00%
Gayawayi	*Capparis umbonata*	Nil	25	15.00%
Gayawayi	*Capparis umbonata*	Nil	35	1.00%
Wajurru	*Cynanchum floribundum*	Nil	30	1.00%
Wajurru	*Cynanchum floribundum*	Nicking	30	2.00%
Wajurru	*Cynanchum floribundum*	Nil	25	6.00%
Wajurru	*Cynanchum floribundum*	Nil	35	0.00%
Wajurru	*Cynanchum floribundum*	Nicking	25	1.00%
Wajurru	*Cynanchum floribundum*	Nicking	35	1.00%
Burdardu	*Santalum lanceolatum*	Nil	35	1.00%
Burdardu	*Santalum lanceolatum*	H2SO4 + GA	35	1.00%
Burdardu	*Santalum lanceolatum*	Ga	35	0.00%

7 Seed processing, storage and propagation protocols

A major focus of the current project has been practical seed collection and training, seed processing for both use and storage, plus propagation trials for the target species to inform future plant production. Some of the species tested are poorly understood given limited previous studies, however, information from the trials has been collated as preliminary protocols for each species.

These protocols are included at Appendix A.

8 Collection and propagation outcomes

8.1 Additional species collected

Table 11 lists the plant species collected through the seed collection program that were additional to the target species, including reference numbers and associated data relating to the seed batches. Although not the focus of the propagation/growth trials, these valuable seed resources add value to the project and are available for future plant propagation and growth trials.

Table 11: Additional plant species opportunistically collected through the project collection program.

Accession Number	Seed lot Number	Species Name	Yindjibarndi name	Common Name	Estimated number of seed in seed lot	Estimated viability
20181661	17655	*Solanum diversifolium*	Garlumbu	Native Tomato	22800	45.00%
20190192	19580	*Amaranthus undulatus*		Desert Raisin	11500	95.00%
20181660	17654	*Solanum albostellatum*		Native Tomato	70	87.00%
20190426	19654	*Solanum horridum*		Lace Flower	8585	95.00%

8.2 Plant production

While the main focus of the nursery propagation trials was to test a range of seed pre-treatments and establish germination rates, these trials produced healthy germinants that were subsequently gown on as tube stock. Most of the plants produced were made available to project partners for planting on Yindjibarndi country and around the Roebourne town site, so that their performance could be monitored over time. In addition, some selected plants have been retained for cultivation in the Western Australian Botanic Garden at Kings Park to enhance the living collections and monitor their performance in the cooler climate.

Kings Park Horticulturists reviewed the stock in terms of developmental stage, health, vigour and pest/disease status to ensure the plants provided to the partners met high horticultural standards. A total of 368 quality tube stock plants from the target species were transported to Roebourne in July 2019. Plant production outcomes are documented in Table 12.

Table 12: Plant stock resulting from propagation trial

Kings Park plant record numbers	Plant Name	Quantity sent to Roebourne	Quantity for WA Botanic Garden	Notes on remaining stock in Kings Park nursery
20190112*4/19A	*Capparis lasiantha*	50	20	Small number of undeveloped plants remain
20190114*4/19A	*Capparis spinosa*	80	11	A small number of plants with poor root development remain
20190113*4/19A	*Capparis umbonata*	7	Potential to cultivate if plants progress	A small number of poorly developed plants remain - growth arrested due to seasonal change.
20190116*4/19A	*Cynanchum floribundum*	4	Potential to cultivate if plants progress	A very small number of poorly developed plants remain
20190117*4/19A	*Ficus aculeata*	38	Potential to cultivate if plants progress	A very small number of poorly developed plants remain
20190118*4/19A	*Ficus brachypoda*	29	Potential to cultivate if plants progress	A very small number of poorly developed plants remain
20190118*4/19B	*Ficus brachypoda*	80	Potential to cultivate if plants progress	A number of undeveloped plants remain
20190115*4/19A	*Santalum lanceolatum.*	80	Potential to cultivate if plants progress	A number of undeveloped plants remain

It is strongly recommended that the plant stock transported to Roebourne is planted as soon as possible after the initial hardening off process of four weeks. Plants will need supplementary watering through the first year in warm dry weather until they begin to develop their root systems in the native soil. A temporary drip irrigation system is recommended for this purpose.

