RHS LEVEL 3 ADVANCED CERTIFICATE IN HORTICULTURE
WRITTEN EXAMINATION

10:00am Tuesday 7th July 2009

MODULE A

Understanding of Plant Propagation Processes and Application of Soils, Growing Media and Plant Nutrition

Section A – Short Answer Questions

Candidate Number:………………………………...

Candidate Name:…………………………………..

Centre Number/Name:…………………………….

IMPORTANT – Please read carefully before commencing.

i) The duration of the papers in Module **A** is **2 hours**.
ii) Answer **ALL** questions in Section **A**.
iii) **ALL** questions in Section **A** carry equal marks.
iv) Write your answers legibly in the spaces provided.
v) Use metric measurements **ONLY**.
vi) Where plant names are required, they should include genus, species and where appropriate cultivar.

Please turn over/…..

ANSWER ALL QUESTIONS

MARKS

Q1 Define the term ‘colloid’ in relation to soil. **2**

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Q2 State the advantages of a water balance sheet. **2**

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Q3 Identify **FOUR** possible causes of the non-germination of seed. **2**

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Q4 Identify **FOUR** treatments which can be used to break seed dormancy. **2**

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ANSWER ALL QUESTIONS

MARKS

Q5 State **FOUR** distinct examples of soil structure found in the United Kingdom. **2**

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Q6 State, with reference to stock plants used for propagation, the significance of **EACH** of the following:

i) juvenility;
ii) stage of growth. **2**

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Q7 Explain, with a crop example, how a mychorrizal association assists with plant growth and development. **2**

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ANSWER ALL QUESTIONS

MARKS

Q8 Explain how the cation exchange capacity of a sandy loam soil can be improved. **2**

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Q9 Explain the importance of **EACH** of the following in relation to vegetative plant propagation:

i) cambium;
ii) node. **2**

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Q10 Explain the use, as alternates to peat in the container production of plants, of **EACH** of the following materials:

i) garden compost;
ii) air-dried digested sewage sludge. **2**

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RHS LEVEL 3 ADVANCED CERTIFICATE IN HORTICULTURE WRITTEN EXAMINATION

10:00am Tuesday 7th July 2009

MODULE A

Understanding of Plant Propagation Processes & Application of Soils Growing Media & Plant Nutrition

Sections B & C - Structured Questions

IMPORTANT – Please read carefully before commencing.

i) The duration of the papers in Module **A** is **2 hours**.
ii) Answer **ONE** question from Section **B** and **TWO** questions from Section **C**.
iii) **ALL** questions carry equal marks.
iv) Write your answers legibly in the answer booklets provided.
v) Use metric measurements **ONLY**.
vi) Where plant names are required, they should include genus, species and where appropriate cultivar.

Please turn over/…..

Section B – Understanding of Plant Propagation

Answer ONE question only from this section

			MARKS
Q11	a)	State **TWO** advantages and **TWO** limitations of propagating bulbous plants by scaling **OR** chipping.	**4**
	b)	Describe the technique of **EITHER** scaling **OR** chipping for the production of narcissus.	**10**
	c)	Explain, how the management of the environment for propagation will influence the success rate of the technique stated.	**6**
Q12	a)	Describe the preparation of an outdoor seedbed for tree propagation.	**6**
	b)	Explain, how a **NAMED** tree can be successfully propagated from **SEED** in the open ground.	**8**
	c)	Evaluate the propagation of tree seed in the open ground.	**6**

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Please see over/…..

Section C – Processes & Application of Soils, Growing Media & Plant Nutrition

Answer TWO questions from this section

			MARKS
Q13	a)	Describe the differences in profile between brown earth, podzol, rendzina and seasonal gley soils in the United Kingdom.	**8**
	b)	Explain, why a visual and physical examination of the soil profile is important in the production of field grown crops.	**8**
	c)	Identify **FOUR** problems, noted in b), which could lead to detrimental plant growth and development.	**4**
Q14	a)	Describe the visual plant symptoms associated with the deficiency of **SIX** different elements.	**12**
	b)	Review the means by which nutrients can be added to remedy the deficiencies described in a).	**8**
Q15		Define **EACH** of the following terms and relate **EACH** to **TWO NAMED** soil types:	
		i) soil moisture deficit;	**5**
		ii) available water content;	**5**
		iii) field capacity;	**5**
		iv) permanent wilting point.	**5**
Q16	a)	Describe the methods available to assess the structure of soil.	**8**
	b)	Explain, how machinery can affect the soil structure with field grown crops.	**6**
	c)	State **TWO** methods of reducing potential soil structure damage, when using machinery with field grown crops.	**6**

