

Mutants among us

The environment, phase change and mutations are three reasons why all plant clones do not grow alike

By Richard Regan

One of the topics I like to discuss in the plant propagation course I teach is plant clones. Students' ears perk up when I ask, "So, in the *Star Wars* movie series, how is it that the Imperial Stormtroopers, which were all clones of a great warrior, became rather inept over time and Princess Leia could pick them off so easily?"

After a brief discussion about technical improvements in cinema, the "Force" and mutants (characters from another movie franchise, *X-Men*), someone will usually ask, "What does this have to do with plant propagation?"

Good question! Basically, you want to make sure that your customer is getting a clone that will act in a consistent way.

One of the obligations of a plant propagator is to provide plants that are true to type. Asexual propagation of plant clones is a common practice, which provides for uniform plants, flowering time and fruit set. The genotype is unchanged from the original mother plant when compared to propagating plants by seed. But this is not always the case.

There will always be some level of variation that exists within a clone. Let's break this variation into three separate categories:

1. Plant interactions with the environment
2. Phase change
3. Mutations



A red Darwin hybrid tulip, "Appeldoorn," with a mutation resulting in half of one petal being yellow.
PHOTO BY LEPORELLO (WIKIPEDIA)

The environment

I grew up in a wine-growing region in California and remember clearly a distinct case of clonal variation due to the environment.

There was a very old vineyard that produced world-class wines that was

being removed to make room for more houses. Great care was taken to propagate these clones, including the original rootstock. The new plants were planted in a different location a few miles away and grown to fruiting maturity.

For many years after, the wine- ▶

makers tried and tried to reproduce the world-class wine from these vines with total failure.

Even when plant propagators take care to produce plants that are true to type, the environment plays a significant role on the phenotype. There are hundreds of examples of plant clones that do not look, taste or act the same when grown in different locations.

Their genotypes have not changed, but the environment influences which genes are active and which ones are not, including the many physiological processes a plant goes through as it grows and develops.

When I say the environment, I mean everything that the plant is exposed to, such as the atmosphere, soil, cultural practices and microbes. This means that soil type, nutrient availability, day length, light quality, temperature and seasonal

patterns, and microbe associations will determine how a clone behaves.

Microbial variation depends on the presence or absence of viruses, phytoplasm, bacteria or fungi. These organisms can benefit plant growth or cause subtle changes, even disease.

Since it is very difficult (if not impossible) to manage the environment, you should approach this clonal variation based on plant selection.

It is hard to imagine the number of clonal plants used for landscapes and fruit production. Many of these have been selected for their phenotype under a limited number of environments; often, they have not been evaluated at all. It then comes down to trial and error over time, with some successes and some failures.

Currently, plants released from many of the private and public breeding/selection programs have established

a number of diverse test sites to evaluate clonal phenotypes under different environments. But they cannot test them all, and some plant traits are very difficult to evaluate, including cold hardiness, fall color, and insect and disease resistance.

Phase change

Another variation in clones can occur during phase change. This is part of the plant's natural progression from a seed embryo to a mature flowering plant.

The four phases of a seed plant, in order, are embryo, juvenile, transitional and mature (adult). This maturation process is a function of plant development in terms of the number of cell divisions (or distance) from the root system and is not a function of age. The youngest part of a fruit tree is the upper mature branches that bear fruit.

During asexual propagation, the



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embryonic phase is bypassed. If you are rooting cuttings of woody plants, then you want to use the most juvenile plant tissue. Many propagators work at keeping their clonal stock blocks from reaching the mature phase by hard pruning and only taking cuttings that are close to the ground.

On the other hand, when selecting grafting scion, it is best to collect wood from the mature part of the plant. This allows a fruit tree, for instance, to flower and bear fruit much earlier. The juvenile phase will vary for each plant species; it is only 20–30 days for many roses, and 30–40 years for a beech tree.

Plants can differ in many traits depending on their phase. Some examples of these traits include vigor, thorniness, fruit taste, fruit color, timing of leaf abscission, leaf shape, growth habit, ability to flower, and propagation potential.


So, what is the big deal about phase change? The phenotypic variation during phase change has been made quite clear with the increased use of plant tissue culture methods such as micropropagation.

This is the only truly reliable method to ensure that plant phase can be reversed from mature to transitional, and even to the juvenile phase. But if we change the phase of a clone, then it might not look or perform the same, and once again our customers will not be happy with us.

