R3102

THE ROOT ENVIRONMENT, PLANT NUTRITION AND GROWING SYSTEMS

Level 3

Thursday 17 February 2011

13:30 – 14:45

Written Examination

Candidate Number:...

Candidate Name:...

Centre Number/Name:...

IMPORTANT – Please read carefully before commencing:

i) The duration of this paper is **75 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.

Ofqual Unit Code M/601/1007

ANSWER ALL QUESTIONS

MARKS

Q1 a) Define the term ‘air filled porosity’ in soils. **2**

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b) State **TWO** factors which influence the amount of ‘available water’ in the soil. **2**

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c) Describe management techniques to help maintain soil moisture levels for optimum plant growth. **6**

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MARKS

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MARKS

Q2 a) List **THREE** soil types commonly found in the United Kingdom. **3**

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b) i) Describe with the aid of a clearly labelled diagram, the soil type most suited to horticultural use, and **4**

ii) Explain the advantages of this soil type for plant growth. **3**

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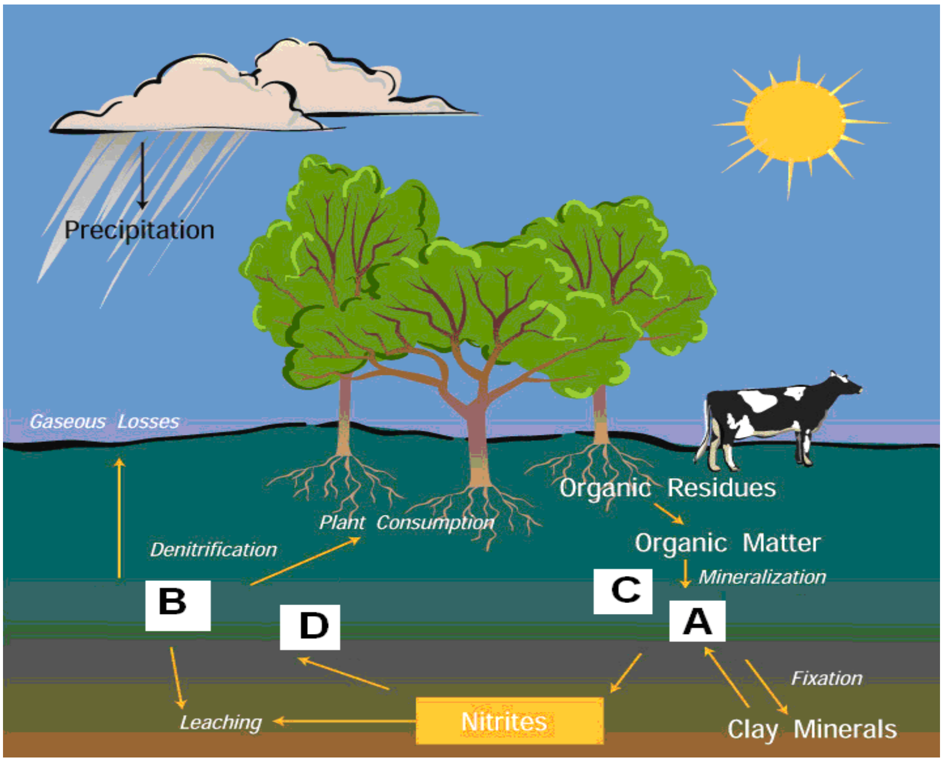
MARKS

Q3 a) Identify in the diagram of the nitrogen cycle:

i) the products **A** and **B**;
ii) the organisms involved in the process at **C** and **D**. **2**



The source of this material is windows to the universe, at the National Earth Science Teachers Association (NESTA).

b) State the soil conditions that influence the loss of different **NAMED** forms of nitrogen from the soil. **5**

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MARKS

c) Explain how the addition of straw or woody material to a soil can affect nitrogen availability. **3**

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MARKS

Q4 Compare the physical and chemical properties of peat with those of **FOUR NAMED** alternatives commonly used in horticulture as constituents of growing media. **10**

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MARKS

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MARKS

Q5 a) Explain how **EACH** of the following factors affect the availability of **NAMED** plant nutrients in soils:

i) pH;
ii) temperature. **5**

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MARKS

b) i) Compare the symptoms of iron and magnesium deficiency in plants, and

ii) Suggest **ONE** treatment for each. **5**

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MARKS

Q6 Explain the requirements of UK certification schemes for organic status. **10**

