WINNING WITH WILLOWS

Extending the supply of nutritious pollen for bees in spring

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Trees For Bees

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Introduction

Pollen from willows is one of the most important sources of protein for honey bees to feed their brood in the spring. The role of willows can be experienced by watching bee populations rapidly expand every spring wherever willows are abundant. Beekeepers seek apiary sites with willows to build up their bee colonies to maximum strength before the start of pollination services and honey flows. Few other plant species play such an important role in beekeeping.

Willows belong to the genus *Salix*. Most willow species are known to flower for only a few weeks. If only one or two species are planted then the extent of the willow flowering season would barely cover one month. Yet the full diversity of all the willow species in New Zealand flower in succession from late July to December – a period of five months. To study willow flowering times, a Ministry for Primary Industries Sustainable Farming Fund project was undertaken from July 2014 to January 2015 by Trees for Bees NZ and the New Zealand Poplar and Willow Research Trust. We investigated 30 species and 21 hybrids of willows located in a living germ plasm collection at the Aokautere nursery held by Rural Supplies Technologies (RST) Environmental Solutions in Palmerston North.

The many suitable candidate species presented here are an untapped resource to extend the willow flowering season for bee nutrition. Willows along waterways are considered essential management tools, and they are a premier species for erosion control and animal fodder as well. While *S. fragilis* (crack willow) and *S. cinerea* (grey willow) are not included as they are recognised as weed species around water courses and wetlands, with careful siting and management the other species listed in this publication should not pose an issue for weediness. It is recommended that you consult with your regional council, particularly around vulnerable sites such as rivers and wetlands.

Importance of Willows

Role of Willows on Farms and Public Land

Willows in their various guises are among the most common trees in our landscape. They are planted extensively for land stabilisation along rivers and on farms. They are significant shade, shelter and fodder trees and are grown commercially to provide material for erosion control, amenity trees, basketry and other farm and public uses. The NZ Poplar and Willow Research Trust custodial germ plasm collection holds over 200 different willow genotypes, representing 38 species and 21 hybrids – a total of 59 taxa. New hybrids are added from the breeding programme, and some of these are commercialised. For further information on the many roles of willows on farms and in regional council plantings see www.poplarandwillow.org.nz.

Role of Willows in Bee Nutrition

Willows play a key role in reproduction and population growth of bee colonies after their winter rest. By summertime every year, a bee colony must reach the population size needed for pollination services and honey harvesting. Bee colonies typically build up during spring from a winter low of about 10,000 bees per hive to full strength of 60,000 to 80,000 per hive. Wherever willows are abundant, bee colonies rapidly build up to maximum strength because willow pollen is plentiful and easily accessible to bees. Foraging bees bring huge willow pollen loads back to their hive to feed their brood.

Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Spring Population Build Up and Fruit Pollination				Summer Crop and Fruit Pollination and Honey Flow				Autumn Preparation for Winter			Winter Rest	

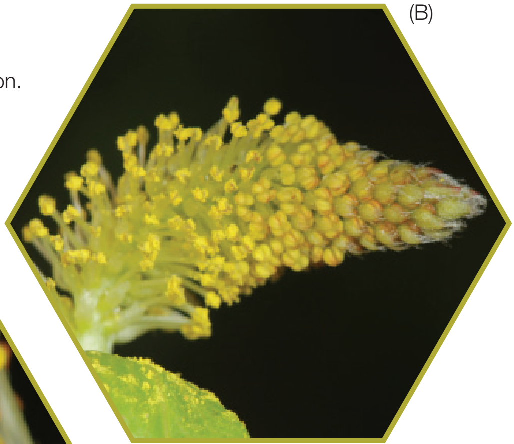
Fig 1 Time line for bee colony life cycle from spring to winter showing the major activities of the bees for each season.

