Royal Horticultural Society

RHS LEVEL 3 DIPLOMA IN HORTICULTURE
WRITTEN EXAMINATION

Thursday 10th February 2011
2:00pm – 4:00pm

MODULE G

Genetics, Plant Breeding & Systematic Botany, Plant Physiology II

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 **G** 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 ‘backcrossing’ in plant breeding. **2**

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Q2 State what occurs at the site of the nucleolus. **2**

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Q3 State **TWO** reasons for maintaining herbarium specimens. **2**

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Q4 State **TWO** advantages of ‘genetically modified’ crops (GM). **2**

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Please see over/.....

MARKS

Q5 For the purposes of a risk assessment when intending to apply plant growth regulators to crops, state:

i) **TWO** hazards; and
ii) how the risk may be reduced for **EACH**. **2**

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Q6 Describe how physiological age is related to flowering. **2**

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Q7 Describe how crop spacing is influenced by the part of the plant to be harvested, using **TWO NAMED** crops. **2**

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Q8 Describe what is meant by the term ‘climacteric’ in relation to fruit. **2**

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MARKS

Q9 a) State what is meant by 'phytochrome'.

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b) Give **TWO** examples of developmental processes phytochrome controls in the plant. **2**

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Q10 Explain how **TWO** aspects of quality may be controlled in protected environments with reference to a **NAMED** crop. **2**

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MODULE G

Genetics, Plant Breeding & Systematic Botany, Plant Physiology II

Sections B & C - Structured Questions

IMPORTANT – Please read carefully before commencing.

i) The duration of the papers in Module **G** 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 – Genetics, Plant Breeding & Systematic Botany

Answer ONE question only from this section

MARKS

Q11 a) Describe, with the aid of clearly labelled diagrams, the processes of:

i) pollination; **4**
ii) fertilisation. **6**

b) State **FOUR** plant factors that influence the success of pollination. **4**

c) Describe how plant breeders control pollination in the production of F_1 hybrids. **6**

Q12 a) Describe the structure of DNA (deoxyribonucleic acid). **6**

b) Describe the sources of genetic variation in plants. **10**

c) Describe the effect of **ONE NAMED** genetic variation used in breeding programmes. **4**

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Please see over/.....

Section C – Plant Physiology II

Answer TWO questions from this section

MARKS

Q13 a) State the end products of respiration in plants under **EACH** of the following conditions:

i) aerobic;
ii) anaerobic. **5**

b) Relate the optimum conditions required to maximise the shelf-life of a **NAMED** crop for **EACH** of the following:

i) respiration; **3**
ii) plant growth regulators; **3**
iii) transpiration; **3**
iv) pests and diseases; **3**
v) nutrition. **3**

Q14 a) Explain how **EACH** of the following is naturally controlled in plants:

i) apical dominance; **3**
ii) stem extension; **4**
iii) fruit set. **3**

b) Describe, using plant examples, how **EACH** of the above in a), may be artificially controlled in horticulture. **10**

Q15 a) Define short day, long day and day neutral plants in relation to photoperiod, using **ONE NAMED** example in each case. **6**

b) Define the term photoinductive cycle. **2**

c) Describe the mechanism of day-length perception in vegetative plants. **6**

d) Describe how artificial manipulation of photoperiod may be used to control flowering in a **NAMED** plant/crop. **6**

Please turn over/.....

MARKS

Q16 a) Describe the physical causes of seed dormancy. **4**

b) Explain the process of induction of dormancy in deciduous woody plants using **NAMED** examples. **6**

c) Describe methods of breaking dormancy in horticulture. **10**

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MODULE G

Genetics, Plant Breeding & Systematic Botany
Plant Physiology II

Candidates Registered	**61**		**Total Candidates Passed**	**27**	**52.94%**
Candidates Entered	51	83.61%	Passed with Commendation	6	11.76%
Candidates Absent	8	13.11%	Passed	21	41.18%
Candidates Deferred	1	1.64%	Failed	24	47.06%
Candidates Withdrawn	1	1.64%			

Section A – Short Answer Questions

Q1 Define the term 'backcrossing' in plant breeding.

The aim of the question is to ascertain if the candidates can define the term 'backcross' and give an example of its use in plant breeding.

High marks were awarded for a clear, accurate definition of a 'backcross' which used scientific terminology, followed by an appropriate example.

Q2 State what occurs at the site of the nucleolus.

The aim of the question is to ascertain if the candidates know what occurs at the site of the nucleolus.

