Pilot Assessment Schedule – 2023

Agricultural and Horticultural Science: Demonstrate understanding of how soil properties are managed in a primary production system (91930)

Assessment Criteria

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrates understanding of how soil properties are managed in a primary production system.	Explains how soil properties are managed in a primary production system.	Evaluates how soil properties are managed in a primary production system.

Question ONE: Soil pH

	Sample evidence	Achievement	Achievement with Merit	Achievement with Excellence
(a)	Soil pH is the measure of soil acidity or alkalinity. While soil pH can range from 4–10. Optimum pH is between 5.8 and 6.0 for pasture and other common crops. Some crops (such as blueberries) lie outside of this, having an optimum pH of 4.8. pH has a major effect on nutrient availability. When the pH is between 5.8 and 6 it means: • Nutrient availability increases when soil pH is optimum. When pH is too low macro nutrients such as N, P, K become unavailable to plants. • there is an increased biological activity, both macro and micro, in soil. This increases the rate of accumulation and breakdown of soil organic matter, allowing nutrients such as N, P, and S to become more readily available for plant growth. • aluminium toxicity decreases – when soil pH sits below 5.5, aluminium becomes plant available and can be toxic to plants by restricting the growth of plant roots. • Molybdenum (Mo) becomes more plant available with a higher soil pH. Mo is important for nitrogen metabolization by clover and other legumes.	Defines the effect pH has on soil properties.	Explains the effect of pH on soil properties.	

(b)	• Adding lime (calcium carbonate / magnesium carbonate) to soil, increasing pH (decreasing acidity). • Excess hydrogen ions in the soil solution cause soil acidity. When agricultural lime is applied, carbonate from calcium carbonate (or magnesium carbonate) neutralises acid in the soil. In wet acidic soil, calcium carbonate ionises into calcium and carbonate ions. The carbonate ions react with hydrogen ions in the soil solution to form carbon dioxide and water. • Liming reduces soil acidity. During this process it enhances the mineralisation of organic matter and thereby increases the release of plant nutrients, making more available for plant growth. It also improves soil structure and makes phosphorus more readily available to plants. Lime encourages earthworm activity and helps to increase their numbers. • Using lime on soil is the most common way of increasing pH (reducing acidity) of soil in New Zealand and is a practice that allows farmers to care for the soil and ensure that it will keep producing sustainably. • Ground limestone consists of calcium carbonate and variable proportions of sand, silt, or clay. • When calcium carbonate is in contact with a slightly acidic soil, the calcium carbonate dissolves gradually in the soil moisture and reduces acidity. • Lime neutralises the soil in two ways: - The acidic hydrogen ions (H^+) react with the $CaCO_3$ to produce carbonic acid and calcium ions (Ca^{2+}). Carbonic acid is unstable and breaks down to form water and carbon dioxide. - The Ca^{2+} displace the H^+ ions in the soil. • Raising the pH of acidic soils promotes plant growth and soil health through the availability of nutrients, reduction in the toxicity of other nutrients, improved soil structure, and the promotion of macro and micro fauna in the soil. • By raising the soil pH, lime affects the availability of major and trace elements including nitrogen, calcium, magnesium, molybdenum, manganese, boron, zinc, and aluminium. • Lime has a beneficial effect on some soil fauna, especially earthworms and nitrogen-fixing bacteria. All these factors work together and contribute to significant increases in pasture production. • The addition of lime increases the population of the bacteria responsible for breaking down organic matter. The decomposition of organic matter is believed to assist soil crumb formation, possibly through the formation of gum-like substances, which act as cements, or through soluble humic materials that coat the soil crumbs and bind them on drying. Another indirect benefit on soil structure is a significant increase in earthworm numbers and activity.	Describes a way in which pH can be modified in a primary production system.	Explains how pH can be modified in a primary production system. Explains how pH affects plant growth.	Evaluates a technique used to modify soil pH in terms of soil health and optimising plant growth.

	• Casting earthworms depend on a constant supply of calcium in greater amounts than are naturally present in New Zealand soils. Calcium supplied through liming stimulates earthworm production and activity. • When farmers or growers use management practices, such as the use of lime or sulphur to rectify the pH of soil and promote the biological components of soil, they are demonstrating tiakitanga and ensuring the ongoing health of the soil. (This does not need to be explicitly stated but evidence of Māori values should be evident in the candidate's answer for achievement). • Encourages flocculation of clay particles in the soil, improving the soil structure and the air / water ratio in the soil.			

N1	N2	A3	A4	M5	M6	E7	E8
Shows minimal understanding of management of soil properties or any relevant Māori value.	Shows limited understanding of management of soil properties but no relevant Māori value.	Demonstrates some understanding of management of soil properties using the chosen management practice and a relevant Māori value.	Demonstrates understanding of management of soil properties using the chosen management practice and a relevant Māori value.	Explains in some detail how a soil management practice is used to modify soil properties leading to optimised plant production, along with a relevant Māori value.	Competently explains how a soil management practice is used to modify soil properties leading to optimised plant production, along with a relevant Māori value.	Evaluates the usage of soil management practices that modify soil properties with a focus on optimised plant production with some reasons, along with a relevant Māori value.	Competently evaluates the usage of soil management practices that modify soil properties with a focus on optimised plant production with detailed reasons, along with a relevant Māori value.

