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КАФЕДРА ИНОСТРАННЫХ ЯЗЫКОВ

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АНГЛИЙСКИЙ ЯЗЫК ДЛЯ АУДИТОРНЫХ ЗАНЯТИЙ И САМОСТОЯТЕЛЬНОЙ РАБОТЫ СТУДЕНТОВ НАПРАВЛЕНИЯ ПОДГОТОВКИ

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Пособие предназначено для обучающихся по направлению подготовки 35.04.04, изучающих дисциплину «Английский язык». Основной целью пособия является приобретение коммуникативной компетенции, необходимой для квалифицированной информационной и творческой деятельности в различных сферах и ситуациях делового партнерства, совместной производственной и научной работы.

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ВВЕДЕНИЕ

Основной целью обучения в магистратуре является приобретение коммуникативной компетенции, необходимой для квалифицированной информационной и творческой деятельности в различных сферах и ситуациях делового партнерства, совместной производственной и научной работы. Обязательным условием достижения поставленной цели является решение следующих задач

- достижение зрелого владения всеми видами чтения и перевода литературы разных функциональных стилей.
- овладение всеми видами монологического высказывания (информирование, пояснение, уточнение, инструктирование и иллюстрирование высказывания, а также умение сделать доклад на иностранном языке).
- осуществление и понимание высказываний профессионального и научного характера в ситуациях приема зарубежных специалистов, обмена профессионально-значимой информацией в процессе повседневных бесед, деловых переговоров, при заключении сделок и контактов, обсуждении условий делового партнерства.

Предлагаемое учебное пособие построено с учетом преемственности обучения и состоит из самостоятельных блоков (Units). Цель каждого блока - развитие умения чтения и адекватного перевода текстов по направлению подготовки и написания тезисов, докладов, рефератов и аннотаций. Работа с данным пособием способствует формированию у обучающихся следующих компетенций: ОК-1, ОК-3, ОПК-1.

Учебные тексты служат для первичного введения языковых явлений и иллюстрацией их употребления в иноязычной речи. При подборе текстов учитывалась их актуальность, информативность, частотность представленной в них лексики и уровень языковой подготовки студентов.

Перед каждым текстом даётся подробный список лексики, предназначенный для активного изучения и закрепления в ходе выполнения послетекстовых упражнений. Упражнения направлены на активизацию лексического материала и развитие навыков устной речи.

Грамматический материал охватывает основные явления грамматики английского языка и направлен на закрепление знаний, полученных на бакалаврском уровне подготовки.

PART 1. Unit 1
EDUCATION IN MODERN SOCIETY. HIGHER EDUCATION

1. Read and translate the text:

Text 1. HIGHER EDUCATION IN RUSSIA

learning materials — учебные материалы
to bring up to date — довести до современных требований
information explosion — информационный взрыв
training and instruction — подготовка и обучение
over years — за многие годы
curricula are enriched and broadened — программы (курсы обучения) обогащаются и расширяются

Higher education plays an important part in the life of any country as it provides the country with highly-qualified specialists for future development and progress. It trains people to become teachers, engineers, doctors and other professional workers.

In all the industrial countries standards of living are steadily changing; this means that the kind of education, which was good enough thirty years ago, is not necessarily good for them today. The serious need to find ways and means of ensuring continuous and thorough adoption of the universities to contemporary needs in our rapidly changing world is widely recognized. And this means that styles of teaching, quality of learning materials and organization of the university itself have to be continuously brought up to date and improved.

Besides, knowledge and information which comes through the mass media must also be taken into consideration. This information explosion has affected every field of study, especially, of course, in the natural and applied sciences and in all other sciences as well. The increase of information requires new methods and new approaches to students' training and instruction.

At present a new system of education is introduced in this country — a distance education system. This computer system of learning helps working professionals to continue their education while remaining at their jobs. This system enables people to get knowledge and a good foundation in the sciences basic to his or her field of study. Distance learning has developed over years from satellite video courses to modern videoconferencing through personal computers.

The academic year usually lasts 9 months and is divided into two terms (semesters). The first- and second-year students obtain thorough instructions in the fundamental sciences of mathematics, physics, chemistry and drawing as well as computer engineering and a number of others. The curricula are enriched and broadened by instructions in such subjects as foreign languages, history and economics.

At the third year students get more advanced knowledge and begin to concentrate on their special interests, so to say, their «major» subject and take many courses in this subject. Specialized study and courses will help students to become specialists and prepare them for their future work.

After four years students will get a bachelor's degree. Then the students may go on with their studies and in a year or two of further study and research get a master's degree. After graduating from the university they may go on with their study and research and may get a still higher degree.

About 75 percent of students receive state grants and 15 percent are sponsored by enterprises. Universities have their own students' hostels and some of them have large and excellent sport centers.

Education is a process through which culture is preserved, knowledge and skills are developed, values are formed, and information is exchanged. Education is the way to success.

2. Practice the pronunciation of the following words:

Highly-qualified, steadily, ensuring, thorough, adoption, contemporary, instructions, science, curricula, preserve.

3. Answer the questions:

1. When does the academic year begin in this country? 2. How many exams did you pass to enter the University? 3. Do you pay for your education? 4. Do students get grants? 5. What subjects do students study in the first year? 6. Which subject is the most interesting for you? 7. Is there a sport center in your University? 8. What degree do students get after four years of study? 9. What degree can a student get after two years of further study and research? 10. What new education system is introduced in this country? 11. What specialties do people get after graduating from a university? 12. Why is higher education important in the life of every country?

4. Use Active and Passive Voice.

1. Students asked the lecturer many questions. The lecturer was asked many questions. 2. The monitor told the first-year students to come to the laboratory. The first-year students were told to come to the laboratory. 3. Usually a lab assistant shows the equipment to the students. Usually the equipment is shown to the students by a lab assistant. Usually students are shown the equipment by a lab assistant. 4. Students watched the process with great attention. The process was watched with great attention. 5. Tomorrow our teacher will give us a new task. A new task will be given tomorrow. We shall

be given a new task tomorrow. 6. Practice accompanies theory. Theory is accompanied by practice. 7. He asked me to bring a dictionary. He was asked to bring a dictionary. 8. The teacher told the students to sign their drawings. The students were told to sign their drawings. 9. The dean will send the students to a big plant in summer. The students will be sent to a big plant in summer. 10. He taught us to use the lab equipment. We were taught to use the lab equipment.

5.

A. Transform into Passive Voice.

1.You open the door. 2. We asked questions. 3. He will finish his project next week. 4. He can do this exercise. 5. They invited me to their conference. 6. 1 saw a new film. 7. My sister writes letters regularly. 8. Universities develop new methods of students' training. 9. After graduating from the University the students may get a still higher degree. 10. The study of foreign languages, history and economics must improve the curricula of technological universities.

B. Translate.

1. Mathematics, strength of materials, mechanics, and elements of machines as well as engineering physics are studied at technological institutes. 2. The development of science is closely connected with the development of higher education. 3. Students are provided with hostels, well-equipped laboratories and libraries. 4. Any country must be provided with good specialists in all branches of science and technology for its further development. 5. Large sums of money are spent by the state to train highly-qualified engineers. 6. Much attention must be paid to improve the standards of higher education. 7. Students of technological institutes are trained to analyze various facts and theories. 8. The scientific and technological progress of a country is determined by the qualification of specialists. 9. Some institutes of technology are reorganized into universities. 10. The country must be provided with specialists capable of working with the technology of tomorrow effectively.