Think of it this way: if you reset a mature plant to a juvenile phase using tissue culture, then asexual propagation from these plants will have more juvenile traits. As you continue to propagate from the first set of plants that are maintained in a stock block, the cuttings will slowly become more mature. Over time, the plants you provide to your customers will start to exhibit more mature traits each year.

Not all plants will respond the same way, and some will not even be affected by phase change or become subject to changes caused by tissue culture.

I think this is what happened to the Empire's Stormtroopers — they became more juvenile! ▶

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Mutations

There are plant mutants among us. Heck, you could argue that every living thing is a mutant.

Evolution of the species resulting from changing environments and sexual recombination of genes (and mutated genes, referred to as an allele) is a fascinating topic. For the purpose of this article, let's just say that many of the plant clones we know of resulted from mutations that occurred either during the formation of sexual gametes (meiosis) or during normal cell division (mitosis).

Mutation of a minuscule part of DNA or a gene is a frequent event, but most of the time it is not noticed. More often than not, these mutations are lethal to a plant cell, it dies, and that is the end of it.

Once in a great while though, the mutated gene survives. It could have the potential to change the phenotype of a plant, but it is recessive. The non-mutated gene on the other matching chromosome (most living things have two sets of chromosomes) is dominant to the mutated gene, and thus no change in any of the plant traits can be seen. These mutations can cause changes in growth habit, such as weeping, dwarf, prostrate, some forms of variegation, and changes in fruit color and quality.

A complex set of situations in both meiosis and mitosis will allow the mutated gene to be expressed. For the purpose of managing an already existing clone, I think it is best just to discuss one such situation — somatic mutation.

Somatic mutations occur in any plant cell other than the cells that give rise to gametes. Therefore, this type of mutation cannot be passed on to the offspring through seed of the original plant.

Here again, the mutated cell, or small group of cells that divided from the original mutation, will never be noticed — unless it happens to become incorporated into an adventitious meristem. This is an area of the plant that is very active in mitotic cell division, causing these cells to have the potential to develop into a shoot or branch.



Pinot gris (center) and pinot blanc (right) are color mutations of pinot noir (left). Pinot — of any berry color — can occur as a complete mutation or as a chimera of almost any other pinot. WIKIPEDIA PHOTO

If this happens, then the shoot will grow and show the mutant trait. This is what is called a “sport” or “bud sport.”

Asexual propagation is used to perpetuate a bud sport to maintain the identical genetics of the desired clone. But we cannot always “see” a bud sport because the trait may not be visible, like a red versus a yellow apple. It could be taste, water use or photosynthetic efficiency.

You could end up with many different types of clones that on the surface appear similar to the original mother plant. Pinot noir is a genetically unstable plant, and there are a couple hundred clones or more with very subtle differences.

With some clones it has been noted that a branch of a mutant clone will revert back to its original form. This “reversion” has been observed in a stressed environment, and some clones are more prone to it than others. It is thought this phenomenon is related to the type of mutation that occurred to begin with.

At this point in my lecture, I like to switch from science fiction to Greek mythology and introduce the “Chimera.” You know, that fire-breathing creature composed of three types of animals — lion, goat and snake.

A plant chimera is when a shoot is composed of genetically different layers. This occurs when mutant cells growing adjacent to normal cells both become part of a shoot. The pattern and frequency of cell division will determine the type of chimera. Sometimes the mutant cells appear on just the surface layer of cells (epidermis), other times deeper in

the plant tissue.

Variegated foliage is one of the more common, recognized plant chimeras. To propagate these clones, stem cuttings are used. Leaf cuttings usually will not work, because adventitious shoots that develop in the mutated cells will be all mutants (such as yellow foliage) and other shoots will be all green (normal chlorophyll). A chimera can be grafted successfully onto a compatible rootstock.

Parting thoughts

There is a higher risk of plant mutation during tissue culture. The callus tissue generally has a higher rate of mutation; thus, any shoots that arise from those cells will be off-type clones. This condition is called “somaclonal variation.”

Labs must be very diligent about examining vessels for off types. Taking microcuttings from axillary shoot proliferation is a good method to reduce off types, since these cuttings do not originate from the callus tissue.

Plant propagators spend a lot of time observing their plants and removing any off types. On the other hand, plant breeders and those interested in selecting new clones are always trying to induce mutation. ☺

Richard Regan is an associate professor at Oregon State University. Since 1984, he has conducted Extension programs related to nursery and greenhouse crop production. Currently, he teaches several courses for the Department of Horticulture, including floriculture and greenhouse systems. He can be reached at rich.regan@oregonstate.edu.