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RHS LEVEL 3 ADVANCED CERTIFICATE IN HORTICULTURE
WRITTEN EXAMINATION

10:00am Tuesday 7th July 2009

MODULE A

Understanding of Plant Propagation Processes & Application of Soils, Growing Media & Plant Nutrition

Section A – Short Answer Questions

Candidates Registered	**194**		**Total Candidates Passed**	97	58.43%
Candidates Entered	166	85.57%	Passed with Commendation	23	13.85%
Candidates Absent	22	11.34%	Passed	74	44.58%
Candidates Deferred	5	2.58%	Failed	69	41.57%
Candidates Withdrawn	1	0.51%			

Section A – Short Answer Questions

Q1 Define the term ‘colloid’ in relation to soil.

The names were usually given of the materials that can be colloids, eg. clay and humus, with a large surface area that can be reactive, but further detail, eg. that they stay in permanent suspension within the soil solution, and their size, ie. less than 0.001mm, were also required.

Q2 State the advantages of a water balance sheet.

Most responses included the fact that both inputs and outputs are recorded but the timing (starting from 1st April) and that the soil is taken as being at field capacity (FC) at this point, were less well covered. The advantages of knowing how far the soil is away from FC and therefore how much is required to return it to it, thereby applying irrigation of a known amount only when required resulting in saving both time and water, was usually mentioned by the candidates.

Other advantages accepted were that records from year to year would result in informed crop selection to match the soil type, avoidance of water stress; reduction of leaching and disease. Some confusion was also noted with the term water table and the measurement of it and drainage need.

Q3 Identify **FOUR** possible causes of the non-germination of seed.

A number were acceptable such as non-viable embryo; lack of oxygen; lack of water; incorrect temperatures and a dormancy statement, eg. hard testa. Physical and chemical dormancy were taken as different causes.

Q4 Identify **FOUR** treatments which can be used to break seed dormancy.

Clear methods of treatment were accepted: scarification, stratification, seed washing and applying the correct levels/duration of light or dark. The methods of acid treatment and chipping/nicking were included alongside scarification, with marks being awarded for all.

Q5 State **FOUR** distinct examples of soil structure found in the United Kingdom.

This question caused some confusion with the word structure being read as texture. The required responses included: crumb, platy, columnar, massive and blocky. Also, as the phrase “United Kingdom” was included, soil series names and general soil profile types were listed. These were not required.

Q6 State, with reference to stock plants used for propagation, the significance of **EACH** of the following:

i) juvenility;
ii) stage of growth.

An overall understanding of the required terms was usually given but stronger linkage back to the stock plants was required, eg. the type of plant (*Hedera helix* with two clear forms), active meristematic tissue and the balance of hormones, including higher levels of auxin.
For the stage of growth, strong linkage was provided with the relationship for grafting, eg. *Wisteria sinensis* being brought much earlier into flower.

Q7 Explain, with a crop example, how a mychorrizal association assists with plant growth and development.

Clear understanding of the assistance provided was given: wider access to nutrients, especially phosphates in low nutrient level situations; greater access to water, due to increased surface area and some disease resistance, but a crop example was not always included. Some confusion was seen with nitrogen fixing bacteria and their beneficial roles.

Q8 Explain how the cation exchange capacity of a sandy loam soil can be improved.

The materials, humus and clay, that can provide this were named, but their roles/actions of providing a high level of negative charge, resulting in additional cation exchange, was less understood. The addition of lime products will only stimulate the situation, once the negative charge is elevated.

Q9 Explain the importance of **EACH** of the following in relation to vegetative plant propagation:

i) cambium;
ii) node.

A clear understanding of the cambium being matched for grafting was provided, but further detail was required as to the fact that it is meristematic, forms callus, and the cells will differentiate into new plant tissues/organs.
Nodes are meristematic areas with a higher level of natural accumulation of hormones for plant growth and development. Also, an easily found point on a plant for staff training.

Q10 Explain the use, as alternates to peat in the container production of plants, of **EACH** of the following materials:

i) garden compost;
ii) air-dried digested sewage sludge.

