Konjac: Production in Japan and Potential for New Zealand©

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INTRODUCTION

Konjac (*Amorphophallus konjac* syn. *A. rivieri*), devil's tongue, snake palm, umbrella arum, or konnyaku, as it is known in Japan, is a member of the Araceae (aroid) family which contains ninety or so species of cormous perennial, deciduous herbs. Konjac is a native of Asia from Indonesia to Japan. In Japan it is grown for its large edible corms which are traditionally made into noodles. Now almost the entire crop grown in Japan is processed to extract gluco mannan, a carbohydrate which is used as a thickening and gelling agent, and as a fat replacement in a wide range of food preparations in the fast food industry. In Japan konjac is regarded as a health food because it is high in dietary fibre and can be used in food preparations suitable for diabetics. It is also often incorporated into slimming preparations because it is low in calories. Eleven to twelve thousand tonnes of konjac are produced annually in Japan with 80% produced in Gumma Prefecture, north west of Tokyo. Outside Asia, konjac is also grown as an ornamental in shady situations and is popular because of its impressive compound foliage and marbled petioles and stems.

ENVIRONMENTAL FACTORS

The main production area for konjac is near Shibukawa in Gumma Prefecture which is situated 360 m above sea level. Shibukawa has an annual mean temperature of 12.4°C and annual rainfall of 1215 mm. This climate is similar to the Waikato, in New Zealand, where konjac trials are currently underway. Maximum growth occurs at temperatures from 20 to 25°C (Hetterscheid and Ittenbach, 1996).

Research in Japan indicates that konjac grows better and produces larger corms under 60% shade (Miura and Osaka, 1981) while Seo et al., (1988) found yields increased from 5.83 to 7.91 tonnes ha^{-1} as light intensity was reduced from full sun to 75% shade. In spite of these results all production observed in Gumma Prefecture was being grown under full sun. Maximum recorded light intensity at the Konjac Research Station in the middle of summer was 398 $J \cdot m^{-2} \cdot s^{-1}$. In New Zealand light intensity can reach 543 $J \cdot m^{-2} \cdot s^{-1}$.

Konjac can tolerate winter snow but is susceptible to early spring frosts and in the Waikato they can cause considerable damage especially to flowering stems which appear first after the winter dormancy. The large leaves and stems of konjac can also be severely damaged by strong winds and good shelter is needed to grow the crop on exposed sites.

Soil Type. A rich, friable, free-draining soil is preferred. The main production area in Japan has a volcanic ash soil with appreciable quantities of pumice. This is very similar to the sandy loam soils found in the Waikato and the Central North Island of New Zealand.

PRODUCTION METHODS

Dormant konjac corms are planted in the spring and grow through the warm part of the year. The foliage dies down in late autumn and the plant overwinters as a corm, re-emerging again in the spring. It has a strong winter dormancy and it will often emerge in late spring or early summer after a mild winter.

Propagation. Konjac is propagated either by seeds, offsets, corms, or tissue culture. For commercial production, offsets, which are produced on the main corm, are used. These are removed from the main corm at harvest and planted in a nursery area for 1 year. Offsets are usually planted about 10 cm deep. Roots form at the top of the corm so shallow planting can cause new roots to dry out during a dry spring. Only offsets from high-yielding disease-free corms should be used. Our research conducted at the Rukuhia Research Station in the Waikato in a shade house has shown a relationship between harvested corm wet weight and the number of offsets produced per corm, represented by the equation:

$$\sqrt{\text{offset number}} = -2.42 + \log_{10}(\text{final corm weight}) \times 2.538$$

An R^2 of 0.85 indicates a close relationship between offset numbers and corm weight (Fig. 1). This shows that there is a steep rise in the number of offsets a corm produces up to about 30 to 40 offsets for a corm of about 1 kg in weight. Generally there was little increase in offset numbers above this corm weight although one monster corm of about 4 kg produced 50 offsets.

Small corms independent of the mother corm or offsets cut off the mother corm were compared as propagation material. Both can be successfully used to produce new plants. Offsets are generally smaller than the corms and there is an obvious advantage in using the bigger offsets as they gave the largest new plants (Table 1). The use of corms larger than the offsets resulted in even larger corms being produced. The largest corms were produced by planting corms greater than 15 g (Table 1) but clearly to produce large ornamental plants there is an advantage in using corms of 1 kg or more (Fig. 1).