Plate 9: Seedlings grown in Greenhouse

Plate 10: Delivery of plants to Roebourne

8.3 Seed remaining in storage

As not all the seed collected during the project was used in the propagation and germination trials, some seed remains in storage at the Western Australian Seed Centre Kings Park for future use. Table 13 lists the remaining seed resources retained in storage at Kings Park.

Table 13: Untreated seed in storage collected for the Wanggalili Project

Accession Number	Seed lot Number	Species Name	Yindjibarndi name	Common Name	Estimated No of Seeds Remaining	Estimated Viability by X-Ray	Storage Condition
20190112	17841	*Capparis lasiantha*	Jirrwirliny	Split Jack	1988	95.00%	-18 °C Freezer Vault
20190114	17908	*Capparis spinosa*	Bajila	Caper Bush	18460	95.00%	-18 °C Freezer Vault
20190113	17905	*Capparis umbonata*	Gayawayi	Wild orange/Mango	85	60.00%	-18 °C Freezer Vault
20190116	17915	*Cynanchum floribundum*	Wajurru	Native Pear	907	< 1%	-18 °C Freezer Vault
20190117	17919	*Ficus aculeata*	Tharburi	Sandpaper Fig	Nil remaining - all seed utilised in project		
20190118	17920	*Ficus brachypoda*	Winyarrangu	Rock Fig	Nil remaining - all seed utilised in project		
20190115	17914	*Santalum lanceolatum*	Burdardu	Northern sandalwood	Nil remaining - all seed utilised in project		
20181661	17655	*Solanum diversifolium*	Garlumbu	Native Tomato	22800	45.00%	-18 °C Freezer Vault
20190192	19580	*Amaranthus undulatus*		Desert Raisin	11500	95.00%	-18 °C Freezer Vault
20181660	17654	*Solanum albostellatum*		Native Tomato	70	87.00%	-18 °C Freezer Vault
20190426	19654	*Solanum horridum*		Lace Flower	8585	95.00%	-18 °C Freezer Vault

9 Conclusion and recommendations

The Wanggalili Project has provided a unique opportunity for staff at Kings Park and Botanic Garden to collaborate with the Yindjibarndi people in the identification of potential native plants for future agricultural production, collection of seed and plant propagation trials to inform the feasibility study for the overall project. Site visits to the Pilbara have enabled sharing of knowledge and understanding between the parties and provided some useful training for the Yindjibarndi collection team in appropriate seed collection methods for the future. A respectful working relationship has been developed that acknowledges the Traditional Owners' connections to country and the plants within it and important new networks have been established.

In addition, some valuable information has been derived from the propagation and germination trials and documented in this report for future reference. Important data has been collected in this first stage of the trial, and results provide important understandings, methods and principles from the study thus far. In the longer term, planned later stages will potentially further advance the knowledge base relating to the local regionally important species, broadening the palette of species beyond those targeted in stage one, and reflecting the great utility of the flora as understood by the Yindjibarndi people.

Outcomes to date:

1. Effective collection, cleaning and storage program for initial target species.
2. Initial familiarisation and training sessions for Yindjibarndi participants in relation to field collection of seed of native plant species.
3. Important fundamental knowledge relating to seed metrics and plant propagation leading to a better understanding of poorly studied species.
4. Beneficial seed treatments to enhance germination and seed batch viability.
5. Production and delivery of over 300 native plants for planting on Yindjibarndi country, to enhance motivation among community members to become involved in the Wanggalili project.
6. Some seed resources stored at Kings Park and available to the program.
7. Documentation of production protocols for seven target species (Appendix A).

