CONTENTS

UNIT 1

INTRODUCTION TO GREENHOUSE

READING

A greenhouse (also called a glasshouse or hothouse) is a building where plants are cultivated.

A greenhouse is a structure with a glass or plastic roof and frequently glass or plastic walls; it heats up because incoming solar radiation from the sun warms plants, soil, and other things inside the building. Air warmed by the heat from hot interior surfaces is retained in the building by the roof and wall. These structures range in size from small sheds to very large buildings.

Greenhouses can be divided into glass greenhouses and plastic greenhouses. Plastics mostly used are PE film and multi-wall sheet in PC or PMMA. Commercial glass greenhouses are often high tech production facilities for vegetables or flowers. The glass greenhouses are filled with equipment like screening installations, heating, cooling, and lighting and may be automatically controlled by a computer.

The glass used for a greenhouse works as a selective transmission medium for different spectral frequencies, and its effect is to trap energy within the greenhouse, which heats both the plants and the ground inside it. This warms the air near the ground, and this air is prevented from rising and flowing away. This can be demonstrated by opening a small window near the roof of a greenhouse: the temperature drops considerably. This principle is the basis of the auto vent automatic cooling system. Greenhouses thus work by trapping electromagnetic radiation and preventing convection. A miniature greenhouse is known as a cold frame.

Greenhouses are often used for growing flowers, vegetables, fruits, and tobacco plants. Bumblebees are the pollinators of choice for most greenhouse pollination, although other types of bees have been used, as well as artificial pollination. This helps the plants to produce more offspring for future plantations.

Besides tobacco, many vegetables and flowers are grown in greenhouses in late winter and early spring, and then transplanted outside as the weather warms. Started plants are usually available for gardeners in farmers' markets at transplanting time.

The closed environment of a greenhouse has its own unique requirements, compared with outdoor production. Pests and diseases, and extremes of heat and humidity, have to be controlled, and irrigation is necessary to provide water. Significant inputs of heat and light may be required, particularly with winter production of warm-weather vegetables. Special greenhouse varieties of certain crops, like tomatoes, are generally used for commercial production.

Greenhouses are increasingly important in the food supply of high latitude countries. One of the largest greenhouse complexes in the world is in America, Spain where Greenhouses cover almost 50,000 acres (200 km^2) and where almost 5% of Spain's salad vegetables are grown.

Greenhouses protect crops from too much heat or cold, shield plants from dust storms and blizzards, and help to keep out pests. Light and temperature control allows greenhouses to turn in arable land into arable land. Greenhouses can feed starving nations where crops can't survive in the harsh deserts and Arctic wastes. Hydroponics can be used in greenhouses as well to make the most use of the interior space.

Biologist John Todd invented a greenhouse that turns sewage into water, through the natural processes of bacteria, plants, and animals.

The idea of growing plants in environmentally controlled areas has existed since Roman times. The Roman emperor Tiberius ate a cucumber-like vegetable daily. The Roman gardeners used artificial methods (similar to the greenhouse system) of growing to have it available for his table every day of the year. Cucumbers were planted in wheeled carts which were put in the sun daily, then taken inside to keep them warm at night.

The first modern greenhouses were built in Italy in the thirteenth century to house the exotic plants that explorers brought back from the tropics. They were originally called *giardini botanici* (botanical gardens). The concept of greenhouses soon spread to the Netherlands and then England, along with the plants. Some of these early attempts required enormous amounts of work to close up at night or to winterize. There were serious problems with providing adequate and balanced heat in these early greenhouses.

A. Comprehension questions

1. What is a greenhouse?
…………………………………………………………………………………………………
…………………………………………………………………………………………………
……………………………………………………………………………….
2. What is a greenhouse usually made of?
…………………………………………………………………………………………………
…………………………………………………………………………………………………
………………………………………………………………………………..
3. What are greenhouses used for?
…………………………………………………………………………………………………
…………………………………………………………………………………………………
……………………………………………………………………………….
4. When and where was the first greenhouse built?
…………………………………………………………………………………………………
…………………………………………………………………………………………………
………………………………………………………………………………..
5. Whom was the first greenhouse built by?
…………………………………………………………………………………………………
…………………………………………………………………………………………………
………………………………………………………………………………..

DISCUSSION POINTS

Students in a group of 5 discuss on the following topics:

- ***The definition of greenhouse***
- ***The usages of greenhouse***
- ***The history of greenhouse***

B. Fill in the blanks

Add words or phrases from the text to complete the argument which shows whether the comprehension check is TRUE or NOT TRUE. Note that a dotted line .... requires a phrase to be added, and a straight line______ requires a word to be added.

thermal lost	are closed	cools down	estimated
warmer	temperature	sun energy	effective
adjusting	greenhouse effect	big difference	valuable in

Why is greenhouse ______ than the surrounding? It uses …………………. to heat up and keeps the received heat inside. To be ______, it slows down all known thermal transfer mechanics; thermal convection, thermal radiation and thermal conduction. ______ the greenhouse temperature is made by adjusting the thermal convection; when all windows …………………, convection is fully blocked. Opening windows increases the ………………. by convection and……………….. the greenhouse.

It is ______ that the major heat trapping is achieved by preventing convection; however, if either conduction or radiation is not prevented at all, the greenhouse will cool down to almost the same ______ than the environment. Term "Greenhouse effect" is somehow misleading; blocking thermal convection is more important than blocking thermal radiation so actual ……………………………….. is playing smaller role in greenhouse.

The effectiveness of blocking thermal conduction and thermal radiation is depending on the materials used to build up the greenhouse.

Trapping thermal radiation is more …………………… environments where atmosphere moisture is low and night temperatures are also low. ……………………………… in environment and greenhouse temperatures increases the radiation loss greatly, especially if the heat can radiate directly to the space due to low natural greenhouse effect. Slowing down thermal conduction (insulating material) is more important when greenhouse is in windy environment and wind cools the walls quickly.

C. Use of English

Match one word in box A with a word in box B to make word partnerships

A	B	A+B
solar	land	
interior	effect	
electromagnetic	surfaces	
in-arable	pollination	
artificial	convection	
outdoor	production	
natural	radiation	
thermal	radiation	
greenhouse	energy	
sun energy	vegetables	
transfer	mechanics	
atmosphere	processes	
production	facilities	
warm-weather	moisture	
commercial	production	

D. Grammar

Passive voice

Look at the following examples

Greenhouses ***can be divided*** into glass greenhouses and plastic greenhouses.

It ***is estimated*** that the major heat trapping ***is achieved*** by preventing convection

The passive is formed by using the appropriate tense of the verb to be + past participle

Active voice: S + V + 0

Passive voice S + to be + P2 + By/ with + 0

* Change the following passive sentences into active ones

1. Greenhouses ***can be divided*** into glass greenhouses and plastic greenhouses.
   - ………………………………………………………………………………
2. It ***is estimated*** that the major heat trapping ***is achieved*** by preventing convection
   - ………………………………………………………………………………
3. This air ***is prevented*** from rising and flowing away.
   - ………………………………………………………………………………
4. Greenhouses ***are often used*** for growing flowers, vegetables, fruits, and tobacco plants.
   - ……………………………………………………………………………..
5. The first modern greenhouses ***were built*** in Italy in the thirteenth century
   - ………………………………………………………………………………
6. They ***were originally called*** *giardini botanici*
   - ………………………………………………………………………………
7. Cucumbers ***were planted*** in wheeled carts which ***were put*** in the sun daily, then ***taken*** inside to keep them warm at night.
   - ………………………………………………………………………
8. Pests and diseases, and extremes of heat and humidity, ***have to be controlled.***
   - ………………………………………………………………………….
9. Many vegetables and flowers are grown in greenhouses in late winter and early spring
   - ………………………………………………………………………….

* Change the following active sentences into passive ones

1. Greenhouses protect crops from too much heat or cold.
   - …………………………………………………………………

2. Biologist John Todd invented a greenhouse that turns sewage into water, through the natural processes of bacteria, plants, and animals

- ➢ …………………………………………………………………………………… ……………………………………………………………………………

3. The Roman gardeners used artificial methods.

- ➢ …………………………………………………………………………………

4.The greenhouse must, however, provide the proper environment for growing plants.

- ➢ …………………………………………………………………………………… ……………………………………………………………………………

5. You should aim to maximize winter sun exposure, particularly if the greenhouse is used all year

- ➢ …………………………………………………………………………………… …………………………………………………………………………………

Preparing a presentation

Work in pairs, Prepare an introduction to a presentation. Then introduce the presentation to each other
Here is tips to prepare a presentation

Structure for Introduction

- **Greeting**

  Your name

  Your nationality

  Your position

- **Topic**

  Your class, your company, your project

- **Plan**

Useful languages

Greeting
Good morning/ afternoon. I'm…

Hello, everyone. Nice to see you again

Topic
My subject today is…………..
I'd like to talk to you about……………..
I'm going to talk about………………………

Plan
There are three parts to my presentation.
My presentation is in three sections.
Firstly,…………………………
Secondly,…………………….
Finally,………..………………

Aims
By the end of my presentation, you will have a clear idea of……………….
By the end of my talk, you will understand how/why…………….

Extra Reading Resources

Present and discuss as a group or class the content of the article below

1. http://www.ams.usda.gov/standards/
2. http://en.wikipedia.org/wiki/Solar_greenhouse_(technical)

Extra Challenge

1. Translate the text in Reading Comprehension into Vietnamese.
2. Write a reflection on what you have learned:

- What did you learn from it?
- What did you do well?
- What part of the unit you like best?
- What was difficult for you?
- What do you want to improve?

New words

Students look up the following new words in the dictionary before going to class

Words and phrases	***Pronunciation***	***Notes of meaning***
radiation		
to retain		

commercial glass		
transmission		
medium		
spectral frequencies		
to trap energy		
electromagnetic radiation		
bumblebees		
pollinators		
hydroponics		
latitude		
harsh deserts		
artificial methods		
sheets of mica		
exotic plants		
conservatory		
to winterize		
horticultural		
non-horticultural		
monumental		
merchant		

HOME WORK

Read the text carefully and translate into Vietnamese

Planning and Building a Greenhouse

Careful planning is important before a home greenhouse project is started. Building a greenhouse does not need to be expensive or time-consuming. The final choice of the type of greenhouse will depend on the growing space desired, home architecture, available sites, and costs. The greenhouse must, however, provide the proper environment for growing plants.

The greenhouse should be located where it gets maximum sunlight. The first choice of location is the south or southeast side of a building or shade trees. Sunlight all day is best, but morning sunlight on the east side is sufficient for plants. Morning sunlight is most desirable because it allows the plant's food production process to begin early; thus growth is maximized. An east side location captures the most November to February sunlight.

The next best sites are southwest and west of major structures, where plants receive sunlight later in the day. North of major structures is the least desirable location and is good only for plants that require little light.

Deciduous trees, such as maple and oak, can effectively shade the greenhouse from the intense late afternoon summer sun; however, they should not shade the greenhouse in the morning. Deciduous trees also allow maximum exposure to the winter sun because they shed their leaves in the fall. Evergreen trees that have foliage year round should not be located where they will shade the greenhouse because they will block the less intense winter sun. You should aim to maximize winter sun exposure, particularly if the greenhouse is used all year. Remember that the sun is lower in the southern sky in winter causing long shadows to be cast by buildings and evergreen trees (Figure 1).