N0 = No response; no relevant evidence.

Question TWO: Soil compaction or pugging

	Sample evidence	Achievement	Achievement with Merit	Achievement with Excellence
(a)	Livestock • Avoid grazing heavy stock on steeper, more vulnerable soils, especially when wet. • Supplementary feed, e.g. hay and baleage, needs to be placed away from vulnerable soils and waterways, and ideally fed in drier parts of the paddock. • Supplementary feed should be put into the paddock prior to grazing. • A stand-off area or temporary bedding should be used to allow stock to rest on firm, dry ground. • Back-fence land that has already been grazed should be used to minimise further soil damage, especially when soil is wet. Back-fencing can be done every 4–5 days. Machinery • Use low-pressure tyres. • Avoid driving on wet soils. • Minimise tractor passes through undertaking multiple operations in a single pass. • Use permanent vegetation under vines and trees to provide cushioning. • Increase organic matter of soil by mulching (inter-row, pruning, compost) and using side throw mowers (under-vine mulching from inter-row).	Describes a management practice that helps avoid soil compaction or pugging.		
(b) (i)	• Areas with high water tables. • Dense clay soils are at higher risk of pugging and compaction. • Soils with poor structure are more prone to pugging and compaction.	Describes the properties of soils that are more susceptible to soil compaction or pugging.		
(ii)	Soil compaction occurs when soil pore space is compressed, and typically occurs in moist, rather than saturated soils. Soil compaction also affects soil structure, soil water transmission and storage, root penetration, and plant yield. Soils become compacted when under pressure from machinery (such as tractors or haulers) or livestock. Compaction has similar effects to pugging. Pugging typically occurs when the soil is very wet and soil pores are filled with water. Trampling creates a pugged surface, or in extreme cases, slurry, with considerable soil and pasture damage.	Describes the effects of soil compaction or pugging.	Explains the effect of soil compaction or pugging related to the soil properties of the chosen primary production system.	

	When grazing pasture in winter, wet conditions and high stocking rates when break-feeding can cause pugging and damage to pasture, resulting in an increase in weeds, pasture pulling, and damage to the soil structure. Soil structure changes from compaction and pugging can result in greenhouse gas emissions, nutrient leaching, and a loss of nutrients, such as phosphorus, and loss of sediment and bacteria via surface runoff. Soil compaction can have a major negative impact on soil properties – increases in bulk density, decreases in total carbon, oxygen diffusion rate, air permeability, hydraulic conductivity, and macroporosity to below the levels known to affect root development and plant growth. Compacted soil is less permeable to air and water and is resistant to root penetration. Even after tillage operations, soil that has lost its structure can resettle and consolidate quickly, particularly if there is heavy rainfall or subsequent wheel traffic.			
(c)	Pasture that has been seriously pugged in spring will produce about 40% less dry matter (DM) than undamaged pasture through the following season. Pasture yield reductions of up to 80% have been recorded. Losses will continue over the following years as the affected areas will likely become infested with weeds and unproductive grasses. If soil structure is not repaired, affected areas will also become more prone to future pugging due to impeded drainage. One form of rectifying the damage through pugging is subsoiling or ripping. Subsoil aeration is the term used to describe the loosening of the subsoil structure along with the removal of any compacted layers to create a more porous and aerated soil in which nutrients, along with water, can flow. This increase in soil permeability enables fertilisers and nutrients to flow to the root zone to be taken up more effectively, and also for the roots themselves to grow more vigorously as the resistance becomes less. This more vigorous root growth allows roots to grow to deeper levels, making the pasture and crop more resilient to dry summers and wet winter periods. The subsoiler is able to rip deep into the subsoil and shatter the hard-packed layers of soil, lifting the ground and allowing oxygen, fertiliser, and moisture to flow freely through the ground at the plant root level. Care must be taken not to subsoil too deep (more than 450 mm in most New Zealand soil types) as this, aside from being a waste of fuel and wearing parts, means that the water level could drop too low. Breaking up the compacted soil allows oxygen to pass through the soil, allowing the growth of microorganisms that break down organic matter, and releasing nutrients for the uptake by plants. This release of nutrients makes increased growth possible. When the soil is too tightly packed, or the soil pores are filled with	Describes a technique used to restore compacted soil.	Explains how restoration of compacted soil impacts plant growth.	Evaluates how a technique used to restore compacted soil will optimise plant growth and ensure the long-term sustainability of the soil.

	water, these microorganisms cannot access the oxygen they need to function and produce plant nutrients. While subsoiling is a time consuming and expensive management practice, using it to restore compacted soils allows for long-term improvements to soil health, and increased plant yield.			

