consistency ensure that seeds remain evenly suspended during sowing.

Fluid drilling of germinating vegetable seeds has produced earlier emergence in widely varying soil conditions. More uniform emergence can also occur and produce uniform growth of some crops right through until harvesting. British research shows 5 to 12 days earlier emergence and up to 20% increase in total emergence of carrots, while celery has emerged up to 21 days earlier with an increase of up to 58% in the total number of seedlings emerging.

Direct seeding pre-germinated seeds has important implications for extending growing seasons and allowing the grower more accurate control over crop production, but there are other prospects. Materials such as fertilizers for seedling growth, fungicides, insecticides or growth regulating compounds could be incorporated with the seed-gel mix and provide a completely artificial environment around the seed.

These seed treatments have not been tried with many ornamental or Australian native plants but I feel that they are worthy of investigation.

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TEACHING PLANT PROPAGATION TO HORTICULTURE STUDENTS

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Abstract. Horticulture students are instructed in the principles and practices of plant propagation which are employed in commercial nurseries It

will be shown that not only practical aspects of plant propagation but also a thorough knowledge of plants is required to become a proficient plant propagator

INTRODUCTION

The course of instruction outlined in this paper is the Horticulture Certificate Course of the Department of Technical and Further Education in N.S.W This course is designed for students studying at technician level. On enrolling in the course, students have had little experience in plant propagation. However, their attitude is positive because they have at some time grown seeds or struck cuttings and so believe that plant propagation is an easy subject.

It is pointed out at an early stage that plant propagation on a commercial basis is not the job for an amateur. To become a proficient plant propagator the student must have both practical skills and a knowledge of the principles involved This is achieved by:

a) attendance at the college for practical and theory classes.

b) on the job training.

BRIEF OUTLINE OF TOPICS COVERED IN THE SUBJECTS, PLANT PROPAGATION I & II

Stage I:

i) An understanding of the basic difference between sexual and asexual plant propagation and the advantages and limitations.

ii) Seed sowing practices and principles

iii) Vegetative propagation
- a) Stem cuttings — soft wood
  — semi-hardwood
  — hardwood
- b) Root cuttings
- c) Leaf cuttings
- d) Stem bud cuttings

iv) Controlled environment in plant propagation
- a) Glasshouse; polyhouses, frames
- b) Misting systems
- c) Bottom heating
- d) Heating, ventilation
- e) Artificial light
- f) CO_2 enrichment

v) Media — propagation of seed and cuttings
  — potting

vi) Hormone use
vii) Hygiene and sanitation
viii) Economical use of various practices.

Stage II:

Propagation by: a) Division
b) Separation
c) Layering
d) Grafting
e) Budding
f) Tissue and aseptic culture

These topics are taught to coincide with the most appropriate time of the year Further instruction is given to the student so that he is able to grow the plants on in the best possible way

Plant propagation is taught in conjunction with botany because a thorough knowledge of morphology, anatomy and physiology of plants is the basis of plant propagation.

SEED SOWING

Principles: A large number of nurseries propagate their plants by seed and so it is important that the student have a clear understanding of the principles underlying the practice. The following are points that the student is required to understand.

1. Morphology of the seed and the function of various parts.
2. Anatomy of the seed so that it is known that the embryo is a new individual with sufficient reserve carbohydrate in one form or another to survive for a time and to be able to grow until it can manufacture its own carbohydrate after the germination process. How environmental conditions affect the seed and control of conditions during seed storage.
3. Physiology of the germination process and physiology of plant growth. With this understanding sufficient water can be provided for imbibition, adequate oxygen, and optimum temperature for the metabolism. Pre-treatment of certain seed to break down or remove inhibiting growth regulators. Provide the optimum environmental conditions.
4. Media and components to give the optimum germination of seeds, stressing the need to provide for movement of water through capillaries and an adequate supply of oxygen. Consolidation of medium.