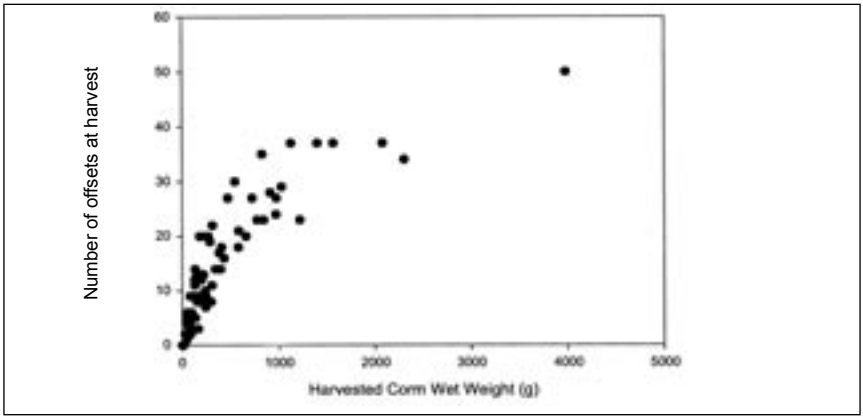

Figure 1: Relationship between corm wet weight and the number of offsets produced per corm after 2 years.

Table 1: Effect of planting corms or offsets on the resultant corm size (g) after 2 years. Size range of corms or offsets at planting (g).

	0-5	5-10	10-15	15-25	25-35	>35
Corms	*	340.3	579.0	1321.2	934.8	969.9
Offsets	120.9	285.7	815.7	*	*	*
LSR (5%)		3.7NS	4.2NS			

* No available data.
NS, LSR not significant at 5% level.

It is recommended that the cut ends of the corms and offsets used for propagation purposes are dipped in lime flour to reduce the incidence of fungal and bacterial root rots. The lime is believed to prevent plant disease mainly through its effect on nutrient availability and uptake although high soil calcium is known to suppress the spore germination of some fungal diseases (Huber, 1990).

Konjac can be grown from seed and is a useful method to produce virus-free plants. Konjac generally flowers in late spring (May in Japan) 4 years after sowing seed. The seeds develop over the summer and can be harvested in late summer early autumn. Once harvested the seed can be sown as soon as the seed pulp has been removed. Depulped seed weighs approximately 17 g per 100 seed. The seed is recalcitrant and rapidly looses viability if it is allowed to dry out (Hetterscheid and Ittenbach, 1996). Fresh seed germinates in 7 to 28 days. Soaking seed in gibberellic acid (0.5 g•liter^{-1} GA_3) for up to 24 h has no effect on the rate of germination.

Plant Density. In the 1st year offsets are planted 10 cm apart in rows 10 cm apart. There are two rows per bed with beds 1.0 to 1.2 m apart. In the 2nd year the resultant corms are planted in rows 1.0 to 1.2 m apart. Spacing in the row is three times the diameter of the corm. For example, 15-cm diameter corms are spaced at 45 cm in the row. Density arrangements vary greatly depending on grower preference. Konjac can also be planted in beds with up to four rows per bed or on ridges with up to two rows per ridge.

Weed Control. A stale seedbed technique is applied to konjac production areas prior to planting. The desiccants paraquat or Buster® (glufosinate-ammonium) (Hoechst Schering AgrEvo GmbH) are often used or glyphosate if there are problem perennial weeds. After planting the pre-emergence herbicides linuron or Stomp® (pendimethylin) (American Cyanamid Company) are often used. Our trials found that konjac was tolerant to a variety of herbicides when applied pre-emergence: Roustabout® (acetochlor) (Monsanto Company, U.S.A.), chloro-IPC (chlopropham), Frontier® (dimethanamid) (BASF AG, Germany), linuron, Tribunal® (methabenzthiazuron) (Bayer AG., Germany), Surflan® (oryzalin) (Dow Agrosciences), Foresite® (oxadiazon) (Rhone-Poulenc Ltd), Goal® (oxyfluorfen) (Rohm and Haas, U.S.A.), and Stomp® (pendimethalin) (American Cyanamid Company). Post-emergence: Asulox® (asulam) (Rhone-Poulenc Ltd), Preside™(flumetsulam) (Dow Agrosciences), and Granstar® (tribenuron) (E.I.Du Pont de Nemours and Co. Inc., U.S.A.) were safely used. Emblem® (bromoxynil) (CFPI Agro/Nufarm, France) was also safely used if applied before the leaves emerged from the developing shoot (James and Follett, 2000). In Japan, paraquat and trifluralin are used in combination and applied as a directed spray after transplanting or ridging for weed control.