6. Find Participle I and Participle II, translate.

1. The students studying at the institutes passed entrance exams in summer. 2. The subjects studied in the first two years are very important for future engineers. 3. The lecture delivered by our dean was on new methods of technology. 4. The man delivering this lecture is our professor on mathematics. 5. An article discussing the new system of school education appeared in all newspapers. 6. The results of the experiments discussed yesterday will be published. 7. The attention paid to the study of fundamental subjects is great. 8. Students interested in computer engineering enter technological institutes. 9. The number of specialists connected with new branches of science and engineering is increased every year.

7. Read and translate the text.

Text 2. HIGHER EDUCATION IN THE UK AND THE USA

to consist of - состоять из
self-governing - самоуправляющийся
tuition - обучение
to proceed - продолжать делать (что-либо)
a gown - мантия
a major subject - профилирующий предмет
a graduate school - старшие курсы
a five point scale - пятибалльная шкала

Part 1

Cambridge is one of the two main universities of England which is located at the Cam River. It was founded at the beginning of the 12th century. The University consists of 24 different colleges including 4 colleges for women. Each college is self-governing.

The head of the University is the chancellor who is elected for life. The teachers are commonly called «dons» and «tutors». Part of the teaching is by means of lectures organized by the University. Besides lectures teaching is carried out by tutorial system for which Cambridge University is famous all over the world. This is a system of individual tuition organized by the colleges.

Each student has a tutor who practically guides him through the whole course of studies. The tutor plans the student's work and once a week the student goes to his tutor to discuss his work with him. The training course lasts 4 years. The academic year is divided into 3 terms. The students study natural and technical sciences, law, history, languages, geography and many other subjects.

After three years of study a student may proceed to a Bachelor's degree, and later to the degrees of Master and Doctor. Students are required to wear gowns at lectures, in the University library, in the street in the evening, for dinners in the colleges and for official visits. All the students must pay for their education, examinations, books, laboratories, university hostel, the use of libraries, etc. Very few students get grants. Not many children from the working class families are able to get higher education, as the cost is high. The cost of education depends on the college and specialty.

A number of great men, well-known scientists and writers studied at Cambridge. Among them are: Erasmus, the great Dutch scholar, Bacon, the philosopher, Milton and Byron, the poets, Cromwell, the soldier, Newton and Darwin, the scientists.

Part 2

There is no national system of higher education in the United States. Higher education is given in colleges and universities. There are over 2100 various higher educational institutions, including colleges, technological institutes and universities. The average college course of study is 4 years. The academic year is usually 9 months or 2 terms (semesters) of four and a half months each. Classes usually begin in September and end in June. The first-year students are called freshmen. Students choose a major subject and take many courses in this subject. After four years, they get a traditional Bachelor’s degree. Then the students may go on to graduate school and with a year or two of further study get a Master’s degree.

After another year or two of study and research, they may get a still higher degree as Doctor of Philosophy (Ph. D.). The student’s progress is evaluated by means of tests, term works and final examinations in each course. The student’s work is given a mark, usually on a five point scale. Letters indicate the level of achievement.

«A» is the highest mark. «F» denotes a failure.

Most American colleges and universities charge for tuition. The methods of instruction in the universities are lectures, discussions, laboratory and course works and seminars. Most cities have colleges or universities that hold classes at night as well as in daytime. In this way people may work for a degree or just take a course in the subject that interests them.

8. Practice the pronunciation of the following words:
Tutor, tutorial system, guide, through, languages, chancellor, major, require, sciences, law, scholar, further, evaluated, Bachelor's degree, Master's degree, failure, method.

9. Read and translate the text.

Text 3. OXFORD UNIVERSITY

Oxford is renowned the world over. It ranks in importance with Athens, Rome and Paris because of the stream scholars who, for hundreds of years, and particularly in the 20th century, have come to sit at the feet of learned men, and have returned to their own countries, their minds enriched with the distilled learning to be found here, and imbued with an abiding love for the place. They have absorbed the almost indefinable “spirit of Oxford”, and many of them return again and again, so strong is the pull of the place.

This book is designed to help the visitor whose stay is short. So many visitors want to know where the University is. In their home country, the universities are easily identifiable because they are compact, purpose-built places, and probably isolated from the domestic and commercial buildings which form the heart of the city from which they take their name.

Oxford is different. It has a golden heart - an area of less than half a square mile in which is to be found the most varied assortment of historic buildings in the world. But they do not stand in isolation; they are intermingled, in the must delightful way, with houses, shops and offices.

Over the last decade millions of pounds have been spent in restoring and cleaning the stonework of college and university buildings, which had become blackened and decayed, and in many cases was in danger of disintegrating. Great care was taken in the restoration, and the result is that the university buildings present the honey-colored facades which the great architects such as Wren and Hawksmoor created.

Interiors too, have been cleaned and restored - notably those of the Sheldonian Theatre and the Bodleian Library. Oxford is a place of great beauty, but it is not just a shrine to the past. It is a living entity and its historic buildings are the homes of masters and students whose learning, thinking and ideas have a profound influence on culture, education, science and politics, not only in England, but throughout the world.

The University did not come into being all at once. Oxford had existed as a city for at least 300 years before scholars began to resort to it. The end of the 12th century saw the real beginnings of the University. It is known that early in that century distinguished scholars were lecturing in Oxford, but it had no recognition as a place of learning. In about 1184 the University had become an accomplished fact as result of the migration to Oxford of students who brought their own traditions with them.

It is generally assumed that between 1164 and 1169, when Henry II forbade English clerks to go to the University of Paris, which at that time was the foremost in Europe, the scholars had to find somewhere else to continue their studies. Their choice fell on Oxford. The first group of scholars at Oxford may have been joined by others from Paris, and from other parts of Britain.

There is no '"university" as such. Each college is practically autonomous, with its own set of rules for its good government. There is a central administration, providing services such as libraries and laboratories.

10. Practice the pronunciation of the following words:

Rank, scholars, particularly, imbued, indefinable, short, purpose, varied, delightful, autonomous, distinguished, profound, disintegrating, foremost, migration.

11. Answer the questions:

1) Why is Oxford ranking amongst the world's top universities?
2) How does Oxford differ from other educational institutions?
3) Why do the Oxford's buildings need to be restored?
4) What architects have worked on the University's facades?
5) Why didn't Oxford deserve any recognition until the 12th century?
6) When was the heyday of Oxford?

7) Why does the author claim that there's no university such as Oxford?
8) Why did English clerks give up going to the University of Paris, which was considered to be the foremost in Europe?

12. Make up definitions:

Distinguished	Ahead of all others, especially in position or rank.
A scholar	Something that exists as a particular and discrete unit.
To intermingle	Standing above others in character or attainment or reputation.
An entity	An exposition of a given subject delivered before an audience or a class, as for the purpose of instruction.
Foremost	To mix or become mixed together.
A lecture	One who attends school or studies with a teacher.

Unit 2
THE QUALITY OF ENVIRONMENT. ENVIRONMENT PROTECTION

1. Read and translate the text.

Text 1.ENVIRONMENT PROTECTION MUST BE GLOBAL

That the problem of pollution and ecology has become the most important one for mankind is evident to all. The more civilization is developing, the greater the ecological problems are becoming. Air and water pollution by industry is now reaching tremendous proportions. In our era it is changing from a national to an international problem, especially in territories where rivers cross several countries. The seas and oceans are also becoming seriously polluted. A similar situation is developing in the atmosphere. It is known that many cities throughout the world suffer from air pollution.

However, our scientific knowledge and technological advancement make it possible to eliminate it if people use good will and make considerable investments for that purpose. The development of natural resources on a global scale is already possible from a scientific and technical standpoint. Large-scale experimental work in this area is successfully being carried out.