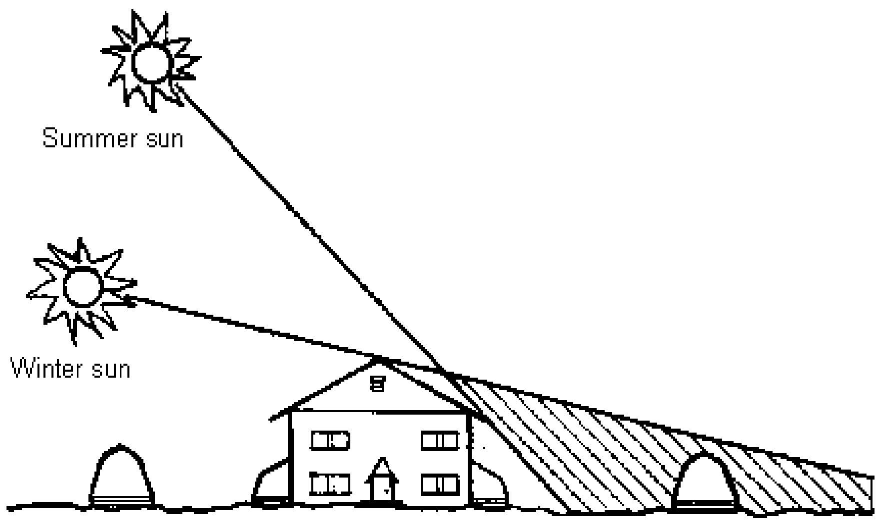

Figure 1. Select location carefully. Note where the shade line occurs in both the winter and summer.

Good drainage is another requirement for the site. When necessary, build the greenhouse above the surrounding ground so rainwater and irrigation water will drain away. Other site considerations include the light requirements of the plants to be grown; locations of sources of heat, water, and electricity; and shelter from winter wind. Access to the greenhouse should be convenient for both people and utilities. A workplace for potting plants and a storage area for supplies should be nearby.

UNIT 2

GREENHOUSE VEGETABLE PRODUCTION

READING

Greenhouse vegetable production is a highly intensive enterprise requiring substantial labor and capital inputs. Because of this, potential growers should carefully consider all of the factors necessary for a successful enterprise.

Greenhouse vegetable production is in many ways a 24-hour-a-day commitment. Greenhouse maintenance, crop production and handling emergencies require constant vigilance. Every 4,000 square feet of greenhouse space requires an estimated 25 to 30 hours of crop care and upkeep.

Greenhouse structures require constant maintenance and repair. Many of the selected greenhouse covers must be replaced on a regular basis. Heating, cooling and watering systems must be maintained and routinely serviced. In addition, contingency plans and backup systems must be in place in case any of these major systems should break down. Even a one-day loss of cooling, heating or water during a critical period can result in complete crop failure.

Along with the essential skills, capital and labor to build, maintain and grow a crop, producers must develop markets willing to pay the relatively high prices necessary to make the enterprise economically viable. Greenhouse-grown vegetables cannot compete with comparable field-grown crops based on price; therefore, greenhouse-grown vegetables often are marketed to buyers based on superior quality and off-season availability.

Finally, the personality and skills of the person or people involved in the enterprise should be considered. As mentioned earlier, this can be a 24-hour-a-day commitment. If you don't have the personality to commit and to be available day or night as needed, then this is not for you. In addition, a successful greenhouse vegetable production operation requires mechanical aptitude, crop production skills and business acumen.

Although greenhouse production is an intensive undertaking, it can be very satisfying and rewarding. One advantage of greenhouse vegetable production is the relatively small amount of area required compared with field-grown produce. In addition, the return on investment can be good if the requisite markets can be found.

A. Decide if the following statements are true or false

1. The greenhouse vegetable production's successes are mainly depended on the growers
2. The greenhouse vegetable production requires great labor and capital inputs.
3. Sometimes greenhouse structures require maintenance and repair
4. Heating, cooling and watering systems can be maintained and serviced at an interval
5. Greenhouse-grown vegetables cannot compete with comparable field-grown crops based on price because of the labor cost only

B. Answer comprehension questions

1. What would happen if growers had a one-day loss of cooling, heating or water during a critical period?
…………………………………………………………………………………………
…………………………………………………………………………………………
……………………………………………………………………………..
2. Why can't greenhouse-grown vegetables compete with comparable field-grown crops based on price?
…………………………………………………………………………………………
…………………………………………………………………………………………
……………………………………………………………………………..

3. Why is greenhouse vegetable production called a highly intensive enterprise?
…………………………………………………………………………………………
…………………………………………………………………………………………
………………………………………………………………………………

4. What does a successful greenhouse vegetable production operation need?
…………………………………………………………………………………………
…………………………………………………………………………………………
………………………………………………………………………………

5. What are the advantages of greenhouse vegetable production?
…………………………………………………………………………………………
…………………………………………………………………………………………
………………………………………………………………………………

C. Fill in the blanks

Add words or phrases from the text to complete the argument which shows whether the comprehension check is TRUE or NOT TRUE. Note that a dotted line .... requires a phrase to be added, and a straight line______ requires a word to be added.

challenges	relatively	production	yields
specific to	compared to	due to	level of
highlighted separately		are encouraged to consult	

The tomato is a very popular crop for _________ in greenhouses. Tomatoes are _________ easy to grow ……………………… cucumbers and lettuce, and _________ can be very high. Demand for tomatoes is usually strong ………………… the vine-ripe nature and general overall high ………………….. eating quality.

Production of tomato is not without serious _________, however. This chapter presents the production techniques ……………….. tomato. Techniques used with certain systems (bag, rock-wool, or NFT) will be ………………….. The production information is presented as recommended procedures. Minor adjustments might be needed as individual growers require and as research indicates the need. Growers……………………….. a knowledgeable expert prior to making adjustments.

GRAMMAR

VERB TENSES

This reading introduces the Present Simple Tense. This is one of the six most common verb tenses in English. Others include the Present Continuous tense, the Future Simple tense, the Future with 'going to', the Past Simple tense, and the Present Perfect tense. These tenses describe when something happens. All of the sentences in the reading are in the 'Present Simple Tense'. They describe things that happen every year, always, every day, usually or sometimes.

The table below describes when to use each tense.

Tense	Example	When?
1. Present Simple	People eat rice	every day
2. Present Continuous	People are eating rice	now
3. Future Simple	People will eat rice	in the future
4. Future with 'going to'	People are going to eat rice	in the future
5. Past Simple	People ate rice	in the past
6. Present Perfect	People have eaten rice	up to now

Examples

Present Simple

Used to describe things which happen every year, always, every day, usually or sometimes

Examples:

1. Most people in the Philippines **eat** rice.
2. She **cooks** rice everyday.

Present Continuous

Used to express an action in the present; something that is currently happening

Examples:

1. They **are eating** rice.
2. He **is cooking** rice for dinner

Future Simple

Used to express the future.

Examples:

1. They **will eat** rice for breakfast.
2. I **will cook** more rice tonight.

Future 'with going to'

Also used to express the future except you use the verb *to be + going to*
The meaning is the same as the future simple

Examples:

1. They **are going to** eat rice for dinner.
2. She **is going to** cook more rice tomorrow.

Past Simple

Used to express a completed action in the past

Examples:

1. I **ate** rice for lunch.
2. They **cooked** rice.

Present Perfect

Used to show that an action was completed sometime before the present time. Used to indicate that an action started in the past and continues to the present time

Examples:

1. She **has eaten** rice every day of her life.
2. They **have cooked** rice over a fire for years.

Writing Tips

When writing a typical paper, you will normally use both the past and present tenses.
When you refer to previously published work you should generally use the present tense.
When you refer to your present results you should use the past tense.
When you are writing an abstract, most of it should be in the past tense because you are referring to your own present results. The Materials and Methods and Results sections should also be in the past tense because you are describing what you did and what you found. Most of the Introduction and Discussion should be in the present tense because you are usually talking about previously established knowledge.

That farmer works on the land all year round.

Using the above sentence, construct the sentences in all 6 important tenses. Use the time phrases (last year, now, in the future, this month, etc.) where appropriate.

1. Last year……………………………………………………………………
2. Now…………………………………………………………………………..
3. In the future………………………………………………………………..
4. This month…………………………………………………………………
5. For two years……………………………………………………………….
6. Every year………………………………………………………………….

WRITING

Write a short description of the main Greenhouse vegetable production activities in your country (about 100 words). Try to use at least 10 terms and 3 verb tenses introduced in this lesson.

The following questions may help you get started:

- ***How important is Greenhouse vegetable production in your country? Why?***
- ***What type of Greenhouse vegetable production is most common in your country?***
- ***Where are the main Greenhouse vegetable production regions?***
- ***What are some of the problems facing your country's Greenhouse vegetable production?***

Negotiating to deal with problems

Describing the problem	➔ Responding
There is too much……………	I'm sorry but…………….
There isn't enough……………	I understand but………….
Emphasizing the problem	➔ Explaining the reasons
It's really important………..	The problem is…………..
We need to………………….	The reason is……………
Making suggestions	➔ Responding
Why don't you……………..	Ok, I'll think about it
We could…………………..	All right, I'll get back to you

Extra Reading Resources

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Extra Challenge

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- What did you learn from it?
- What did you do well?
- What part of the unit you like best?
- What was difficult for you?
- How do you feel about your performance?
- What do you want to improve?

New words

Students look up the following new words in the dictionary before going to class

Words and phrases	***Pronunciation***	***Notes of meaning***
substantial		
commitment		
vigilance		
maintenance		
contingency		
critical		
essential skills		
critical period		
comparable		
superior quality		
off-season		
availability		
mechanical aptitude		
intensive undertaking		
satisfying		
rewarding		
investment		
enterprise		
emergencies		
routinely serviced		
contingency		

HOMEWORK

EXERCISE 1: Choose the word or phrase which best completes each sentence by writing the letter A, B, C or D

1. Can you tell me the…………… of these shoes?

A. charge B. price C. amount D. expense

2. Do you know the reason ……………. she was very angry.
A. what B. that C. why D. because

3. I would rather be a doctor………….. a teacher.
A. than B. more than C. better D. better than

4. He writes more…………with fewer mistakes than the previous term.
A. careless B. careful C. carelessly D. carefully

5. …………….. scientists have observed increased pollution in the water supply.
A. Late B. Later C. Latter D. Lately

6. …………….. he had no money for a bus, he had to walk all the way home.
A. For B. Thus C. So D. As

7. Bill Gates is one of the………………… men in the world.
A. rich B. richest C. richer D. most rich

8. We gave………….. a meal.
A. at the visitors B. for the visitors C. to the visitors D. the visitors

9. My arms are aching now because……………….. since two o'clock.
A. I swim B. I swam C. I 'm swimming D. I've been swimming

10. Someone suggested………….. for a walk.
A. go B. going C. of going D. to go

11. There was no news;…………… she went on hoping.
A. moreover B. in other word C. otherwise D. nevertheless

12. "I am sorry…………so long. I forgot the keys".
A. Keep you waiting B. to have kept you waiting
C. to keep you to wait D. to keep you wait

13. Of course I'm a Christain……….. I expect everyone who works here to be a Christain too.
A. since B. then C. and D. but

14. ……………..to an accident in the High Street, traffic is moving slowly on the London Road
A. Though B. Owing C. Because D. Since

15. ……………. he wasn't feeling very well, Mr. Graham went to visit his aunt as usual
A. Although B. However C. Therefore D. Still

16. He saw a young man…………..on the pavement outside the shop.
A. stood B. standing C. has stood D. was stood

17. " If he is not willing to go, why …………….somebody else?"
A. are not ask B. you do ask C. you not ask D. don't you ask

18. "I don't want a holiday", she said; "I'd rather…………..the money"
A. saved B. save C. have saved D. will save

19. It's no use…………..a language if you don't try to speak it too.
A. to learn B. learned C. learning D. learn

20. The shirt in the window was……………..expensive for me to buy.
A. enough B. too C. so D. such

<u>EXERCISE 2:</u> ***Read the passage carefully then choose the best answer to each of the questions by writing the letter A, B, C or D***

Our bodies produce heat or energy from the food we eat. The energy – producing value of food is measured in calories. Some people count their calories as carefully as they count their money. They know that the calorie is the unit of measurement that influences weight.

