Assessment Schedule – 2015

Agricultural and Horticultural Science: Demonstrate understanding of techniques used to modify physical factors of the environment for NZ plant production (91290)

Evidence Statement

Question One: Drainage in pastures and crops

Achievement	Achievement with Merit	Achievement with Excellence
Describes how the use of drains modifies TWO physical factors of soil.	**Explains** how the use of drains leads to an increase in pasture or crop yield.	**Evaluates** the decision to use mole drains over open drains to modify the physical factors of the soil for improved yield in crop or pasture production.

N0	No response; no relevant evidence.
N1	Some writing, but does not describe how the use of drains modifies TWO physical factors of the soil.
N2	Partial or insufficient description of how the use of drains modifies TWO physical factors of the soil.
A3	Describes how the use of drains modifies TWO physical factors of the soil.
A4	Fully describes how the use of drains modifies TWO physical factors of the soil, with reference to growth rates in pasture or crop production.
M5	Explains how the use of drains leads to an increase in pasture or crop yield, linking improved plant processes.
M6	Fully explains how the use of drains leads to an increase in pasture or crop yield, linking improved plant processes to the effect on plant growth.
E7	Evaluates the decision to use mole drains over open drains to modify the physical factors of the soil for improved yield in crop or pasture production, in terms of their environmental and economic impacts. Comprehensive evidence given for ONE technique with both impacts, with the other technique well supported with both impacts.
E8	Evaluates the decision to use mole drains over open drains to modify the physical factors of the soil for improved yield in crop or pasture production, in terms of their environmental and economic impacts. Comprehensive supporting evidence for BOTH techniques, with BOTH impacts.

Q1	Sample evidence
(a)	**Describes** how the use of drains modifies TWO physical factors of the soil. Drains such as mole drains are forged by a torpedo-ended drill being dragged through soil to create a drainage channel. The mole drain sits in clay soil and the sides are compacted so it does not collapse in on itself. Drains remove the excess water from the soil, leaving space for more air in the soil, which leads to warmer soil temperatures. They are used when natural drainage needs improving due to lack of slope or an impermeable, heavy clay subsoil. They drain both groundwater and excess water from above. The water drains into the channels and can lower the water table by 40–60 cm, which creates a drier soil with a high air and oxygen content. Good drainage / irrigation aims for field capacity. Macropores are filled with air, and micropores with water.
(b)	**Explains** how the use of drains leads to an increase in pasture or crop yield. Mole drains reduce water in the soil profile by adding subsoil channels for the water to run through, away from the actively growing plants. An increased air content leads to higher soil temperature, and therefore more soil microbial and earthworm activity. This improves yield, as root respiration and growth are quicker, leading to an increase in water and nutrient uptake, and this increases overall plant growth and therefore pasture and crop yield. Soil which remains waterlogged for more than a day or two can result in poor root growth, as there is a reduction in water and nutrient uptake by the plant. A lower water and nutrient uptake leads to reduced photosynthesis and growth in the plant and a lower production yield overall. Plants that are left in saturated or waterlogged soil will have no access to oxygen and will die, hence overall crop or pasture yield will decrease.
(c)	**Describes** how the use of open drains modifies TWO physical factors of the environment. Wet winter soils are a common problem. Surface and sub-surface drainage can be used to improve the situation by removing the excess soil water and increasing the oxygen content and temperature of the soil. Surface drainage often relies on the natural slope of the land, and often this is not enough to avoid waterlogged soils. Open drains are deep trenches running down the field, which the water drains into. Open surface drains and mole drains are sub-surface drainage systems which aim to remove water from the root zone of the soil to allow healthier plant growth. **Explains** how the use of open drains leads to an increase in pasture or crop yields. The removal of water gives space for air and therefore oxygen in the soil, which leads to higher soil microbial activity and better root growth. Sub-surface drainage also helps to reduce compaction. An increased air content leads to higher soil temperature, and therefore more soil microbial and earthworm activity. This improves yield, as root respiration and growth are quicker, leading to an increase in water and nutrient uptake, which increases overall plant growth, and therefore pasture and crop yield. Soil which remains waterlogged for more than a day or two can result in poor root growth, as there is a reduction in water and nutrient uptake by the plant. This leads to lower photosynthesis and growth in the plant, and a lower yield overall. Plants that are left in saturated or waterlogged soil will have no access to oxygen and will die, hence overall crop or pasture yield will decrease. **Evaluates** the decision to use mole drains over open drains to modify the physical factors of the soil for improved yield in crop or pasture production, comparing environmental and economic impacts. *Environmental impacts* Mole drains are found under the soil surface, and the impact on the environment above is limited. The machinery used to drag the torpedo plough to form the drain has a negative impact on the soil environment, such as compaction, but once the drains are installed there is limited work required to maintain them. In contrast, open drains are open-ditched and dug using machinery. They are exposed above, and require ongoing maintenance to ensure they do not lose effectiveness through excess weeds, fallen trees, or stock damage. Open drains can lead to some negative impacts on the environment, such as utilising sprays to control weeds in drains, and these can contaminate waterways and increase the number of waterborne pests, particularly if there are areas of stagnant water. Bridges and culverts need to be built to allow access across the drains, which can have a further impact on the surrounding soil environment through compaction, and there is also the issue of disposal of the excess soil removed from the ditch.

