Including Examiners Comments

Royal Horticultural Society

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# R3102

# THE ROOT ENVIRONMENT, PLANT NUTRITION & GROWING SYSTEMS

**Level 3**

**Wednesday 27 June 2012**

**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 the formation of a sandy soil from its parent rock. **4**

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b) i) **NAME TWO** mineral components of a sandy soil. **1**

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**MARKS**

ii) Review the properties of the **TWO** mineral components named in i). **5**

Total Mark

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**MARKS**

**Q2** a) Describe the likely consequences of a soil flooded during the growing season. **6**

**MARKS**

b) State **FOUR** factors that may affect the efficiency of a pipe drainage system. **4**

Total Mark

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**MARKS**

**Q3** a) Identify **TWO** nitrogen fixing organisms. **2**

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b) Describe nitrogen fixation with reference to the two organisms named in a). **5**

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c) Give **ONE** example of organic matter for **EACH** of the following carbon to nitrogen (C:N) ratios:

i) high; **1**
ii) low. **1**

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d) State a typical C:N ratio for soil microorganisms. **1**

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**MARKS**

**Q4** a) State what is meant by the term ‘rhizosphere’. **1**

b) Summarise the effects of the ‘rhizosphere’ on plant growth. **3**

**Please see over/…..**

**MARKS**

c) Compare ectomycorrhizal and endomycorrhizal associations. **6**

Total Mark

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**MARKS**

**Q5** a) State what is meant by 'cation exchange capacity'. **2**

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b) Describe **FOUR** situations in which the process of cation exchange occurs in the soil. **8**

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**MARKS**

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**MARKS**

**Q6** a) List **SIX** factors which affect the availability of phosphorous in soils and other growing media. **6**

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b) Explain how nutrients from controlled release fertilisers become available for plant growth. **4**

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**MARKS**

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**MARKS**

**Q7** a) State **FOUR** principles of organic growing. **4**

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b) Describe **THREE** ways by which the harmful effects of pests are minimised in organic systems. **6**

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**MARKS**

Total Mark

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**MARKS**

**Q8** a) Describe the following soil structures, indicating where in the soil **EACH** would usually be found:

i) crumb;
ii) blocky;
iii) prismatic. **6**

**MARKS**

b) Describe what is meant by 'structureless' soil. **2**

c) Describe **TWO** effects on soil structure which can result from repeatedly ploughing a clay soil to the same depth. **2**

Total Mark

**Please turn over/…..**

**MARKS**

**Q9** a) State **FOUR** factors that will affect the reserves of nitrogen in a soil at the start of a new growing season. **4**

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b) Describe the symptoms of nitrogen deficiency in plants. **4**

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**MARKS**

c) State **TWO** reasons why an excessive application of nitrogenous fertilisers can be harmful to plant growth.

**2**

Total Mark

**Please turn over/…..**

**MARKS**

**Q10** Compare a ‘rendzina’ and a ‘podsol’ including their effects on plant growth. **10**

**Please see over/…..**

**MARKS**

Total Mark

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# R3102

# THE ROOT ENVIRONMENT, PLANT NUTRITION & GROWING SYSTEMS

## Level 3

## Wednesday 27 June 2012

| | | | | | |
|---|---|---|---|---|---|
| **Candidates Registered** | **105** | | **Total Candidates Passed** | **52** | **61.18%** |
| Candidates Entered | 85 | 80.95% | Passed with Commendation | 17 | 20.0% |
| Candidates Absent | 15 | 14.29% | Passed | 35 | 41.18% |
| Candidates Deferred | 1 | 0.95% | Failed | 33 | 38.82% |
| Candidates Withdrawn | 4 | 3.81% | | | |

**Q1** a) Describe the formation of a sandy soil from its parent rock.

b) i) **NAME TWO** mineral components of a sandy soil.

ii) Review the properties of the **TWO** mineral components named in i).

In part a) candidates correctly identified physical and chemical weathering together with the effects of biological agents. Although several later mentioned that quartz was inert, few linked this with resistance to carbonic acid weathering or pointed out that the inherent lack of mineral nutrients in sandstones slowed the biological processes.

'Sand, silt and clay' were the expected answers to the second part of the question but responses such as silica and quartz were also accepted.

The third part offered a wide choice of physical and chemical characteristics and attracted several detailed answers.

**Q2** a) Describe the likely consequences of a soil flooded during the growing season.

b) State **FOUR** factors that may affect the efficiency of a pipe drainage system.

The first part of the question specified soil flooding during the growing season. The displacement of oxygen and impaired root respiration were well covered. Few scripts touched on the consequences for seeds and seedlings or differentiated the effects on woody and herbaceous plants, or the severe effects on mycorrhiza.

There were several suggestions that flooding would cause leaching of nutrients. For the soil to be flooded the movement of water through the soil is less than the inflow. The effects of fertile topsoil being washed away (or imported and deposited from elsewhere) would have the greater significance.

Several candidates suggested that flooding caused compaction or pans. Saturation of the clay fraction of a soil causes it to become plastic and therefore *liable* to compaction rather than compacting it *per se*.