The number of calories a person needs each day depends upon ages, body structure, and the kind of work one does. Calorie needs differ from one individual to another. Boys between the age of 13 and 15 may need about 3100 calories a day. Girls of the same age usually need only about 2600 calories a day. People who do physical hard work may need as many as 4000 calories a day.

The food a person eats in three, well – balanced meals each day usually provides the energy – making calories needed. Sometimes individuals take in more calories than their bodies can use. Such extra calories are deposited in the body as fat. Those people who have stored too much fat, or wish to maintain the weight at which they feel to look their best, must carefully watch their intake of food. They must also count their calorie. How surprised some of them are to find that a teaspoonful of honey contains 100 calories.

21. This reading as a whole tells us about:
    A. Energy from honey
    B. The food a person eats each day
    C. What we should do if we are overweight
    D. A unit of energy: calorie

22. From the reading we can understand:
    A. Nowadays people know the calorie values of food.
    B. Different foods contain different amounts of calories..
    C. It is better to be overweight than underweight.
    D. All men need more calories per day than women

23. Which sentence is not true?
    A. All foods may be measured in calories.
    B. A calorie measures the temperature of the body.
    C. A teaspoonful of honey contains 100 calories each day.
    D. A good weight is the weight at which you look and feel your best.

24. All boys and girls need to eat exactly the same amount of food every day.
    A. No
    B. Yes
    C. This information isn’t in the passage
    D. Both A and B are correct

25. A teaspoonful of honey has:
    A. little calories
    B. a little calories
    C. more than 100 calories
    D. as much as 100 calories

UNIT 3

HOW TO BUILD A GREENHOUSE

READING

If you are concerned about protecting your plants from extreme conditions in the weather or just want to create a comfortable environment for your plants, then a having a greenhouse is important. Sometimes for financial reasons or if you are a do-it-yourself type person, building a greenhouse is a great option.

Consider using salvage materials if you intend to make a larger greenhouse. You can use these materials in designing and planning for a low cost budget greenhouse. This will also help minimize the expenses of the other supplies and materials needed.

Determine the climate of the place where you live. An insulated greenhouse should be appropriate for cold climate areas. This will help provide the needed warmth and heat for your plants. For warm places, a greenhouse that has a shade control is advisable.

Make sure that your greenhouse will be designed with proper air circulation spaces, ventilation, pest control soil, heaters for winter season, and humidity control devices. You can create an environment that would be appropriate for the types of plants that will grow in the greenhouse.

Locate in a sunny position. The location of the greenhouse should be built were there is enough sunlight. You may choose a solar greenhouse for vegetables and exotic fruit bearing plants if you want your greenhouse to be situated on the east-west part where it is more exposed to sunlight.

Consider the covering of the greenhouse. The most advisable shades are the expensive glass made coverings and fiberglass. They provide more durability and they do not deteriorate quickly compared to plastic coverings. A greenhouse covered with glass or fiberglass allows more humidity and warmth.

Choose what kind of foundation you would like to use. The foundations can be concrete for a more secured greenhouse. Others prefer the less expensive lightweight foundation where they use improvised materials such as railroad ties, which they can easily attach to the ground. It all depends on how much you are willing to spend on the structure of the greenhouse.

Consider building a greenhouse that will maximize its full potential. You can add benches or materials that will be used for comfort every time you want to relax in the greenhouse. You can add many accessories to the place like automatic watering systems, heating systems, ventilation system and other automatic equipments that are effective in maintaining the plants.

Use the “good bugs” for pest control chemical. They prevent and control the spread of the bad bugs in a greenhouse. If you ever find insects on a plant, you can isolate the plant and place the plant outside the greenhouse so that the insects would not harm the other plants.

Make a space where you can store fertilizers, potting soil and other tools that are essential in the greenhouse. You may place a tool rack nearer to the potting place so that it would be easier for you to transfer the soil from the pot of the plants. You can also place buckets and tool holders to accommodate the other equipment when they are not in use.

A. Decide if the following statements are true or false

1. To build a greenhouse is one of great option for financial reasons
2. In order to minimize the expenses of the other supplies and materials we should use salvage materials
3. A shade control is advisable in all kind of greenhouse
4. Different types of plants that grow in the greenhouse need different environment
5. The greenhouse must be designed with proper air circulation spaces only

B. Answer comprehension questions

1. Why should a greenhouse be located in a sunny position?
…………………………………………………………………………………………………
…………………………………………………………………………………………………
……………………………………………………………………………………..

2. Why must grower create an environment for greenhouse?
…………………………………………………………………………………………………
…………………………………………………………………………………………………
……………………………………………………………………………………...

3. What are the advantages of expensive glass coverings and fiberglass compared to plastic coverings?
…………………………………………………………………………………………………
…………………………………………………………………………………………………
……………………………………………………………………………….…

4. What should growers do to prevent insects on a plant in greenhouse?
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………….……………..

5. Where can we store fertilizers?
…………………………………………………………………………………………………
…………………………………………………………………………………………………
……………………………………………………………………………….

C. Fill in the blanks

Add words or phrases from the text to complete the argument which shows whether the comprehension check is TRUE or NOT TRUE. Note that a dotted line .... requires a phrase to be added, and a straight line______ requires a word to be added.

dressed	lightweight	differ
easy to construct	winter frosts	is ideal for using
rough sawn or rough timber	for the difference in	benefit
measurement	site	level or in a place

Description
This greenhouse is 2400mm wide x 3000mm long. It is __________, portable (can be fixed more permanently if required), inexpensive and ………………………. The cover is clear UV-resistant polythene film. This greenhouse ……………… in those areas with a tendency to suffer just enough ………………………. to be annoying.

Timber and timber size
The timber used in this project is 'sawn' also called ……………………….. That means that the timber has not been __________ (surfaced, planed or gauged). If you prefer to use dressed timber, then the sizes (width and thickness) of the timber will __________. For example; a piece of 75mm x50mm timber when dressed will end up being approximately 70mm x45mm. If you use dressed timber some __________ adjustments will need to be made to compensate …………… timber size.

Where to place the greenhouse
Pick a site likely to get the most __________ of winter sun. The __________ should not be in an area that could be boggy and should be ……………………… that is easy to make level. If the site is below a hill or slope, then it might be necessary to put in a drain (open, tile or scoria) to re-direct any water flow away from the greenhouse site.

C. Use of English

Match one word in box A with a word in box B to make word partnerships

A	B	A+B
comfortable	greenhouse	
financial	greenhouse	
salvage	site	

insulated	position	
solar	potential	
sunny	equipments	
full	materials	
greenhouse	frosts	
winter	reasons	
automatic	environment	
rough	level	
plastic	soil	
potting	timber	
tool	rack	
make	coverings	

D. Grammar

Advisability: Modals and expressions

An insulated greenhouse ***should***/ ***ought to*** be appropriate for cold climate areas
The location of the greenhouse ***should*** be built were there is enough sunlight.

Study the following rules

For general advice	You **ought to/ should/ shouldn't** build a greenhouse
For strong or urgent advice and warnings	You ***'d better see*** a doctor
For general belief according rules or laws	They are ***not supposed to*** judge on what you wear

Fill in each blank with an appropriate expression

Supposed to / start	**ought to / try**	**had better (not) / touch**
Should / do	**had better / see**	**(not) supposed to / park**

1. I feel tired all the time. What…………………..
2. Look at the "No Parking" sign. You………………………here
3. You………………………. to visit that new greenhouse. It's great
4. You………………………. the door of that greenhouse. It's going to fall down.
5. Where is everyone? The meeting ………………………..right now.
6. You've had a fever for a week. You…………………….a doctor!

Answer these questions

1. Which expression use "to"

2. Which expression doesn't use "to"

3. How is the native formed for each one?

Participating in discussions

Agreeing

You are right.
I really like the idea.

Disagreeing

(Sorry) I don't agree with you
I'm afraid I don't agree

Asking for an opinion

What do you think?
How do you feel about this?

Giving an opinion

I think……….
In my opinion……….

Making a suggestion

Let's……….
How about………….

Extra Reading Resources

Present and discuss as a group or class the content of the article below

1. http://www.ams.usda.gov/standards/

2. http://en.wikipedia.org/wiki/Solar_greenhouse_(technical)

Extra Challenge

1. Translate the text in Reading Comprehension into Vietnamese.

2. Write a reflection on what you have learned:

- What did you learn from it?
- What did you do well?
- What part of the unit you like best?
- What was difficult for you?
- How do you feel about your performance?
- What do you want to improve?

New words

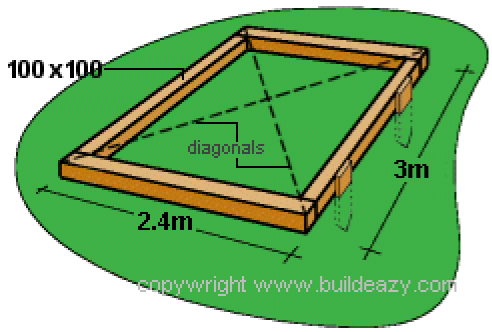
Students look up the following new words in the dictionary before going to class

Words and phrases	***Pronunciation***	***Notes of meaning***
financial reasons		
do-it-yourself		
salvage materials		
insulated greenhouse		
shade		
appropriate		
advisable		
ventilation		
exotic		
deteriorate		
foundation		
fiberglass		
ventilation		
to isolate		
accessories		
potting soil		
to accommodate		
solar greenhouse		
greenhouse site		
full potential		
insulated greenhouse		
automatic equipments		

HOMEWORK

Study the ideas for the following steps in building a greenhouse

- **STEP 1. The greenhouse base**



Once the level greenhouse site has been chosen, construct the base out of 100x100 treated sawn timber. This timber is readily available at any timber merchants and commonly used for fence posts. Standard lengths are 2400mm and 3000mm.

Make an oblong 3000mm x 2400mm as shown in the drawing above. Fix the timber together in the corners by using galvanized nails and nail plates.

Check that the two diagonal measurements are equal and if they are not, make any necessary adjustments. When the diagonals are equal, then the base is square.

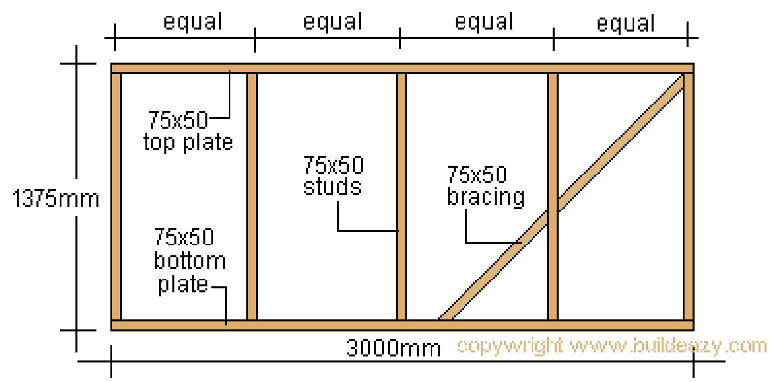
Check that the base is level, either by using a spirit level and a straight edge or by using the water level method

Secure the base in place by hammering pegs around the perimeter.

Nail the pegs to the base and cut flush any pegs protruding higher than the base timber.