At present scientists in industrially developed countries are working on the theory of interaction of all the atmospheric and oceanic global processes that determine the climate and weather of the world. Increasing growth of population, industrialization and the use of resources are slowly but surely changing the global climate and water balance. This can be described as a great experiment, one that may bring about changes in the environment more serious than ever before.

The essential feature in the environment protection is that many problems can be solved only on the level of world community. Therefore, the planning of protection against pollution by human society as a whole is imperative today and in the near future. It is necessary to develop an international program to study data on land, forest, atmospheric and oceanic resources, both renewable and non-renewable. It is the joint efforts of many scientists and special public organizations that can deal with the problem and take necessary measures to protect the environment.

It is still a big job and much remains to be done. However, scientists are confident that planned actions of all countries can eliminate pollution and achieve successes in purifying air, water and soil and in safeguarding natural resources. At the same time one must realize that social and political circumstances may stand in the way of further progress in this field.

2. Answer the questions:

1. What is this text about? 2. What is ecology? 3. How does water (air) become polluted? 4. Why is the problem of water pollution becoming a global problem?

3. Read and translate the following international words:

Global, resources, problem, ecology, proportion, era, territory, ocean, oceanic, situation, atmosphere, process, climate, balance, experiment, social.

4. **Read and translate the following words:**

Environment, pollution, achieve, success, successful, successfully, purify, air, natural, however, job, remain, mankind, reach, special, especially, serious, throughout, world, knowledge, advance, eliminate, purpose, scale, weather, essential, therefore, data, joint, measure, realize, circumstance.

5. Answer the questions according to the example:

What is one of the most important problems for mankind now? *(**<u>the problem of pollution and ecology</u>**).*

<u>The problem of pollution and ecology</u> is one of the most important problems for mankind now.

1. What problem is becoming a global problem? (the problem of air and water pollution). 2. What makes it possible to eliminate air and water pollution? (scientific knowledge and technological advance, good will and large investments). 3. What are scientists in industrially developed countries currently working on? (the theory of interaction of the atmospheric and oceanic global processes). 4. What factors are slowly changing the global climate and water balance? (the growth of population, industrialization and use of resources). 5. What actions are necessary to take to deal successfully

with the problem of protecting the environment throughout the world? (planning, developing international programs to study ecological data, joint efforts of scientists and special public organizations).

6. Read and translate the following text without a dictionary:

It is difficult for mankind to predict changes in the environment accurately. It is known that natural changes in weather and climate may have more catastrophic global effects than human activity. But scientists are developing a new concept that can help make such prediction more accurately. It is based on our understanding that the Earth is an integral system. Its parts — oceans, atmosphere, land or life — cannot be understood in isolation to predict changes in the most accurate way. Modern scientific and technological progress made it possible to use new technologies for that purpose. That satellites can control physical, chemical, biological and geological changes on a global scale is well-known now. One must also know that the study of environmental problems with the help of satellites is becoming international. Russia, the US, France, Japan, Canada, India, China and Italy are planning to send their satellites in both polar and geostationary orbits.

7. Read and translate the text 2.

Text 2. LAST CHANCE FOR MOTHER EARTH?

(*From Scientific American)*

man's intrusion upon nature - вторжение человека в природу
to intrude upon - вторгаться
to violate the laws of nature - нарушать законы природы
to destroy the balance - нарушать равновесие
to combat pollution - бороться с загрязнением атмосферы
to be faced with the problem of - стать перед проблемой
environment - окружающая среда
industrial waste - промышленные отходы
to govern the process - управлять процессом
to harm - наносить ущерб
to be aware of the consequences - осознавать последствия
radioactive fallout - радиоактивные осадки
to affect nature - влиять на природу
to threaten - угрожать
to contaminate the atmosphere - загрязнять атмосферу

The U.S. environment is seriously threatened by the garbage of the economy. The Apollo 10 astronauts could see Los Angeles as a smudge from 25000 miles in outer space. What most Americans now breathe is closer to filth than to air. Americans know pollution well. It is car-clogged streets and junk-filled landscape – their country's visible decay.

California's air pollution is already so bad that on many days Los Angeles school children are warned not to breathe too deeply because of heavy smog conditions.

The United States is far from alone in its pollution and waste. The smog is dense in Tokyo. Some of Norway's legendary fjords are awash with stinking industrial wastes.

Sections of the Rhine River which flows through the industrial Ruhr Valley to the North Sea are so toxic that even hardy eels have difficulty surviving. In Sweden, not long ago, black snow fell on the province of Smoland.

The earth has its own waste-disposal system, but it has limits. The winds that ventilate the earth are only six miles high; toxic garbage can kill the tiny organisms that normally clean rivers. Meanwhile, modern technology is pressuring nature with tens of thousands of synthetic substances, many of which almost totally resist decay. This includes aluminum cans that do not rust, inorganic plastics that may last for decades, floating oil that can change the thermal reflectivity of oceans and radioactive wastes whose toxicity lingers for centuries.

Where do most of the pollutants end up? Probably in the oceans, which cover70 per cent of the globe and have vast powers of self-purification. Yet even the oceans can absorb only so much filth; many scientists are worried about the effects on plankton — passively floating plants and animals, which produce about one fifth of the earth's oxygen. Emerging now is the importance of the science of survival — ecology. Trying to awaken a sense of urgency about the situation, ecologists sometimes do not hesitate to predict the end of the world. Yet they hold out hope too.

Ecology is the study of how living organism and the nonliving environment function together as a whole, or ecosystem, in the biosphere — that extraordinarily thin global envelope which sustains the only known life in the universe. Hundreds of millions years ago, plant life enriched the earth's atmosphere to a life supporting mixture of 20 per cent oxygen, plus nitrogen, argon, carbon dioxide and water vapor. The mixture has been maintained ever since by plants, animals and bacteria, which use and retain the gases at equal rates. The result is a closed system, a balanced cycle, in which nothing is wasted and everything counts.

The process is governed by distinct laws of life and balance. One is adaptation; each species finds a precise niche in the ecosystem. Another law is the necessity of diversity: the more different species in an area, the less chance that any single type will destroy the balance. Man has violated these laws — and endangered nature as well as himself.

A primitive community could harm only its own immediate environment. When it ran out of food, it had to move on or perish. But a modern community can destroy its land and still import food, thus possibly destroying ever more distant land without knowing or caring. Technological man forgets that his pressure upon nature may provoke revenge.

What most appalls ecologists is that technological man remains so ignorant of his impact. Neither the politicians nor the physicists who developed the first atomic bomb were fully aware of the consequences of radioactive fallout. The men who de-signed the automobile did not foresee that its very success would turn cities into parking lots and destroy greenery in favor of highways, all over the world.

Man's inadvertence has even upset the interior conditions of the earth. Wherever huge dams are built the earth starts shuddering. The enormous weight of the wa-ter in the reservoirs behind the dams puts a new stress on the subsurface strata. In consequence the earth quivers.

If technology got man into this environment crisis ant pollution mess, surely technology can get him out of it again.

There is no lack of hopeful ideas for balancing the environment and the most encouraging today is the swell of public opinion. We are at least starting to combat gross pollution. Even so, real solutions will be extremely difficult and expensive. Ideally, entire environment should be subjected to computer analysis. Whole cities and industries could measure their inputs and outputs via air, land and water. But this is a far-off dream. Far more knowledge is needed.

Even the simplest ecosystem is so complex that the largest computer cannot fully unravel it.

Technological man is bewitched by dangerous illusion that he can build bigger and bigger industrial society with scant regard for the iron laws of nature. Pessimists argue that only a catastrophe can change that attitude – too late. By contrast, the hopeful ecologist put their faith in man's ability.