	Economic impacts Mole drains can be more expensive to install, due to the specialised equipment required. Mole drains allow the full area to be used in production and further drains the subsoil. These factors combined lead to larger and higher-quality yields, which can have a large impact on the economics of production. If the soil is not waterlogged, the soil temperature can rise more quickly; this increases root activity, which in turn improves production of the crop. The larger financial outlay to have them installed can often be recouped quickly from increased profits. The simple nature of open drains means they are easier to install and therefore require a lower capital outlay. However, open drains may need to be fenced, which can add significantly to the relatively low cost of having them built. The fences prevent stock from entering the drains by accident. Otherwise, the area where the ditch is becomes unusable, and this can reduce the yield due to decreased space. There is also a limitation on what machinery can be used, which limits options for harvesting and spraying of crops. Open drainage may not sufficiently drain the subsoil, nor may it lower the water table, so soils can still become waterlogged, thereby increasing production costs for a smaller yield.

Question Two: Improving yields in fruit crops

Achievement	Achievement with Merit	Achievement with Excellence
Describes how either misting, or frost pots, modify two physical factors of the environment to improve the fruit yield in commercial fruit production.	**Explains** how either misting, or frost pots, modify two physical factors of the environment to improve the fruit yield in commercial fruit production.	**Compares and contrasts** misting, and frost pots, to improve the fruit yield in commercial kiwifruit production, considering the economic and social impacts of each technique.

N0	No response; no relevant evidence.
N1	Some writing, but does not describe how misting or frost pots modify two physical factors of the environment in fruit production.
N2	Partial or insufficient description of how misting or frost pots modify two physical factors of the environment in fruit production.
A3	Describes how misting or frost pots modify two physical factors of the environment in fruit production.
A4	Fully describes how misting or frost pots modify two physical factors of the environment in fruit production, in relation to growth rates.
M5	Explains how misting or frost pots modify two physical factors of the environment, linking improved plant processes to improved fruit yield in fruit production.
M6	Fully explains how misting or frost pots modify two physical factors of the environment, linking improved plant processes to the effect on plant growth and improved fruit yield in fruit production.
E7	Compares and contrasts misting and frost pots to improve the fruit yield in commercial kiwifruit production, considering the economic and social impacts of each technique. Comprehensive evidence given for ONE technique with BOTH impacts, with the other technique well supported with both impacts.
E8	Compares and contrasts misting and frost pots to improve the fruit yield in commercial kiwifruit production, considering the economic and social impacts of each technique. Comprehensive supporting evidence for BOTH techniques, with BOTH impacts.