- **STEP 2. The side walls**

Construct all the framing out of 75x50 treated sawn timber. This timber is readily available at any timber merchants and usually comes in lengths of 4800mm. It is commonly used for fence rails.

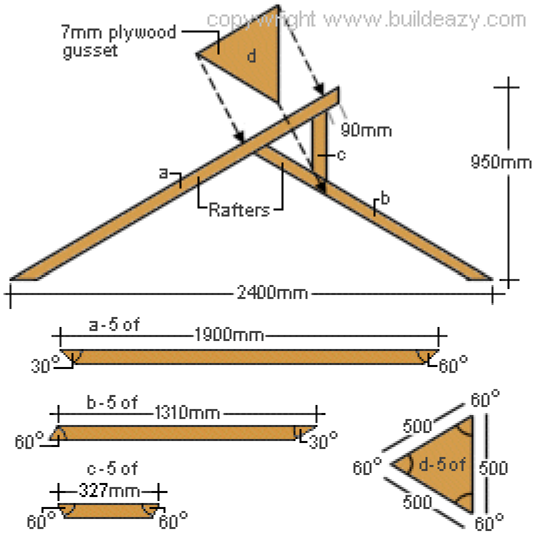


On a flat piece of ground, make two side wall frames as per dimensions shown in the drawing above.

Make the diagonal measurements equal (in the same way as with the base in Step 1) and when the walls are square, cut and fix the bracing members in place. (See above drawing.)

Stand the two side walls upright and temporarily prop up in place on top of the base. Fix the bottom plate of the side walls to the base boards with galvanized nails.

- **STEP 3. The roof frames**



Cut all roof frame pieces as per dimensions shown above. Use 75x50 treated sawn timber.

In total, cut 5 rafters @ 1900mm, 5 rafters @ 1310mm and 5 uprights @ 327mm, all with end angle cuts as shown in drawing.

Also cut five triangular gussets 500mmx500mmx500mm from a sheet of 7mm treated plywood.

Make up the five roof frames to the pattern and dimensions (as shown in the above drawing) on a flat piece of ground. Ensure the two furthest points are 2400mm apart and then nail the triangular gussets in place with galvanized flathead nails spaced about 50mm apart, one gusset to each roof frame.

Lift the 5 roof frames in place on top of the side walls: one roof frame to each end of the side walls and the other three spaced evenly in between. Fix the roof frames to the side wall top plate with galvanized nails.

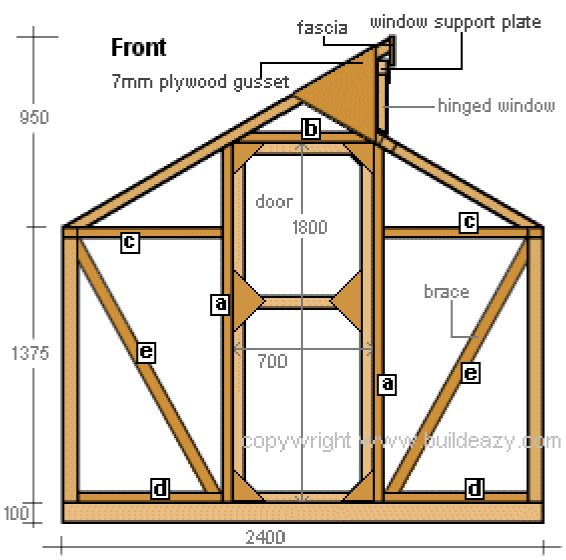
Temporarily prop the two end roof frames plumb (vertical).

Nail the fascia board (150x50 treated board) to the top of the roof frames as shown below, making sure all the roof frames are vertical and parallel with each other.

Fix the window support plate (75x50) in place under the roof frame apex and behind the fascia board, as shown in the drawing below.

Brace the roof on the side that has no windows. Nail metal strapping from the apex of both end roof frames down to the middle of the side wall top plate.

- **STEP 4. The end walls**



Ensure side walls are plumb (vertical).

For all wall framing use 75x50 treated sawn timber.

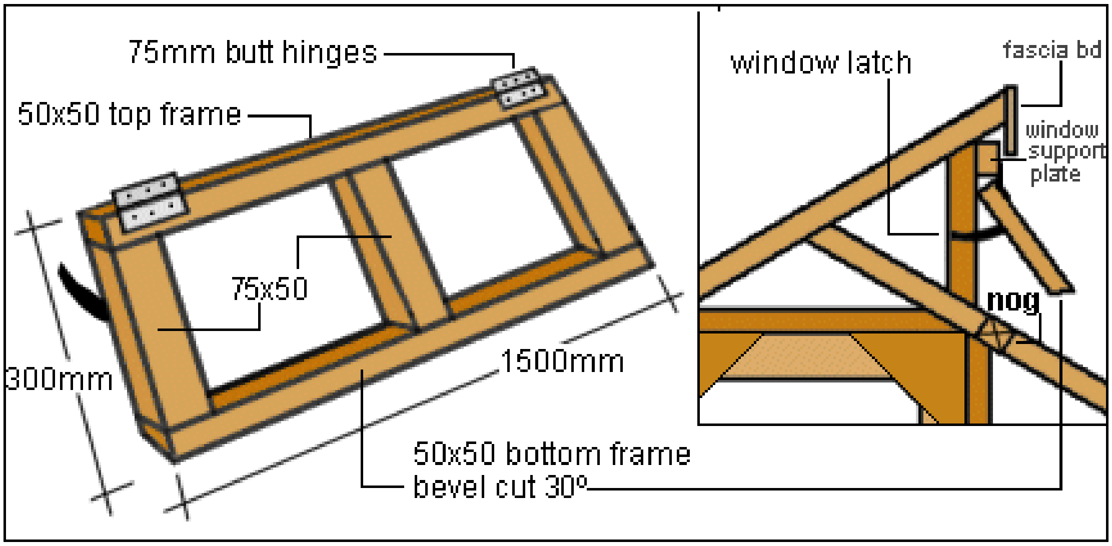
Cut studs (a) to size and fix in place. They should be 700mm apart to allow for the door.

Cut top plates (b) and (c) to size and fix in place.

Cut bottom plates (d) to size and fix in place.

Measure, cut and fix the bracing timbers (e) in place.

- **STEP 5. The windows**



For the windows use 50x50 treated sawn timber for the top and bottom frames and 75x50 treated timber for the side and middle mullions.

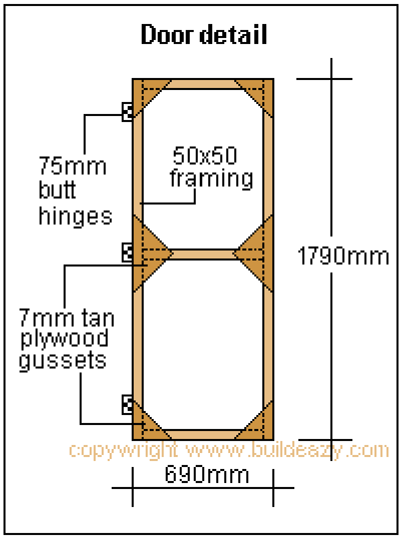
Angle cut the bottom of the window frame 30 degrees (the same pitch as the roof).

Make two windows as per dimensions above. Fix in place with two butt hinges on each window screwed to the top frames of the windows and the window support plate.

Fit a window latch to each window.

Measure, cut and fix a row of nogs (*blocking, short pieces of timber set between the rafters) below the window and in between the roof frames as per the above drawing.

- **STEP 6. The doors**



Construct the doors (2, one each end of the green house) as per above dimensions.

Use 50x50 treated timber for the frames and cut the gussets from 7mm treated plywood.

Make the door frames up on an even piece of ground. Ensure frames are square and then nail the gussets in place on both sides of the doors.
Hinge the doors in place and fit handles or pad bolts of your choice.

- **STEP 7. The greenhouse cover**

Cover the greenhouse with UV-resistant polythene.

Hold the coverings in place by laying thin battens over the polythene (when the polythene is taut) and nailing the battens to the greenhouse studs, roof rafters etc.

Cover the doors and windows also.

Most hardware merchants or garden suppliers only stock the standard plastic polythene that is not UV resistant but they should be able to advise you where to get the polythene required for the greenhouse covering.

UNIT 4

SITE SELECTION FOR GREENHOUSE

Several factors should be considered in selecting a suitable site. Whenever practical, the site should be level or nearly so. Sloped sites are not completely out of the question, but they do raise construction costs considerably because the site must be leveled or terraced to accommodate the new structure.

Zoning regulations must be checked to determine if a greenhouse is allowed at the chosen location. In this regard, care concerning waste disposal (irrigation water run off, etc.) should be considered.

The site should be near a power source and have a ready supply of usable water. Typically, water from a well is better than surface water because there is less likelihood of disease and algae contamination. Water is critically important in greenhouse production, especially if one of the various hydroponics systems, as outlined here, is used. The water used in the fertilizer solutions must be tested before beginning the crop cycle. In addition, the water may contain significant levels of dissolved minerals, particularly calcium and magnesium. City water systems may be troublesome for growers, especially if the water has been chlorinated. Chlorine can cause problems for plants, particularly lettuce.

Availability of labor is very important. Although much of the work in crop production is repetitive and tedious, one should not expect suitable labor performance at minimum wage levels. Labor that is conscientious and skilled, or at least trainable, is less expensive and more reliable in the long run.

Access to good roads and proximity to expected markets should also be considered. Modern refrigeration and transportation reduces the need to locate the facility near markets, but shipping costs are reduced when the facility is nearer the expected markets.

A. Answer comprehension questions

1. What factors should be considered in selecting a suitable site for a greenhouse?
…………………………………………………………………………………………
…………………………………………………………………………………………
………………………………………………………………………….

2. Why must Zoning regulations be checked?
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………...

3. Why is water critically important in greenhouse production?
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………..

4. Why is availability of labor very important too?
…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………….

5. Should growers consider market for greenhouse production? Why?
…………………………………………………………………………………………
…………………………………………………………………………………………
……………………………………………………………………….….

B. Use of English

Match one word in box A with a word in box B to make word partnerships

A	B	A+B
1. usable	A. location	
2. chosen	B. cycle	
3. power	C. costs	
4. crop	D. solutions	
5. fertilizer	E. systems	
6. construction	F. systems	
7. suitable	I. source	
8. expected	G. markets	
9. hydroponics	H. water	
10. water	K. site	

DISCUSSION POINTS

Students in a group of 5 discuss on the following topics:

- ***Practical site***
- ***Zoning regulations***
- ***Availability of labor***

GRAMMAR

Compound Sentences
Using although / though / even though

Remember this sentence

Although *much of the work in crop production is repetitive and tedious, one should not expect suitable labor performance at minimum wage levels.*
Although *there are thousands of cereal types, only a few are cultivated.*

This is an example of a compound sentence. This sentence could be written as two sentences using 'However,' to start the second sentence, like this:

There are thousands of cereal types. However, only a few are cultivated.

Compound sentences contain two verbs and sometimes two subjects. They express two ideas or points.

If we want to make a compound sentence, we use *but* or *although.*

- *although* is similar to *but*
- *although* can be used at the start of sentences or between phrases.
- *but* should not be used at the start of sentences.

Examples:

1. There are thousands of cereal types, but only a few are cultivated.
2. There are thousands of cereal types, although only a few are cultivated.
3. Although there are thousands of cereal types, only a few are cultivated.

Please note:

- the position of the comma (,)

- *Although* can be replaced with *though* or *even though*.

To illustrate, Example 2 can also be written as follows:

There are thousands of cereal types, **though** only a few are cultivated.

Telephoning: making contact

Making calls

Could I speak to………..

Yes, this is…………….

I'm calling about……….

Could you tell him/ her that I rang?