5. Depth of sowing
6. Effect of density of seed sowing on growth and disease occurrence and transplanting of seedlings.
7 Growth of plants after germination Photosynthesis, respiration, transpiration, and how environment plays a role in this. The effect of auxins on growth habits of the plant

Skills: The students are assessed on the following skills after they have had some exercises to obtain a degree of competency

1 Pretreatment of seed, if required, by stratification, scarification, hot water, acid treatment.
2 Hygiene
3 Selection of the most appropriate medium
4. Correctly fill and consolidate medium in containers.
5 Select and use the most appropriate sowing method. i.e., hand or machine sowing, drill or broadcast, seed shaker with or without added inert material.
6 Correct distribution and density
7 Select and use appropriate seed covering material
8. Sowing depth
9. Consolidation and watering in
10 Accurately label and record
11 Select the most appropriate propagation structure.

A further step in seed sowing skills is an assignment in which the students have to collect seed. The seed from this assignment is used for exercises or assessment. The aims of the assignment are.

1. Identify the plants from which fruit is collected
2. Collect fruit at the correct stage of ripeness.
3. Extract seed from fruit by the most appropriate and economical method
4. Dry seed to the correct moisture content
5. Correctly store the seed
6. Accurately label and record

SANITATION AND HYGIENE

Sanitation and hygiene are emphasized throughout the subject. Media used in all stages of propagation and growing on are pasteurized so that as little disease as possible is transmitted via the medium.

In selecting plant material the student is taught to collect only that material which has obviously not been infected or affected by pests and diseases. All plant material is surface disinfected since it comes from varied sources. The economics are stressed with sanitation and hygiene.

ENVIRONMENT CONTROLLED AREAS AND MAINTENANCE

The controlled environmental aids to plant propagation are examined and the principles discussed so that the student will have a clear understanding of their purpose and function. Various types of propagation structures are discussed and the advantages and limitations pointed out Maintenance of environmental conditions is discussed although the skills involved can not be taught or assessed because of the time limitation. However, as many points as possible are discussed for certain situations.

VEGETATIVE PROPAGATION

Principles. The main vegetative propagation method taught in Stage I is that of stem cuttings which is carried out in a large number of nurseries. Other forms of cuttings are also taught and are applicable in various nurseries with particular or specialized plants.

Grafting and budding, which are not commonly used in general nurseries, are also treated because of their special application for certain plants or plant forms. In these a degree of competency is required in keeping with the time limitation.

The students, particularly those who will find themselves in supervisory positions in garden maintenance, should also have an understanding of the division of herbaceous softwood perennials, bark grafting, and bridge grafting

Specialised propagation of bulbs, corms, pseudobulbs, and tubers is practised, as well as layering, e.g., aerial, simple, trench.

Tissue culture techniques must be understood but since facilities are limited to small groups it is not practised any further than aseptic culture of seed.

To be proficient in vegetative propagation techniques the student must have a full understanding of the following:

1. Vegetative propagation: although this is a natural phenomenon in many plants, scientific knowledge enables man to simulate and enhance the process with more sophisticated methods.
2 Morphology of plants: an understanding of the parts of

the plant will enable the student to select the most appropriate material for vegetative propagation.

3. Anatomy of plants· an understanding of plant anatomy will give the student knowledge of tissue function and enable him to provide optimum conditions for the regeneration of tissue The student must know the position and function of the meristematic tissue in the plant and the direction of flow and types of solutes which pass through the xylem and phloem
4. Physiology of plants· an understanding will enable the student to select the correct plant material and provide the best environmental conditions for propagation. Although growth is controlled from within, the application of hormones can help the plant to produce faster and more uniform root growth. Timing of propagation method and hardening off
5. Environmental conditions. the ability to control environmental conditions will enable the best results to be obtained in the various vegetative propagation methods, e g , a gradient of temperatures in a bottom heated misting system increases the metabolism at the base of the cutting and encourages root production whereas high temperatures above the medium will increase top growth to the detriment of root production. Misting also provides increased humidity and cooling through evaporation from leaf surfaces.
6. Media and their functions, so that the most appropriate medium can be mixed for the particular plant material.