Further recommendations:

1. Further collections of target species are made in following seasons to:
    a. Re-collect seed lots of species which were found to have low viability in the initial trial such as *Cynanchum floribundum* and the *Ficus* species to enable further investigation of propagation techniques.
    b. Expand the genetic resource including selection for superior plant traits.
    c. Develop a reliable seed bank of native species with commercial potential future programs and local commercial activities.
2. Focus collection programs on a wider distribution of the species and target a range of collection times with emphasis on later collections for *Cynanchum floribundum* and *Capparis umbonata* for which some underdevelopment of seed is suspected.
3. Record all collection data and collect a pressed plant specimen for each location.
4. Investigate formal training opportunities through the relevant TAFE colleges, for Yindjibarndi horticultural skills and knowledge development.

Appendix A Seed processing and propagation protocols

A 1 Capparis lasiantha

Species Name	***Capparis lasiantha***
Yindjibarndi name	Jirrwirliny
Common Name	Split Jack
Accession number (BGBASE)	20190112
Seed Lot Number (BGBASE)	17908
Estimated Viability (X-RAY)	95.00%
Best Germinability	0.95
Seed Cleaning Method	1 - If dry break open fruit to dislodge seed. If the fruit is fresh cut open and scoop out seeds. 2 - Remove as much pulp (non-seed matter) as possible. 3 - Soak overnight in pectinase solution of 1 g/L. 4 - Rinsed and agitated through a sieve to remove remaining pulp. 5 - Dry seed for storage.
Target Seed Moisture Content	10-12%
Recommended Seed Drying Method	Place in thin layers in a dry area with good ventilation and under cover. Avoid extremes of temperature and humid conditions. Seeds should finish their drying in low humidity conditions such as an air-conditioned room. Best conditions are a dedicated drying room which regulates temperature to 18 °C and relative humidity to 15%.
Recommended Seed Storage Method	In hermetically sealed bags or airtight jars/containers. -20 °C freezer storage for long terms storage or 5–15 °C for medium to short term storage.
Recommended pre-sowing seed treatment	Nil
Sowing methodology	Sow directly into forestry tubes or cell trays. Raise seed with 5mm vermiculite.
Recommended Sowing Temperature	Average daily temperatures around 35 °C
Notes	

Seed Image, Photo: D. Blumer

Flower, Photo: L. Sweedman

A 2 Capparis spinosa

Species Name	***Capparis spinosa***
Yindjibarndi Name	Bajila
Common Name	Caper bush
Accession number (BGBASE)	20190114
Seed Lot Number (BGBASE)	17908
Estimated Viability (X-RAY)	95.00%
Best Germinability	67.50%
Seed Cleaning Method	1 - If dry break open fruit to dislodge seed. If the fruit is fresh cut open and scoop out seeds. 2 - Remove as much pulp (non-seed matter) as possible. 3 - Soak overnight in pectinase solution of 1 g/L . 4 - Rinsed and agitated through a sieve to remove remaining pulp. 5 - Dry seed for storage.
Target Seed Moisture Content	10-12%
Recommended Seed Drying Method	Place in thin layers in a dry area with good ventilation and under cover. Avoid extremes of temperature and humid conditions. Seeds should finish their drying in low humidity conditions such as an air-conditioned room. Best conditions are a dedicated drying room which regulates temperature to 18 °C and relative humidity to 15%.
Recommended Seed Storage Method	In hermetically sealed bags or airtight jars/containers. -20 °C freezer storage for long terms storage or 5–15 °C for medium to short term storage.
Recommended pre-sowing seed treatment	Nil
Sowing Methodology	Sow directly into forestry tubes or cell trays. Raise seed with 5mm vermiculite.
Recommended Sowing Temperature	Average daily temperatures around 35 °C
Notes	Diurnal temperature change may be an important requirement for this species.