Could you ask him/ her to call me back?

Receiving calls

Who's calling, please?

Could you tell me what it's about?

I'll put you through

Can you hold?

I'm afraid there is no answer. Can I take a message?

Extra Reading Resources

Present and discuss as a group or class the content of the article below

1. http://www.ams.usda.gov/standards/
2. http://en.wikipedia.org/wiki/Solar_greenhouse_(technical)

Extra Challenge

1. Translate the text in Reading Comprehension into Vietnamese.
2. Write a reflection on what you have learned:

- What did you learn from it?
- What did you do well?
- What part of the unit you like best?
- What was difficult for you?
- How do you feel about your performance?
- What do you want to improve?

New words

Students look up the following new words in the dictionary before going to class

Words and phrases	***Pronunciation***	***Notes of meaning***
Sloped sites		
terraced		
accommodate		
zoning regulations		
contamination		
hydroponics		
repetitive		
tedious		
conscientious		
proximity		
dissolved minerals		
chlorinated		

HOMEWORK

PASSAGE 1: *Read the following passage and choose one best answer by writing the suitable letter A, B, C or D*

How to get accepted to Fullgate University

It is time to start applying for university. Some students will be successful, but others will not. If you have dreamed of being admitted to Fullgate University, this article can show you what to do to improve your chances of success. First, you must apply early. You must apply before the application deadline. This is, perhaps, the most important consideration. We receive a lot of applications from excellent students who we have to reject because they sent us their application far too late. Make sure to apply before January 17th. Fullgate University believes that after-school activities such as volunteer work, sports participation, and employment are very important. We look for any activities that help develop a student's character. Your grades are not the only aspect we consider. Finally, Fullgate University looks closely at letters of recommendation.

We require at least three letters of recommendation. These should be written by people such as your teachers, sports club coaches, employers and the leaders of any volunteer organizations you belong to. We suggest that you get these as soon as possible so you can submit them with your application.

1. Who would be interested in this information?

   A. High school students B. Fullgate University students
   C. Volunteers D. School teachers

2. What is the most important thing to consider?

   A. Volunteer work B. Sport participation
   C. The application deadline D. Employment

3. The word "deadline" in the passage refers to:

   A. January 17^{th} B. before January 17^{th}
   C. after January 17^{th} D. on any day

4. How many letters of recommendation does the university require?

   A. None B. Three C. Four D. Five

5. Which of the following is NOT mentioned as some one to write a letter of recommendation?

   A. Teacher B. Employer C. Sport coach D. Priest

SEMINAR

- ***Students are allowed to prepare topics at home two weeks before they present.***

- ***The topics are about the areas of greenhouse such as greenhouse vegetable production, how to build a greenhouse, site selection for greenhouse, the types, designs and construction of greenhouse The students may conduct a survey on any special related topics which they are interested in or they are persuaded to prepare an advertisement***
- ***Students prepare their ideas on power point slide.***

- ***Students are willing to present in front of the whole class for 15 minutes.***
- ***Other students listen and may ask any questions related to the presented topics, the presenter answer the questions. Incase the presenter can not answer, the whole class discuss. The teacher can give some ideas to help.***
- ***Students may prepare hand out materials to provide the other students and teacher right before they present.***
- ***Teacher gives remarks and mark on the presenting.***

UNIT 5

GREENHOUSE TYPES, DESIGNS AND CONSTRUCTION

Greenhouses can range from simple homemade designs to sophisticated prefabricated structures. Materials used to construct a greenhouse frame can be wood, PVC, aluminum or steel; coverings can be glass or various rigid or flexible plastic materials.

Greenhouse design can vary from stand-alone to gutter connected.

Several factors should be considered when choosing a particular greenhouse design, not the least of which are local building codes. Make sure all building codes are met and necessary permits secured before construction begins. Structural load from environmental forces as well as for trellises should be considered in the design. Sufficient heating and cooling capacity must be incorporated into the design to meet the crop's needs for the given geographic location. Because of the specialized nature of a greenhouse structure, obtaining a proven design before construction begins is advisable. In addition, an experienced designer and builder may be in order.
Several covers can be used with a greenhouse. The most widely used covering materials are ultraviolet (UV) light resistant polyethylene plastics. These covers are often installed two layers thick with an inflated air space between. This increases the cover's insulating capabilities while reducing the chances of a catastrophic loss because of wind-induced flexing. These materials are specially manufactured for the greenhouse industry. Common polyethylene plastic is not the same, because it has not been manufactured to withstand UV radiation.

Common polyethylene will not last a year; UV resistant polyethylene plastic is designed to last one to four years, depending on the grade. Many of these coverings have additives to reduce condensation in the house as well as to trap more infrared (heat) radiation.

Rigid plastic materials such as polycarbonate have advantages and disadvantages. The initial cost is higher than polyethylene but generally less than glass. Light transmittance is greater than polyethylene but, again, less than glass. Impact resistance is the best of any material available. Rigid plastic materials are available in different grades with guarantees ranging from five to 20 years. They are also available in single- (corrugated) or double-layer construction.

Glass is an excellent choice for high light transmission and longevity. Glass can last 25 years or more. Glass does have some disadvantages, such as high initial cost and low impact resistance.

A. Answer comprehension questions

1. What materials should be used to construct a greenhouse frame?
   …………………………………………………………………………………………
   …………………………………………………………………………………………
   ……………………………………………………………………………………
2. What factors should be considered when choosing a particular greenhouse design? Why?
   …………………………………………………………………………………………
   …………………………………………………………………………………………
   ………………………………………………………………………………………….
3. Why must sufficient heating and cooling capacity be incorporated into the greenhouse design?

   …………………………………………………………………………………………
   …………………………………………………………………………………………
   …………………………………………………………………………………
4. What covers can be used with a greenhouse?

   …………………………………………………………………………………………
   …………………………………………………………………………………………
   ……………………..…………………………………………………………………..
5. What are the advantages and disadvantages of rigid plastic materials?

   …………………………………………………………………………………………
   …………………………………………………………………………………………
   ………………………………………………………………………………………..

B. Fill in the blanks

Add words or phrases from the text to complete the argument which shows whether the comprehension check is TRUE or NOT TRUE. Note that a dotted line

.... requires a phrase to be added, and a straight line ______ requires a word to be added.

growing	specialized
production	In addition
growing agricultural industries	production costs on acres
are considerable	entering the greenhouse business
must have	often start as a single unit
experienced people function	decisions

Ornamental plant ______ is one of the fastest …………………. in West Virginia. It is a highly ______ and intensive form of agriculture. Unlike field or row crop agriculture, which bases …………………, greenhouse costs are calculated on a /per square foot of ______ area or per plant basis. ……………….., expenditures for greenhouse structures and plant material …………………….. These circumstances allow little room for error, so a great deal of planning is required before ……………………………. A person considering entering the greenhouse business ………………… a basic knowledge of propagation, plant nutrition, soil management, greenhouse structures, pest management, environmental control systems, marketing, employee relations and business management. Greenhouse operations ………………………….. operated by a family. With modest-sized operations, …………………… as "jack of all trades" while larger operations usually require a full-time and part-time staff. This fact sheet will explain the steps to follow and ______ to make before starting a greenhouse business.

Use of English

Match one word in box A with a word in box B to make word partnerships

A	B	A+B
homemade	industry	7
plastic	plastic	
building	business	
cooling	plastic	
greenhouse	codes	
greenhouse	capacity	
greenhouse	nutrition	
polyethylene	structure	
Rigid	designs	
plant	materials	

<u>Negotiating to reach agreement</u>

Here are some negotiating tips

- Be friendly

- ❖ Have clear aims
- ❖ Tell the other side what you want
- ❖ Listen carefully
- ❖ Pay attention to the other side's body language
- ❖ Don't change your plan during the meeting
- ❖ Never be the first to make an offer

Work in pairs then practice negotiating in order to:

State aims

I'd like to……

We must ……

Make concessions

If we have to…..…

That could be all right as long as we……

Reject suggestions

We'd prefer to…….

Focusing the discussion

Let's ……..

Extra Reading Resources

Present and discuss as a group or class the content of the article below

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Extra Challenge

1. Translate the text in Reading Comprehension into Vietnamese.
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- What did you learn from it?
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- What was difficult for you?
- How do you feel about your performance?
- What do you want to improve?

New words

Students look up the following new words in the dictionary before going to class

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sophisticated		
prefabricated		
permits		
trellises		
catastrophic		
catastrophic		
condensation		
transmittance		
longevity		
expenditures		
circumstances		
modest-sized		
rigid		

HOME WORK

Students read an extra reading text and get ready to present on:

1. The definition of solar greenhouse

2. The applications of solar greenhouse

Extra Reading text

Solar greenhouse

A **solar greenhouse** works by letting in solar radiation to warm the ground, with the structure then trapping the energy to increase and maintain the temperature at a higher level than it otherwise would be. Generally, a greenhouse blocks the heat inside from mixing with the air outside. See the articles on the greenhouse effect or Earth's atmosphere for more details.

The most basic aspects of greenhouse design are: first, to thermodynamically isolate the system to stop convection and conduction from equalizing the inside temperature with the outside temperature; and second, to provide a covering with a controlled difference between the transparency in the solar radiation band (280 nm to 2500 nm wavelengths) and the terrestrial thermal radiation band (5000 nm to 35000 nm), for the purpose of either raising or lowering the temperature inside the greenhouse. A greenhouse covering which is more transparent to the solar radiation band and less transparent to the thermal radiation band will result in a temperature higher than the surrounding environment, and a greenhouse covering which is more reflective of solar radiation and more transparent to thermal radiation will lower the temperature relative to the surrounding environment.

For the traditional case of a warming greenhouse, such as with a glass covering, a covering material is chosen which will absorb some of the outgoing IR and radiate a portion of it back into the greenhouse environment to reduce radioactive energy loss to the sky from the amount that the ambient environment experiences. The use of insulation and more infrared-absorbent glazing enhances the effect by reducing heat loss by conduction and IR radiation.

The soil mass at the base of the greenhouse acts to absorb a portion of the available heat during the solar period of the day for later use as a night time radiant heat source. Installations of subterranean air circulation tubing can be designed to enhance the soil mass heat absorption potential.

With proper subterranean design, underground air circulation tubing can absorb most of the daytime solar gain directly into this soil mass to provide air cooling, prevent overheating and serve as an additional heat source at night. Also the addition of heat storage materials with high heat capacity, such as containers of water or bins of sand and rock absorb heat energy during the day to help prevent greenhouse overheating, and release that energy to maintain the internal temperature during cooling periods, such as during the night.

Practical applications

The modern development of new plastic surfaces and glazing for greenhouses has permitted construction of greenhouses which selectively control the transmittance of both incoming solar radiation wavelengths and outgoing thermal IR wavelengths.

The new materials also provide insulation to reduce conductive loss through the glazing in order to better control the growing environment. The research starts with the blocking of convective heat loss as a given in an isolated system and works toward improving IR absorption and insulation to further reduce radioactive and conductive energy loss.

Gardeners sometimes use a "greenhouse-in-a-greenhouse" technique, in which they lay additional IR absorbent plastic sheeting inside a greenhouse in order to provide additional warmth in an isolated area to plants or water pipes.

Another practical application of the greenhouse effect is in the creation of solar cookers. The analysis here compares the thermodynamic properties of several solar cooker designs.

UNIT 6

PRODUCTION METHODS IN GREENHOUSE

Several different methods can be used to produce vegetables in a greenhouse. These include planting directly in the soil within the greenhouse, using containers with soil less mixes, nutrient film technique (NFT), rock wool production and production in partite. The last three techniques are called hydroponics production because all of the nutrients required by the plant are supplied in the irrigation water.

