RHS
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Including examiner comments

R3102

THE ROOT ENVIRONMENT, PLANT NUTRITION & GROWING SYSTEMS

Level 3

Wednesday 8 February 2023

13:30 – 15:10

Written Examination

Candidate Number: .....

Candidate Name: .....

Centre Name: .....

IMPORTANT – Please read carefully before commencing:

i) The duration of this paper is **100** minutes;
ii) **ALL** questions should be attempted;
iii) **EACH** question carries **10 marks**;
iv) Write your answers legibly in the spaces provided. It is **NOT** necessary that all lined space is used in answering the questions;
v) Use **METRIC** measurements only;
vi) Use black or blue ink only. Pencil may be used for drawing purposes only. Ensure that all diagrams are labelled accurately with the line touching the named object;
vii) Where plant names are required, they should include genus, species and where appropriate, cultivar;
viii) Where a question requires a specific number of answers; only the first answers given that meet the question requirement will be accepted, regardless of the number of answers offered;
ix) Please note, when the word 'distinct' is used within a question, it means that the items have different characteristics or features.

ANSWER ALL QUESTIONS

MARKS

Q1 Describe the characteristics of the following soil horizons:

i) organic layer **2**
ii) A Horizon **2**
iii) B Horizon **2**
iv) C Horizon **2**
v) E Horizon **2**

i)

ii)

iii)

Please see over/…..

MARKS

iv)

v)

Total Mark

Please turn over/…..

MARKS

Q2 Describe how the relative proportions of sand and clay within a soil affect the following soil properties:

i) available water content **2**
ii) nutrient holding ability **4**
iii) buffering capacity and its impact on liming requirement **4**

i)……

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ii)……

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Please see over/…..

MARKS

iii)

Total Mark

Please turn over/…..

		MARKS
Q3	Describe **FIVE** distinct ways in which the soil structure can affect plant growth.	**10**

Please see over/…..

MARKS

Total Mark

Please turn over/…..

MARKS

Q4 a) Describe the physical properties of **THREE NAMED** substrates used in the formulation of growing media (excluding peat). **6**

Total Mark

Please see over/…..

MARKS

b) Describe the chemical properties of **TWO NAMED** substrates used in the formulation of growing media (excluding peat). **4**

Total Mark

Please turn over/…..

MARKS

Q5 a) Name **TWO** macro organisms involved in humus production. **2**

b) For **ONE** of the organisms named in a) specify **FOUR** distinct ways to optimise its activity. **8**

Please see over/…..

MARKS

Total Mark

Please turn over/…..

MARKS

Q6 a) Describe what is meant by the term rhizosphere. **2**

b) Describe **FOUR** ways in which the rhizosphere benefits plant growth. **8**

Please see over/…..

MARKS

Total Mark

Please turn over/…..

Q7 a) State the role **AND** deficiency symptom of **EACH** of the following elements in plant metabolism by completing the table below:

MARKS

Element	Role	Deficiency symptom	
Magnesium			**2**
Iron			**2**
Potassium			**2**
Calcium			**2**

Please see over/…..

b) State how the location of nutrient deficiency symptoms is influenced by the mobility of nutrients in the plant.

MARKS 2

Total Mark

Please turn over/…..

MARKS

Q8 a) Compare **TWO NAMED** liming materials. **6**

Please see over/…..

MARKS

b) Discuss how the purity of soluble fertilisers impacts on their usage in horticulture. **4**

Total Mark

Please turn over/…..

Q9 Describe **FIVE** soil management practices that support soil health and fertility in organic growing.

MARKS
10

Please see over……

MARKS

Total Mark

Please turn over……

Q10 Describe **FIVE** methods to manage potato blight, which are available to organic growers.

MARKS
10

Please see over/…..