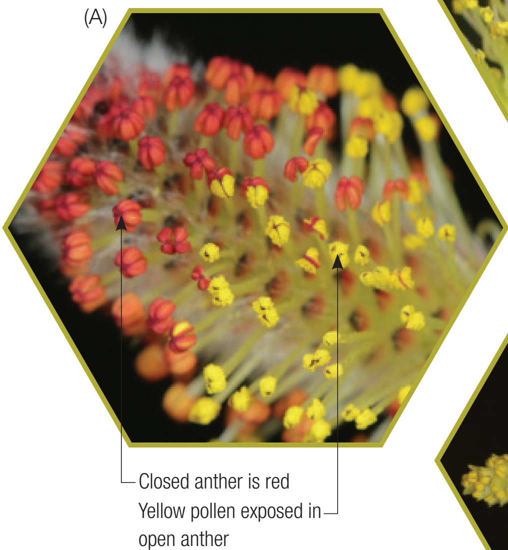
Willow Flowers

Normally a willow tree or shrub produces either male or female flowers, so the whole plant is classified as either a male or a female plant. The tiny flowers, called florets, are aggregated into catkins. Very few willow species produce both male and female catkins on the same plant (e.g. *Salix aegyptiaca*). Only male flowers produce pollen, but usually both male and female flowers produce nectar. It is important to know the sex of the willow tree before planting. Planting only male willows will prevent seed production because there are no female catkins. This can help to reduce possible weed problems from seed dispersal events. In rare cases, a few female florets can appear on a male catkin but they are not common.

Male Catkins

Male catkins have numerous florets each containing only a few stamens and no petals (Fig 2). Each stamen has a filament holding up the anther which contains the pollen. When the anther opens, the mature pollen is exposed and can be collected by bees. Usually anthers are yellow but in some species, such as *S. purpurea*, anthers are red or purple. The pollen itself is normally yellow. Male catkins can be short and fat (e.g. *S. reinii*) or long and thin (e.g. *S. alba*). The anthers grow, mature and open progressively along the catkin.





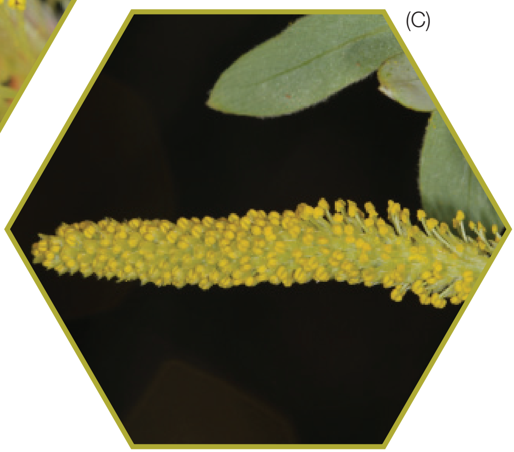


Fig 2 Types of male catkins with male florets each bearing one to a few stamens. (A) *S. X dichroa* (a hybrid with *S. purpurea* parent) has red anthers; (B) *S. reinii* short fat catkins and yellow anthers; (C) *S. alba* long thin catkins and yellow anthers.

Female Catkins

Female catkins have green florets but no stamens and no petals. Instead, each floret has one green ovary which bears a stigma at the top to receive the pollen. Often bracts or hairs surround the ovary of female florets. Female florets produce nectar to attract bees. When the egg is fertilised, the ovary swells and will produce a seed. In many species fluffy hairs are attached to the seed for wind dispersal.

Pollen Quantity

To assess pollen quantity for a given tree, we multiply estimates of the density of stamens on a catkin, catkins on a branch and reproductive branches on the plant. Differences in quantity can be genetic and/or environmental. Although some shrub willows (e.g. *S. X reichardtii*) have huge very densely arranged catkins, some tree willows have more pollen because they are taller with more reproductive branches than a shrub (e.g. *S. alba*)

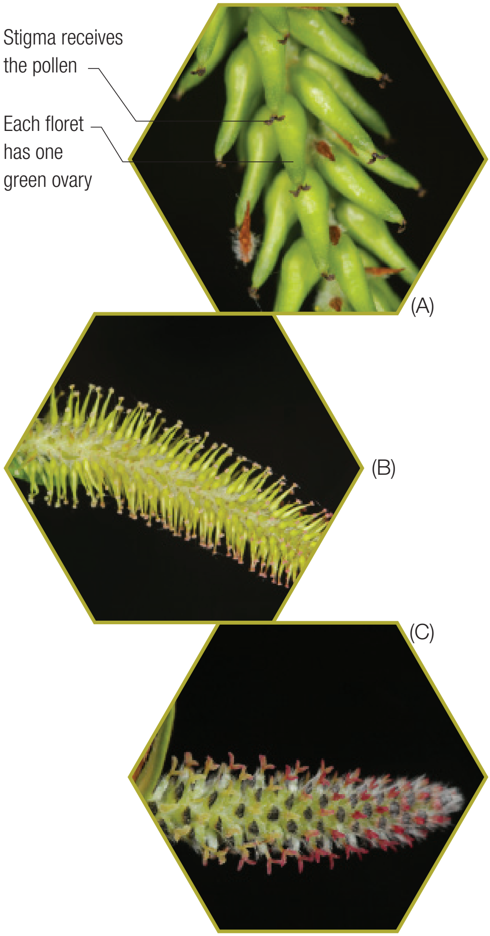


Fig 3 Types of female catkins. (A) *S. alba*; (B) *S. rigida*; (C) *S. X forbyana* (hybrid with *S. purpurea* parent).