Soil System

Planting directly into the soil requires the least amount of initial labor. The big disadvantage is possible disease, insect and weeds problems that can be present in the soil. This problem can increase over time with successive cropping, particularly if the same crop is grown repeatedly. Fumigating the soil may minimize these problems. Care must be exercised when using a chemical fumigant in an enclosed structure; removing the greenhouse cover before fumigation may be advised.

Soil polarizations, in which the greenhouse structure itself acts as the polarizing unit, may control some problems with the soil system. This works best if the soil is turned and moistened during the hot summer months. The house is then closed for at least two weeks to reduce the number of soil borne pathogens.

Soil fertility should be determined and managed with soil testing. As with any field soil, the soil pH should be adjusted to 6.0 to 6.5. Soluble salts buildup can be particularly severe with the soil system. To minimize this problem, the house can be uncovered when not in production to allow rainfall to leach the soil. In addition, use fertilizers that do not contribute excess soluble salts. This would include calcium nitrate, potassium nitrate, triple super phosphate, dominium phosphate, potassium sulfate and sulphate of potash-magnesia.

Plants should be mulched to control weeds, retain soil moisture and prevent soil compaction. Plants can be set in plastic mulch, or organic mulches can be used.

Hydroponics Systems

In perlite bag culture, plants grow in polyethylene bags filled with perlite. Note the fertigation emitter at each plant.

The various methods of hydroponics production have become the facto standard for producing greenhouse vegetables. These methods are very clean, with no organic material present. In addition, they give the grower complete control over the crops' nutritional needs. This allows the grower to maximize growth and fruit production. The disadvantage of this method is that it requires calculating and measuring exact amounts of fertilizers. This usually means handling several different fertilizer compounds. Mistakes in calculations or quantities used are more likely to show up as deficiencies or toxicities in the crop than in other methods employed.

Plants can be grown in various media in these systems; all are essentially nutrient free. In one system called the nutrient film technique (NFT), plants are placed in a polyethylene tube that has slits cut in the plastic for the roots to be inserted. Nutrient solution is pumped through this tube, bathing the roots. The solution recalculates, and nutrients are added as depletion occurs. Other systems use rock wool as the supporting medium. More recently, polyethylene bags of perlite have been used as the supporting medium.

Regardless of the production system, most will require some type of automation to supply water. This is particularly important in any of the hydroponics systems.

A. Answer comprehension questions

1. What are different methods to produce vegetables in a greenhouse?

……………………………………………………………………………………………
……………………………………………………………………………………………
………………………………………………………………………………..

2. What should be done to reduce the disadvantages of planting directly into the soil?

……………………………………………………………………………………………
……………………………………………………………………………………………
………………………………………………………………………………..

3. Why should plants be mulched?

……………………………………………………………………………………………
……………………………………………………………………………………………
…………………………………………………………………………

4. How is soil fertility determined and managed?

……………………………………………………………………………………………
……………………………………………………………………………………………
………………………………………………………………………….

5. What are the advantages and disadvantages of methods of hydroponics production?

……………………………………………………………………………………………
……………………………………………………………………………………………
…………………………………………………………………………

B. Fill in the blanks

Add words or phrases from the text to complete the argument which shows whether the comprehension check is TRUE or NOT TRUE. Note that a dotted line .... requires a phrase to be added, and a straight line ______ requires a word to be added.

placed	liquid application	combinations of fertilizer
more	compared to	Large greenhouse operations
growers	refer to	mixed together in
production	essential nutrients	three primary macronutrients
require	in determining	how much of each

Soluble fertilizers for ……………. to greenhouse crops may be ______ in one of two broad categories; *commercial fertilizers* or *tank mixes*.

Commercially available, pre-mixed fertilizers are ………………. salts called *fertilizer carriers*. A portion of fertilizer carriers are ……………… for plant growth while the rest are non-nutritive. Commercial fertilizers used in greenhouse ______ come in a wide variety of formulations. Complete fertilizers contain the ………………………, nitrogen, phosphorus, and potassium in various proportions,

Tank mixes ……………… liquid fertilizers formulated by ______**growers** using individual fertilizer carriers packaged and purchased separately and …………………… a stock tank. ………………………. often find it ______ cost effective to mix their own liquid fertilizers ……………………… purchasing commercial fertilizers. Tank mixes have the added advantage of making possible a wider range of nutrient combinations and concentrations providing a great deal of flexibility in adjusting the nutrient status of crops. However, tank mixes ______ greater skill ………………….. which carriers to use and ……………………… to mix. Most tank mixes are formulated from two to eight individual carriers. Tank mixes may also include commercially-available, soluble micronutrient formulations.

In the greenhouse businesses, high-analysis fertilizer carriers are dissolved in water to make concentrated solutions which are diluted and applied to crops using a fertilizer injector or proportioned.

C. Use of English

Match one word in box A with a word in box B to make word partnerships

A	B	A+B
soil	needs	
weeds	salts	
chemical	testing	
soil	fumigant	
soil	mulches	
soluble	system	
organic	growth	
hydroponics	problems	
nutritional	production	
maximize	fertility	

Extra Reading Resources

Present and discuss as a group or class the content of the article below

1. http://www.ams.usda.gov/standards/
2. http://en.wikipedia.org/wiki/Solar_greenhouse_(technical)

Extra Challenge

1. Translate the text in Reading Comprehension into Vietnamese.
2. Write a reflection on what you have learned:

- What did you learn from it?

- What did you do well?
- What part of the unit you like best?
- What was difficult for you?
- How do you feel about your performance?
- What do you want to improve?

New words

Students look up the following new words in the dictionary before going to class

Words and phrases	***Pronunciation***	***Notes of meaning***
successive		
fumigating		
polarizations		
borne pathogens		
to leach		
excess		
soluble		
mulch		
retain		
calculating		
measuring		
deficiencies		
toxicities		
polyethylene		
slits		
depletion		
regardless		
automation		

Reference reading passages

CROP SELECTION

Several vegetables have been successfully produced in a greenhouse, including cucumbers, peppers, lettuce, herbs and, by far the most important, tomatoes. Each has different requirements for production.

Cucumbers

Cucumber varieties grown in greenhouses are known as European types. These special cucumbers are parthenocarpic; that is, they produce fruit without the need for pollinization. In fact, care should be taken to avoid pollinization by non-parthenocarpic cucumbers because this will result in bitter, misshapen fruit.

Cucumbers are a warm season crop; therefore, greenhouse temperatures should not be allowed to drop below 65°F. Seed germination can occur with media temperatures above 60°F, but optimal germination occurs at 85° to 95°F.

Typically, cucumbers will be germinated in flats of rock-wool or foam blocks, usually with a single seed per well to ensure plants can be transplanted with minimal root damage. Plants should be transplanted to final spacing in the greenhouse when they are large enough to handle without damage. They will usually be ready for transplanting in two to three weeks under optimal conditions.

Cucumbers are vining crops, so they are grown with a trellis system. As the plant is trained, all fruit below 24 to 30 inches are removed to maximize foliar growth.

Above this height, fruit are allowed to set. Several different trellis systems have been developed to produce greenhouse cucumbers. These systems, using either one or two wires strung approximately 8 feet above the crop, are referred to as single and V-cordon systems. Both single and double rows of plants can be used with the single cordon system. In either case, the plants are trained up a string to the suspended wire where the plant is draped over the wire. At this time, the plant may be pinched and two laterals allowed to grow down to the ground, or the primary stem may be allowed to continue growing to the ground. In either case, all other laterals are removed as they appear and at least one fruit is allowed to develop at each node. In the V-cordon system, two wires are suspended so that the plants can be alternately strung to one wire or the other. This results in a V-shaped system of plants growing to the respective wires. In all other ways they are treated the same as the single wire system in terms of pruning laterals and draping over the wire.

In addition, the in-row spacing will differ between the two systems. In the single cordon system, plants are spaced 12 to 18 inches apart. If a single wire with a double row is used, the plants are spaced 18 to 24 inches apart with 2 feet between the double rows. With the V-cordon system, the plants are spaced 12 inches apart with plants alternatively strung to one wire or the other.

Between-row spacing for the double-row single-wire system is 5 to 6 feet; for the single-row single-wire system, 4 to 5 feet. With the V-cordon system, between-row spacing is 5 feet.

Fruit matures continuously as the plants grow. Flower opening to harvestable fruit will take between 10 and 14 days. Therefore, harvesting is a continual process usually done three times a week. Harvested fruit must be protected from desiccation and bruising because the skin is rather tender and prone to water loss.

Greenhouse cucumbers are individually shrink-wrapped to restrict desiccation and extend shelf life. This is a labor-intensive process.

Peppers

Peppers require a long growing period to reach transplant size. This may be from 30 to 85 days depending on the time of year and greenhouse conditions.

Because of this, a fertility program should begin shortly after the plants have emerged and continue throughout the production cycle.

Optimal temperature for pepper seed germination is between 80° and 85°F. After germination, the greenhouse temperature should be lowered to about 75°F. A relative humidity of 75 percent is ideal for pepper growth. Higher humidity will encourage disease development.

After transplanting, greenhouse temperatures should be maintained above 60°F and below 100°F, with ideal growth between 70° and 85°F. Plants should be pruned to the two strongest stems, and these should be supported by tying to a wire suspended 8 feet above the plants. All lateral stems are removed for the first five to seven nodes above the ground. Above this, plants are allowed to branch from the two main stems. One to two fruit will set per node. Plants are often vibrated or trellis wires tapped to ensure proper pollination and fruit set.

Leafy Vegetables

The most important leafy vegetable grown under greenhouse conditions is lettuce. Many different types and varieties of lettuce can be grown under greenhouse conditions, including specialty types. Generally, the loose leaf, butter head and romaine or coos types are grown in greenhouses rather than the crisp head types.

Many varieties specifically developed for greenhouse production are available. A crop of lettuce can be produced from seed in about 35 to 45 days. Greenhouse lettuce is harvested earlier and thus is smaller than those grown in the field. Seed are germinated at 75°F and should emerge in two to three days. When seedlings are large enough to handle, they are transplanted to their final spacing based on the production system and lettuce type grown. In float systems, they may be moved twice after seeding to an initial spacing of 16 square inches per plant after 10 to 11 days and to 41 square inches per plant 21 days after seeding.

Tomatoes

Tomatoes selected for greenhouse production are indeterminate types. Indeterminate tomatoes continue to grow and set fruit throughout their life cycle. Varieties selected for greenhouse production fall into two broad categories: large beefsteak or slicing types and cluster or hand types. The larger types are harvested singly. The cluster or hand types are harvested in clusters of four to seven fruit and are sold with the cluster stem still attached.

Indeterminate tomatoes are trained up a string supported by an overhead wire. After the plants have reached the wire, some of the string must be unwound each week and the plants lowered and leaned. This results in plants 30 feet or longer.

Tomatoes can be seeded into various soilless mixes as well as into rock wool or foam cubes. The seed should be kept at 75° to 80°F during germination. Seedlings emerge in seven to 10 days. Plants for transplanting should be available in about three to four weeks after seeding. Make sure the medium the plants will be grown in is thoroughly moistened with water or dilute nutrient solution. If bags of perlite are used for production, they should be moistened as described above, and the irrigation emitters should be placed in each bag before slits are cut to allow excess solution to drain away. In general, for perlite bag culture or rock wool culture, plants are set 18 to 24 inches apart in the row with a between-row spacing of 4 to 5 feet. Plant spacing for tomatoes in the soil system should have a between-row spacing of 3 feet and an in-row spacing of 16 to 18 inches. Plant spacing can vary widely depending on individual preferences and needs. Indeterminate tomato varieties are trained to a single stem and supported by twine. Spacing will vary based on the system used.

