Royal Horticultural Society

R3102

THE ROOT ENVIRONMENT, PLANT NUTRITION & GROWING SYSTEMS

Level 3

Wednesday 29 June 2011

13:30 – 15:00

Written Examination

Candidate Number:.....

Candidate Name:.....

Centre Number/Name:.....

IMPORTANT – Please read carefully before commencing.

i) The duration of this paper is **90 minutes**.

ii) **ALL** questions should be attempted.

iii) **EACH** question carries **10 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.

vii) Please note, sufficient lined space is provided. It is not necessary that all lined space is used in answering the questions.

Ofqual Unit Code M/601/1007

ANSWER ALL QUESTIONS

MARKS

Q1 a) Describe what is meant by **EACH** of the following terms in relation to rocks and soil formation:

i) sedimentary;
ii) sedentary;
iii) sorting. **3**

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b) State **FOUR** characteristics of a gley. **4**

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MARKS

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c) State **THREE** possible reasons why a gley is not suitable for field production. **3**

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MARKS

Q2 a) Explain how **FOUR** soil factors affect the maximum water available to a plant. **8**

MARKS

b) State **TWO** ways in which the irrigation needs of a crop can be determined through the growing season. **2**

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MARKS

Q3 a) State how humus differs from the organic matter from which it is derived. **2**

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b) Describe the processes that occur to woody shreddings when added to the soil. **8**

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Q4 a) State what is meant by the term ‘anion’ and list **TWO** anions of horticultural importance. **3**

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b) Explain the processes that affect the availability of anions to plants grown in soil. **7**

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MARKS

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MARKS

Q5 a) Describe what is meant by a ‘frit’. **2**

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b) i) Describe **TWO** distinct formulations of solid compound fertilisers used in growing media.

ii) Outline for **EACH** of the factors which affect the rate of release of nutrients into the medium. **4**

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MARKS

c) Explain how incorrect fertiliser levels affect plant growth. **4**

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MARKS

Q6 a) Explain the term ‘UK5’ on organic produce. **2**

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b) Describe **FOUR** ways of controlling weeds on a field scale in organic systems. **8**

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MARKS

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Q7 a) Describe **FOUR** ways to ensure that a newly planted whip has optimal access to nutrients. **4**

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b) Describe techniques to avoid water-logging when planning to plant whips in a clay soil. **4**

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MARKS

c) Explain how the incorporation of undecomposed organic matter at the base of the planting hole could be a disadvantage in clay soils. **2**

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MARKS

Q8 a) State **FIVE** advantages of peat as a growing media. **5**

MARKS

b) State **TWO** reasons why loam is added to a peat based medium. **2**

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c) State **THREE** limitations of using loam as a component of a growing medium. **3**

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MARKS

Q9 a) State **ONE** material and method of application which can be used to rectify magnesium deficiency without raising pH. **2**

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b) Describe the symptoms of deficiency of the following plant nutrients:

i) potassium;
ii) calcium. **4**

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MARKS

c) Explain:

i) why the lime requirement of **TWO** distinct soils with the same pH can be different.

ii) how the addition of lime can affect the availability of other nutrients. **4**

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Q10 a) Describe the structure of a mature podzol by means of a fully labelled diagram. **5**

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MARKS

b) Explain the formation of an iron pan podzol. **5**

Total Mark

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RHS LEVEL 3 CERTIFICATE IN THE PRINCIPLES OF PLANT GROWTH, HEALTH AND APPLIED PROPAGATION WRITTEN EXAMINATION

13:30pm Wednesday 29 June 2011

R3102

THE ROOT ENVIRONMENT, PLANT NUTRITION AND GROWING SYSTEMS

Candidates Registered	**77**		**Total Candidates Passed**	**23**	**46.0%**
Candidates Entered	50	64.93%	Passed with Commendation	9	18.0%
Candidates Absent	16	20.78%	Passed	14	28.0%
Candidates Deferred	6	7.79%	Failed	27	54.0%
Candidates Withdrawn	5	6.49%			

Q1 a) Describe what is meant by **EACH** of the following terms in relation to rocks and soil formation:

i) sedimentary;
ii) sedentary;
iii) sorting.

b) State **FOUR** characteristics of a gley.

c) State **THREE** possible reasons why a gley is not suitable for field production.