High marks were awarded for a clear, accurate statement which included the fact. The nucleolus is the site of transcription of ribosomal RNA.

Q3 . State **TWO** reasons for maintaining herbarium specimens.

The aim of the question is to ascertain if the candidates are able to identify TWO reasons for maintaining herbarium specimens.

High marks were awarded for clear, accurate statements of why herbarium specimens should be maintained. Such as: herbarium specimens are type specimens which are housed for ID and reference purposes, thus facilitating accurate nomenclature.

Q4 State **TWO** advantages of 'genetically modified' crops (GM).

The aim of the question is to ascertain if the candidates are able to state **TWO** advantages of genetically modified crops (GM).

High marks were awarded for clear, accurate statements of the advantages of genetically modified crops (GM) which were well qualified e.g. the reduced use of pesticides; citing e.g. the advantage conferred by BT corn.

Q5 For the purposes of a risk assessment when intending to apply plant growth regulators to crops, state:

i) **TWO** hazards; and
ii) how the risk may be reduced for **EACH**.

The aim of the question is to ascertain if the candidates are able to state **TWO** hazards of applying plant growth regulators to crops, and are also able to identify how the risk may be reduced for **EACH**.

High marks were awarded for clear, accurate statements of hazards e.g. inhalation/ ingestion of chemical by the operator and the appropriate risk reduction strategy e.g. in this case: wear appropriate PPE/ READ THE LABEL.

Q6 Describe how physiological age is related to flowering.

The aim of the question is to ascertain if the candidates understood the concept of physiological age and were able to relate it to flowering.

High marks were awarded for clear, accurate descriptions of how physiological age is related to flowering. High marks were awarded for a clear description of the key stages i.e. embryonic growth, juvenility, reproduction, maturity, senescence and death and a succinct discussion of which stages affected flowering and why. High marks were also awarded for a description of minimum leaf number.

Q7 Describe how crop spacing is influenced by the part of the plant to be harvested, using **TWO NAMED** crops.

The aim of the question is to ascertain if the candidates were able to describe how crop spacing is influenced by the part of the plant to be harvested by reference to **TWO NAMED** crops.

High marks were awarded for clear, accurate descriptions of this relationship that included **TWO NAMED** crops as per the rubric and a succinct description of the part of the plant to be harvested and how this choice, influenced crop spacing.

Q8 Describe what is meant by the term ‘climacteric’ in relation to fruit.

The aim of the question is to ascertain if the candidates were able to describe the term ‘climacteric’ in relation to fruit.

High marks were awarded for clear, accurate descriptions of this relationship that included a statement that the respiratory climacteric is the rise in respiration rate observed in certain fruits during ripening with examples and a description of the process.

Q9 a) State what is meant by ‘phytochrome’.

b) Give **TWO** examples of developmental processes phytochrome controls in the plant.

In part a), the aim of the question is to ascertain if the candidates are able to state succinctly what phytochrome is.

High marks were awarded for succinct statements such as; phytochrome is a light – sensitive pigment that controls many developmental responses in plants to light.

In part b), the aim of the question is to ascertain if the candidates are able to give **TWO** examples of developmental processes it controls in the plant.

High marks were awarded for clear, accurate examples, e.g. seed germination in certain species.

Q10 Explain how **TWO** aspects of quality may be controlled in protected environments with reference to a **NAMED** crop.

The aim of the question is to explain how **TWO** aspects of quality may be controlled in protected environments with reference to a **NAMED** crop.

High marks were awarded for clear, accurate explanations of how **TWO** aspects of quality may be controlled in protected environments in the context of a single **NAMED** crop. High marks were awarded for an accurate explanation of each aspect of quality and the appropriate control measure.

Sections B & C – Structured Questions

Section B - Genetics, Plant Breeding & Systematic Botany

Q11 a) Describe, with the aid of clearly labelled diagrams, the processes of:

i) pollination;
ii) fertilisation.

b) State **FOUR** plant factors that influence the success of pollination.

c) Describe how plant breeders control pollination in the production of F_1 hybrids.

The aim of this question was to allow candidates to describe the biological processes of pollination and fertilisation, to identify some of the plant factors that influenced whether pollination was successful and thirdly to allow candidates to describe the techniques that plant breeders use to control pollination in the production of F_1 hybrids.

Most candidates were able to describe and differentiate between pollination and fertilisation but more successful candidates described the two processes in detail with large, clear, appropriately labelled diagrams.
Pollination, whether self pollination or cross pollination, is defined as the transfer of pollen from anther to stigma of the same flower or another flower on the same plant for self pollination, or a flower on another plant of the same species for cross pollination. The process involves dehiscence or release of pollen from the anthers, transfer of pollen by wind or animal vector, usually insect, and deposition and attachment of pollen to a compatible stigma.