Fertiliser. Fertilisers are applied both as basal dressings and side dressings during the season. Application rates depend on soil nutrient levels, but usually consist of 100 to 150 • kg • ha^{-1} of a proprietary NPK mix. The first fertiliser application is usually applied prior to planting. A side dressing is applied 1 month after planting and is done in conjunction with mounding up of the soil. Our research has shown that potassic fertilizer is more important than nitrogen for corm production. The preferred soil pH is around 6.0 to 6.5.

Pests and Diseases. Aphids are considered to be a serious pest mainly because of their ability to act as virus vectors. Virus diseases can seriously affect the vigour of konjac. The main virus diseases (konnyaku mosaic virus and cucumber mosaic virus) affecting konjac are not transmitted by seed allowing growers to rejuvenate the crop by propagating from seed although this does increase the rotation time by 1 year in Japan.

The bacterial soft rot erwinia (*Erwinia carotovora*) which has also been identified on New Zealand-grown konjac is considered to be the main disease problem with this crop. Erwinia is also a major disease in *Zantedeschia* tuber production in New Zealand (Wright, 1998). Fungal diseases including fusarium (*Fusarium solani*) and pythium (*Pythium* species) can also cause problems. In Japan soils are often fumigated prior to planting and the crop is always grown on free-draining soil and is usually grown in rotation with other crops to avoid the build up of soil-borne diseases. Crop rotation is the preferred option for the control of soil-borne diseases but because of the scarcity of suitable land for production the soil is usually fumigated.

Winter barley is also grown as a companion plant to konjac. In the 1.0 to 1.2 m space between the rows of konjac winter barley is sown in early spring. Aphids find the barley more attractive as a food source thus reducing the infestations on the konjac. By mid summer the barley is cut to form a mulch which prevents soil splash onto the konjac thus reducing the risk of infection from soil-borne rots.

Harvesting. Harvesting is carried out in late autumn after the tops have died down. This is commonly done with modified small-plot potato harvesters. The corms are then divided into size classes. Those with a diameter greater than 20 to 25 cm or with a fresh weight over 300 g are marketed while the propagation stock are stored one layer deep on lattice frames in heated warehouses at 7°C in readiness for spring planting.

RELEVANCE TO NEW ZEALAND

Our initial trials have shown that konjac grows well under shade in the free draining pumice soils of the Waikato. Grown outside in full sun the plants develop severe leaf chlorosis. Currently we are conducting research to assess what level of shade the plant needs to produce good quality corms. Further work is required to evaluate Japanese production techniques in the New Zealand environment to determine whether economic quantities of gluco mannan can be produced.

The level of interest currently being generated in konjac as a health food in Japan and the rest of Asia indicates there is an untapped potential for the production and processing of this crop in New Zealand if the production methods can be made to be cost effective.

The Japanese industry is highly controlled with grower co-operatives running many of the primary processing facilities. To develop a industry based on konjac

production in New Zealand a primary processing facility will need to be developed.

Along with other *Amorphophallus* species, such as *A. kiusianis, A. bulbifer, A. henryi,* and *A. coaetaneus*, konjac also has good potential as an ornamental. Its attractive marbled petiole can reach a height of up to 1 m and its umbrella shaped leaf has many divisions giving it a very complex leaf shape. It can make an attractive summer foliage plant or outdoor bedding plant. The flowers are also very impressive although the smell can be a little distracting. Konjac is already sold as an ornamental in New Zealand and is likely to become more popular with gardeners with an eye for the more unusual.

CONCLUSIONS

1) Konjac has been successfully grown as a crop under experimental conditions in New Zealand. Further agronomic research is required to confirm that the crop can be grown cost effectively to the required quality standards.
2) Konjac has good potential as a more widely grown ornamental. Along with other aroids it is becoming more popular with gardeners but does require more education to reach its full market potential.

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