The information sought in the first part of this question was:

i) fragmented materials solidified under pressure in seas and lakes (to form for example, sandstones and chalks),
ii) soils formed above parent rock, *not* transported,
iii) separation by particle size following for example, frost heave or transportation.

In part b) several candidates implied that gley soils and clay soils were the same thing. A *surface water gley* may be created by a fine, poorly structured soil and a perched water table, but a *ground water gley* with a permanently high water table could be of coarser texture. Both are gleys – wet conditions are the key feature.

A frequent point was that gleys exhibited low levels of organic matter whereas organic matter can *accumulate,* there not being aerobic organisms present to process it efficiently. However, a majority of candidates did point to the poor drainage, lack of oxygen and the characteristic grey colour caused by the presence of ferrous oxides.

Appropriate answers to the third part which did not just repeat the second section included the possibility of shallow rooting, root damage or death following anaerobic conditions, infertility, and the practical difficulties of working such soil with conventional machinery.

Q2 a) Explain how **FOUR** soil factors affect the maximum water available to a plant.

b) State **TWO** ways in which the irrigation needs of a crop can be determined through the growing season.

Factors relating to soil texture and soil structure were commonly mentioned with most candidates being aware of the implications of fine and coarse textured soils. There was less precision about which pores are drained by gravity, which hold water available to plant roots and which are too small to do so. Not everyone could distinguish between soils with *high* total water much of which is *not* available, and soils with *low* total water the majority of which *is* available.

A minority of candidates made the observation that soil depth had a bearing on available water and no one discussed the differences in AWC between topsoils and subsoils.

Although perhaps the majority of papers referred to the improved water regime that was one of the benefits of improved structure following the incorporation of organic matter, fewer added that that humus itself is a useful water reservoir.

It was expected that the second part of the question might produce water balance sheets, Penman calculations, tensiometers and evaporimeters but these were in the minority. Several candidates put their faith in observing the turgor or wilting of plants. Few qualified this by reference to the possibility of high levels of evaporation causing wilting to occur even when soil water is available, nor the possibility of sub optimal growth before symptoms are seen. Candidates who interpreted this question as relating to crop knowledge, the physiological stages of crop development or maximising irrigation efficiency in pre harvest weight gain were credited for appropriate statements.
Candidates who ignored the phrase 'ways in which needs can be determined' to make general comments about irrigation were not able to gain marks.

Q3 a) State how humus differs from the organic matter from which it is derived.

b) Describe the processes that occur to woody shreddings when added to the soil.

The instruction 'state how humus differs' requires a comparison. In these answers humus was described in varying degrees of detail but the characteristics of organic matter (identifiable heterogeneous components in various state of division and not decomposed) were generally assumed rather than stated.
The carbon to nitrogen ration of woody shreddings is high – 400:1 or more. The majority of candidates pointed out that in order to break down cellulose micro-organisms will require nitrogen from another source such as the surrounding soil. Nitrogen is immobilized until sufficient C02 has been lost and mineralisation can proceed. The question invited a progression such as:

- the build up of detritivore micro-organisms,
- incorporation of soil N into micro-organisms,
- soil N depletion, (immobilisation),
- partial breakdown of woody material,
- details of the organisms involved: fungi (basidiomycetes) processing lignin and cellulose, bacteria processing cellulose,
- the bacteria and fungi are themselves eaten: reduction and distribution of carbon (into the bodies of other organisms, CO2 lost to the atmosphere) with a reduction of C:N ratio,
- CO2 loss allows minerilisation to proceed,
- eventual formation of humus: associated benefits and physical changes (e.g. water retention) that follow.

Q4 a) State what is meant by the term 'anion' and list **TWO** anions of horticultural importance.

b) Explain the processes that affect the availability of anions to plants grown in soil.

The majority of answers correctly stated that an anion is a negatively charged particle (or form of atom or molecule). Whilst several gave examples such as $H_2P0_4^-$ or $N0_3^-$ vaguer answers such as nitrogen or incorrect ones such as calcium were not uncommon.