Tomatoes are usually transplanted to their final spacing in the greenhouse in September for winter and spring production. High temperatures can be a problem at this time of year. The grower should try to keep temperatures at 80° to 85°F as much as possible. Using fans, cool pads and shading the house are all methods that can help reduce the temperature. The best yields for tomatoes occur with day temperatures of 80° to 85°F and night temperatures of 62° to 72°F.

Temperatures higher or lower than this range can result in fruit quality problems. High temperatures can result in flower abortion.

The indeterminate tomato varieties grown in greenhouse culture must be trellised and pruned on a regular basis. Over the 10 months the plants are in production, they will grow as long as 30 feet. Clearly, the greenhouse will not be able to accommodate the plants vertically. Therefore, the plants are trellised up a string to a cable suspended about 8 feet above, at which time the plants are lowered and leaned. Sufficient string is used with each plant so that the string can be unwound and extended as the plants are lowered and leaned. As the plants continue to grow, they are periodically lowered from the overhead cable and leaned. At the same time, more string is unwound to accommodate the growing plant.

The plants must be pruned and the fruit thinned throughout the crop cycle. As the plants grow up the string, lateral branches are removed from leaf axials while the main stem is allowed to continue to grow. Fruit must be thinned as they form in the flower clusters. The variety will determine how many fruit should be left at each flower cluster. Hand or cluster tomatoes can support more fruit in a cluster than larger types, which may only support three to five fruit per cluster.

The flowers must be vibrated or shaken in order to ensure pollination. This can be done with an electric tomato pollinator, an old electric toothbrush, a modified door bell motor or a small lawn blower. The flowers must be vibrated or shaken each day that flowers are produced. The best time to do this necessary operation is between 10 a.m. and 3 p.m. During overcast or rainy days, pollen will not be dry enough to adequately pollinate the crop; therefore, plants must be shaken during sunny, dry days.

Bumblebees are also available to handle pollination. These small hives can be purchased commercially and placed in the greenhouse. These hives will last from eight to 12 weeks. Bumblebees tend to be more efficient at pollinating flowers, but less aggressive, than honeybees.

Fertilization

Figure 4. Dual tanks and injectors ensure that chemicals will stay concentrated in the solution.

The solution pH is critically important when growing plants hydroponically. The nutrient solution has no buffering capacity like that in solid media. This means that pH can readily change during the production cycle and must be monitored and adjusted to 5.5 to 6.5.

Most hydroponic production systems require the use of two stock solutions. This is done to avoid precipitates that can occur if all the nutrients are mixed in a concentrated form in a single stock tank. Mixing calcium nitrate with phosphorus materials can result in insoluble calcium phosphate. In addition, calcium sulfate can precipitate when calcium nitrate is mixed with magnesium sulfate. To avoid these problems, one stock solution is prepared with calcium nitrate and iron chelate. The remaining materials are mixed in a second stock solution.

Nutrient requirements are listed in parts per million (ppm) as shown in for various stages of greenhouse tomato growth. Any combination of chemicals that meets these requirements is acceptable, including prepackaged materials. Growers may find that purchasing stock chemicals rather than prepackaged materials is cheaper. Once they feel comfortable mixing these materials, they will have the added benefit of allowing more fine tuning of plant nutrient needs.

Insect and Disease Control

Figure 5. *Fine mesh screening over all openings prevents insect entry.*

Modern greenhouse design has tried to minimize or eliminate insect and disease problems so that plants can be grown pesticide free under many conditions. Some of the innovations have included using ultra-fine screening over all openings to prevent insects, including thrips, from entering the house.

Building a vestibule at all entrances is also helpful in preventing insects from entering the greenhouse.

Figure 6. *Vestibules at all entries help prevent insect entry.*

Preventing insects from entering the house is the best way of controlling insect problems. Plants should, however, be inspected daily for insect infestations. If pesticides are to be used, care must be exercised in selecting materials. Products that are registered for field use may not be registered for greenhouse use. In addition, caution should be exercised when applying pesticides because certain materials, such as emulsifiable concentrates, can cause plant damage under greenhouse conditions.

Moving fan jets to ground level and automating the watering and fertilizing process have eliminated free water on plant surfaces, which reduces disease incidence.

The use of disease resistant varieties when available have also helped reduce disease problems. As mentioned above, care should be exercised when selecting products for disease control in greenhouses. For more information on insect and disease control under greenhouse conditions, contact your local county Extension office.

Harvesting and Handling

Harvesting of tomato, pepper and cucumber will be a continual process throughout the growing cycle. All of the lettuce, on the other hand, will be ready at the same time after seeding. Tomatoes and peppers are harvested with stems attached and are packed that way to avoid bruising and damage. Care should be taken so that tomatoes are not stored or transported with other vegetables such as peppers, lettuce or cucumbers. Tomatoes produce ethylene during the ripening process that can damage other vegetables.

Harvest should occur during the cooler part of the day, and the vegetables should be protected from heat. Harvested material should be precooked as soon as possible if this is part of the post harvest procedure.

Greenhouse Production

Ornamental plant production is one of the fastest growing agricultural industries in West Virginia. It is a highly specialized and intensive form of agriculture. Unlike field or row crop agriculture, which bases production costs on acres, greenhouse costs are calculated on a /per square foot of growing area or per plant basis. In addition, expenditures for greenhouse structures and plant material are considerable. These circumstances allow little room for error, so a great deal of planning is required before entering the greenhouse business. A person considering entering the greenhouse business must have a basic knowledge of propagation, plant nutrition, soil management, greenhouse structures, pest management, environmental control systems, marketing, employee relations and business management. Greenhouse operations often start as a single unit operated by a family. With modest-sized operations, experienced people function as "jack of all trades" while larger operations usually require a full-time and part-time staff. This fact sheet will explain the steps to follow and decisions to make before starting a greenhouse business.

Selecting a Crop

Determine the market potential for a crop before you grow it. Every grower should conduct a market analysis to determine what specific crops, product sizes and quantities are in demand.

Wholesale or Retail?

The crops grown are principally a function of the type of operation in which they are sold. Wholesale operations might produce both cell-pack bedding plants and seasonal pot plants. Retail operations in urban markets may find a stronger market for larger bedding plants and a wide selection of flowering plants. For example, fall sales of large chrysanthemums in 3-gallon and larger containers may appeal to individuals who want "instant landscapes."

To determine which crops have excellent market potential, visit florists and garden centers both in your area and neighboring states. Local landscapers and professional gardeners also can provide insight into new crops.

Cut flower consumption is high, but the majority of greenhouse operators produce potted and bedding plants. Although the information here focuses on potted and bedding plant production, the information presented is applicable to cut flowers as well.

Selecting the Marketing Channel

Choosing the type of crops you will produce will help establish the marketing channels. The primary marketing channels are wholesale and retail.

Wholesale Growers

Wholesale growers produce a diverse group of plant material for use by vegetable growers, landscapers or for resale by florists or garden centers. Wholesale growers produce plants for daily, seasonal or contract sales. If there are a number of local florists and garden centers that need products in your potential trade area, then a wholesale growing operation should be investigated.

Wholesale-daily sales

For successful daily sales, growers produce at least five different crops simultaneously. Growers produce different species and cultivars in order to have for sale up to 15 different items. In addition to the blooming material, growers purchase foliage plants from growers in Florida for resale.

Wholesale-seasonal sales

Many plants are associated with specific holidays or seasons. The wholesale-seasonal grower will produce a variety of plants but will specialize in the one or two most popular crops sold at a holiday. Wholesale-seasonal growers usually sell directly to one or more major buyers. To increase the amount and price range of offerings, growers produce and sell a diversity of sizes and cultivars. For example, a grower may offer white, pink or red poinsettias in sizes ranging from 1 bloom in a 4-inch pot up to 25 blooms in an 8-inch pot. Growers will produce poinsettias for sale as early as November 15.

Wholesale-contract sales

If there is a landscape maintenance or vegetable industry near the site you are considering, then contract growing is a possibility. Contract growers produce specific crops under contract for one or more customers. For example, bedding plants grown for landscapers consist of specific cultivars based on the landscaper's need to quickly fill a planting area with plants in full color. Landscapers may replant a given area three or more times a year with seasonal plants. In addition, the constant replacement of damaged plants by landscapers requires the contract grower to have replacement plants available at all times. To provide for replacement plants, contract growers must plant continuously April through October. Initial plants are grown in 3-inch pots, but by late summer only 6-inch pots are in production.

Vegetable transplant producers grow specific vegetable varieties based on the requirements of farmers who have placed orders. Some producers grow one crop and then shut down the greenhouse for the rest of the season, while others produce an additional crop of bedding plants to better utilize their greenhouse. Seeds are sown based on the farmers' anticipated dates of planting into fields.

The market for contract growing fluctuates. It is not uncommon for a grower to discard large portions of a crop during the season because markets did not materialize. Although the demand for products may vary, prompt servicing of the landscaper's and farmer's needs is the cornerstone of a successful business relationship.

Retail Growers

Retail growers produce crops to sell through their retail operation. A retail grower's crops may include some of the crops that a wholesale-daily sales operation produces. The exact product mix depends on the retail outlet. For instance, a retail grower with a garden center may produce crops for sale from mid-March through October. In contrast, a retail florist may produce crops for sale year-round with the majority of the production between January and June.

To increase the number of crops that can be grown in a single year and decrease the amount of time the crop is in the greenhouse, retail growers often purchase prefinished crops, which they grow on a flower. For example, a grower may receive prefinished poinsettias in the first week of October and then grow them for 10 weeks until they flower. Traditional wholesale growers would have the same crop in their greenhouse for more than 17 weeks. Another strategy that works for retail growers is to produce crops that are not available from wholesalers during peak market periods. During the spring, garden centers may have trouble purchasing high-quality flowering baskets, geraniums, impatiens and begonias from wholesalers. Some retail growers produce only those crops that are in short supply and purchase the remainder of the products they need from local suppliers.

Whether to undertake a retail operation depends mainly on two factors. The first is simply the grower's interest in retailing--many do not want to deal with consumers on a daily basis. The second factor is zoning restrictions, which prohibit many growers from conducting full-service retail operations on their property. Check with the appropriate county zoning office before beginning retail sales.

Specialize or Generalize?

Both wholesale and retail growers must decide whether to specialize or generalize their crops. Specialty growers improve their capability of efficiently producing a top-quality crop. When growers are able to reduce costs and improve quality through specialization, their products are more competitive than plant material imported from outside the region. A common error new growers make is trying to diversify when they are still too small to service any one market. When small growers devote a major portion of their production area to one crop, they are able to improve their production program and become well known in the marketplace. The best advice is to first determine your options and then decide which option will become profitable most rapidly.

KEEPING CROP RECORDS FOR SOLVING GREENHOUSE PROBLEMS

In the greenhouse industry, growers are dealing primarily with a product that is a living organism. Like all living organisms, the growth and development of plants are subject to a multitude of factors in the environment which may modify the duration and magnitude of growth. Some of the factors imposed by the greenhouse environment may be a natural response to light, temperature, photoperiod, water, and nutrition. Others may not normally be encountered in the natural environment such as applications of pesticides and plant growth retardants. However, plants react to these factors to varying degrees, and the total effect governs final crop quality.

Greenhouse crop production is composed of a series of procedural steps that when carried out with an acceptable degree of precision and timeliness are designed to control plant growth in a way that results in a crop with the characteristics we perceive as quality. These procedural steps, often referred to as "cultural practices", have been developed over time based on scientific research, experience, and trial-and-error. However, when cultural practices are not followed with the precision required or when outside or unexpected factors intervene, problems can arise which may reduce crop quality or modify crop timing.