Q2	Sample evidence
(a)	**Describes** how misting may modify two physical factors of the environment. A frost below –2°C will freeze swelling buds, killing the flower (ovary or the surrounding tissues). Overhead sprinklers provide a continual sprinkling of water, which freezes on the trees, instead of the buds. Misting using overhead sprinklers supplies the plant with water that is colder than the surrounding air temperature. As the water evaporates off the buds, it cools them and increases the level of chilling they receive. Temperature is one of the signals from the environment that plays an important part in letting the plant know when it should stop growing (becoming dormant) and when it should start again. Low temperatures or chilling in autumn and winter are signals that allow the plant growth cycle to stay in tune with the environment. Misting also provides additional water to the plant for growth. **Explains** how misting may modify two physical factors of the environment and improve the yield of fruit in commercial fruit production. A frost can destroy all emerging buds, flowers, and fruit, and even a light frost can reduce the crop significantly. This means that buds are unable to develop and flowers are unable to be pollinated or fertilised, so therefore cannot develop into fruit. As water freezes it gives off latent heat, sufficient to keep the buds from freezing, ensuring tree tissues do not fall below 0°C. This temperature is not damaging to either bud or fruit formation, thereby maintaining the fruit yield and allowing further development into mature fruit. If misting is not used, late-harvested fruit run the risk of being frosted and damaged, reducing the yield of saleable fruit. Frosting causes physical damage to the fruit. Less damage to the fruit crop increases the volume / yield of saleable fruit / fruit of a high quality containing no surface or flesh damage. The change in the temperature provided by misting reduces daytime temperatures. Some deciduous fruit trees require a certain number of chilling hours, where the plant experiences a certain number of hours below a certain temperature. For example, apples require 800–1,800 hours below 7°C but higher than freezing. In deciduous fruit trees, chilling breaks down hormonal chemical inhibitors like abscisic acid, which control flower bud dormancy. The cold temperature replaces abscisic acid with gibberellic acid, which encourages the flower buds to grow. If the plant's chill requirement is not met, the plant will blossom late and poorly, and this could have an adverse effect on ripening. If misting occurs and the chill requirements are met earlier in the season, bud break happens earlier and is increased, thus giving a higher fruit yield. The additional water applied to the plant via misting would help to irrigate the plants. An increase in available water would increase water uptake and root pressure. Root pressure drives water flow to swell the buds, and cell division within the bud. This leads to an increase in fruit yield.

(b)

Describes how frost pots may modify a physical factor of the environment.

The frost pots are placed throughout the orchard and are fuelled by oil, diesel, natural gas, LPG, special solid fuel blocks, candles made from wax, compressed wood waste, or other similar materials. Frost pots are lit if the temperature drops below a critical low level (5°C), providing heat that increases the air temperature, thus preventing frost.

Explains how frost pots may modify a physical factor of the environment and improve the yield of fruit in commercial fruit production.

Frost damage can cause significant crop losses, especially with kiwifruit, which are harvested in early winter after the first frosts have arrived. Using frost pots helps protect the plant and its crop from the damaging effects of frost. Using frost pots means that the orchard temperature does not fall below 0°C (increasing heat / preventing temperature from dropping), thus preventing a frost and therefore frost damage to the buds and fruit, thus maintaining the crop yield. Frosting causes physical damage to the fruit. Less damage to the fruit crop increases the volume / yield of saleable fruit / fruit of a high quality containing no surface or flesh damage.

Compares and contrasts misting and frost pots to improve fruit yield in commercial kiwifruit production, considering the economic and social impacts of each technique.