In part b) several candidates referred from the outset to cation exchange capacity making it difficult to produce a logical answer. Although the availability of anions such as phosphate is complex, factors which could have been discussed include the relative paucity of anion exchange sites when compared to cation exchange sites and thus the importance of humus and clay minerals. Specific anions critical to horticulture are nitrate and forms of phosphate. Nitrate ions lacking exchange sites are subject to leaching with practical implications for well drained soils. The availability of phosphate depends on the movement between insoluble, labile and available forms. Available anions depend on the soil pH. $H_2PO_4^-$ is available at slightly acid conditions, HPO_4^{--} being partially available as the pH rises. At very high pH, PO_4^{---} is not available to plant roots.

Q5 a) Describe what is meant by a ‘frit’.

b) i) Describe **TWO** distinct formulations of solid compound fertilisers used in growing media.

ii) Outline for **EACH** of the factors which affect the rate of release of nutrients into the medium.

c) Explain how incorrect fertiliser levels affect plant growth.

Candidates scoring maximum marks identified a frit as nutrients fused in glass which is then ground, offering slow release when in contact with soil and a measure of control over elements where there is a fine line between deficiency and toxicity.

In part b) slow release, controlled release (and perhaps quick acting and ion exchange) were the answers expected in response to the phrase ‘distinct formulation’. In the event, the majority of candidates mentioned specific compound fertilisers. These answers were accepted where the use was current or feasible. Growmore is not a fertiliser used in growing media.

All nutrients eventually reach plant roots in solution, so moisture is a key control. Beyond this the factors are; limited solubility, microbial action in the case of animal based products and temperature for controlled release fertilisers. When CRFs are incorporated into a growing medium, water vapour passes through the micropores of the resin or polymer coating. The nutrients inside are dissolved and diffuse into the medium at a rate which is controlled by the temperature and the thickness of the coating. The latter characteristic allows for the manufacture of formulations of different longevity.

This third part of the question was generally well answered with most candidates outlining more than one effect of excess fertiliser. The side effects of lush growth caused by too much nitrogen was commonly mentioned as was the possibility of root damage by osmotic effects and the need for balance between different nutrients. ‘Poor growth’ was generally stated as the effect of too little fertiliser, fuller answers identified that this might leave plants susceptible to pests, diseases or disorders or that it could affect the production of the crop portion of a plant, for example insufficient potassium leading to a lighter tomato crop.

Q6 a) Explain the term ‘UK5’ on organic produce.

b) Describe **FOUR** ways of controlling weeds on a field scale in organic systems.

For full marks, candidates identified the Soil Association (Soil Association Certification Ltd) as the relevant certifying body. Different certifying bodies share key standards but with some distinct differences, an example would be whether steam sterilisation is allowed.

There was scope for a wide range of answers to the second part of the question. These could have included:

- tractor mounted inter-row hoes or brushes,
- stale seed bed techniques,
- mulches: inorganic or organic,
- hand weeding.

Some candidates were tentative in suggesting hand weeding fearing it was not a field scale operation but mechanised platforms allowing workers to assume a prone position whilst weeding are not unknown.

The answer 'organic herbicide' was not allowed but rotations, weed suppressing crops, green manures, the use of composted organic matter (to reduce the seed burden), crop selection, high seed rates, undersowing, field and machine hygiene and solarisation (in suitable climates) were possible alternatives.

Q7 a) Describe **FOUR** ways to ensure that a newly planted whip has optimal access to nutrients.

b) Describe techniques to avoid water-logging when planning to plant whips in a clay soil.

c) Explain how the incorporation of undecomposed organic matter at the base of the planting hole could be a disadvantage in clay soils.

The first part of the question was generally well answered with references to the addition of nutrients via fertilisers or organic matter, the incorporation of mycorrhizal material or physical methods to ensure the roots had the maximum opportunity to ramify through the soil in search of nutrients. The need to suppress weed competition was commonly stated and some candidates pointed out that over-improving the planting mix can inhibit roots from penetrating beyond the planting hole. At level three the response 'incorporate slow release fertiliser such as bone meal, blood fish and bone, Enmag or CRF tablets.' rather than 'incorporate fertiliser' is a reasonable expectation.