MARKS

Total Mark

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Charity Registration Number: 222879/SC038262

Inspiring everyone to grow

R3102

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Level 3

Wednesday 8 February 2023

Candidates Registered	**TBC**		**Total Candidates Passed**	TBC	85%
Candidates Entered	60	TBC%	Passed with Commendation	17	28%
Candidates Absent/Withdrawn	TBC	TBC%	Passed	34	57%
Candidates Deferred	TBC	TBC%	Failed	9	15%

General comments

Questions - It is essential to read the question carefully and to note the **key words** before starting to write to ensure answers are relevant. Candidates should take account of the command statements in the question e.g. 'list', 'describe', 'explain', together with the mark allocation, to judge the depth of the answer required. Extra information, even if it is accurate, does not gain extra marks.
Where a number of answers were specified in the question and a candidate gave a list with more than that number, **only the first answers** in the list were marked, e.g. where the question stated 'Name **TWO** locations' or 'State **TWO** ways' only the first **TWO** answers were marked even if the correct answers were given further down. It is helpful (but not essential) if the answers are numbered in the text or separate paragraphs or bullet points are used.

Plant names - Where named plant examples were asked for, **full botanical names are required** to achieve full marks: genus, species and where appropriate variety, cultivar etc. needed to be written and spelt correctly. Where genus alone was given, all species in that genus need to show the characteristic asked for to gain any credit. **Common names were NOT accepted** and misspellings were penalised. Candidates needed to use unambiguous plant examples from sources such as the RHS Plant Finder and/or the RHS A-Z Encyclopaedia of Plants together with examples given in the syllabus and avoid obscure or difficult to verify plant examples, which risked being not credited.

Labels on diagrams must be carefully and correctly positioned to avoid ambiguity. Marks can be easily lost if this is not followed. Labels must actually touch the appropriate part of the diagram and must not be left hanging in mid air. Annotations on diagrams can be accepted as an alternative to description in the text as long as these are clear and answer the question. No marks were awarded for artistic merit or for unlabelled diagrams.

Continuation sheets - Where these have been included, it is vital that the relevant question number is included in the left hand margin if information written here is to be considered. These should also be attached to the answer booklet in the appropriate place and candidates should indicate in their answer booklet that they have written part of their answer on the attached sheet/s.

Q1 Describe the characteristics of the following soil horizons: **MARKS**

i) organic layer **2**
ii) A Horizon **2**
iii) B Horizon **2**
iv) C Horizon **2**
v) E Horizon **2**

Q1 Candidates were expected to describe the characteristics of a range of soil horizons.

i) Organic layer:

Responses correctly identified either leaf litter or organic material in addition to stating that the layer was often dark, due to decomposition taking place. Credit was also given to stating that the layer also had a proportion of undecomposed material.

ii) Horizon:

Credit was given to candidates stating this layer was the uppermost layer of soil or if it was referred to as topsoil. Again, reference to a dark colour, decomposing material and humus were also correct for a final mark.

iii) Horizon:

Most candidates correctly identified this as being a layer situated under the A horizon or referred to it as subsoil. The second mark was given for reference to it being lighter in colour to the A horizon or that it was an illuvial layer containing finer mineral materials or contained lower quantities of organic matter.

iv) Horizon:

A common error by candidates was assuming that the horizon layers were in the order of a typical soil profile and so the C horizon was sometimes confused with the E horizon.

Credit was given for reference to the position of C being under the B horizon and for it being mainly weathered parent rock. Credit was also given for stating little if any organic matter present.

v) Horizon:

As stated above it was quite common for candidates to identify this horizon incorrectly as the parent rock due to the order of the soil horizons question. Correct responses included stating that it was situated above the C horizon and reference to it being an eluvial horizon due to rainfall leaching out materials in soluble or suspension. Credit was also given to it being a leached horizon.

