National Certificate of Educational Achievement
TAUMATA MĀTAURANGA Ā-MOTU KUA TAEA

Exemplar for Internal Achievement Standard

Agricultural and Horticultural Science Level 2

This exemplar supports assessment against:

Achievement Standard 91291

Demonstrate understanding of advanced plant propagation techniques used for commercial production in New Zealand

An annotated exemplar is an extract of student evidence, with a commentary, to explain key aspects of the standard. It assists teachers to make assessment judgements at the grade boundaries.

New Zealand Qualifications Authority

To support internal assessment

	Grade Boundary: Low Excellence
1.	For Excellence, the student needs to demonstrate comprehensive understanding of advanced plant propagation techniques used for commercial production in New Zealand. This involves the evaluation of advanced plant propagation techniques. This involves comparing and/or contrasting or justifying the use of these techniques or steps within techniques in terms of quality, quantity, genetic potential, timing, and the economics of production. The student briefly justifies the use of tissue culture as an asexual propagation technique in terms of quality (1), quantity (2), genetic potential (3), timing (4) and the economics of production (5). For a more secure Excellence, the student could provide more extensive comparison using the terms of quality, quantity, genetic potential, timing and the economics of production.

Student 1.

Justification for Utilising Tissue Culture as an Advanced Propagation Technique.

Tissue culture is an asexual technique that enables the propagator to produce large amounts of plants off one plant by using tissue off the parent plant. It enables the propagator to produce large amounts of one plant [2] with the desired traits [3] quickly [4]. It ensures that there is no genetic variation [3] as the propagation is carried out under sterile conditions. This however, can also be a disadvantage because as the plants have no genetic variation it means that they are clones and no mutations have taken place to enable that plant to build up an immune system to pests and diseases which means that one disease can kill a whole crop much more easily than it would be able to if the seeds had been genetically different i.e. sexual propagation. The process, however, is carried out under sterile conditions, which means that it kills any pathogens, pests or diseased already contained on the plant therefore reducing the risk of the parent plant transferring diseases to the offspring [1]. The whole process however can also be quite expensive because there is a lot of materials involved and it is a very delicate process [5], but the success rate if high [2] compared to other asexual and even sexual propagation techniques. Tissue culture is most often used for plants such as orchids.

	Grade Boundary: High Merit
2.	For Merit, the student needs to demonstrate in-depth understanding of advanced plant propagation techniques used for commercial production in New Zealand. This involves explaining how advanced plant propagation techniques, or steps within techniques, provide conditions that are important for successful propagation. Reference to related plant structural features and functions, and/or to horticultural science concepts is required. The student explains how steps within the advanced plant propagation technique of tissue culture provide asexual environmental (1) and biological (2) conditions that are important for successful propagation. To reach Excellence, the student could either compare and contrast two advanced plant propagation techniques, or justify their decision on utilising tissue culture with reference to examples of plants propagated in New Zealand, such as orchids or *Pinus radiata*.

Student 2.

Steps within Tissue Culture that Provide Conditions that are Important for Successful Propagation.

Steps that are very important in plant tissue culture are collecting the correct sample, making it sterile, correct hormone concentrations, then growing process and hardening off.

First of all, a sample has to be collected from a plant that you want to have more of. For example, if a plant is a good fruiter you would want to have a whole crop of them, you can use an asexual propagation technique like tissue culture. To do this, you take a sample off the plant, it must demonstrate totipotency, normally pieces of plant leafs or sometimes the roots are used as these parts demonstrate totiopotency and the collection of these does not harm the parent plant [2].

Secondly these explants are taken and put through a strict sterilisation process involving glass that is heated under pressure, the heating under pressure is to render the glass aseptic. The sterilisation process of the explants involves them being rinsed in an alcohol or bleach solution, being swirled then rinsed after which they are really aseptic. The water must be pure to reduce contamination. The sterilisation is extremely important as any bacterial or fungal growth in the extremely nutrient rich tissue culture solution would destroy the explants, rendering it useless, the tissue culture would have to be repeated which is costly. So the explants and glassware must be totally aseptic before it placed in the tissue culture medium [2].