The second part of the question was designed to encourage a response that went beyond adding grit or sand to a planting mix.

If the drainage water from a planting pit has nowhere to go it makes no difference how free draining the planting mix is. Improving the drainage of an entire plantation by the addition of granular material is not practical. The improvement of the overall structure and therefore drainage by the addition of organic matter is a good long term objective but in terms of more immediate techniques, the possibilities are mole ploughing and/or pipe drainage or sump (if large enough) installation pre planting, mound planting and hand techniques to avoid soil compaction and smearing of pit sides.
Poor drainage, anaerobic conditions, denitrification, ammonia release, root scorch slumping and settlement following decomposition were possible answers to the third section.

Q8 a) State **FIVE** advantages of peat as a growing media.

b) State **TWO** reasons why loam is added to a peat based medium.

c) State **THREE** limitations of using loam as a component of a growing medium.

On the assumption that it related to moss peat, the first part of the question was well answered. Advantages included:

- good water holding capacity,
- high air filled porosity,
- good drainage,
- effectively sterile,
- light and pleasant to handle,
- predictable nutrients (effectively none),
- pH appropriate to calcifuges but easily raised,
- competitively priced.

Although the incorporation of loam would mean from an environmental view that less peat is used, the quantities are relatively small. Even the 'soil based' John Innes compost is 25% peat. One practical reason is to add weight for stability. This is not the same as adding bulk. Another reason is to give some buffering capacity. The (modest) addition of nutrients and improved wettability were accepted as answers.

Candidates saw a wide range of limitations of using loam in composts ranging from textural and structural inconsistency, the inclusion of weeds or pathogens or the need (and cost) to sterilise against them and the weight affecting ease of handling and cost of transport.

Q9 a) State **ONE** material and method of application which can be used to rectify magnesium deficiency without raising pH.

b) Describe the symptoms of deficiency of the following plant nutrients:

i) potassium;
ii) calcium.

c) Explain:

i) why the lime requirement of **TWO** distinct soils with the same pH can be different.

ii) how the addition of lime can affect the availability of other nutrients.

Magnesium sulphate (or Epsom salts) and foliar application (spray to run off) gained many candidates full marks in part a).

The answers to the second part of the question were varied. Besides specifying subjects where symptoms might be expected, marginal scorch (also rolling of margins and sight chlorosis of older leaves) together with flower and fruit effects were possible answers for potassium (interestingly termed kalmium by several candidates). For calcium, symptoms of tip damage and the specific disorders of blossom end rot and bitter pit were the most common answers.

It is difficult to answer the third part of the question without considering the phrase 'lime requirement'. It had been expected that candidates would understand this standard horticultural term to mean 'the amount of lime needed to correct acidity' and would therefore refer to the differing buffering capacity of clay and sandy soils. However, a wider interpretation of 'requirement' was accepted with interpretations which involved other reasons for liming namely flocculating the soil or as a precaution against club root.

That lime affected the availability of other nutrients through antagonisms and particularly through altering pH (affecting for example, phosphorus and iron) was generally understood.

Q10 a) Describe the structure of a mature podzol by means of a fully labelled diagram.

b) Explain the formation of an iron pan podzol.

Most answers did successfully *describe* a podzol to accompany a diagram of a soil profile although several of the latter were generalised horizons of topsoil, subsoil and parent rock. Some of the features expected were:

- indication of depths,
- distinct horizons – A (organic, eluvial) B (illuvial) and C: parent rock,
- comments on colours especially the bleached eluvial horizon,
- litter layer, type of humus,
- acidity: maximum acidity at surface,
- humus pan,
- iron pan,
- type of bedrock (e.g. sand).

Answers to part b), which concentrated on the formation of the podzol in general or the iron pan specifically were accepted. The factors involved are a suitable (i.e. free draining) soil texture, precipitation exceeding evaporation, the leaching of nutrients, acidification and the formation of humus and iron pans. The iron pan specifically results from soluble iron being leached through the profile to the zone of deposition. Where this becomes cemented and impervious to water the podzol is no longer free draining and waterlogging and gleying can occur.