MARKS

Q2 Describe how the relative proportions of sand and clay within a soil affect the following soil properties:

i)	available water content	**2**
ii)	nutrient holding ability	**4**
iii)	buffering capacity and its impact on liming requirement	**4**

Q2 The question required candidates to demonstrate an understanding of certain soil properties surrounding differing proportions of clay and sand.

i) Available water content

Most candidates correctly made reference to sand and clay particle size, citing sand as having a large proportion of macropores (due to the large sand particles) and limited available water content, due to the lower number of mesopores and micropores, as contrasted to clay which had much smaller particle size and a high proportion of micropores where water was held but often unavailable to plants. Stronger responses also included relevant actual particle size for sand and clay to illustrate their answers. **Some candidates presented answers which were oversimplified or lacking in depth, for example failing to appreciate the interactions between drainage characteristics of soils, and pore sizes with their water holding capabilities**.

ii) Nutrient holding ability

Most candidates correctly identified a predominantly sandy soil as inert with very little/any electrical charge in comparison to soils with a high proportion of clay where the particles have a negative charge and are able to attract positively charged cations. Hence correctly stating soils with a high clay content had a high cation exchange capacity and thus good nutrient holding ability compared to sandy soils having a much lower nutrient holding ability. Occasionally a candidate would incorrectly cite this relationship the other way round, i.e., sand had a high nutrient capacity and clay low.

iii) Buffering capacity and its impact on liming

Correct responses included stating that clay soils have a high buffering capacity, that is the ability to maintain a constant pH and resist changes in pH, and sandy soils have a low buffering capacity. The stronger responses included reference to the relationship of the attraction of H^+ ions and clay particles.

Many candidates also correctly concluded that clay soils have a higher liming requirement than sandy soils, this being due to the high CEC of clay soils and the required displacement of H^+ ions by liming materials such as calcium carbonate. Whereas much smaller amounts of liming material are required to raise the pH of a sandy soil.

Quite often candidates stated that clay soils do not need liming due to their high buffering capacity – **this is an example of an over simplification which is inconsistent with Level 3.**

		MARKS
Q3	Describe **FIVE** distinct ways in which the soil structure can affect plant growth.	**10**

Q3

The question invited candidates to describe five ways soil structure could impact plant growth.

A common error by candidates was a discussion of soil textural properties instead of soil structure, **this severely restricted the marks that could be awarded.**

Strong candidate responses included examples of soil structure in their response, such as platy, massive, granular and columnar soils and how these were linked to root respiration and water uptake in plants, thus directly affecting plant growth.

In addition, reference to the level of organic matter in well-structured soils and therefore the inherent ability of these soils to hold nutrients for plant growth was also creditable.

Other ways in which soil structure could affect plant growth included ability of plants to form well developed root systems, for stability, as well as greater access to water and nutrients.

The expected level of detail required in answers for maximum marks was:

Poorly structured soils or compacted soils, for example those with an iron pan or cultivation pan have fewer peds, or aggregates, and fewer macropores which result in poor drainage and anaerobic conditions. This results in reduced respiration by roots and less energy for root growth and nutrient uptake, which reduces plant growth.

Poor examination technique was evident in candidates suggesting six, seven or eight ways that soil structure could impact on plant growth. Examiners only mark the first five points made; the remainder of the written script being unmarked. Candidates restricting their answer to the question would have more time available on other questions.

Some candidates failed to give sufficient depth to their answers to gain maximum marks in a Level 3 examination, examples of such answers include statements such as, 'in certain soils', marks can only be allocated against factual candidate responses and so such answers receive a zero mark.

Q4 a) Describe the physical properties of **THREE NAMED** substrates used in the formulation of growing media (excluding peat). **MARKS 6**

b) Describe the chemical properties of **TWO NAMED** substrates used in the formulation of growing media (excluding peat). **4**

Q4 The question required an understanding of the physical properties of named growing media constituents.

a)

Credit was given to named constituents such as bark, coir, vermiculite and perlite used as examples.

In addition, it should be noted that this part of the question required physical properties of these constituents; as such no credit was given to responses that included reference to CEC or buffering capacity, these are chemical properties which were required in part b).

Coir was a common constituent cited by candidates and credit was given to the physical properties of being fibrous, having a high air-filled porosity in addition to high moisture holding capacity.

Rockwool was also often included, and again credit was awarded for high water retention and porosity.

Properties of Perlite are that it is lightweight, porous with high air-filled porosity.

b)

Candidates were required to provide the chemical properties of named growing media constituents.

Again, credit was given to named substrates, e.g., coir, with a correct description of a relatively high CEC capacity or generally being low in nutrients.