8. Read and translate the following words and word-combinations

Garbage, smudge, breathe, decay, synthetic substances, radioactive wastes, linger, self-purification, filth, carbon dioxide, vapor, govern, species, violate, immediate environment, subjected to computer analysis, bewitched.

9. Agree or disagree with the statements given below. Use the following phrases:

1. What most Americans now breathe is very clean air and they have no idea about pollution.
2. Some other countries are faced with the same problem of pollution and waste as the U.S.

3. Modern technology does not affect nature in any way.
4. We needn't worry about the resources of our environment for they are inexhaustible.
5. The oceans can absorb as much filth as necessary.
6. It is plants that help maintain the mixture of oxygen, nitrogen, carbon dioxide and water vapor.
7. Ecology is a linguistic science.
8. Man has violated laws of nature and is going to pay for it.
9. When the primitive community ran out of food it perished.
10. The men who designed automobiles knew only too well that some day the automobiles would turn cities into parking lots and destroy all the greenery in them.
11. More attention ought to be paid to ecology.
12. We are actually ruining our own habitat.
13. It will be very difficult to balance the environment now.
14. Technical progress has greatly affected nature.
15. The big cities of today are not faced with any important problems such as traffic and so on.
16. A catastrophe is inevitable and there's no solution to the problem.

10. Sum up discussion. Use the following phrases:

Summing it up… On the whole…

Summarizing the discussion I'd like to say that…

Model: The garbage of economy is a serious threat to our environment.

Summing it up I'd like to say that the garbage of economy is a serious threat to our environment.

1. Pollution has grown into an urgent problem.
2. Nature is being seriously damaged by civilization.
3. Immediate measures must be taken to change the grave situation.
4. Politicians and scientists must realize full well dangers we are faced with.
5. The consequences of this violation of nature are hard to foretell.
6. Measures must be taken to save the plankton of oceans.
7. The problem of man and biosphere is very acute.
8. Radioactive fallout must be strictly controlled.
9. Computers must be of much help in solving the problem.
10. Technology will help man to get out of this critical situation.

11. Comment upon the following problems.

1. Modern technology and its impact upon nature.

2. The resources man has been using for centuries are not inexhaustible and there is an urgent need for an efficient research into our environment.
3. How do you picture the development of science in ten years' time?

12. Dispute the problems given below. The group can be divided into two opposing parties, each advocating their viewpoint.

Use the following phrases:
It must be admitted that…
My point is that…
It seems reasonable to assume…

1. There can hardly be any solution to the problem raised in the text. A catastrophe is inevitable.
2. Big cities are now becoming self-defeating for their growth entails numerous insoluble problems. They ought not to be developed, renewed or replanned.
3. Nature is being destroyed by growing civilization. We can hardly stop or prevent it.

13. Read and translate the text 3.

Text 3.THE QUALITY OF ENVIRONMENT

emissions – выбросы в атмосферу
pollutants– загрязняющие примеси
automobile exhausts – автомобильные выхлопные газы
to expose to air pollution – подвергаться воздействию воздушного загрязнения
portable water – питьевая вода
water pipe network – городской водопровод
ferrous metallurgy – черная металлургия
mechanical engineering industry – машиностроение
non-ferrous metallurgy – цветная металлургия
eroded soil–эродированная почва
degrading land– приходящая в упадок почва
coniferous forest – хвойный лес

Poisonous atmospheric emissions by Russia's industry were close to 32 m tons in 1991. Russia's European part accounts for nearly 65% of the country's industrial air pollution. Automobile exhausts in Russian cities contaminated the air with another 21 m tons of pollutants in 1990. Some 50 m people in Russia were breathing air with harmful content amounting to 10 MAC; over 60 m were exposed to air pollution of between 5 and 10 MAC. (Maximum admissible concentration).

In 1991 the water run-off of some southern rivers was decreasing at a progressive rate, as a result of human economic activity. A lot of Russia's small rivers, most badly affected by human activity throughout the last 10 or 15 years, were deteriorating rapidly. The quality of portable water in Russia is far from satisfactory. About a quarter of municipal water pipe networks and one- third of industrial ones carry water which was not properly purified. The most common water surface pollutants include petroleum products, phenols, organic matter, copper and zinc compounds, etc. Surface water is heavily polluted by ferrous and non-ferrous metallurgy, the coal, oil, 25gas, chemical and petrochemical industries, farms, municipal drainage, etc. chemicals arc washed in large quantities into rivers and lakes from adjacent areas. Livestock farms, pastries and sown land are responsible for high content of biological and organic matters in water.

The ozone content in the atmosphere has been decreasing lately in high and medium latitudes of the Northern Hemisphere. The ozone layer depletion is especial-ly fast (10% in ten years) in the lower stratosphere, that is, at altitudes between 15 and 20 kilometers.

Many small and detached fields were overgrown with woods and shrubs. Soils on large areas were eroded, flooded or turned into marsh. Arid lands are degrading everywhere in Russia, giving way to deserts. Soils contaminated with heavy metallic isotopes, oil products and other toxic substances lay in rings dozen of kilometers wide around big cities and centers of metallurgical, chemical petrochemical and mechanical engineering production.

The national timber wealth in standing trees totals 81.6 bn cubic meters. Over the past 20 years, timber cutting and forest fires reduced the country's reserve of ripe wood in coniferous forests by 8 bn cu meter, including by 3 bn cu m. over the past 5 years.

14. Read and translate the following international words:

Atmospheric, industry, automobile, progressive, economic, human, activity, satisfactory, industrial, portable, products, phenols, zinc , metallurgy, chemical, ozone, biological, organic, stratosphere, eroded, isotope, toxic, petrochemical, production, reserve, substance.

15. Practice the pronunciation of the following words:

Exhausts, content, admissible, throughout, deteriorating, purify, water surface, quantify, adjacent, decrease, latitude, altitude, flooded, dessert, wealth, timber, reduce, ripe, coniferous, include.

16. Sum up a discussion. Use the following phrases:

Summing it up… On the whole…

Summarizing the discussion. I'll like to say that…

Model: The garbage of the economy is a serious threat to our environment. Summing it up I'd like to say that the garbage of economy is a serious threat to our environment.

1. The atmosphere, rivers, lakes and underground stores hold less than 1% of all fresh water and this tiny amount has to provide the fresh water needed to support the Earth population.
2. Fresh water is a precious resource and the increasing pollution of our rivers and lakes is a cause for alarm.
3. Industry often uses water for cooling processes sometimes discharging large quantities of warm water back into river.
4. Raising the temperature of the water lowers the level of dissolved oxygen and upsets the balance of life in the water.
5. Contaminants in the soil can adversely impact the health of animals and humans.
6. Everywhere in the world where people change a natural ecosystem into agriculture, the land degrades.
7. Soil can degrade without actually eroding. It can lose its nutrients and soil biota.
8. Probably one of the most dangerous disasters that can be averted to a great extent is a forest fire.
9. When out of control, forest can cause extensive damage not only the forest cover, but also to human life and the environment.

17. Agree or disagree with the following statements given below.

1. Nature means simply what is around us.
2. We never know the world of water till the well is dry.
3. There are no passengers on Spaceship Earth. We are all crew.
4. We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong we may begin to use it with love and respect.
5. There is enough oxygen in the water and in the atmosphere.
6. Rivers are not polluted, because factories don't produce a lot of waste and don't pour it into rivers.
7. Economic advance is not the same thing as human progress.
8. Take care of the earth and she will take care of you.
9. The ozone layer in the atmosphere protects us from dangerous radiation.
10. Understanding of laws of nature does not mean that we are immune to their operations.