Where the full requirements of the question were read and noted, then clear explanations were given. With garden compost, it can display a variable structure (prone to slumping), differing nutrient content and be cheap to produce. But it can also contain contaminants, such as weed seeds and old roots. For air-dried digested sewage sludge, its use in mixtures was recommended, due to air filled porosity concerns; the risk of pathogens was highlighted but less so was the higher risk of heavy metal levels (certification of the levels within each batch should be expected). Also the higher active bacterial level was commented on. General recommendations for these products as soil conditioners/improvers were included in answers, but were not requested.

Recommendations

All plant names need to be given a full botanical name at this level of qualification. The genus can only be abbreviated to an initial on second and subsequent use.

Understanding of Plant Propagation, Processes & Application of Soils, Growing Media & Plant Nutrition.

Sections B & C – Structured Questions

Section B – Understanding of Plant Propagation

Q11 a) State **TWO** advantages and **TWO** limitations of propagating bulbous plants by scaling **OR** chipping.

b) Describe the technique of **EITHER** scaling **OR** chipping for the production of narcissus.

c) Explain, how the management of the environment for propagation will influence the success rate of the technique stated.

Question Aims

The aims of the question are to test the candidate's knowledge of vegetative propagation of bulbous subjects with the main part of the question focussing on a specific technique. Finally the question requires the candidate to understand how the management of the propagating environment will influence the success or failure of the technique used.

Most candidates were able to make a reasonable attempt at this question and followed the structure of the question to provide them with this best chance of gaining marks. Where candidates did less well was in demonstrating good understanding of a specific technique often confusing or combining techniques rather than describing a single technique. Candidates who described the significance of humidity, light, temperature and hygiene scored well in section C.

Taking the time to read and understand the question is essential and to gain the maximum marks a candidate needs to be aware of the number of marks available per section and to tailor an answer accordingly.

Diagrams must be relevant and clearly annotated.

It is important for the candidate to review their answer and be able to see the required pieces of information to gain maximum marks.

Recommendations

No amount of reading is a substitute for practical experience so it is worthwhile contacting the RHS Education Department to learn of the range and location of practical workshops that take place throughout a network of gardens and colleges. Gain work experience on your local commercial nursery. Check the following website www.ipps.org for an insight into the world of the commercial propagator.
Make use of the following texts:-
RHS Propagating Plants (Alan Toogood)

Q12 a) Describe the preparation of an outdoor seedbed for tree propagation.
b) Explain, how a **NAMED** tree can be successfully propagated from **SEED** in the open ground.
c) Evaluate the propagation of tree seed in the open ground.

Question Aims

The main aims of this question are to test a candidate's understanding of propagating a specific tree from seed in an open ground environment, having first described how best to prepare a seedbed outdoors. Finally the question probes a candidate's ability to assess the success of propagating tree seeds outdoors.

This question was not very well answered and those candidates who had both good knowledge of tree seed propagation and an ability to evaluate gained the most marks.

Whether describing a seedbed prepared in a town garden or within a commercial nursery, it is important that the candidate applies the same level of professionalism to the preparation.

Many candidates concentrated on describing breaking seed dormancy and the process of seed germination, both may be parts of the answer for section B, depending on tree selection, however candidates who went on to consider timings, field factors, densities and irrigation etc scored more highly.

Taking the time to read and understand the question is essential and to gain the maximum marks a candidate needs to be aware of the number of marks available per section and to tailor an answer accordingly.

It is important for the candidate to review their answer and be able to see the required pieces of information to gain maximum marks.

Section B) requires a full botanical name to gain maximum marks.

To gain a good score for section C the candidate needs to assess both the strengths and limitations of open ground propagation and compare this with, for example, trees propagated from seed within a protected structure.

Recommendations

Practical experience is often the key to answering questions authoritatively, so it is worthwhile contacting the RHS Education Department to learn of the range and location of practical workshops that take place throughout a network of gardens and colleges.

Gain work experience on your local commercial nursery.

Check the following website www.ipps.org for an insight into the world of the commercial propagator.

Make use of the following texts:-

RHS Propagating Plants (Alan Toogood)

Plant Propagation principles and practices (Hartmann, Kester, Davies and Geneve)

Hardy Woody Plants from Seed (McMillan Browse). This text was first published in 1979, contains very useful information on collecting, storage and growing a range of woody plants from seed.

Visit the Millennium Seed Bank.

Section C – Processes & Application of Soils, Growing Media & Plant Nutrition

Q13 a) Describe the differences in profile between brown earth, podzol, rendzina and seasonal gley soils in the United Kingdom.

b) Explain, why a visual and physical examination of the soil profile is important in the production of field grown crops.

c) Identify **FOUR** problems, noted in b), which could lead to detrimental plant growth and development.

a) The aim of this part of the question was to test candidate's knowledge of soil profiles by describing differences between four different profiles.