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MARKS

Q7 Compare organic and non-organic soil management of:

i) nutrients; **4**
ii) water; **3**
iii) micro organisms. **3**

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MARKS

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MARKS

Q8 a) Define the term cation exchange capacity. **2**

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b) Explain how plant nutrition is affected by the cation exchange capacity of different soil types. **4**

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c) Compare the cation exchange capacity of soils and **NAMED** growing media constituents. **4**

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MARKS

Q9 a) Explain how mycorrhizal associations aid healthy plant growth. **6**

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b) Distinguish between mycorrhizal associations and the rhizosphere. **4**

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MARKS

Q10 a) Identify the soil structures labelled **A** and **B** in diagrams 1 and 2. **2**

Diagram 1

A ....

Diagram 2

B..

Please turn over/.....

MARKS

b) Identify the soil structures labelled **C** and **D** in diagrams 3 and 4. **2**

Diagram 3

C..

Diagram 4

D..

Please see over/.....

MARKS

c) Explain how **EACH** of the soil structures named, affects the growth of plants. **6**

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

13:30pm Thursday 17th February 2011

R3102

THE ROOT ENVIRONMENT, PLANT NUTRITION AND GROWING SYSTEMS

Candidates Registered	**116**		**Total Candidates Passed**	**53**	**56.99%**
Candidates Entered	93	80.17%	Passed with Commendation	19	20.43%
Candidates Absent	19	16.38%	Passed	34	36.56%
Candidates Deferred	3	2.59%	Failed	40	43.01%
Candidates Withdrawn	1	0.86%			

General

Candidates will have noted that the allocation of the marks varies from question to question. To score highly it is vital to satisfy the requirements of each part. An excellent answer to a part which is worth two marks cannot make up for a skimpy answer for another part which is worth six marks.

In section 3.1 of the syllabus there is a statement that the examination is part of a "route to employment in professional horticulture". This is a reminder that at Level 3, candidates should be aware of professional horticultural practices as well as amateur ones.

Q1 a) Define the term 'air filled porosity' in soils.

b) State **TWO** factors which influence the amount of 'available water' in the soil.

c) Describe management techniques to help maintain soil moisture levels for optimum plant growth.

Part a) asks for a definition of the term ‘air filled porosity’. To write: "the air available in the pores" just repeats the question. The crucial information that it is the percentage of the bulk soil volume occupied by air AFTER gravitational water has been drained was missing from many scripts.

Part b) was well answered.
In discussing management in part c), the idea of keeping crop cover to *avoid evaporation* came up several times. Crop cover whilst beneficial in many ways would not help in this respect, as evaporative losses would be replaced by transpirational ones.

Answers were expected to cover:

- The addition and retention of organic matter, application of FYM (farm yard manure), ploughing in of crop residues, prevention of oxidation of carbon by excessive cultivations.
- Preservation and improvement of soil structure for infiltration of water and prevention of run-off. Avoidance of pans, capping and soil compaction.
- Prevention of evapotranspiration losses: reduction of wind speed, mulches, avoidance of excessive cultivation.

Answers referring to best practice in irrigation and drainage were also accepted.

Q2 a) List **THREE** soil types commonly found in the United Kingdom.

b) i) Describe with the aid of a clearly labelled diagram, the soil type most suited to horticultural use, and

ii) Explain the advantages of this soil type for plant growth.

In part a) many candidates scored highly, identifying brown earth, podsol, rendzina or gley soils.

Brown earth (or brown soil) was the almost universal answer to part b). Most diagrams identified a soil profile showing different horizons, but few had indications of depth and the labels varied greatly in the degree of detail.

Section c) was enthusiastically answered with brown earth identified as having ideal physical, chemical and biological characteristics. However, few candidates indicated that this is a general group (the brown colour being indicative of the permeable nature of the profile) with the more precise characteristics *including pH* depending on the origins of the soil. For instance well drained brown earths in wet parts of the country supporting birch woodland would have a markedly acid reaction.

Q3 a) Identify in the diagram of the nitrogen cycle:

i) the products **A** and **B**;
ii) the organisms involved in the process at **C** and **D**.

b) State the soil conditions that influence the loss of different **NAMED** forms of nitrogen from the soil.

c) Explain how the addition of straw or woody material to a soil can affect nitrogen availability.