11. The universe is not required to be in perfect harmony with human ambition.
12. Man is a complex being: he makes deserts bloom and lakes die.
13. In its broadest ecological context, economic development is the development of more intensive ways of exploiting the natural environment. Give the examples.
14. The system of nature of which man is a part tends to be self-balancing, self-adjusting, self-cleaning. Not so with technology.

18. Comment upon the following problems.
1. In efficiency of timber use Russia lags far behind other countries.
2. Over 80% of timber in Russia is logged in clear cutting.
3. Fortunately there are many ways to reduce erosion.

19. Fill in the blanks with the following words and word-combinations and translate the text 3.

Careful, to say nothing of, in addition, oil, urbanization, to result in, according to, growth of industry, contamination, crude oil, harmful, laundry, poisonous waterways, due to, catastrophe, substances, discharging, depredations, tons.

There are many causes of water pollution which may be classified into four main categories

1. pollution from chemicals, 2. pollution from solids, 3. pollution from radioactive wastes, 4. pollution from living matter.

Text 3. WATER POLLUTION

immense urbanization – колоссальный рост городов.
contamination of water from fertilizers – загрязнение воды удобрениями.
tons of detergents – моющие средства.
crude oil – неочищенная сырая нефть.
refuse – отходы.
to make worse – ухудшать.
to bring about degradation – приводить к деградации.
heavy expenditures - значительные расходы.
mass campaign – массовая компания.
sad statistics – неутешительные данные статистики

The first two causes are perhaps more dangerous than the others due to the tremendous _____and the immense_____ in large cities. Pollution from chemicals and solids includes ______of water from fertilizes and pesticides, acids, alkalis, mercury and cadmium (i.e. from heavy metals) which are widely used in industry_____ detergents from washing _______are also dumped into the water. The above-mentioned _______ are extremely _______ for the living matter and once found in water in large quantities they kill everything and turn our rivers into ______. A remarkable illustration of such pollution is the Thames in England and the Rhine in Europe - up until recently there was no fish in these two rivers.

The banks of these rivers and many others represent a sad picture of cans, plastic containers, paper and refuse. Furthermore man not only pollutes water in the rivers and lakes, but he also pollutes seas and oceans as well. Let us take for example oil from ______tankers and supertankers. As we know each supertanker is capable of carrying hundreds upon thousands of _____. Sea water is used to clean the tankers after _______ and to make things still worse almost every year _____sad statistics there occurs at least one shipwreck in the sea ______bad weather conditions, faulty navigation aids, grounding, etc. This _______ tremendous contamination of sea and the sea shore too. One of the vivid examples of such a disaster was the wreckage of the supertanker TORREY CANYON in the English Channel. Not only the sea but the beautiful beaches in England and in France were covered with oil.

This ______ brought about huge losses of sea birds and animals _____ the heavy expenditures by the French and British governments in a mass clean-up campaign.

We should remember that we are all passengers aboard the ship “Earth”. We must be more ______ and must do everything to protect our beautiful planet from the_______ of man, i.e. ourselves.

20. Read and translate the following international words:

Urbanization, classify, chemicals, radioactive, pesticides, mercury, cadmium, ocean, heavy metals, contamination, illustration, result, substances, tons, supertanker, passengers, protect, campaign.

21. Practice the pronunciation of the following words:

Cause, dangerous, tremendous, immense, fertilizer, detergent, above-mentioned, dump, quantity, turn into, discharging, remarkable, poisonous, occur, due to, ship-wreck, refuse, wreckage, faulty, furthermore, laundry, according to, loss, worse, beautiful.

22. Read the text and give English equivalents to the following Russian words and word-combinations:

Бурный промышленный рост, в соответствии с, разделить на, бытовые отходы, широко применяться, в больших количествах, превратить в, до недавнего времени, загрязнить моря и океаны, происходить, приводить к, вызывать, колоссальный рост городов, тонны моющих средств, сырая нефть, отходы, загрязнение воды, значительные расходы правительств, ухудшать, гибель морских птиц и животных, неутешительные данные статистики, массовая компания.

23. Agree or disagree with the statements given below. Use the following phrases:

That's right
I don't think so
Exactly
You're wrong there
I fully agree with you
Just the reverse

1. The causes of water pollution may be classified into two main categories pollution from solids and pollution from living matter.
2. Pollution from chemicals is unknown to large cities inhabitants.
3. Chemicals and solids contaminate water.
4. Fertilizers and pesticides are seldom used in industry.
5. The above-mentioned substances including acids, mercury and cadmium kill everything.
6. The Thames in England and the Rhine in Europe bound in fish.
7. Sea water is never used to clean the tankers after discharging.
8. The shipwrecks occur due to bad weather conditions, faulty navigation aids.
9. Sea catastrophes do not cause tremendous contamination of sea and the sea shore
10. The supertanker Torrey Canyon catastrophe brought about losses of sea birds and animals.
11. Water pollution doesn't affect people's health.
12. We do everything to protect our planet.

24. Sum up a discussion. Use the following phrases:

Summing it up…
On the whole …
Summarizing the discussion…
I'd like to say that…

1. Powerful purifying systems are urgently needed in Russia.
2. Water contamination has grown into a serious problem.
3. Oil transporters should meet the ecological safety requirements.
4. Water pollution is inevitable in big cities.
5. Contamination from chemicals could hardly be avoided today.
6. The problem of biosphere is very acute.
7. Ecological education of individuals and preventive measures can do more than penalties of the violators.
8. Cars make the human life dependable, thus aggravating the hard ecological situation in small and big cities.
9. Water transport is harmful for sea nature.

25. Comment upon the following problems:

1. Nature is threatened by technological progress.
2. Human mankind acidified lakes and streams and they can't support fish, wildlife, plants or insects.
3. Acid rain is killing forests.
4. Water contamination could lead to shortage of safe drinking water.
5. Civilization has upset nature's sensitive equilibrium polluting rivers and oceans with industrial wastes.
6. Computers project that between now and the year 2030 sea levels would rise by several meters, flooding coastal area and ruining vast tracts of farmland.

26. Dispute the problems given below. The group can be divided into two opposing parties, each advocating their viewpoint. Use the following phrases:

It must be admitted that …
My point is that…
It seems reasonable to assume…

1. We are obliged to remove factories and plants from cities, redesign and modify purifying systems for cleaning and trapping harmful substances.
2. We must review our wasteful, careless ways of life, we must consume less, recycle more, conserve wildlife and nature.
3. We should act according to the dictum «think locally, think globally, act locally».
4. We are obliged to protect and increase the greenery.
5. 159 countries – members of the UNO hold conferences and set up environmental research centers.
6. The 5th of June is proclaimed the World Environmental Day by the UNO and is celebrated every year.

Unit 3
MASS MEDIA AND THEIR ROLE IN CONTEMPORARY SOCIETY

1. Read and translate the following international words:

Politics, communication, process, individual, group, term, technical, type, publication, classify, electronically, function, specific, totalitarian, democratic, electorate, idea, contrast, rehabilitation, paralyze, focus, idealize.

2. Practice the pronunciation of the following words:

Lament, among, citizen, government, heterogeneous, disperse, audience, circulation, relative, population, through, target, entertainment, interpreting, influence, agenda, socialize, moreover, official, accountable, dual, capability, view, although, prominent, particularly, doggedly, resignation, award-winning, severely, wounded.