Many candidates provided diagrams of profiles which were not required by the question.

Descriptions of how the profiles were created and typical areas where they can be found were also provided by many candidates and again these descriptions were not required.

Good answers used descriptive terms and gave an account of the recognisable horizons in each profile, from the litter layer to the parent rock. Marks were given for describing horizon depth, horizon colour, soil structure, pH (range of pH, and the terms acid, alkaline or neutral being accepted) and organism activity. Apart from pH these factors are visible in the field. pH could be predicted.

Good answers were well structured, used technical terms and contained detailed technical information.

Generally candidates showed a good knowledge of the four horizons and their distinct differences.

b) This part of the question required an in-depth understanding of the information provided by soil examination and testing.

Most candidates showed good knowledge of soil profile examination and soil testing. Generally answers were well structured and explained the positive and negative factors relating to the characteristics of soils as affected by: drainage potential, horizon depth, horizon colour, soil pans, cultivation pans, soil texture, soil air filled porosity, soil structure, nutrient status, pH and mechanical damage. Some candidates included soil contamination and bulk density in their answer which was acceptable. Some candidates divided their answer into visual and physical soil examination and testing which focused their answer on what was required.

Lower marks were a result of limited in-depth knowledge or a limited knowledge of the different ways to examine and test soil.

Good answers were well structured, used technical terms and contained detailed technical information.

c) This part of the question required candidates to relate the soil characteristics explained in b) to plant growth and development.

Most candidates were able to readily identify four problems noted in b) and relate them to plant growth and development. Although the question only asked for the problems to be identified most candidates gave a brief explanation of the effect of the problem on growth and development, which was good. Full marks were gained by many candidates.

In some cases candidates missed out on marks as their answers to b) were weak and therefore did not provide a good list from which to choose soil problems for c).

Q14 a) Describe the visual plant symptoms associated with the deficiency of **SIX** different elements.

b) Review the means by which nutrients can be added to remedy the deficiencies described in a).

a) The aim of this question was to test detailed knowledge of very specific visual symptoms of nutrient deficiency in plants.

Some candidates provided information about the role of nutrients in plant growth, development and systems. This was not required by the question so could not attract marks.

Generally the question was answered by listing the symptoms. Generally answers were not descriptive but did contain accurate information. The more descriptive answers contained key words that showed an understanding of how similar deficiency symptoms were different depending on the lacking nutrient, e.g. using the term ‘interveinal chlorosis’ rather than ‘yellowing of the leaves’. There was overuse of some non-specific terms such as poor growth.

Good answers described MOST of the deficiency symptoms for each nutrient (bearing in mind that some nutrients cause more visible symptoms than others). The symptoms described, when added together, would have resulted in the correct identification of the lack of a specific nutrient.

For nutrients that have few visual deficiency symptoms good use was made of well documented examples of the effect on specific plants. Calcium and boron are two such nutrients and, for example symptoms such as blossom end rot (calcium deficiency) in tomatoes was cited. Marks were given where this was appropriate.

Good answers were well structured and covered each nutrient deficiency in turn.

b) The aim of the question was to test candidates knowledge of fertilisers (both organic and inorganic), organic matter, chemicals and crops that can be used to remedy nutrient deficiencies.

Some candidates were confused by the word ‘added’ and confirmed what they added the remedies to - either plants or soil. Many candidates showed a very good knowledge of fertilisers (and associated materials)

and the ways in which they could be applied to remedy specific nutrient deficiencies.

Only limited detailed and technical knowledge resulted in low marks.

Some candidates provided too much detail relating to soil chemistry.

Candidates could answer this question in one of two ways – both acceptable. Good answers contained the following information:

The application of materials, and methods adopted, to plants and soil, would be reviewed. Foliar feeds, liquid feed, chelated fertilisers, adjusting soil pH, organic matter, inorganic and organic fertilisers, improving the cation exchange capacity, and the use of green manures were cited and all were acceptable answers.

or

The alternative way of answering the question was to list each nutrient deficiency and review the various ways of raising its presence and availability to plants in soil. Specific materials were cited and their use reviewed according to specific factors such as cost, speed of action, environmental considerations, availability, nutrient antagonism, soil type, possible soil nutrient status, and plant type.

Good answers were well structured and written using technical terms and language.