Seed Image, Photo: D. Blumer

Flower, Photo: L. Sweedman

A 3 Capparis umbonata

Species Name	***Capparis umbonata***
Yindjibarndi name	Gayawayi
Common Name	Wild orange/mango
Accession number (BGBASE)	20190113
Seed Lot Number (BGBASE)	17905
Estimated Viability (X-RAY)	60.00%
Best Germinability	17.50%
Seed Cleaning Method	1 - If dry break open fruit to dislodge seed. If the fruit is fresh cut open and scoop out seeds. 2 - Remove as much pulp (non-seed matter) as possible. 3 - Soak overnight in pectinase solution of 1 g/L . 4 - Rinsed and agitated through a sieve to remove remaining pulp. 5 - Dry seed for storage.
Target Seed Moisture Content	10-12%
Recommended Seed Drying Method	Place in thin layers in a dry area with good ventilation and under cover. Avoid extremes of temperature and humid conditions. Seeds should finish their drying in low humidity conditions such as an air-conditioned room. Best conditions are a dedicated drying room which regulates temperature to 18 °C and relative humidity to 15%.
Recommended Seed Storage Method	In hermetically sealed bags or airtight jars/containers. -20 °C freezer storage for long terms storage or 5–15 °C for medium to short term storage.
Recommended Pre-Sowing Seed Treatment	Nil
Sowing Methodology	Sow directly into forestry tubes or cell trays. Raise seed with 5mm vermiculite.
Recommended Sowing Temperature	Average daily temperatures around 35 °C
Notes	

Seed Image, Photo: D. Blumer

Fruits, Photo: L. Sweedman

A 4 Cynanchum floribundum

Species Name	***Cynanchum floribundum***
Yindjibarndi name	Wajurru
Common Name	Native pear
Accession number (BGBASE)	20190116
Seed Lot Number (BGBASE)	17915
Estimated Viability (X-RAY)	75.00%
Best Germinability	6.00%
Seed Cleaning Method	1 - Break open fruit to dislodge seed. 2 - Remove as much pulp (non-seed matter) as possible. 3 - Soak overnight in pectinase solution of 1 g/L . 4 - Rinsed and agitated through a sieve to remove remaining pulp. 5 - Dry seed for storage.
Target Seed Moisture Content	10-12%
Recommended Seed Drying Method	Place in thin layers in a dry area with good ventilation and under cover. Avoid extremes of temperature and humid conditions. Seeds should finish their drying in low humidity conditions such as an air-conditioned room. Best conditions are a dedicated drying room which regulates temperature to 18 °C and relative humidity to 15%.
Recommended Seed Storage Method	In hermetically sealed bags or airtight jars/containers. -20 °C freezer storage for long terms storage or 5–15 °C for medium to short term storage.
Recommended Pre-Sowing Seed Treatment	Nil
Sowing Methodology	Sow directly into forestry tubes or cell trays. Raise seed with 5mm vermiculite.
Recommended Sowing Temperature	Average daily temperatures around 25 °C
Notes	