The section on fertilisation, as a process, was less well answered. Clear annotated diagrams enabled candidates to describe the details of double fertilisation to include germination of the pollen grain on the stigma and growth of the pollen tube down the style, formation of tube nucleus and 2 male gametes (all haploid), explanation of the structure and contents of the embryo sac including haploid egg cell, synergids, antipodal cells, and polar nuclei (all haploid),or primary endosperm nucleus (diploid) or secondary endosperm nucleus (triploid), the entry of the pollen tube into the embryo sac through the micropyle, release of and fusion of a haploid male gamete with an egg cell to produce diploid zygote and fusion of male nucleus with endosperm nucleus to produce triploid endosperm.

There are a very wide range of plant factors that can be considered to influence the success of pollination which were identified by candidates and credited but these do not include the direct affect of weather on the behaviour of pollinating insects. Plant factors included production of viable pollen, or non viable pollen due to polyploidy, factors preventing or reducing incidence of self pollination such as incompatibility mechanisms, dioecious plants, monoecious plants, dimorphism, protandry and protogyny, timing of flowering as in availability of suitable pollinators, and availability of vectors. Better candidates were able to link these factors to specific plant examples such as fruit crops.

Other well recognised plant factors identified were attraction of pollinators to flowers by scent, colour, and shape of petals, the rewards of nectar or pollen, position of anthers in relation to visiting pollinators and position and receptivity of stigma. For wind pollinated flowers the plant factors could be the amount of smooth, light pollen produced, exposed anthers and exposed stigmas hanging outside the flower to trap the pollen.

Candidates were able to describe in some detail the methods that plant breeders used to ensure self pollination in the production of pure line parents, and to eliminate self pollination and ensure cross pollination when crossing pure line parents to produce F_1 hybrids.
These methods included bud pollination to overcome self incompatibility in brassicas to enable selfing and creation of homozygous pure lines, and preventing selfing when crossing by exclusion of unwanted compatible pollen by distance or isolation of seed crop, exclusion of pollinators and pollen by physical means /netting, prevention of self pollination by male sterility, emasculation, supply of compatible pollen, and application by hand pollination, or using introduced insect pollinators.

Q12 a) Describe the structure of DNA (deoxyribonucleic acid).

b) Describe the sources of genetic variation in plants.

c) Describe the effect of **ONE NAMED** genetic variation used in breeding programmes.

The aim of this question was to allow candidates to show their knowledge of the structure of DNA, the ways in which the structure and amount of DNA in plants could be varied and to describe a specific genetic variation that is used in plant breeding programmes.

The first section of the question required candidates to describe the structure of DNA in detail. Most candidates used diagrams to describe the double helix molecule, consisting of linked nucleotides, each formed from a phosphate group, deoxyribose sugar and a base, and the specific pairing of bases - adenine with thymine and cytosine with guanine by hydrogen bonds forming complementary strands enabling semi-conservative replication of DNA.

The second section of the question was widely interpreted by candidates.
A range of endogenous sources of genetic variation linked to the processes of DNA replication and mitosis and meiosis were described as well as the effects of mutagenic agents and genetic modification on DNA structure and content. These included gene mutations due to addition, deletion or substitution of bases, chromosome mutations, inversions or doubling of chromosome numbers, and crossing over between chromatids and independent assortment of homologous chromosomes in meiosis.
Other allowed sources were cross pollination and fertilisation in outbreeders, recombination of gametes in sexual reproduction, wild populations as a source of genetic variation for breeding programmes and selection pressure on populations of outbreeders.

Better candidates named the genetic variation used in breeding programmes, defined and described its mode of operation or how it was achieved, and described the effect on plant growth or breeding behaviour with specific plant examples. Various examples were chosen including blue flowered carnations created by genetic modification transfer of a gene for production of blue pigment from pansy to carnation, or use of cytoplasmic male sterility in breeding programmes to create F1 hybrids in onion where the female seed parent was male sterile thus avoiding the need for emasculation. Another example was the use of colchicine as a mutagenic agent to double chromosome numbers in cells by preventing formation of the spindle in mitosis. This technique is used to form homozygous diploid plants from haploid plants grown from individual pollen grains by anther culture. These homozygous plants can then be used as pure line parents in a breeding programme to produce F_1 hybrids in Brassica oleracea.