Because a multitude of factors may interact when a crop either turns out correctly or is less than expected, the grower is often left perplexed concerning what was done right or wrong. The goal should be to identify and *repeat* those cultural practices that resulted in an above average crop or identify and *correct* those practices which resulted in a substandard crop. With all the different crops and production times a grower faces, it's no wonder that one individual cannot remember all the details necessary to identify those factors involved in success or failure.

One useful planning and problem-solving tool that growers often overlook or may consider too much effort is to develop a system of crop record-keeping. A well-designed record-keeping system can provide meaningful clues when things go right or wrong and provide a temporal history for crop scheduling. These records may be as simple as a crop diary in a notebook, a structured form with fields to fill-in, or as sophisticated as a computer database. Some growers prefer to keep records outside the greenhouse in a notebook or filing cabinet while others use large plastic cards or labels that follow a crop through the greenhouse from planting to finish. Each system has its advantages and disadvantages. For example, it's easy to forget to record important items if records are far away in an office. Records that follow a crop in the greenhouse are readily available when a task is completed. However, records that follow a crop are easily lost when a crop is moved and must be gathered-up and filed when the crop is ready for shipping. In addition, records kept in the greenhouse must be water-proof in one way or another.

Whatever the medium chosen for crop record-keeping, the information chosen to be recorded should have some future value as a "check" for standard cultural practice, as a reminder of unexpected events that may re-occur, and as a timetable for the progress of a particular crop at a certain time of the year and greenhouse location. It is easy to say, simply record everything you do to a crop with the date, but this information is more useful in a form that is easily collated and understood. Forms can be developed for each crop species which might start with the crop schedule and contain fields for pertinent information such as fertilizer rates, growth retardant, and pesticide applications. Certain kinds of information may be more easily visualized in graphical form, such as substrate soluble salts and pH readings during the crop. Finishing times for crops that are influenced by the time of year and are grown over consecutive periods, such as many bedding plants in the spring, may be collated in graphical form as a future scheduling tool.

The generic form provided below illustrates some of the information that may be important to record for greenhouse crops. This form is not intended for a particular crop, and would require modification for a specific crop and situation. The form is also probably not all-inclusive. However, four groups of information may be identified:

Section 1: Information in this section identifies the crop and location. The information on location would require extending if the crop is to be moved to different greenhouses during production. A crop identification number may be assigned if an inventory system is used.

Section 2: This section outlines the crop schedule and provides entries for actual completion of key production steps. The number and types of steps would vary depending on the crop. Counts of "quantity sold" and "dumpage" are important to determine the profitability of the crop. Information from this section can be collated to provide actual production times.

Section 3: Information in this section could be highly variable, but is intended to provide a check for cultural procedures and as a diagnostic tool should something go wrong. Entries in this section might include growing substrates, fertilizer regimes, photoperiod manipulation, set-point temperatures, growth retardant, and pesticide applications. In addition, entries might be provided to record light and temperature conditions for growth retardant and pesticide applications.

Section 4: This is a general comment section to record important, and maybe unexpected events not covered by the other sections. Some indication of final crop quality might be appropriate here.

In addition to a general form for specific crops, separate records for several "mixing" procedures can be useful as a problem diagnostic tool and as a check for standard practices. These might include records of fertilizer concentrate mixing, substrate mixing, and growth retardant and pesticide mixing and application. These are especially appropriate where an individual other than the grower in charge of the crop performs the tasks.

Records of plant height during the crop can be very helpful for those crops in which height is a major quality concern such as Poinsettias and Easter Lilies. The average of height measurements from a representative sample of plants each week can be graphed over time, and several years of data can be used to predict where crop height should be for the current crop. Growers practicing graphical tracking use this kind of data to adjust crop height using temperature and growth retardants.

Photographs are another kind of useful record especially for crops targeted for specific holidays such as Poinsettias and Easter Lilies. These crops generally must reach certain stages of development with respect to the target sales date in order to finish on time. Weekly photographs of a representative plant from crops over several years can help the grower judge if a current crop is progressing on schedule or if corrective action should be taken. Some indication of relative size should be considered such as a ruler in each photograph or standardizing the distance between plant and camera.

Reviewing the suggestions outline above, it would seem that crop record-keeping requires some time. However, the payoff is long-term improvement in growing precision and crop quality.

Dealing with the Heat in Southern Greenhouse

By definition and design, the purpose of a greenhouse is to capture solar radiation and provide an optimum environment for the rapid growth of plants. However in the south, greenhouse temperatures during the summer often soar to levels that can limit plant growth. Some of the detrimental effects of high temperatures include reduced stem strength, reduced flower size, reduced leaf size, delayed flowering, flower bud abortion, and reduced growth rate. Greenhouses heat up during the day because of the greenhouse effect, and because a greenhouse is an enclosed space. How much heat builds up during high-light periods depends on how much solar radiant energy is transmitted through the glazing, how that energy is distributed, and how much is retained within the structure.

Solar energy striking the glazing material of a greenhouse can either be reflected, absorbed, or transmitted into the interior. Much of the sunlight striking a greenhouse is transmitted into the interior as shortwave radiation. When this shortwave radiation enters the greenhouse, some is reflected from various surfaces and passes out of the greenhouse, some is absorber by plants, soil, benches, walks, etc. and converted to latent heat, and the rest is absorbed and re-emitted as long wave radiation. When objects absorb radiation, some of the energy is lost as latent heat. The rest is re-emitted as longer wave radiation, mostly infrared. Water in the greenhouse atmosphere absorbs the infrared radiation and converts most of it to latent heat. In addition, glass is transparent to shortwave radiation but opaque to long wave radiation so a lot of the energy of sunlight is trapped in a greenhouse as heat.

Traditionally, excess heat was removed from the greenhouse using passive ventilation. Air in the greenhouse is generally warmer than that outside, so when top vents are opened, the warmer air rises and escapes pulling cooler air from the outside in through side vents establishing a circulating air pattern. Whether vent control is automated or manual, the circulation principle remains the same. Passive ventilation, often viewed as old fashion, has recently undergone a revival in the form of innovative greenhouse designs incorporating hinged roof panels, roll-up sides, and new vent designs. Saw-tooth style greenhouses are gaining popularity in the south because the design is applicable to natural ventilation.

Properly designed forced air ventilation increases the efficiency of excess heat removal from a greenhouse compared to passive ventilation by using mechanical (exhaust) fans to create a negative pressure within the structure. Cooler air from outside then rushes in through side vents to fill the void. Maximum cooling efficacy from forced air systems is usually achieved using one greenhouse volume, air exchange per minute to a height of eight feet. Several design criteria must be considered to achieve maximum efficiency including fan capacity and location and vent opening size.

Fan-and-pad evaporative cooling combines forced air ventilation with the ability of evaporating water to remove heat from the greenhouse. Water absorbs a relative large amount of heat when moving from a liquid state to a gaseous state. The most widely used evaporative cooling system in greenhouses consists of exhaust fans along one wall and cross-fluted cellulose pads along the other wall. Warm air from outside is drawn through the pads by the exhaust fans. The pads are kept constantly wet, and through the process of evaporation, heat is removed from the air passing through the pads into the greenhouse.

More recently, systems utilizing fog evaporative cooling have been developed that operate on the same principle as fan-and-pad systems, but is implemented in a different way. A high-pressure pump delivers water into the greenhouse through overhead water lines. Specially designed fog nozzles generate fog containing water droplets with a size of less than ten microns when the system is activated. These droplets are so small, they stay suspended in the air and evaporate quickly. A properly designed and controlled system generates fog overhead and cools the greenhouse while people and plants below remain dry. This system is especially useful for seed germination and cutting propagation areas where high rates of air exchange from exhaust fans are undesirable.

The application of liquid shading compound or shade cloth to the outside of the greenhouse structure helps reduce the greenhouse heat load in summer by decreasing the amount of solar energy entering through the glazing. A 50% reduction in solar radiation lowers the average inside temperature be at least 6F making other types of cooling systems more efficient. Crop growth is often less affected than might be expected by a 40-60% shade during the summer because even though the light intensity is reduced, the total amount of energy received throughout the day may be large due to longer day lengths. One problem with fixed shading is that light intensities are often reduced to undesirable levels during cloudy days and at the beginning and end of the day. Several greenhouse product suppliers and individual growers have developed automatic shading systems that pull shade cloth over the plants inside the greenhouse. These systems can be adjusted to provide more light during cloudy periods and reduce the light intensity to reduce heat load during bright periods.

Aside from mechanical cooling systems, several steps can be taken by the greenhouse operator on a day-by-day basis to reduce the effects of high summer temperature on plant growth. One of these is to syringe areas of the greenhouse, either manually with a hose or with installed mist nozzles, to take advantage of heat removal when water evaporates. Areas to syringe might include walks, paths, sidewalls, under benches, and empty bench tops. The foliage of many plants can also be syringed as long as disease physiological problems will not occur.

Part of the problem with high temperatures on plants is the drying effect of low humidity. Therefore, another way to diminish the effects of high temperature is to fill the greenhouse as full as possible so that plants create their own humid surrounds. If an area of a greenhouse must be open, group all plants close together and syringe the open areas.

Combining where possible the aforementioned methods for reducing high greenhouse temperatures should provide growers some tools and strategies for dealing with summer heat in the south. A conscious effort should be made to keep track off weather forecasts to anticipate when hot conditions will occur. Steps can then be taken, beginning early in the days, to reduce and prevent heat accumulation within the greenhouse.

Greenhouse Fertilizer Calculations

Soluble fertilizers for liquid application to greenhouse crops may be placed in one of two broad categories; *commercial fertilizers* or *tank mixes*.

Commercially available, pre-mixed fertilizers are combinations of fertilizer salts called *fertilizer carriers*. A portion of fertilizer carriers are essential nutrients for plant growth while the rest are non-nutritive. Commercial fertilizers used in greenhouse production come in a wide variety of formulations. Complete fertilizers contain the three primary macronutrients, nitrogen, phosphorus, and potassium in various proportions, e.g. 20-10-20. Fertilizer packages are labeled with three numbers. The first indicates the percent actual nitrogen (N), the second, the oxide form of phosphorus (P_2O_5), and the third, the oxide form of potassium (K_2O). Other commercial fertilizer formulations may be absent one of the three primary macronutrients, most commonly phosphorus, e.g. 15-0-15. Micronutrients may or may not be included as part of commercial fertilizers.

Tank mixes refer to liquid fertilizers formulated by growers using individual fertilizer carriers packaged and purchased separately and mixed together in a stock tank. Large greenhouse operations often find it more cost effective to mix their own liquid fertilizers compared to purchasing commercial fertilizers. Tank mixes have the added advantage of making possible a wider range of nutrient combinations and concentrations providing a great deal of flexibility in adjusting the nutrient status of crops. However, tank mixes require greater skill in determining which carriers to use and how much of each to mix. Most tank mixes are formulated from two to eight individual carriers.Tank mixes may also include commercially-available, soluble micronutrient formulations.

In the greenhouse businesses, high-analysis fertilizer carriers are dissolved in water to make concentrated solutions which are diluted and applied to crops using a fertilizer injector or proportioner. These machines siphon the concentrated fertilizer solution from a stock tank and injects the solution into the greenhouse water line at the final concentration desired for crop application. The injector delivers the fertilizer concentrate into the water line at a preset, injection ratio. The injection ratio varies depending on the manufacturer, the capacity of the injector, and the setting for a particular unit. An injection ratio of 1:100 means that one gallon of fertilizer concentrate is injected into every 100 gallons of water passing through the water line.

The dilute fertilizer in the water line is then delivered to the crops using manual or automatic irrigation systems.

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