N1	N2	A3	A4	M5	M6	E7	E8
Shows minimal understanding of management of soil properties or any relevant Māori value.	Shows limited understanding of management of soil properties but no relevant Māori value.	Demonstrates some understanding of management of soil properties using the chosen management practice and a relevant Māori value.	Demonstrates complete understanding of management of soil properties using the chosen management practice and a relevant Māori value.	Explains in some detail how a soil management practice is used to modify soil properties leading to optimised plant production along with a relevant Māori value.	Explains in thorough detail how a soil management practice is used to modify soil properties leading to optimised plant production along with a relevant Māori value.	Evaluates usage of soil management practices that modify soil properties with a focus on optimised plant production with some reasons along with a relevant Māori value.	Evaluates usage of soil management practices that modify soil properties with a focus on optimised plant production with detailed reasons along with a relevant Māori value.

N0 = No response; no relevant evidence.

Question THREE: Soil temperature

Question	Sample evidence	Achievement	Achievement with Merit	Achievement with Excellence
(a) (i)	Soil particle sizes impact the size of soil pore spaces, which in turn impact soil temperature. • Sand-based soils have large pore spaces, which allows them to be more aerated and can therefore warm up faster during the day, but then cool down quicker at night. • Clay soils have small pore spaces, which allows them to warm more slowly during the day. Clay soils can hold onto absorbed heat, which means they cool down more slowly at night. • Clay soils have good water retention, which results in these soils holding onto moisture more effectively, and this moisture takes longer to evaporate and heat.	Describes how the composition and structure of soil affects soil temperature.	Explains how the composition and structure of soil affects soil temperature.	
(ii)	• Soils with higher organic matter content are able to heat up faster due to being darker in colour and being able to absorb heat energy from the sun during the day. • Organic matter will provide overall better soil conditions such as, more microorganisms, better soil structure, better soil nutrient retention, and water-holding capacity. In warmer soils the rate of biological cycling of nutrients is increased: • The rate at which organic matter is decomposed by soil microorganisms increases with temperature between the ranges of 5–30°C. • Improved temperatures result in soil organisms working faster, so more organic matter is broken down and there is more tunnel formation. Therefore, soil is better aerated. • More organic matter breakdown results in more nutrients being released or recycled into the soil. This is used by plants to increase growth and decreases the need for synthetic fertilisers to better protect soils and enhance or utilise natural soil processes. • Plants have improved growth rates due to soil temperatures increasing, as the rate of reaction for both photosynthesis and respiration increases due to the temperature increase.	Describes an impact of temperature on the biological properties.	Explains the impact of temperature on the biological properties.	

(b)	• A farmer or grower may add drainage to the soil to modify the conditions to ensure they can better heat up when the environmental conditions allow it. • Subsurface drainage artificially removes excess water for soils that are poorly drained. This allows for a better water : air ratio in the pore spaces to equally allow for plant-growing processes to be enhanced. Water is needed for photosynthesis and osmosis / transpiration, whereas air is needed for root respiration. Both photosynthesis and respiration produce energy for plant growth. • Providing ideal water levels in soil allows for healthy macro and micro fauna in the soil. Worms assist in improving soil structure and decomposition, releasing nutrients to plants. This reduces the need for artificial fertilisers, reduces leaching, as well as water and nutrient runoff. • Healthier soils support greater soil biodiversity and have greater productivity for the farmer or grower, demonstrating manaakitanga. (This does not need to be explicitly stated but evidence of Māori values must be evident in the student's answer for achieved).	Describes how a management practice can modify temperature to optimise plant growth and demonstrate care for the environment.	Explains how the management practice can impact the temperature of soil and possibly other soil properties that lead to optimised plant growth.	Evaluates the usage of a management practice by talking about how impacts on soil temperature, plant growth, and how it shows care for the environment.

N1	N2	A3	A4	M5	M6	E7	E8
Shows limited understanding of management of soil properties but no relevant Māori value.	Demonstrates limited understanding of management of soil properties and no relevant Māori value.	Demonstrates some understanding of management of soil properties of the chosen management practice and a relevant Māori value.	Demonstrates complete understanding of how a soil management practice is used to modify soil properties, leading to optimised plant production, and a relevant Māori value.	Explains in some detail how a soil management practice is used to modify soil properties leading to optimised plant production, along with a relevant Māori value.	Explains in thorough detail how a soil management practice is used to modify soil properties, with a focus on optimised plant production with some reasons, along with a relevant Māori value.	Evaluates usage of soil management practices that modify soil properties, with a focus on optimised plant production with some reasons along with a relevant Māori value.	Evaluates usage of soil management practices that modify soil properties, with a focus on optimised plant production with detailed reasons, along with a relevant Māori value.

N0 = No response; no relevant evidence.

Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 6	7 – 12	13 – 18	19 – 24