After it is rendered aseptic, the explants is placed in a growth medium which is rich in specific hormones (auxin hormones like IAA and NAA, these cause a proliferation of roots) and cytokinins hormones (these cause a proliferation of shoots). These hormones need to be correctly proportioned if the two hormones are in equal proportions a mass of cells form, it is called a callus [2]. The solution is also rich with inorganic salts like ammonium nitrate and organic compounds also vitamins specific to early plant growth. The solution needs to have the nutrients in correct proportions for correct plant growth, too much or too little can cause problems, such as too much nitrogen means the plant grows fast but is brittle and unhealthy. These solutions are chosen over soil for many reasons. They can be scientifically designed for the individual plant with correct hormone and nutrient concentrations also the solution can be aseptic, soil is hard to make aseptic. So these solutions give the explants the best possible chance at growing strong healthy plants [1].

After the explants have reached a stage where they have developed a good root system, 2 healthy leaves with no curling, and a certain size depending on the species of plant. For example, *Pinus radiata* must be 10 – 15 cms tall from shoot to highest part before transplantation can begin. When the explants have reached these milestones, they are removed from the tissue culture media and begin the process of hardening off. This occurs when they are taken out and put into soil in greenhouse where overtime the conditions go towards what the outside environment will be like. This is to get the plants used to the outside environmental conditions, instead if the tissue culture medium, the plants will undergo less shock when transplanted to the field so less plant will die and the process of tissue culture will be successful [1].

	Grade Boundary: Low Merit
3.	For Merit, the student needs to demonstrate in-depth understanding of advanced plant propagation techniques used for commercial production in New Zealand. This involves explaining how advanced plant propagation techniques, or steps within techniques, provide conditions that are important for successful propagation. Reference to related plant structural features and functions, and/or to horticultural science concepts is required. The student briefly explains how steps within the advanced plant propagation technique of whip and tongue grafting provides asexual environmental (1), and the biological (2) conditions that are important for successful propagation. For a more secure Merit, the student could provide a more detailed explanation of how the steps provide conditions for successful propagation. For example, the cambium needs to be aligned so that xylem and phloem connect to allow movement of water and nutrients between the rootstock and the scion.

Student 3. Whip and Tongue Grafting.

Reasons Why the Steps are Carried Out.

We want them to be the same size because they have to be binded together, having them the same size will ensure a very successful graft. We also want a healthy root stock because if we start off with a healthy, strong root stock we will hopefully produce a healthy strong plant [2]. The reason the parent plant has to be older than 2 years old as it needs to be mature enough and big enough [2]. It is grown between February to early to mid March because that is usually when the root stock is dormant. They need to be the same size because for the graft to be successful and healthy they should be the same size. Having them the same size will ensure they bind together correctly. Also they will 'lock' into place better if they are the same size and thickness, all leading to a strong end result. The reason the cambium layers must be aligned is so a union between the root stock and scion is obtained. If the two cuts are made properly, the stock and scion will appear to be one, this will ensure the technique has been done correctly. An uneven cut or wavy will result in gaps between the stock and scions therefore an unsuccessful graft [2]. Having two sets of buds will also ensure the they grow faster and will ensure they produce pears.

The reason you use rubber or tape is to ensure they are still aligned together (the cambium layers) and they are still united / binded together (the rootstock and the scion). The reason for the grafting wax is to keep the new graft from drying out [1].

You did a sharp thin knife for whip and tongue grafting because you need to take a fine cut, also you need a smooth cut to ensure you do not damage any part of the root stock or scion. By doing a single draw instead of multiple you will get a smooth clean line [2]. You need matching cuts so they will bind [2].

	Grade Boundary: High Achieved
4.	For Achieved, the student needs to demonstrate understanding of advanced plant propagation techniques used for commercial production in New Zealand. This involves describing the steps taken when performing advanced plant propagation techniques. The student describes the sequential steps (1) taken when performing the advanced plant propagation technique of tissue culture, linking some to plant parts (2) and their functions (3) as well as some horticultural science concepts relating to plant disease (4). The descriptions are generic in nature, and they would have benefited from references to New Zealand plant material such as *Pinus radiata.* To reach Merit, the student could explain the conditions that are important for successful propagation.

Student 4. Tissue Culture.

Tissue culture is a asexual culturing technique. Tissue culture is using particular cells like leaf stems to create cast amounts of new plants. The new plants are exactly the same.

Step 1: Select suitable suckers (explants) from a desired and healthy plant. It must be free of pests and diseases [4].

Step 2: Sterilise the suckers and put them in a disinfectant to kill any bacteria or diseases.

Step 3: Choose an end of the plant like the end of the stem or lateral bud tip as these tissues have the highest rates of cell division and produce required growth regulating substances [2].

