Breeding for self-fertility in almonds

Many commercial cultivars of almond (*Prunus dulcis*) are self-sterile (self-incompatible) (Figure 1a and 1b). When a self-sterile cultivar is grown in a commercial orchard, polleniser varieties must also be planted to ensure fruit set. Self-fertility would therefore be very useful for almond producers.

This example illustrates the importance of self-incompatibility and self-fertility in the breeding of a tree crop.

Self-fertility occurs in peach and could be introduced into almond by breeding, but many years of backcrossing would be needed to eliminate peach characters. Graselly and Olivier (1976) discovered that some Italian almond cultivars are naturally self-fertile. These cultivars can be used as sources of self-fertility in almond breeding.

Self-incompatibility and self-fertility

In almond, self-incompatibility is under the genetic control of a gene on chromosome 6 (Ballester et al. 1997), with at least 40 alleles (S1 to S39, and Sf) which encode glycoproteins known as S-RNases. When expressed in the style of a flower, S-RNases recognise and degrade RNA from pollen tubes that have grown from pollen grains with matching S alleles. For example, an almond cultivar with the genotype S1S2 will express S1 and S2 S-RNases, which will stop the growth of S1 and S2 pollen tubes (Figure 2) but allow other pollen tubes (S3, S4 etc.) to continue growing (Figures 2 and 3). This type of self-incompatibility, which occurs in the Rosaceae, Solanaceae and Gramineae families, is called gametophytic self-incompatibility because it relies upon recognition of the haploid genotype of the male gametophyte (pollen).
The Australian Almond Breeding Program has used molecular markers based on PCR primers designed from the sequences of the introns of the S-alleles (Channuntapipat et al. 2003; Ortega et al. 2005) to identify the S-alleles of Australian cultivars. These markers have been used to confirm genotypes of imported parental cultivars and to test selected progeny. For a breeder, knowledge of which incompatibility group a tree belongs to is important. For example, when pollen from an S1Sf tree is applied to the stigmas of an S1S2 tree, the breeder can expect that all S1 pollen tubes will be degraded and that any progeny will be S1Sf or S2Sf and will be self-fertile. In contrast, when pollen from an S3Sf tree is applied to the stigmas of an S1S2 tree, the breeder can expect some of the progeny will be self-fertile (S1Sf and S2Sf) and some will be self-incompatible (S1S3 and S2S3).

The Australian Almond Breeding Program has used selected clones from France and Spain as sources of self-fertility. When these parents (genotypes SfS1, SfS2, SfS3, SfS8, and SfS9) are crossed with self-incompatible cultivars such as Nonpareil (an important cultivar in Australia, genotype S7S8) some progeny are self-fertile and others are self-incompatible. Several self-fertile progeny clones are now in advanced stages of testing, with the objective of selecting one that will combine self-fertility with the desirable horticultural and product quality traits of Nonpareil.

**Conclusion**

Most almond clones will not set fruit unless pollinated by trees of different incompatibility genotypes. Accurate identification of S genotypes is useful in designing crosses and selecting progeny in breeding programs and for choosing compatible combinations for use in commercial orchards. Discovery of a naturally occurring allele for self-fertility made it possible to develop self-fertile cultivars of almond.