Q15 Define **EACH** of the following terms and relate **EACH** to **TWO NAMED** soil types:

i) soil moisture deficit;
ii) available water content;
iii) field capacity;
iv) permanent wilting point.

This question seeks definitions for four related states of water in the soil and an understanding of how they are affected by soil type.

Where a question specifies a definition, it implies a standard recognised horticultural definition with units where applicable. It is not sufficient in a Level 3 exam to restate the question by saying for instance, that ‘available water content’ is the water available to plant roots.

Soil moisture deficit is the amount of water required to bring a soil back to field capacity. As soils of different textures will contain different amounts of water, the speed at which a SMD will develop will also vary with texture. Thus instead of saying that a free-draining soil *has* a high SMD, it’s more informative to say that a SMD can build up more quickly in a sandy soil than in a clay soil. The converse is that a deficit can be rectified more quickly with irrigation in a sandy soil than a clay soil. Few candidates mentioned that texture would affect *infiltration* and thus the rate at which irrigation could be applied to rectify a SMD.

Several candidates placed the soil moisture deficit between field capacity and permanent wilting point – this is a useful measure but is the definition

of *maximum* soil moisture deficit rather than soil moisture deficit.

Some answers asserted that SMD was affected by the speed of drainage, but it relates to field capacity, the point at which free water has already drained away – the SMD is built up by evapotranspiration (ET), not drainage.

Available water capacity. Marks were awarded for answers that went beyond a reworking of the question to locate AWC either 'between field capacity and permanent wilting point' or in 'mesopores'[1] or in an acceptable range of pore sizes (eg 0.2 to 60 µm). A minority of candidates pointed out that available water could also be understood in terms of the *tension* with which it was held in the soil (PWP equating to approximately 15 bar).

There was good understanding that *water held in micropores was not available* to plants (see footnote) although the term 'hydroscopic' (relating to deep sea observations) appeared quite frequently in place of *hygroscopic*. It was also well appreciated that clay soils had a high percentage of water held in these micropores and therefore unavailable to roots. However, several candidates interpreted that to mean that clay soils had little available water when compared to sandy soils, whereas they have relatively large quantities of *both,* available *and* unavailable, as a glance at standard textbook charts will show.

Of the water held in coarse textured soils a relatively *large proportion is available* but not all candidates understood that a large proportion of a small total is still a small quantity. These matters are easily confused, and are perhaps most easily expressed as a chart or graph – an option which very few candidates attempted.

The second part of the question was to relate AWC to two soil types. The easiest option would be to take two soils of textural extremes, for example a loamy sand and a silty clay, to give maximum contrast. However many chose examples from the middle range of soil textures and it was clear that many did not appreciate that the differences in AWC between say, a loamy sand, a sandy loam and a silt loam are quite marked. Few candidates quantified AWC figures for soil types or indeed mentioned standard ways of expressing those quantities.

When choosing soil types to compare many candidates selected naturally occurring soil types such as rendzinas and podsols, perhaps influenced by their appearance in an earlier question; gleys also occurred several times. Marks were awarded wherever relevant comments were made but candidates perhaps handicapped themselves in choosing these, rather than textural categories.

Field capacity

All the answers showed appreciation that this represented a maximum amount of water in the soil and most expanded this to be the amount of water held in the soil after drainage. Fewer answers pointed out that for this to be meaningful, the soil must first be saturated, although many did point to the fact that UK soils are generally considered to be at field

[1] Some candidates adopted a binary division of pore space in the soil, specifying macropores and micropores only, the dividing line being about 60 µm. On this basis, statements that water was available in micropores was accepted as long as the candidate made it clear that there was a size of micropore (c.0.2 µm) below which water was no longer mobile or available to plant roots.

capacity at the end of March and that normally a deficit builds up in the months April to September. Candidates generally understood that the macropores do not hold water against gravity and that it is these pores which drain to leave the soil at field capacity.

As in the case of available water capacity and soil moisture deficit, candidates tended to talk in terms of 'high' field capacity or a 'low' field capacity when it would have been better to think in terms of a clay soil having a higher water content at field capacity than a sandy soil. It was generally appreciated that the texture of the soil affected how long it took a soil to drain from saturation to field capacity but suggestions of realistic times varied greatly. A few candidates mentioned the practical importance of appreciating that workability of a soil at field capacity was markedly affected by soil type.