3. Read the text and give English equivalents to the following Russian words and word combinations:

Обычная жалоба, не ладят, для того, чтобы жить мирно, передача информации, от одного человека, разнородная аудитория, живущая в разных местах, основные примеры, тиражи, обычно, средства вещания, для целевого общения, СМИ, зарабатывать деньги, главным образом, развлекательные мероприятия, влияние на общественное мнение, формировать план работы, знакомить граждан с политической жизнью, способствовать, ответственный за свои действия, заметный, кинофильмы, наиболее сильные политические идеи, с упорством разоблачали, перенес болезненную реабилитацию, превратился.

4. Read and translate the text:

Text 1. PEOPLE, GOVERNMENT AND COMMUNICATIONS

lament - жалоба
to get along – ладить, жить мирно
heterogeneous – разнородный, различный
disperse – рассеиваться
technical device – техническое устройство, прибор
circulation —тираж
relative to – относительно, касательно
broadcast media – средства вещания
targeted - целенаправленный
entertainment – развлекательное мероприятие
agenda – повестка дня, план действий
promoting – способствующий
to be responsible to – ответственный за что-либо
moreover –более того
electorate - избиратели
accountable for – ответственный, подотчетный
voter – голосующий, избиратель
capability - способность
reflect – отражать
shape - формировать
prominent - заметный

motion pictures – кинофильм
convey – нести, содержать (информацию)
doggedly – упрямо, упорно
expose - разоблачать
resignation – уход в отставку
paramilitary - военизированный
seamy – *зд.* грязный

«We never *talk* anymore» is a common lament among people who are living together but not getting along very well. In politics, too, citizens and their government need to communicate in order to get along well. **Communication** is the process of transmitting information from one individual or group to another. Mass **communication** is the process by which individuals or groups transmit information to large, heterogeneous, and widely dispersed audiences. The term **mass media** refers to the technical devices employed in mass communication. The mass media are commonly divided into two types:

1. Print media communicate information through the publication of written words and pictures. Prime examples of print media are daily newspapers and popular magazines. Because books seldom have very large circulations relative to the population, they are not typically classified as a mass medium.

2. Broadcast media communicate information electronically through sounds or sights. Prime examples of broadcast media are radio and television. Although the telephone also transmits sounds, it is usually used for more targeted communications and so is not typically included within the mass media.

The mass media are in business to make money, which they do mainly by selling advertising through their major function, entertainment. We are more interested in the five specific functions the mass media serve the political system: *reporting* the news, *interpreting* the news, *influencing* citizens' opinions, *setting* the *agenda* for government action, and *socializing* citizens about politics.

Our special focus is on the role of the mass media in promoting communication from a government to its citizens *and* from citizens to their government. In totalitarian governments, information flows more freely in one direction (from government to people) than in the other. In democratic governments, information must flow freely in both directions; a democratic government can be responsible to public opinion only if its citizens can make their opinions known. Moreover, the electorate can hold government officials accountable for their actions only if voters know what their government has done, is doing, and plans to do. Because the mass media provide the major channels for this two-way flow of information, they have dual capability of reflecting and shaping our political views.

Although this text concentrates on political uses of the four most prominent mass media - newspapers, magazines, radio, and television - you should understand that political content can also be transmitted through other mass media, such as recording and motion pictures. Rock actors like Peter Gabriel and U2 often express political ideas in their music.

And motion pictures often convey particularly intense political messages. In the 1976 film All the President's Men, Dustin Hoffman and Robert Redford played Carl Bernstein and Bob Woodward, the two Washington Post reporters who doggedly exposed the Watergate scandal in a series of articles that led to President Richard Nixon's resignation in 1974. This motion picture dramatized a seamy side of political life that contrasted sharply with an idealized view of the presidency. In his series of "Rambo" films Sylvester Stallone played a paramilitary superhero that solved difficult international problems through combat. In contrast, the award-winning Born on the Fourth of July starred Tom Cruise in the real-life story of Ron Kovic, who enlisted in the marines and was severely wounded in Vietnam. Paralyzed from the waist down, he underwent painful rehabilitation and turned into an antiwar-activist. This film presents a very different view of fighting.

5. Answer the questions:

1. What is the difference between 'communication' and 'mass communication?'
2. What types are the mass media divided into?
3. What are the mass media main functions?
4. What conveys particularly intense political messages?

6. Choose the right variant:

2.1. Communication is

a) speaking on the telephone
b) the transmitting information from one to another object
c) individuals transmit information to large audience
d) a device for transmitting information

2.2. The mass media are commonly divided into ...... types.

a) three
b) five
c)four
d) two

2.3. Which doesn't refer to the print media?

a) books
b) magazines
c)newspapers

d) posters

2.4. Telephone isn't typically included within the mass media because

a) the quality of the sound is bad

b) radio and television are more interesting for audiences

c) it doesn't transmit information through sounds or sights

d) it is commonly used for more specific communications

2.5. The mass media make money by

a) selling valuable information

b) interpreting the news

c) selling advertising through entertainment

d) reporting the news

2.6. Mass media reflect and shape our political views because

a) they are responsible to public opinion

b) they provide the major channels for two-way flow

c) they report topical news

d) they concentrate on political issues

7. Read and translate the text:

Text 2. THE MASS MEDIA

The mass media transmit information to large, heterogeneous, and widely dispersed audiences through print and broadcasts. The main function of the mass media is entertainment, but the media also perform the political functions of reporting news, interpreting news, influencing citizens' opinions, setting the political agenda, and socializing citizens about politics.

The mass media in many countries are privately owned and in business to make money, which they do mainly by selling space or air time to advertisers. Both print and electronic media determine which events are newsworthy, a determination made on the basis of audience appeal. The rise of mass-circulation newspapers in the 1830s produced a politically independent press in the United States and Europe. In their aggressive competition for readers, those newspapers often engaged in sensational reporting, a charge sometimes leveled at today's media.

The broadcast media operate under technical, ownership, and content regulations set by the government, which tend to promote the equal treatment of political contests on radio and television more than in newspapers and news magazines.

The major media maintain staffs of professional journalists in major cities across the world. All professional journalists recognize rules for citing sources that guide their reporting. What actually gets reported in the media depends on the media's gatekeepers, the publishers and editors.

Although more people today get more news from television than newspapers, newspapers usually do a more thorough job of informing the public about politics. Despite heavy exposure to news in the print and electronic media, the ability of most people to retain much political information is shockingly low-and less than it was in the mid-1960s. It appears that the problem is not with the media's inability to supply quality news coverage, but the lack of demand for it by the public. The role of the news media may be more important for affecting interactions among attentive policy elites than in influencing public opinion.

The media's elite including reporters from the major television networks tend to be more liberal than the public.

From the standpoint of majoritarian democracy, one of the most important effects of the media is to facilitate communications from the people to the government through the reporting of public opinion polls. The media zealously defend the freedom of the press, even to the point of encouraging disorder through criticism of the government and the granting of extensive publicity to violent protests, terrorist acts, and other threats to order.

8. Develop the following ideas:

1. The message of an article or a TV program is more important than the form.
2. The media zealously defend the freedom of the press.
3. The media's elite tend to be more liberal than the public.
4. To facilitate communications from the people to the government is one of the most important effects of the media in democratic countries.

9. Additional questions:

1.What electronic media are of importance nowadays?
2. What helps newspaper publishers to win the competition for readers?

10. Read and translate the text:

Text 3. THE INTERNET

The Internet is a magnificent global network with millions and millions of computers and people connected to one another where each day people worldwide exchange an immeasurable amount of information, electronic mail, news, resources and, more important, ideas.

It has grown at a surprising rate. Almost everyone has heard about it and an increasing number of people use it regularly. The current estimate is that over 70 million people are connected, in some way, to the Internet — whether they know it or not.