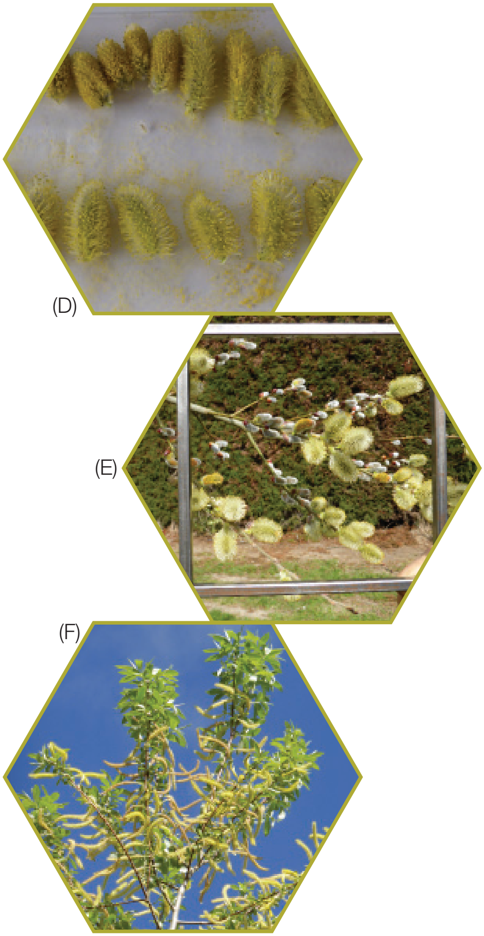


Fig 4 Pollen quantity: (D) *S. hookeriana* 'Furrry Ness' has the largest catkins (E) *S. X reichardtii* a shrub with dense catkins; (F) *S. alba* (PN-361) a tall tree with dense catkins.

Flowering Times for Selected Willows

Selected male trees and shrubs of *Salix*			Wk 0	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5	Wk 6	Wk 7
Species name	Genotype Name	Register No.	Jul 28th	Aug 4th	Aug 11th	Aug 18th	Aug 25th	Sep 1st	Sep 8th	Sep 15th
aegyptiaca		PN 229								
X reichardtii (*caprea X cinerea*)	Pussy Galore	PN 215								
X reichardtii (*caprea* x *cinerea*)	Muscina	PN 714								
viminalis (var. *aquatica*?)	Korso	PN 669								
purpurea	Rubra	PN 221					0.9			0.1
opaca		PN 283					0.3			
eriocephala	Americana	PN 376					0.3			
nigra	Pryor 62-91	PN 735						0.3		
appenina		PN 710						0.3		
candida 'Furry Ness'	Furry Ness	PN 385						0.3		
purpurea	Links Dutch	PN 382							0.9	
caprea	N	PN 233							0.4	
nigra	AR 115	PN 733							0.4	
alba	I 2-59	PN 357								0.9
hookeriana 'Furry Ness'	Furry Ness	PN 685								0.9
reinii		PN 688								
X *dichroa* (*aurita* x *purpurea*)		PN 680								
nigra	Pryor 62-27	PN 734								
alba	I 8-59A	PN 361								
triandra	Black German	PN 374								
X forbyana (*purpurea* x *viminalis*)	Sessilifolia	PN 305								
purpurea	Leicestershire Dicks	PN 610								
purpurea	Lancashire Dicks	PN 611								
alba	Lichtenvoorde	PN 655								
cantabria		PN 712								
pentandra	Dark French	PN 670								

Fig 5 Flowering times of selected male willow trees and shrubs observed from July 28th, 2014 to January 5th, 2015 in the Aokautere living germ plasm collection in Palmerston North. cells = anthers open and pollen available all 7 days of week, = proportion of week with some anthers presenting pollen.