Pine bark was also included by some candidates and credit was given here to the influence of growing medium on pH, such as pine having a relatively low, acidic pH.

Some candidates failed to gain maximum marks by relating their answers to soils rather than to growing media.

			MARKS
Q5	a)	Name **TWO** macro organisms involved in humus production.	**2**
	b)	For **ONE** of the organisms named in a) specify **FOUR** distinct ways to optimise its activity.	**8**

Q5

This question required candidates to demonstrate a knowledge of soil organisms.

a) Correct responses often included earthworms, slugs and springtails. It should be noted that the question asked for macro-organisms and so zero marks were awarded for micro-organisms.

b) This part of the question required candidates to describe four ways their selected macro-organism activity could be increased.

Responses that commonly cited earthworms included reference to soil pH, with earthworms preferring a range of 3.7 to 8 with most thriving at near neutral pH. An additional mark was credited for stating either raising soil pH with the application of lime or reducing soil pH with the application of a mulch of pine needles.

Likewise, the addition of organic matter was also creditable to encourage earthworms, with a second mark being awarded for reference to it as a source of food.

Aeration was also another creditable mark to encourage activity for respiration, and subsequently an additional mark being awarded for either installation of drainage or soil cultivation.

Moisture was also correctly identified with irrigation often cited as a method to encourage activity; earthworms require moisture for gaseous exchange to take place. Stronger responses cited earthworms burrowing deep into soil due to a lack of moisture near the surface.

Poor examination technique was evident in candidates suggesting more than four ways to optimise activity. Examiners only mark the first four points made; the remainder of the written script being unmarked. Candidates restricting their answer to the requirements of the question would have more time available on other questions.

Some candidates failed to gain full marks by citing ways of optimising that were very similar to each other. It should be noted that when a question uses the term distinct, there is a requirement for the points to be different to each other, i.e., moisture, temperature etc.

Q6 a) Describe what is meant by the term rhizosphere. **2**

b) Describe **FOUR** ways in which the rhizosphere benefits plant growth. **8**

Q6 **a)** The first part of the question required a definition of 'rhizosphere'. A mark was awarded for the area immediately surrounding plant roots, and influenced by them. Reference to root exudates and the biological/chemical exchanges that occurred in that zone was also creditable. Some candidates even provided a description of ecto and endomycorrhizal organisms that occupied the root rhizosphere.

b) The second part required four ways the rhizosphere benefitted plant growth and so where candidates had included reference to ecto and endo mycorrhizal fungi it provided the basis to discuss more water availability through the influence of a network of mycelium in the soil connecting with plant roots.

In addition, increased nutrient availability to the plant was a common response with stronger candidates making reference to specifics such as phosphate and improved growth.

Increased numbers of microorganisms including bacteria thrive in the rhizosphere which leads to greater release and uptake of nutrients. Credit was also awarded for soil nitrogen fixing bacteria that occur in root nodules.

The majority of candidates also identified the benefit of increased microorganisms reducing invasive soil pathogens, which are also reduced through secretion of chemical exudates released from plant roots into the rhizosphere.

Several candidates correctly referred to root exudates/mucilage aiding root growth and avoidance of desiccation and therefore subsequent benefit to plant growth.

Q7 a) State the role **AND** deficiency symptom of **EACH** of the following elements in plant metabolism by completing the table below: **MARKS**

Element	Role	Deficiency symptom	
Magnesium			**2**
Iron			**2**
Potassium			**2**
Calcium			**2**

b) State how the location of nutrient deficiency symptoms is influenced by the mobility of nutrients in the plant. **MARKS 2**

Q7 a)

Candidates were required to state the role of a range of nutrients and their deficiency symptoms.

Magnesium

Most candidates correctly identified its role in photosynthesis and being a component of the chlorophyll molecule. Interveinal chlorosis was the main deficiency symptom cited.

Iron

Again, most candidates correctly stated that iron is a component of chlorophyll with deficiency causing interveinal chlorosis, the stronger responses indicating it affected young leaves.