Candidates are reminded to check the question carefully: to distinguish 'organism' from 'product', for example and to be careful about precise meanings. Mineralisation is distinct from nitrification and neither are the same as nitrogen fixation.

Part b) specified named forms of nitrogen so it was expected these would be references to:

- nitrous oxide losses in warm wet soils excessively supplied with N,
- volatilization of ammonia following heavy application of FYM to soils with free lime present,
- losses of nitrate in crops,
- losses of nitrate through leaching in free draining soils,
- physical loss of organic N by erosion of soil or slurry run off.

In part c) the majority of candidates understood the imbalance between the C : N ratio in the source material and that of the detritivore microorganisms breaking it down.

Q4 Compare the physical and chemical properties of peat with those of **FOUR NAMED** alternatives commonly used in horticulture as constituents of growing media.

If the term 'growing media' is not understood, it is difficult to answer this question. The question specified peat alternatives in growing media – in other words materials which carry out all or some of the roles of peat in:

- plant support and root anchorage,
- supply of air, water and nutrients at a suitable pH.

This question did not relate to the environmental concerns about peat extraction.

Most candidates correctly pointed to materials such as coir, composted bark, loam and composted green wastes as being suitable. Materials such as sand were credited where the function in a growing medium was properly understood. The suggestion that adding sand to peat based compost to aid drainage is to misunderstand that moss peat is an inherently porous medium. Adding large quantities of sand will fill up the pore spaces rather than open them out.

Sand may be added to aid the stability of a growing medium with low bulk density or in the case of fine sand, to increase wettability.

Because of its soft, exfoliated structure, vermiculite has a minor use in growing media, principally as a seed covering; it is not an alternative material for peat.

Buffering capacity and cation exchange capacity of peat causes some confusion. Although peat does have good CEC (especially the more humified peats) the physical quality of low bulk density means that for any given volume of medium there is a high percentage of pore space, and pores have no CEC. Therefore, in growing media where a high air filled porosity is a key feature, CEC is *in practice*, low.

The answer ‘bark’ or ‘bark chip’ is not sufficiently precise for this level especially as the chemical properties are markedly different depending on source and degree of composting or ageing.

Many candidates stated that coir is difficult to re-wet. Coir is hydrophilic and will re-wet easily without the use of wetting agents – an advantage over moss peat.

Few candidates pointed out that by far the most important peat in horticulture is moss peat and that many of the characteristics attributed to ‘peat’ are specific to moss peat as opposed to sedge peat.

Q5 a) Explain how **EACH** of the following factors affect the availability of **NAMED** plant nutrients in soils:

i) pH;
ii) temperature.

b) i) Compare the symptoms of iron and magnesium deficiency in plants, and

ii) Suggest **ONE** treatment for each.

Unfortunately, one or two candidates misread this as relating to named plants not named plant nutrients.

Most answers in a) i) correctly identified individual nutrients such as iron being unavailable (rather than deficient) at high pH.

In section a) ii) answers mainly addressed soil nitrogen and its associated micro-organisms. Fewer answers pointed to active transport being affected by root zone temperatures or other nutrients such as phosphorus also being less mobile at low temperatures, or that sulphur conversion was also bacteria (and therefore temperature) dependent.

Generally the differences in leaf symptoms between iron and magnesium were appreciated. In part ii)**,** although any factually correct answer was accepted, the phrase ‘treatment for a deficiency’ implied the need for a prompt response – such as a foliar application of magnesium sulphate. Altering soil pH for iron, or supplying Mg through magnesian limestone (also with pH consequences) are longer term solutions. Given the likelihood that iron deficiency would be lime-induced, the answer ‘ferrous sulphate’ was only accepted if it was made clear that it was by foliar application.

Q6 Explain the requirements of UK certification schemes for organic status.

The phrase: '…requirements of the certification schemes' gives notice that this question is about more than the general benefits of organic systems. Although almost all candidates had heard of the Soil Association (Soil Association Certification Ltd for this purpose), fewer mentioned the overarching role of the EU and DEFRA or the fact that there are other UK certifying schemes such as Organic Farmers and Growers. It is important to note that standards differ from organisation to organisation.

Some general and sweeping assertions were made: that for instance overhead irrigation and non organic seed are not allowed under organic systems. In practice, the Soil Association may give permission for the use of non organic seed if no organic seed is available and spray irrigation may be used (with other provisos) if the application is uniform, and evaporation and run off is minimised.