With a few touches at a keyboard a person can get access to materials in almost everywhere. One can have access to full-text newspapers, magazines, journals, reference works, and even books. The Web is one of the best resources for up-to-date information. It is a hypertext-based system by which you can navigate through the Internet. Hypertext is the text that contains links to other documents. A special program known as «browser» can help you find news, pictures, virtual museums, electronic magazines, etc. and print Web pages. You can also click on keywords or buttons that take you to other pages or other Web sites. This is possible because browsers understand hypertext markup language or code, a set of commands to indicate how a Web page is formatted and displayed.

Internet Video conferencing programs enable users to talk to and see each other, exchange textual and graphical information, and collaborate.

Internet TV sets allow you to surf the Web and have e-mail while you are watching TV, or vice versa. Imagine - watching a film on TV and simultaneously accessing a Web site where you get information on the actors of the film. The next generation of Internet-enabled televisions will incorporate a smart-card for home shopping, banking and other interactive services. Internet-enabled TV means a TV set used as an Internet device.

The Internet is a good example of a wide area network (WAN). For long distance or worldwide communications, computers are usually connected into a wide area network to form a single integrated network. Networks can be linked together by telephone lines or fiber-optic cables. Modern telecommunication systems use fiber-optic cables because they offer considerable advantages. The cables require little physical space, they are safe as they don't carry electricity, and they avoid electromagnetic interference.

Networks on different continents can also be connected via satellites. Computers are connected by means of a modem to ordinary telephone lines or fiber-optic cables, which are linked to a dish aerial. Communication satellites receive and send signals on a transcontinental scale.

11. Answer the questions:

1. What is the Internet? 2. How many people are connected to the Internet today? 3. What is Hypertext? 4. What are computers usually connected into? 5. What advantages do fiber-optic cables offer?

12. Read and translate the text:

Text 4. A "FREE PRESS" MUST MEAN JUST THAT

(by Adriana Lopez)

waffle – *ам. жарг.* болтать, пустословить
toll - потери
misdeed- преступление, злодеяние
trafficking - торговля
volatile – непостоянный, нестабильный
flawed – порочный, с изъяном
ambiguity – неясность, двусмысленность
loophole - лазейка
guerrilla – партизанский
withdraw – отзывать
take for granted –считать (что-либо) доказанным/ не требующим доказательства, само собой разумеющимся.

We take freedom of speech for granted in the United States, but in the rest of the hemisphere it is the exception, not the rule. The Organization of American States met to discuss this issue and, for a while, it looked as if the United States was waffling.

A draft of the Inter-American Declaration on Freedom of Expression stated that the OAS is «convinced that the unlawful restrictions on the exercise of freedom of expression not only violate individual human rights but threaten democratic society itself». But it also said that «freedom of expression may be subject to certain restrictions established under domestic law and international obligations».

That loophole could have licensed Latin American countries to ban – and punish – members of the press.

Journalists in Latin America already face enough threats. In the last decade the death toll has reached nearly 200. Thousands of journalists are being severely punished for exposing the misdeeds of their countries' powerful people. Attacks come as a direct result of their work. Reporters are subjected to harassment, kidnapping, torture, imprisonment and murder.

Gustavo Gorriti, a Peruvian journalist and recipient of the 1998 International Press Freedom Award of the Committee to Protect Journalists, has been continually harassed by the Peruvian and Panamanian governments. Gorriti has said that any journalist in Latin America who engages in serious, substantive reporting «will almost certainly face certain forms of harassment. You are literally taking your life in your hands».

Latin America's rocky road from dictatorship to democracy – with drug trafficking, government corruption, left-wing guerrilla groups and paramilitary organizations all putting up obstacles – has made journalism one of the most dangerous careers in this volatile region. Peruvian novelist and one time presidential candidate Mario Vargas

Llosa once noted that «a fully free press won't be secure until democratic values and a rule of law are more firmly embedded».

Fortunately, Victor Marrero, U.S. ambassador to OAS, withdrew the flawed draft late last month, citing «ambiguities which should be clarified». He requested that the draft return to a working group for further revision before being voted on. This belated move at least puts the United States on the right track. The U.S. government should not back any kind of press restriction, and Latin America should not have to deal with double standards when it comes to freedom.

13. Questions for discussion:

1. Is freedom of speech taken for granted in your country?
2. Are journalists in your country subjected to any forms of harassment? If yes, why?
3. Freedom of expression may be subject to certain restrictions. Do you agree with this statement?

Unit 4
SCIENCE AND SOCIETY IN THE USA

1. Read and translate the text. Comment on the statement: «Science is a powerful engine by which the genius of the few is magnified by the talents of the many for the benefits of all».

Text 1. SCIENCE AND SOCIETY IN THE USA

entitlement – *зд.* установленная норма (панацея)
maintain – сохранять
generate – порождать
outright – полный
frustratingly – потрясающе, слишком уж
volatility – смена, перемена
commitment – обязательство (*зд*. вклад)
vistas – перспективы
embark – начинать (дело), *зд*. основываться
superstring – суперсерия или суперряд
give an account – объяснять, описывать
resolution – *зд*. расширение
underpinning – *зд*. свидетельство, пример
forestall – предвосхищать
poise – *зд*. склоняться (балансировать)
pinnacle – *зд*. кульминация

Science on the scale that it exists and is needed today can, however, be maintained only with large amounts of public support. Large-scale public support will be provided only if science and technology are meeting the critical needs of society. Intellectual progress, as measured by advances in specific public disciplines, is not in itself sufficient to generate such support. Perhaps it should be, but it is not. Public support for science may be wise policy, but is not an entitlement.

The central problem is that the costs of meeting the needs of society are too high, and the time scale for meeting them is too long. Both the ideals and the pragmatics of American society are based on improvement in the quality of life. We expect better health care, better education, and economic security. We expect progress towards the reduction, if not outright elimination of poverty, disease, and the environmental degradation.

Progress towards these goals has recently been frustratingly slow and increasingly expensive. The heavy costs of providing and improving health care and education are examples.

The situation has produced a volatility in public opinion and mood that reflects a lack of confidence in the ability of government and other sectors of society, including science and technology, to adequately address fundamental social needs.

If this mood hardens into a lack of vision, of optimism, of belief in the future, a tremendous problem for science will result. Science, in its commitment to innovation and expanding frontiers of knowledge, is a thing of the future.

The vistas of science are inspiring. Condensed matter physics is embarked on materials by design, nanotechnology and high temperature superconductivity, each containing the seeds of new industries as well as new scientific understanding. Molecular biology is in full bloom with a vast potential for further intellectual progress, betterment of human (and plant and animal) health, and commercialization. Neuroscience seems poised for dramatic progress.

Research into the fundamental laws of physics is aiming at a pinnacle. There is a candidate theory - the superstring theory – which is proposed as a unification of all the known fundamental forces in nature and which is supposed to give an account, complete in principle, of all physical phenomena, down to the shortest distances currently imaginable. At the largest scales of distance, observational astronomy is uncovering meta-structures which enlarge the architecture of the universe a deepening of the problem of cosmology preliminary to its resolution.

Underpinning much of this progress, and progress in countless other areas as well has been the emergence of scientific computing as an enabling technology.

All this is first-rate science. All this is not enough – either to forestall change or to ensure adequate support for science in the present climate. Why it is not enough – and what else is required – are the subjects of a special inquiry.

2. Discussion.

1. Are there statements in the text that you disagree with? What are they?
2. Are you aware of the latest achievements in your field of science? What are they?
3. Do you think the achievements of science are not sufficient to ensure adequate support for science?
4. If you were in power what would you do to support science in Russia?