In connection with this, a minority of candidates mentioned the practical consequence of flooding: the inability to attend to plants, use machinery, maintain schedules or fulfill contracts.

The second part of the question produced very mixed answers, suggesting that some candidates were unaware of the basics of drainage. Drainage is a system of links, the points at which the system can lose efficiency are:

- getting water into the pipes: layout, depth, soil texture, pans, backfill,
- moving the water along the pipes: spacing, size, gradient,
- maintenance: blockages, silt traps, broken pipes,
- outfall: levels, preventing animal ingress, drainage ditches.

**Q3** a) Identify **TWO** nitrogen fixing organisms.

b) Describe nitrogen fixation with reference to the two organisms named in a).

c) Give **ONE** example of organic matter for **EACH** of the following carbon to nitrogen (C:N) ratios:

i) high;
ii) low.

d) State a typical C:N ratio for soil microorganisms.

To answer this question correctly, the candidate had to understand the term 'fixation' – the conversion of $N_2$, gaseous nitrogen, into ammonia and hence protein. Many candidates confused fixation with mineralisation.

Terminology was also an issue. *Rhizobium* or rhizobia identifies bacteria associated with nitrogen fixing nodules in legumes, Rhizobacteria, a common answer, is a vaguer term. Some authorities use it for free living bacteria in the rhizosphere, ie NOT rhizobia or *Frankia*. Others use it generally for any root colonising bacteria, including *Rhizobium*.

*Azotobacter* (not the same as *Azobacter*) was the other most quoted answer.

Answers to the second part generally concentrated on the key features of *Rhizobium*: legumes, specificity, symbiosis, root nodules and nitrogenase. Fewer commented on *Azotobacter*: bacterium, free living, aerobic, and intolerant of low pH.

The third part was well answered except for occasional ratio reversals, and offered an interesting range of carbon rich materials.

**Q4** a) State what is meant by the term 'rhizosphere'.

b) Summarise the effects of the 'rhizosphere' on plant growth.

c) Compare ectomycorrhizal and endomycorrhizal associations.

There was universal agreement in the first part of the question on proximity to the root but fewer references to the intense biological and chemical activity.

In the second part of the question, several candidates confused the rhizosphere with pore space in the soil, concentrating on the essential balance of air and water necessary for healthy plant growth. These are qualities which affect the soil as a whole. The distinguishing feature of the rhizosphere is that it is NOT the soil as a whole, but that part of it (no more than 1 to 2 millimetres thick), which is in intimate contact with plant roots. No plant roots: no rhizosphere. Within the rhizosphere are water, nutrients and exudates from the plant and a complex community of bacteria, fungi and microfauna which are attracted to that nutritious mix. In the main, the micro-organisms are beneficial to the plant, mineralising nutrients, processing complex biochemicals, forming mycorrhizal associations or undertaking a protective role.

The third part of the question invited a comparison. Six marks were on offer, so answers needed to go beyond a translation of ecto- and endo-. Points could have included:

- range and types of plants affected,
- physical appearance of the infected root or the fungal partner,
- appearance of fruiting bodies,
- mycorrhizal structure: Hartig Net, arbuscles,
- degree of protective function.

**Q5** a) State what is meant by ‘cation exchange capacity’.

b) Describe **FOUR** situations in which the process of cation exchange occurs in the soil.

Cation exchange and cation exchange capacity are regular subjects in this exam. One is a process, the other is a measure of that process. 'A measure of the ability of a soil to adsorb cations on colloidal particles' or 'total exchangeable cations at a given pH’, together with the correct units, are possible answers.

The second part of the question caused difficulty. Answers which defined 'situation' as the presence of clay or humus were credited, but specific processes were sought:

- nutrient cation uptake by roots,
- leaching of lime by rainwater (carbonic acid),
- liming: $CaCO_3$ replaces $H_2CO_3$,
- addition of **specific** fertilisers, notably ammonium,
- sea water contamination and rectification with gypsum,
- flocculation.

**Q6** a) List **SIX** factors which affect the availability of phosphorous in soils and other growing media.

b) Explain how nutrients from controlled release fertilisers become available for plant growth.

The first part of the question is most easily answered with the understanding that phosphorus in the soil is in different forms: these forms vary in their solubility and availability.

Answers could have included:

- phosphate: intrinsic component (or not) of any given soil type,
- inorganic and organic forms,
- presence is not the same as availability,
- easily fixed and therefore not available, at high *and* low pH,
- not fixed in peat based growing media, and therefore subject to leaching,
- not very mobile in the soil so placement is critical,
- importance of mycorrhizae,
- significance of the rhizosphere,

Many answers mentioned leaching and compaction. For plant availability the former is only applicable to peat media and sandy soils (although the leaching of sufficient P to cause environmental damage is significant in a different context). Compaction needed to be linked to reduced root ramification and therefore reduced access to phosphorus.

'Controlled release fertiliser' has a specific meaning. The majority of answers were vague about the mechanism, several suggesting that the coating was slowly dissolved: that this is not the mechanism as is evidenced by the presence of old exhausted prills.