Wk 8	Wk 9	Wk 10	Wk 11	Wk 12	Wk 13	Wk 14	Wk 15	Wk 16	Wk 17	Wk 18	Wk 19	Wk 20	Wk 21	Wk 22	Wk 23
Sep 22nd	Sep 29th	Oct 6th	Oct 13th	Oct 20th	Oct 27th	Nov 3rd	Nov 10th	Nov 17th	Nov 24th	Dec 1st	Dec 8th	Dec 15th	Dec 22nd	Dec 29th	Jan 5th
0.7															
0.7															
								0.1							
0.7															
	0.3														
								0.1							
				0.1											
			0.6												
						0.7									
			0.1												
0.9			0.6												
0.9				0.1											
0.9															
0.3			0.6												
0.3											0.1				
		0.9						0.1							
		0.9										0.7			
		0.4													
		0.4									0.1				

Variation in Flowering

Flowering times can vary from one genotype to another within a species such as in *S. alba*. (Fig 6). In New Zealand, *S. alba* is prominent in older plantings on farms, riverbanks and amenity plantings. They are amongst the earliest introductions to New Zealand. Their valuable contribution to spring bee fodder was recognised centuries ago. The most outstanding *S. alba* male genotype is PN-361 because of the large amount of pollen produced (Fig 4F). Another good male genotype is PN-655 which flowered late and had the longest duration flowering of the *S. alba* genotypes. Different genotypes of other species also vary.

Male *Salix alba* trees		Wk 6	Wk 7	Wk 8	Wk 9	Wk 10	Wk 11	Wk 12	Wk 13	Wk 14	Wk 15	Wk 16	Wk 17	Wk 18
Genotype	Register No.	Sep 8th	Sep 15th	Sep 22nd	Sep 29th	Oct 6th	Oct 13th	Oct 20th	Oct 27th	Nov 3rd	Nov 10th	Nov 17th	Nov 24th	Dec 1st
Lievelde	PN 656	0.9							0.7					
NS 107-65-6	PN 672		0.9			0.1								
I 2-59	PN 357		0.9				0.1							
I 4-58	PN 355		0.9							0.1				
I 3-59	PN 358		0.9							0.1				
I 4-59	PN 359			0.9			0.6							
I 6-59	PN 360			0.9					0.7					
I 8-59A	PN 361			0.3			0.6							
I 1-59	PN 356			0.3					0.1					
X	PN 201				0.9					0.1				
Het Goor	PN 654					0.9			0.7					
Bredevoort	PN 652					0.4			0.1					
Lichtenvoorde	PN 655					0.4								

Fig 6 Flowering times of selected male genotypes of *Salix alba* trees observed from July 28th, 2014 to January 5th, 2015 in the Aokautere living germ plasm collection in Palmerston North. cells = anthers open and pollen available all 7 days of week, = proportion of week with some anthers presenting pollen.

Hybridization is used in willow breeding to produce better growth, improve form and develop resistance to diseases. Many of our commercially important willows are hybrids. Most tree willows available commercially are *S. matsudana or S. matsudana* × *alba* (e.g. 'Tangoio', 'Moutere' genotypes). They are planted along riverbanks, and extensively on farms and horticultural shelterbelts. They grow readily from poles and stakes. Flowering times and quantity of pollen produced will be important in the future for breeding willows for bee fodder.

Types of Willows

There are 330 to 500 species of willow worldwide of which around 38 species are found in New Zealand. They can be difficult to identify at the species level due to considerable individual variability and interspecific hybridization. Willows are broadly grouped into (1) **tree willows** up to 20 m high, e.g. weeping willow *S. babylonica*; (2) **shrub willows** (also called sallows) which are low shrubs to small trees, e.g. pussy willow *S. × reichardtii*; and (3) **basket willows** (also called osiers), medium-sized shrubs forming several large stems, e.g. purple osier *S. purpurea*.

Leafing Patterns

Leafing patterns vary among willow species. Willows are deciduous, losing all of their leaves every winter. Depending on the species, flowers may blossom before, during, or after the leaves start to flush. Willow species have a diversity of leaf sizes and shapes. Leaf shape can be long linear or rounded or elliptical. Identifying willows from vegetative material without flowers is a challenge because within a plant the leaf size can vary greatly and sometimes the leaf shapes vary slightly as well.

Fig 7 Types of willow plants. (A) Tree willow *S. matsudana × alba* 'Tangoio' hybrid; (B) Shrub willows or sallow, *S. schwerinii*; (C) Basket willow or osier *S. purpurea*

How to Plant and Establish Willows

The ease of establishment from un-rooted stem cuttings is one of the major features of willow cultivation. Once the farm has one willow plant of a given species it is possible to propagate new plants by taking stem cuttings from the original plant and then multiply that willow genotype on the farm.