Permanent wilting point

Understandably, all the scripts connected drying of the soil with wilting. However many concentrated on the physiological effects on the plant, not appreciating that PWP is a measure of the soil water content and the state of the plant is used as an indicator only. Several answers effectively defined *temporary* wilting point – the state where water output is greater than input, but the majority did point to the irreversible nature of the process in PWP. Maximum marks were given for those answers which identified PWP as being when the plant would not recover turgor when placed in a saturated atmosphere for 12 hours (or overnight).

In relating PWP to soil types it was generally understood that in fine textured soils PWP could be reached even though the soil still contained (hygroscopic) water.

Recommendations

Candidates should have a firm grasp of soil water definitions. Understanding the difference between, for example, the concept of total soil water content and available water content will make it possible to answer more fully questions about the moisture characteristics of different soil types.

It is suggested that candidates ensure they have an understanding of how soil texture groups link with water holding capacity, aeration, drainage and structural matters.

Candidates are reminded to check that they have answered all parts of the question and that they keep to the format and the order laid out there.

Q16 a) Describe the methods available to assess the structure of soil.

b) Explain, how machinery can affect the soil structure with field grown crops.

c) State **TWO** methods of reducing potential soil structure damage, when using machinery with field grown crops.

The aim of this question is to allow the candidate to demonstrate a knowledge of practical methods of assessing soil structure together with an understanding of the impact of machinery on structure. To achieve this the candidate must understand that soil structure is both distinct from soil texture, and from soil horizons and profiles.

Structure refers to the way in which soil particles are arranged together to form aggregates or peds. This distinguishes it from **texture**, which refers to the mixture of different particle sizes in the soil, and **horizons** which are the distinct horizontal layers in a soil naturally formed over a time.

a) Information derived from the horizons and soil texture can help give *indirect evidence* of soil structure, but candidates needed to appreciate the character of soil aggregates before assessing them. Suggesting that a soil sample is wetted and kneaded is relevant to texture, not structure, as the process would involve the loss of all structure.

Most candidates appreciated that a visual assessment was a key requirement. Many suggested digging pits of 1 m^3 or more – useful for looking at the horizons – but for topsoil assessment a spade spit is a more practical proposition. Several did mention the use of soil augers.

Most were also aware of the significance of **pans and layers of compaction** but few pointed out how these might be identified. It is difficult to discuss a sample fully without a vocabulary of appropriate terms – in this case, *platy, blocky, granular* etc. Often the term **capping** was used synonymously with compaction. This is not correct as the former is surface phenomenon of susceptible soils which have lost structure through poor cultivation and are then subject to heavy rainfall or irrigation. This forces soil particles into pore spaces forming, on drying, an impermeable cap.

Bulk density was mentioned by a minority of candidates – the ratio of weight to volume gives a good indication of how compacted a soil sample is, together with its air filled porosity. Soil penetrometers were rarely mentioned.

Valuable *secondary clues* such as the presence of organic matter, drainage characteristics deviating from the textural norm and uncharacteristic plant growth were mentioned by most candidates. Marks were gained by those who clearly explained

how these linked with soil structure rather than soil texture and fertility.

b) This was better answered than part a). Candidates who gained most marks identified positive as well as negative effects of machine cultivation. A complete answer identifies a *cause*, (eg repeated slicing action of a rotavator blade), *modifying factors* (eg high clay content, high moisture content), an *effect* (eg compacted layer, cultivation pan) and brief *implications* (impeded water movement, restricted root run, drought susceptibility).

c) This was generally well answered although with some repetition from part b. Many candidates created a general list of beneficial factors instead of consolidating them into two methods as specified in the question.

Compaction is the quality most readily identified with loss of soil structure but over cultivation by rotavators, power harrows and bed formers can also lead to a weak structure which is subsequently liable to compaction and a further loss of structure.

The most comprehensive answers differentiated between *direct* methods of reducing potential damage (eg various methods of reducing ground pressure and reduced cultivation systems) and *indirect* methods (eg improved drainage to reduce soil plasticity).

Although the question specified reducing the *potential* for soil structural damage when using *machinery*, operations which indirectly involved machinery such as addition of organic matter, and operations which were essentially curative (eg subsoiling) were also accepted.

Several candidates mentioned the use of a **mole plough** as improving soil structure but few mentioned that this operation is not synonymous with subsoiling and is limited by soil type. It requires the clay fraction to be reasonably plastic and the presence of a network of backfilled drains to connect with. The effects on structure are secondary, as a result of improved drainage.

Recommendations

Although texture and structure are linked it is important to understand that they are quite distinct soil characteristics. Candidates are advised to make sure that they are familiar with the terminology used in the syllabus and relevant textbooks.