Controlled release fertilisers have resin or polymer coatings. The coating is permeable and water vapour is absorbed and the nutrients inside dissolved. The release of the nutrients depends on the permeability of the coating and this in turn depends on the temperature and the thickness of the coating. Varying the thickness of the coating gives different longevities.

**Q7** a) State **FOUR** principles of organic growing.

b) Describe **THREE** ways by which the harmful effects of pests are minimised in organic systems.

Although examples of specific organic practices were accepted as answers to the first part of the question, fundamentals include:

- avoidance of agrochemical inputs,
- minimising damage to wildlife and the environment,
- utilising natural systems and cycles, recycling of nutrients,
- maintaining long term soil fertility, using sustainable crop rotations, compost, manure and nitrogen fixing plants.

'Organic fertilisers' were often mentioned. Fertilisers, concentrated sources of plant nutrients, are frowned on by certifiers even if they come from an organic source. They are generally allowed only in specific situations such as glasshouse plant raising.

Conserving water is not just the preserve of organic agriculture.

Candidates are reminded that 'organic' and 'inorganic' in the chemical sense and therefore relating to fertilisers, refers to whether they are carbon based. Therefore it is incorrect to say that organic growers are not permitted to use *inorganic* fertilisers as many systems permit the use of rock potash.

The second part of the question asked for three ways of avoiding the harmful effects of pests. Examples are:

- permitted controls, e.g. garlic, soft soap,
- encouragement of natural controls such as ground beetles and hoverflies,
- resistant cultivars, for example carrot 'Flyaway',
- physical measures such as barriers: fruit netting, insect mesh.

It is recommend that candidates familiarise themselves with a current copy of the standards of a Certifying body such as the Soil Association or Organic Farmers and Growers.

**Q8** a) Describe the following soil structures, indicating where in the soil **EACH** would usually be found:

i) crumb;
ii) blocky;
iii) prismatic.

b) Describe what is meant by 'structureless' soil.

c) Describe **TWO** effects on soil structure which can result from repeatedly ploughing a clay soil to the same depth.

A description of soil structure is asked for: size and shape are key to this. 'Crumb like' or 'block like' doesn't add to the information included in the question. Relevant characteristics include:

**Crumb**
Granular 1 - 5 mm diameter, water holding pores within, easy water movement between. Location: topsoil, associated with fibrous roots.

**Blocky**
Irregularly six faced, +/- equal, 10 - 100 mm sides. Common in heavy sub soils.

**Prismatic**
Vertically orientated, varied length, up to 150 mm diameter, typical of arid subsoils and some poorly drained soils. Several answers referred to prismatic structures being angular or rounded. To be ‘prism-like’ they must by definition be angular**.**

The C horizon is undifferentiated material transported or derived from the parent rock. It has not been subject to the soil forming processes found in the A and B horizons and is therefore commonly structureless.

Several answers to the second part of the question identified one but not both forms. Several candidates understood the concept of a soil without aggregates: fewer use the precise term, ‘massive’.

In answers for the third part of the question, almost every script pointed out the risks of creating a plough pan, fewer stated that this would involve platy structures. The 'loss of structure' in a general way was also alluded to but most did not describe how this came about. Repeated ploughing exposes the organic matter in the soil to oxidisation. The loss of organic matter increases the risk of loss of structure, especially in clay soils. Many scripts mentioned surface compaction due to the weight of machinery, but ploughing would alleviate this type of compaction.

**Q9** a) State **FOUR** factors that will affect the reserves of nitrogen in a soil at the start of a new growing season.

b) Describe the symptoms of nitrogen deficiency in plants.

c) State **TWO** reasons why an excessive application of nitrogenous fertilisers can be harmful to plant growth.

Possible factors include:

- the soil type (mineral texture),
- residues (or harvesting losses) from the preceding crop,
- previous manure or fertiliser applications,
- leaching over winter (modified by texture),
- organic matter content of soil,
- minimum temperatures for mineralization.

Parts b) and c) were well answered with most candidates aware that nitrogen was mobile in the plant and that symptoms would be seen first in the older leaves. The concept of lush growth being susceptible to chill injury or pest damage and upsetting the osmotic mechanism between the soil and root were also well covered.

**Q10** Compare a ‘rendzina’ and a ‘podsol’ including their effects on plant growth.

This question was in a single section. The answers required more detail than would a part question worth (say) four marks. In answering a question about comparisons, a statement that podzols are acid could be expected to be followed with an observation about the pH of rendzinas.

Several candidates mentioned that there was little microorganism activity in rendzinas and therefore little breakdown of organic matter. This is true of podzols but not of rendzinas – there is little organic matter because it is *rapidly* broken down.

The **physical** characteristics relate to the depth of the soil, how well drained it is, typical particle sizes and the nature of the bedrock.

The **chemical** factors are: pH, buffering capacity, the nutrient status of quartz as opposed to chalk.

**Biological** differences could relate to the typical flora, diversity of that flora, potential crops or uses, typical micro-organisms (number and diversity) and the turnover of carbon in the soil.