- Optimum establishment of cuttings is achieved by planting in early spring, providing moist soil conditions at early stages of rooting, full sun exposure and protection from other vegetation.
- Harvest hardwood cuttings from one- to two-year-old shoots during the dormant season either as 2 to 3 m poles, 1 to 1.5 m whips or 18 to 25 cm cuttings. Willows come out of dormancy in New Zealand any time after mid-July.
- Once harvested, soak the basal end of the pole, whip or cutting in water and plant it within two weeks. Material that dries out before planting will weaken and die.
- Plant directly into the final location or grow on in pots for later planting of the rooted cutting. Plant with the buds pointing up.
- Apply water regularly to make sure the cuttings do not dry out.
- Remove competing plants (e.g. weeds) from around the willow cuttings.
- Protect the poles, whips or cuttings from grazing animals (sheep, cattle, hares, rabbits). Commercial plastic sleeves are available for protection of poles.

Willow species can be sourced from many nurseries particularly those that specialise in providing trees for farms. Many regional councils have willow nurseries to provide poles to farmers. Some of the species or genotypes listed in Figs 5 and 6 that are not available in local, regional or national nurseries may be obtainable from RST Environmental Solutions or NZ Poplar & Willow Research Trust on request.

Pests and Diseases of Willows

The biggest problems for young willows are grazing animals and pests such as possums, rabbits and hares. Insect pests that reduce willow growth are willow sawfly, giant willow aphid and less significantly willow gall fly.

Sawfly larvae feed exclusively on willows. The sawfly lifecycle, from egg to adult, is completed in 20 to 30 days during summer (Fig 8A). Willow sawfly larvae appear around the end of November, having hatched from transparent eggs laid under the upper leaf surface. The hatched egg leaves a blister on the leaf surface 1- 2mm long. The newly hatched larva eats a hole in the leaf and then feeds around the edge of the hole. Larvae become more obvious as they get bigger and the leaf gets smaller. Willow sawfly can have several generations in a season and has the potential to defoliate large trees in a short time.

The giant willow aphid is a new insect pest that appeared in New Zealand in December 2013. It occurs visibly on the stems of willow trees from January, with populations peaking in March-April and diminishing with the onset of winter. The strong aggregative tendency of the giant willow aphid can lead to dense colonies on the stems of infested trees (Fig 8B). Giant willow aphid infestations create honey dew on the willow's branches. They are an emerging issue for beekeeping because the honeydew makes honey very difficult to extract and boosts wasp populations that attack honey bees.

Diseases are limited to the fungal diseases such as willow rust and silverleaf fungus. Be sure to collect cutting material from healthy plants as silverleaf is often spread through infected wood. Further information is available from www.poplarandwillow.org.nz.

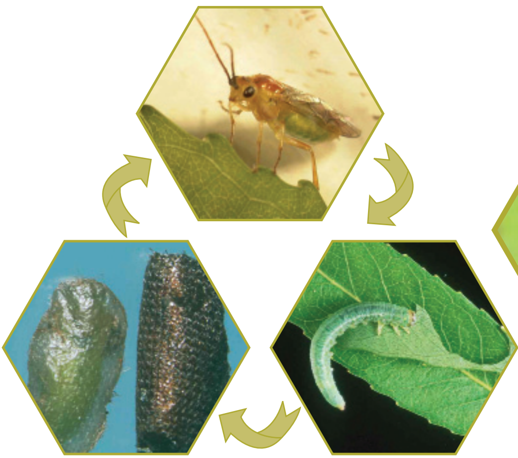


Fig 8A Willow sawfly life cycle

Fig 8B Giant willow aphid

Winning with Willows Research Team

ACKNOWLEDGEMENTS

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1. Nurseryman, Conal Richardson (left) from Rural Supplies Technologies, New Zealand with student Interns, Manon Gabarret (middle) and Blandine Polturat (right), from Agro-Campus Ouest, France

2. Scientists Trevor Jones (left) and Ian McIvor (middle) from Plant and Food Research with Trees for Bees scientist, Linda Newstrom-Lloyd (right) from Landcare Research.

3. Summer students, Berit Mohr from Victoria University (left) and Ashleigh Paap from Massey University (right), both New Zealand.

4. Manon Gabarret taking photos of willow catkins assisted by Linda Newstrom-Lloyd and Blandine Polturat.

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