Skills. Practical exercises assess the student's grasp of the principles· e.g. students collect plant material from work or home and use this to demonstrate to the teacher the various morphological features. At the same time the student shows that he can distinguish the maturity of plant material

The stage of growth or maturity of the plant material is taught in the traditional way by determining whether or not the plant material snaps or bends and by gauging the maturity between fingers and thumb. Also the presence of the definite apical buds and leaf sizes and colour are ascertained for maturity and colour change or cork formation on stems. When this has been mastered the student must bring in appropriate plant materials in good condition for stem cuttings, grafting, or budding.

Practical Skills in Preparation of Cuttings:

1. Selection of appropriate plant material.
2. Hygiene

3 Basal cut (apical cut where applicable) just below node. Removal of lower leaves. Removal of flowers or buds if applicable. Wounding

4. Correct and safe use of propagation knife.

5 Selection of most appropriate medium.

6. Correct filling and consolidation of medium in containers.

7. Correctly apply appropriate rooting hormone.

8 Correct insertion and consolidation of cuttings in medium.

9 Correctly label and record.

10 Water in and place in appropriate propagation structure.

Practical Skills in Grafting and Budding.

1. Selection of the appropriate understock. (theory lesson on compatibility and other aspects given beforehand)
2. Selection of correct scion or budwood: e.g., budwood for roses — petals of flowers falling, etc.
3. Selection of most appropriate method of grafting or budding for the species concerned. e.g., roses (T-budding); conifers (side veneer grafting).

4 Cutting the understock correctly and evenly.

5. Cutting the scion correctly and evenly, or removing bud from budwood and dewood.
6. Align properly.
7. Tie correctly.

8 Wax where appropriate.

In stage II the students must submit a report on an assignment on a hard-to-propagate species of their choice The report will have. a summary of a literature search and a hypothesis which they have developed as how the species may be propagated. Then they will carry out a trial according to the hypothesis and report in a meaningful way the method, results, and a conclusion.

LIMITATIONS

The subjects, Plant Propagation I and II, are studied for only 36 hours each year so that trade proficiency testing cannot be *fully* implemented. However, each student should be able to perform the skills listed earlier. The College considers that quality is more important than quantity. On-the-job training in these areas is therefore vital for proficiency.

Besides Plant Propagation I and II the student will learn about other aspects of plant propagation in subjects such as Botany, Soil Science, Plant Identification and Culture, and Plant Protection.

The facilities are limited, allowing each student only 60 cm^2 of mist bench space and 90 cm^2 of glasshouse or frame space. This works out to three 10-cm pots of seeds, three 10-cm. pots of semi-hardwood cutting, three 10-cm pots of leaf cuttings, and leaf-bud cuttings, and three 10-cm pots of softwood cuttings. Similarly, in Stage II the number of grafts is limited to about 6 plants. Budding, too, is usually limited to 3 or 4 rose understocks.

Potting shed space also limits the amount of practical work. Thirty students with teacher are crowded into potting sheds designed for a maximum of 18 students. There is a student/teacher ratio of 15 to 1 but it is not always possible to find enough teachers so that often classes are greater than 20 students to one teacher

The products from the students' exercises and assessments are given to the students because there is not enough space or staff to maintain all the plants propagated In the end left-over plants are discarded.

Since the College year runs from March to November an important part of the year is missed when plant propagation practice could be carried out with less elaborate facilities, e.g., misting in open beds.

Not all minor differences in propagation method can be taught, although they are discussed, e g., type of cutting implements (razor blades, scalpels), auxin applications; methods of grafting and budding, etc.

CONCLUSION

At the end of their time at the College the students will have a good knowledge of plant propagation principles and can apply this knowledge to the plants he is likely to encounter in the industry If he has not had on-the-job training concurrently with the topics taught at the College, the students skills will not be of the same standard as his knowledge of the principles of propagation This is due to the limited time and facilities at the College.