Section C – Plant Physiology II

Q13 a) State the end products of respiration in plants under **EACH** of the following conditions:

i) aerobic;
ii) anaerobic.

b) Relate the optimum conditions required to maximise the shelf-life of a **NAMED** crop for **EACH** of the following:

i) respiration;
ii) plant growth regulators;
iii) transpiration;
iv) pests and diseases;
v) nutrition.

The aim of part a) of the question is to ascertain if the candidates can state the end products of aerobic and anaerobic respiration in plants.

High marks were awarded for clear, accurate statements which included the relevant respiratory equations.

The aim of part b) of the question is to ascertain if the candidates are able to correlate optimum shelf-life conditions and the variables which affect this relationship i.e. respiration, plant growth regulators, transpiration, pest and diseases and nutrition.

High marks were awarded for clear accurate reports of these variables .e.g. in the case of nutrition, high marks were awarded for reports on the relationship between calcium and bitter pit , potash and sturdy stems, potassium and good fruit set and ultimately fruit quality.

Q14 a) Explain how **EACH** of the following is naturally controlled in plants:

i) apical dominance;
ii) stem extension;
iii) fruit set.

b) Describe, using plant examples, how **EACH** of the above in a), may be artificially controlled in horticulture.

The aim of part a) of the question is to determine whether the candidates can demonstrate a clear understanding of how apical dominance, stem extension: and fruit set is naturally controlled in plants.

High marks were awarded for clear accurate reports of these natural phenomena e.g. in stem extension, high marks were awarded for an explanation that included the role of gibberellic acid in extension growth and its synergistic relationship to auxin. High marks were also awarded for a mention of the mode of action of the plant hormones and factors which affect their efficacy e.g. light.

The aim of part b) of the question is to determine whether the candidates can describe the role of exogenous hormones in horticulture.

High marks were awarded for clear accurate descriptions of the role of exogenous hormones in horticulture e.g. the use of anti-gibberellins such as
Ancymidol (A-rest), used on a wide range of plants; as is Paclobutrazol, (Bonzi).
They act by reducing the amount of gibberellin in the plant thus causing stunting
Trinexapac-ethyl inhibits gibberellin synthesis, thereby slowing down growth: It is used on turf and amenity grassland to that effect.

Q15 a) Define short day, long day and day neutral plants in relation to photoperiod, using **ONE NAMED** example in each case.

b) Define the term photoinductive cycle.

c) Describe the mechanism of day-length perception in vegetative plants.

d) Describe how artificial manipulation of photoperiod may be used to control flowering in a **NAMED** plant/crop.

The aim of part a) of the question is to ascertain if the candidates can relate photoperiodism and associated processes to the flowering of plants.

High marks were awarded for a clear, accurate definition which used scientific terminology such as a long-day plant is a plant that will only flower, or will flower more rapidly, when the day length is longer than a particular value, known as the critical day-length eg. *Sinapsis alba CDL =14, OR Spinacea oleracea; CDL= 13.*

In part b), high marks were awarded for a clear, accurate definition which used scientific terminology. It is a ratio of dark and light periods in 24 hours that induces flowering.

In Part c), a very small number of candidates answered this correctly. The mechanism involves phytochrome in the leaves coupled with a circadian clock. Details of the interconversion of the two states of phytochrome should have been given.

In part d), high marks were awarded for clear, accurate descriptions of the practices used to artificially manipulate photoperiod in horticulture with the sole aim of controlling flowering in an appropriately NAMED crop.

Q16 a) Describe the physical causes of seed dormancy.

b) Explain the process of induction of dormancy in deciduous woody plants using **NAMED** examples.

c) Describe methods of breaking dormancy in horticulture.

The aim of the question is to determine whether the candidates understand the facts of seed and plant dormancy.

In part a), high marks were awarded for clear, accurate descriptions of the physical causes of seed dormancy but NOT physiological causes of seed dormancy.

In part b), high marks were awarded for clear, accurate explanations of the process of induction of dormancy in deciduous woody plants using **NAMED** examples.
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Dormancy can be induced by low temperatures and short days. The onset of dormancy is coincident with leaf fall, decreased cambial activity, and increased cold hardiness. Phytochrome is involved and leaves perceive the photoperiodic stimulus. Dormancy in buds is characterised by low respiratory activity, an inability to grow even if temperature, oxygen and water supply are adequate.

In part c), high marks were awarded for clear, accurate descriptions of breaking dormancy in horticulture that included descriptions of both seeds and plants.

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