Seed Image, Photo: D. Blumer

Fruits\Foliage, Photo: L. Sweedman

A 5 Ficus aculeata

Species Name	***Ficus aculeata***
Yindjibarndi name	Winyarrangu
Common Name	Sandpaper Fig
Accession number (BGBASE)	20190117
Seed Lot Number (BGBASE)	17919
Estimated Viability (X-RAY)	2.00%
Best Germinability	53.33% (After seed separation by specific gravity see section)
Seed Cleaning Method	1 - If dry break open fruit to dislodge seed. If the fruit is fresh cut open and scoop out seeds. 2 - Remove as much pulp (non-seed matter) as possible. 3 - If fresh soak overnight in pectinase solution of 1 g/L . 4 - Rinsed and agitated through a sieve to remove remaining pulp. 5 - Dry seed for storage.
Target Seed Moisture Content	10-12%
Recommended Seed Drying Method	Place in thin layers in a dry area with good ventilation and under cover. Avoid extremes of temperature and humid conditions. Seeds should finish their drying in low humidity conditions such as an air-conditioned room. Best conditions are a dedicated drying room which regulates temperature to 18 °C and relative humidity to 15%.
Recommended Seed Storage Method	In hermetically sealed bags or airtight jars/containers. -20 °C freezer storage for long terms storage or 5–15 °C for medium to short term storage.
Recommended Pre-Sowing Seed Treatment	Nil
Sowing Methodology	Thin seed with clean sand. Sow into seed trays. Prick out seedlings at the 3 true leaf stage. Raise seed with 5mm vermiculite.
Recommended Sowing Temperature	Average daily temperatures around 35 °C
Notes	

Seed Image, Photo: D. Blumer

Foliage, Photo: L. Sweedman

A 6 Ficus brachypoda

Species Name	***Ficus brachypoda***
Yindjibarndi name	Winyarrangu
Common Name	Rock Fig
Accession number (BGBASE)	20190118
Seed Lot Number (BGBASE)	17920
Estimated Viability (X-RAY)	2.00%
Best Germinability	54.00% (After seed separation by specific gravity see section)
Seed Cleaning Method	1 - If dry break open fruit to dislodge seed. If the fruit is fresh cut open and scoop out seeds. 2 - Remove as much pulp (non-seed matter) as possible. 3 - If fresh soak overnight in pectinase solution of 1 g/L . 4 - Rinsed and agitated through a sieve to remove remaining pulp. 5 - Dry seed for storage.
Target Seed Moisture Content	10-12%
Recommended Seed Drying Method	Place in thin layers in a dry area with good ventilation and under cover. Avoid extremes of temperature and humid conditions. Seeds should finish their drying in low humidity conditions such as an air-conditioned room. Best conditions are a dedicated drying room which regulates temperature to 18 °C and relative humidity to 15%.
Recommended Seed Storage Method	In hermetically sealed bags or airtight jars/containers. -20 °C freezer storage for long terms storage or 5–15 °C for medium to short term storage.
Recommended Pre-Sowing Seed Treatment	Nil
Sowing Methodology	Thin seed with clean sand. Sow into seed trays. Prick out seedlings at the 3 true leaf stage. Raise seed with 5mm vermiculite.
Recommended Sowing Temperature	Average daily temperatures around 35 °C
Notes	

Seed Image, Photo: D. Blumer

Foliage\Fruit, Photo: L. Sweedman

A 7 Santalum lanceolatum

Species Name	***Santalum lanceolatum***
Yindjibarndi name	Burdardu
Common Name	Sandalwood Fig
Accession number (BGBASE)	20190115
Seed Lot Number (BGBASE)	17914
Estimated Viability (X-RAY)	67.00%
Best Germinability	67.00 %
Seed Cleaning Method	1 - Peel the endocarp (out layer) from fruit to expose seed. Soak in water to assist this process. 2 - Dry seed for storage.
Target Seed Moisture Content	10-12%
Recommended Seed Drying Method	Place in thin layers in a dry area with good ventilation and under cover. Avoid extremes of temperature and humid conditions. Seeds should finish their drying in low humidity conditions such as an air-conditioned room. Best conditions are a dedicated drying room which regulates temperature to 18 °C and relative humidity to 15%.
Recommended Seed Storage Method	In hermetically sealed bags or airtight jars/containers. 5–15 °C for medium to short term storage.
Recommended Pre-Sowing Seed Treatment	Seed Nicking
Sowing Methodology	Sow directly into forestry tubes or cell trays. Raise seed with 5mm vermiculite.
Recommended Sowing Temperature	Average daily temperatures around 35 °C
Notes	

Seed Image, Photo: D. Blumer

Foliage, Photo: L. Sweedman