It was generally stated that only organic pesticides and fungicides and fertilisers may be used. Apart from the ambiguity of what comprises an organic pesticide, certification bodies are stringent about the conditions of use of most inputs. Organic fertilisers such as hoof and horn, rather than having blanket approval for use are only permitted for use in growing media by the Soil Association. Other certification bodies allow their use with specific permission.

There are also non organic substances (in the chemical sense) allowed, for example natural rock phosphate, ('with justification') but copper products are now allowed by the Soil Association; only where there is a major threat and then only with approval and subject to annual maxima.

Candidates for future exams are referred to the freely available standards of bodies such as the Soil Association Certification Ltd and Organic Farmers and Growers Ltd.

Q7 Compare organic and non-organic soil management of:

i) nutrients;
ii) water;
iii) micro-organisms.
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In the first part of the question, many candidates seemed only vaguely to appreciate that in ideal organic systems, the fertility of the soil is built up and maintained by the application of bulky organic manures, green manures and leguminous crops rather than the use of fertilisers such as hoof and horn or dried blood even where these are permitted.

In part ii), non-organic growers were generally cast in the role of indiscriminate users of tap water. This may have been so in the past but a general appreciation of the finite nature of water resources and publications such as 'Water in Horticulture' by the Environment Agency and 'Irrigation Best Practice' by Defra means that non-organic growers are also conscious of the need for water management if only in an economic, regulatory and best practice sense, rather than for ideological reasons.

The third element of the question was well answered although only a minority of answers pointed out that micro-organisms are crucial to recycling and are therefore the main driver of organic systems.

Q8 a) Define the term cation exchange capacity.

b) Explain how plant nutrition is affected by the cation exchange capacity of different soil types.

c) Compare the cation exchange capacity of soils and **NAMED** growing media constituents.

The fact of cation exchange was understood but the notion of 'capacity', indicating that it was quantifiable was infrequently explained and no candidates ventured to specify units such as meq per litre or cmol/kg.

Part b) sought a description of clay (or organic) soils having high CEC, with many sites to occupy and therefore good reserves of cations to replace those used or lost. Sites are available to store nutrients when fertilisers are added. Sandy soils on the other hand, have few available sites with which to store nutrients. Nutrient minerals are also not naturally present in large numbers. Therefore nutrients in solution are subject to leaching (exacerbated by the physical characteristics of sandy soils and associated climates). The lack of available bases means that hydrogen and aluminium ions) occupy sites leading to acidity. Poor buffering is a further effect of the lack of exchange sites.

In part c) candidates generally correctly identified whether materials had high, low or no CEC. The CEC of soils depends on the percentage and type of clay and humus:

- Peat has a high exchange capacity weight for weight. The more humified the peat, the higher the CEC. The low bulk density of the younger peats used in growing media results in a relatively low CEC on a volume basis.
- Bark aged: low, typically <100 meq/l,
- Vermiculite: high, < 200 meq/l (but used in such small amounts to have minor effect),
- Perlite: virtually none,
- Sand: very low,
- Green compost: high,
- Clay minerals: high (effective buffering because of high CEC *and* bulk density),
- Coir: low, <100 meq/l.

Q9 a) Explain how mycorrhizal associations aid healthy plant growth.

b) Distinguish between mycorrhizal associations and the rhizosphere.

Question 9 was generally well answered with references to the:

- exchange of carbohydrates for nutrients,
- importance of phosphorus,
- ramification of the fungal mycelia increasing effective root area, and
- drought resistance.

Fewer references were made to tree planting, the significance for the Ericaceae and the ubiquity of mycelial associations save in the families Brassicaceae and Chenopodiaceae.

In part b) the question sought references to the proximity to plant roots, the multiplicity of organisms attracted to root secretions and the large number of interactions compared with those in the bulk soil.

Q10 a) Identify the soil structures labelled **A** and **B** in diagrams 1 and 2.

b) Identify the soil structures labelled **C** and **D** in diagrams 3 and 4.

c) Explain how **EACH** of the soil structures named, affects the growth of plants.

Most photographs were correctly identified and the advantages of a granular or crumb structure clearly stated, as were the disadvantages of platy structures. The qualities of prismatic or columnar structures (water and root movement possible but the aggregates themselves difficult for roots to penetrate; located low in the profile, in heavier soils, often poorly drained) were infrequently mentioned.