Step 4: Cut out a small part of the tissue or isolate individual cells and place them in a tissue culture container, containing agar.

Step 5: The tissue will grow and it will make a big blob of tissue called callus. Callus is tissue that forms over wounds in plants protecting inner tissues and causing healing [3]. The cells may make new shoots directly from the cells. The cells are now called plantlets.

Step 6: Once the plantlets develop into seedlings some can be removed and the whole process can start again. This is a quick way of building up identical plants to make a forest. This results in a rapid multiplication of new plants and thousands can be produced in just a few months.

Step 7: When the seedlings are big enough they can be removed and put into pots with soil. The seedlings are now grown in a greenhouse like any other seed or cutting would [1].

Step 8: The hardening process takes three to four months before they can be planted outside in a plantation. This increases the rate of survival.

	Grade Boundary: Low Achieved
5.	For Achieved, the student needs to demonstrate understanding of advanced plant propagation techniques used for commercial production in New Zealand. This involves describing the steps taken when performing advanced plant propagation techniques. The student describes the basic steps (1) taken when performing the advanced plant propagation technique of cleft grafting. For a more secure Achieved, the student could provide a more detailed description of steps for cleft grafting, such as binding of the graft.

Student 5.

Asexual: Cleft grafting.

The cleft graft is usually used to top work a tree which change the tree from one variety to another. When grafting on young trees you cleft graft on the trunk, where as on mature trees you graft on the branches no more than 2.5 metres in diameter, as older trees so not grow as well as younger ones after grafting.

The best time to do grafting of any kind is just as growth begins in the spring as it will grow together better.

Preparing the stock

It is best to get a knot free straight grained section of the branch as it is the easiest and best place to graft. You must saw off the branch at a perpendicular angle to the grain and when doing so make sure not to split or tear the bark so the cut is smooth. Then use a grafting tool to split the stock in the centre to extend 10 centimetres into the branch.

Preparing the scion

The scion wood for the cleft graft should be a centimetre thick, ideally have 3 buds on it and be inserted into the stock with the lowest bud just above the stock. Always note the bottom of a scion, as a scion will not grow if it is inserted upside down. When cutting start just below the lowest bud and make long smooth cuts towards the base and the cut should have surface of about 8 centimetres long. Do the same on the other side and ideally one side should be slightly thicker than the other.

Inserting the scion

Carefully open the crack with a grafting chisel or small wedge in the stock wide enough to get the scion inserted easily. While inserting the scion make sure the thicker side is outwards with the cambium in contact. After positioning the scion in the stock to ensure contact remove the tools you used to open the stocks a lot. When the scion is located the cut of the scion wedge should be almost invisible. Usually two scions are inserted into a slit one on each side of the stock so that at least one grows [1].

Waxing the cleft graft

Cleft graft should be waxed to cover all surface cuts to prevent drying out and you would need to check the wax regularly as sometimes cracks develop after the wax sets.

Caring for the graft

When the graft begins to grow you will need to give is lots of attention but never prune the branches that grow as it may kill the graft and you will have wasted your time.

	Grade Boundary: High Not Achieved
6.	For Achieved, the student needs to demonstrate understanding of advanced plant propagation techniques used for commercial production in New Zealand. This involves describing the steps taken when performing advanced plant propagation techniques. The student briefly describes some very basic steps (1) of what is done when performing the advanced plant propagation technique of whip and tongue grafting. To reach Achieved, the student could describe more accurate steps about how the technique of whip and tongue grafting is performed, such as what it means to make a straight slanting cut and match the two parts, so that the technique can be carried out successfully.

Student 6.

Grafting – the whip graft.

Step One: Cut off a branch of the under stock, leaving a foot left on the ground. Leaving the foot allows the remainder of the plant to keep growing.

Step Two: Make a strong slanting cut about 6cms long on the scion and stock.

Step Three: Make the cut straight to insure they fit into each other perfectly.

Step Four: Make a straight cut but insure you do not split the branch. Begin near the top and cut about the full length of the level for the tongue.

Step Five: Match the two parts of the lemon branches together.

Step Six: If the toe of either the stock or the scion are larger than the heel of the other, cut it off evenly. This is so the two pieces fit together neatly to ensure best possible growth.

Step Seven: Bind tightly with tape, so that it keeps disease out of the open cuts. Then cover the union and binding material with grafting compound [1].