Potassium

Several candidates confused potassium with phosphorous making incorrect reference to improved root growth. Correct responses included regulation of stomatal apertures or regulation of water uptake/osmotic balance or its role in fruit and flower production which was more commonly evidenced. Deficiency symptoms include browning on leaf edges.

Calcium

Correct responses included reference to being a component of cell membranes and cell walls.

Deficiency symptoms commonly identified blossom end rot in tomatoes, bitter pit in apples and deficiency often occurring in the younger tissues and growing points.

b) The second part of the question required students to discuss deficiency symptoms in relation to the mobility of plant nutrients. In the main, the question was answered well with candidates often citing iron as an example of an immobile nutrient and deficiency symptoms being observed on young plant tissue/leaves. Credit was given to examples of mobile nutrients too, such as magnesium, and deficiency symptoms appearing on older plant tissue.

			MARKS
Q8	a)	Compare **TWO NAMED** liming materials.	**6**
	b)	Discuss how the purity of soluble fertilisers impacts on their usage in horticulture.	**8**

Q8 **a)** Ground limestone (calcium carbonate) and hydrated lime (calcium hydroxide) were two common liming materials given.

Credit was awarded to comparing neutralising values, in the range of NV 44-55 and NV 70-75 for the examples above; together with other creditable points such as treated soil requiring a greater quantity of ground limestone compared to hydrated lime to achieve the same effect.

Other comparisons could be made between the fineness, particle size and solubility of the compared liming materials affecting the rate at which the pH of a soil or growing medium will change.

Some candidates named Dolomitic limestone as a liming material which contains Magnesium and Calcium carbonate and the presence of magnesium within this as a benefit as a plant nutrient.

b) Pure soluble fertiliser can be used in fertigation, can be precisely calibrated, does not contain impurities and so is used for hydroponics.

Impure soluble fertilisers can cause blocked irrigation nozzles, unwanted precipitation of salts when mixing, phytotoxicity. Also, inaccurate nutrient analysis in low purity fertilisers can lead to over or under application.

Most candidates found this question to be challenging with many incorrect responses.

		MARKS
Q9	Describe **FIVE** soil management practices that support soil health and fertility in organic growing.	**10**

The majority of candidates identified the addition of organic material such as farm yard manure or green manure to increase soil fertility and soil structure – there was strong reference to increased soil flora and fauna in achieving this.

In addition, minimum cultivation practices were cited, linking reduced soil disturbance of macro and microorganisms, in addition to a reduction in soil erosion.

Most candidates also indicated reduced chemical control of pests and pathogens and reference to allowable products used in organic growing as provided by the Soil Association. It should be noted that some candidates still make reference to copper sulphate incorrectly as this use of this product has now been disallowed by the association.

Other candidates made reference to companion planting and cover crops/inter row crops, again to reduce soil erosion as well as reducing the ingress of weeds.

Reduced fertiliser usage can result in increased soil microflora, particularly soil bacteria.

Some candidates provided only three or four soil management practices, and so could not gain maximum marks, some did not answer the specific question and discussed general cultivation of crops. Some candidates provided six or seven practices, and so wasted time providing responses which would remain unmarked.

		MARKS
Q10	Describe **FIVE** methods to manage potato blight, which are available to organic growers.	**10**

Candidates were expected to provide five methods to reduce potato blight in an organic context.

Many candidates correctly referred to the selection of disease resistant cultivars often providing an example of cultivars, as well as planting certified potato stock. In addition, removal of volunteers or infected material was commonly given.

Good hygiene practice, such as cleaning tools and equipment after use to reduce risk of spread, and not using tools or machines that have been used on infected crops.

Choice of early potato cultivars were also often included in terms of avoiding the main blight periods. Reference to 'Smiths' period and blight forecasting was also a common answer (though this has been amended slightly by the Hutton Institute). As was reference to organic approved chemicals for control.

Finally crop rotation was a common answer making reference to using disease free land.

Some candidates incorrectly described the use of copper-based fungicides. Copper has been withdrawn from use as a horticultural fungicide for several years, and is only permitted to be used through emergency usage authorisations. Candidates, and those preparing candidates for examination, are reminded of the need to ensure that advice is current and relates to UK cultivation practices.

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