Social impacts

Misting

- Misting uses a large volume of water (a limited resource) to protect the crop, as a good water supply is needed to keep sprinklers operational. This can cause both supply and drainage problems in some orchards. The orchard would need to apply for water consents, and also manage the run-off of this water. This may have an effect on the local community and their water supply.
- The flow of water over and through soil can lead to nutrient leaching. This can affect neighbouring farms and waterways.
- Possible leaching of chemicals from tanalised posts into the soil and nearby water systems.

Frost pots

- If there was to be a significant reduction in the level of production of kiwifruit and a subsequent reduction in skilled and unskilled employment as a result of frost, then there would be significant flow-on effects to the affected communities. The social and community beneficial effects of frost pots, particularly the flow-on effects of employment, are considered to be potentially significant. It is estimated that there are 25,000 to 30,000 permanent and seasonal workers in the kiwifruit industry. Although the industry has increasingly become an employer of skilled labour, it still remains a significant employer of unskilled labour.
- Smoke drift could be a problem when using frost pots – visual and smell pollution.
- Utilises a non-sustainable resource, and this may have future social implications.

Economic impacts

Misting

- Misting has a lower cost attached to it, as the main cost is the irrigation system and the management of waste water.
- The extra run-off can be directed to irrigate the plants to further improve growth, increasing yield and therefore profit.
- The application of water can be done through an overhead irrigation system which is already in place, so an extra workforce is not required and it can be machine-operated to reduce costs.

Frost pots

	• It is understood to be a cost-effective method of reducing frost damage in kiwifruit, if utilising a waste product, such as waste oil or diesel. • The cost of supplying fuel for the frost pots can be high, depending on the fuel used. • A higher yield of kiwifruit due to avoidance of damage by frost at harvest, means a larger export yield and therefore better prices. This all means more profit for the grower. • Frost pots can effectively save a harvest that may otherwise be lost. It is considered that an economic loss to the kiwifruit industry would occur if frost pots were not able to be used, and this would result in an economic loss to New Zealand. New Zealand's premium position would be affected or lost entirely through the industry's inability to continue to meet customer requirements due to reduced and variable fruit supply and quality. The consequence of this into the future would be lower returns per tray and a significantly smaller market share.

Question Three: Germinating seeds

Achievement	Achievement with Merit	Achievement with Excellence
Describes how control of two physical factors of the germination environment can lead to more uniform size at harvest.	**Explains** how control of two physical factors of the germination environment can lead to more uniform size at harvest.	**Justifies** the use of lighting techniques to treat seeds during germination, over untreated seeds, to increase the quality of plant production, with consideration of economic and environmental impacts.

N0	No response; no relevant evidence.
N1	Some writing, but does not describe how control of two physical factors of the germination environment can lead to more uniform size at harvest.
N2	Partial or insufficient description of how control of two physical factors of the germination environment can lead to more uniform size at harvest.
A3	Describes how control of two physical factors of the germination environment can lead to more uniform size at harvest.
A4	Fully describes how control of two physical factors of the germination environment can lead to more uniform size at harvest, with reference to growth rates.
M5	Explains how germinating seeds indoors before planting outdoors improves control of two physical factors of the germination environment, linking improved germination to more uniform size at harvest.
M6	Fully explains how germinating seeds indoors before planting outdoors improves control of two physical factors of the germination environment, linking improved germination to the effect on plant growth and a more uniform size at harvest.
E7	Justifies the use of lighting techniques, to treat seeds during germination, over untreated seeds, to increase the quality of plant production, with consideration of economic and environmental impacts. Comprehensive evidence for superiority in ONE impact, with the other impact well supported.
E8	Justifies the use of lighting techniques, to treat seeds during germination, over untreated seeds, to increase the quality of plant production, with consideration of economic and environmental impacts. Clear evidence for superiority in BOTH impacts.

Q3	Sample evidence
(a)	**Describes** how control of two physical factors of the germination environment can lead to more uniform size at harvest. By germinating seeds indoors, physical factors are able to be controlled by the grower so that plants can grow to their full capacity in optimum conditions. When growing outdoors, the physical factors cannot be controlled and the germinating seeds are at the mercy of the elements. The amount of light which the seeds receive for germination can be easily controlled using lamps, whitewash, etc. Temperature can be controlled by using glasshousing, heaters, heat pads, etc. Uniform irrigation of seeds allows more even germination through the use of sprinklers. **Explains** how control of two physical factors of the germination environment can lead to more uniform size at harvest. Some seeds require more light than others for successful germination. By ensuring the seeds all receive the same amount of light at the same time, germination will be more likely to occur at the same time, creating an even rate of germination. All seedlings grow at the same rate, so care is easier and more economic. They will be all at the same stage when they are planted out. An even temperature day and night improves the germination rate. A higher strike rate means that more seedlings can be planted out at one time. Warmth encourages plant growth as metabolic processes increase. The larger and more uniform the crop when it is planted out, the easier it is to care for it outside. This leads to a hardier crop. Uniform irrigation of seeds allows more even germination. Water is needed to mobilise food stores for germination, and by controlling the amount to all the seeds, they are more likely to germinate at the same time. By germinating indoors, a 90% germination rate can be achieved. When growing outside, often five times the quantity of seed is needed for the same quantity of seedlings produced. An indoor environment gives uniform germination, so those seedlings are growing at the same rate. Seedlings which emerge just 2– 3 days after the main crop may never catch up in size. When they are transplanted out in the field, they are all at the same stage. This reduces competition from larger neighbours and reduces shading. At harvest, a crop of uniform size and quality is more likely and increases profit.
(b)	**Justifies** the use of lighting techniques to treat seeds during germination, over untreated seeds, to increase the quality of plant production, with consideration of economic and environmental impacts. Light can stimulate or inhibit seed germination, or have no effect at all. Some plants like lettuces require light for germination, and many growers who provide supplemental light for seed germination have used fluorescent lamp fixtures. These lamps are typically suspended 15–30 cm above the seed trays. They can be used to provide supplemental light for both germination and growing on a crop, especially during dark weather periods and the shorter days of the year. The provision of light for seeds ensures the seeds germinate in optimal conditions. *Economic impacts* Using treated seeds can give measurably larger yields, as the rate of germination will be higher, as well as giving more evenly timed germination. All seeds being at the same stage of growth allows for easier care and growth, and therefore lowers the cost of production. Growers commonly recover the cost of seed treatment with increased yield and reduced thinning costs. The total value is dependent on the crop and market value. The use of non-treated seeds is a cheaper and less time-consuming process, but the saving at the germination stage will not be reflected in the end crop. A staggered and poor germination rate leads to a lower end yield from germinated seeds. Much seed may be wasted with a low strike rate. More germination increases the likelihood of a larger yield, and therefore more profit. The use of lights requires indoor germination so that the lighting can be more easily controlled. The operation of lights carries a cost with electricity charges, as do the structures used to germinate the seeds inside rather than out in the field. These costs can impact on final profits. *Environmental impacts* The lights are generally operated for 14–16 hours a day. Some growers who operate more elaborate production facilities have installed high-intensity discharge (HID) lamps. These can be used to provide supplemental light for both germination and growing-on of a crop, especially during dark weather periods and the shorter days of the year. This can lead to visual and light pollution for surrounding properties. The environmental impact of using light to aid germination can include reduced growth of weeds. The germinated seeds when planted out are more competitive against weeds; they will be bigger, and this means there will be less use of pesticides to suppress weed growth compared to when using untreated seeds, leading to a higher-quality product. Untreated

	seeds require more weeding and thinning, and this can lead to greater compaction of the surrounding soil, potentially reducing air available for root growth, which can lower plant growth overall. The larger the plants are before being planting out, the quicker they will reach maturity, due to more photosynthesis and quicker growth. A larger, more competitive plant should produce a higher-quality end product.

Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 7	8 – 12	13 – 18	19 – 24