PART 2. ESPECIAL FIELD OF SCIENCE AND RESEARCH

Unit 5
TEMPERATE FRUITS

APPLE (Malus domestica Borkh.)

Introduction. Apple is the leading temperate fruit crop of the world. It is primarily cultivated for the edible fruits. Fruits are eaten fresh or processed as jam, juice, and cider. Fruits are rich in sugar and also contain high amounts of minerals, such as calcium, phosphorus, iron, and potassium, and vitamin thiamine. Trees have showy flowers and are used in landscaping and in home gardens for ornamental purposes.

Origin and Distribution. Apple is largely cultivated in Europe and North America. It is likely derived from Malus pumilain southwestern Asia. The major apple-growing countries are Australia, Brazil, Canada, China, Denmark, Egypt, England, France, India, Israel, Italy, Japan, Mexico, New Zealand, Russia, and the United States.

Morphology. Apple belongs to family Rosaceae, and its somatic chromosome number is 2n = 34. Trees are of medium size; leaves are soft and less pubescent; flowers are small, borne in clusters, and bright pink in color. Fruit is large and sweet and contains brown seeds. A thousand seeds weigh 25 to 50 g.

Seed Storage. Apple is propagated by both sexual and asexual methods. Seeds are predominantly used for raising rootstocks but are also involved in evolving better varieties through hybridization. Seeds survive for fairly long periods under ambient conditions. They exhibit orthodox storage behavior. Fresh seeds do not germinate readily due to innate dormancy, and they require cold stratification for removing dormancy. Dormancy is helpful in extending storage life of seeds for short periods. Normally, apple fruits are stored for several months in cold storage, which helps to preserve seed quality.

Seed Collections. Apple is a cool-season crop and is widely grown in cooler regions, particularly at higher latitudes and altitudes. It requires chilling temperatures for induction of flowering. It prefers deep, fertile, and well-drained soil. Apple is commonly propagated by grafting using suitable dwarfing rootstocks.

Many apple cultivars are self-incompatible and need suitable pollenizers. Honeybees largely bring about pollination. The grafted plant bears fruit in two to four years after planting. Ripe, healthy, good-sized fruits are collected for seed purposes. Seeds are removed from the fruit, thoroughly washed, dried at low temperature and relative humidity, and suitably packed for storage.

Seed storage in fruit. Apple seeds preserve viability and vigor in fruits up to 180 days. Fruits stored for shorter periods showed high seed quality. The longer the seeds remained in the fruit (150 to180 days), the higher their susceptibility to mildew. Seeds stored in fruit for 30 days showed maximum seedling growth and development. Seedling emergence in seeds extracted from fruits kept in cold storage was higher than for those kept at room temperature. It is advantageous to preserve fruits at 5°C for a short period prior to seed extraction.

Seed Germination. Apple seeds exhibit dormancy and do not germinate immediately after extraction. Storing fruits at low temperature eliminates the dormancy, but it increases time to germination. Seed dormancy can be overcome by exposing moist seeds to low temperature (5°C) for various periods. Germination of dormant seeds is higher at lower temperatures (5 to 10°C). Radicles emerge at lower temperatures and hypocotyls develop at higher temperatures. Seeds of late-harvested fruit and rotten fruits need shorter periods of stratification.

Seed coat removal facilitates germination but produces more abnormal seedlings. Normal growth is resumed after a certain period or through stratification of seeds or seedling exposure to low temperatures. The longer period of stratification is reduced by growing excised embryo or treating seed with ethephon (250 ppm) followed by 60 days exposure to low temperature, which gave high seed germination.

Early and rapid techniques for determination of viability in apple seeds have been developed. Seeds are soaked for 2 to3hinsulfuric acid, followed by soaking in benzyladenine (10 ppm) or equal volumes of benzyladenine (15 ppm) and gibberellic acid (150 ppm). Seeds germinate in the presence of continuous light at room temperature. The viable embryo germinates in three to four days of sowing, while nonviable ones deteriorate.

Storage Conditions. Temperature. Apple seed exhibits orthodox storage behavior. Higher seed moisture and temperature reduce the storage life of seeds. The estimated storage life of apple seeds with 5 percent mc is 100 years and 37 years at –18 and

5°C, respectively. Seed moisture is lowered rapidly in apple seeds by exposing them to low relative humidity. It takes about eight days to reduce moisture from 50 (fresh seeds) to 5 percent. Seed germination decreases with increase in moisture during storage. Seeds stored in a damp atmosphere show low germination, while seeds stored at 50 to 55 percent RH exhibit higher germination.

It is recommended sealed storage of apple seeds at –3°C for longer retention of viability and vigor. Drying stratified seeds at a higher temperature (25°C) induces secondary dormancy, not the lower temperature (5°C). Therefore, it is recommended storing seeds in moist sand at 0°C and not allowing the seeds to dry. Some scientists suggested drying seeds at 15°C with 10 percent RH for storage. Seeds (8 to 10 percent mc) were stored at 10°C in jute or polyethylene bags up to 25 months. In jute bags, viability was reduced from 90 to 30 percent within nine months, and in polyethylene bags, seeds showed 90 to 95 percent germination after 25 months of storage. Seed viability can be preserved for two years in desiccators with calcium chloride at 2 to 10°C. Seed longevity is extended further to seven years by packaging seeds in hermetically sealed bottles and storing them at –3 to –5°C. Seed drying to 5 percent moisture and storage at –18°C are beneficial for longer retention of high seed viability and vigor.

Invigoration of Stored Seeds. Seedling emergence is slow and less with an increase in storage period. Seed stratification in moist sand at 5°C followed by seed soaking in gibberellic acid (100 milligrams per liter [mg liter –1]) for 12 h increased the seed viability in three-year-old apple seeds.

PEAR (Pyrusspp.)

Introduction. Pear ranks second after apple as a popular cultivated fruit in temperate regions. The two important cultivated are Pyrus species P. communisand P. pyrifolia. Pear cultivation is also extended to subtropical regions due to its hardy nature and wider adaption. Fruits are used for table purposes and processed for preparation of jam, jelly, juice, wine, and candied and sweet pickles. Fruits are rich in organic acids, such as malic and citric acids; minerals, such as copper, sulfur, and phosphorus; and vitamins, such as thiamine, riboflavin, and vitamin C. Pear flowers are beautiful and the trees are planted in house gardens for ornamental purposes.

Origin and Distribution. Wide genetic diversity exists among pear cultivars in Europe and Asia. Pear originated in eastern Asia, probably in western China. European cultivars are descendants of P. communis, while Chinese and Japanese cultivars are derived from P. pyrifolia. Pear cultivation is mainly confined to temperate and subtropical regions of the northern hemisphere. It is grown in Argentina, Australia, China, France, Germany, Italy, Korea, Romania, Russia, South Africa, Spain, Switzerland, Turkey, and the United States.

Morphology. Pear belongs to family Rosaceae, and its somatic chromosome number is 2n = 34. The commonly cultivated varieties belong to P. Communisand P. pyrifolia, while P. serotinaand P. pashiaare used as rootstocks. Pear is a small deciduous tree. Leaves are small, ovate, and margin serrated; flowers are showy, hermaphrodite, and white. Fruit is a pome, is pyriform and fleshy, and contains a stone. Seeds are formed inside the stones.

Seed Storage. Pear is commonly propagated by vegetative means such as budding and grafting. Seeds are primarily used for raising rootstocks. Seeds are also used in evolving better cultivars through hybridization and for conservation of genetic diversity in the gene bank. Pear seeds exhibit orthodox storage behavior and their longevity is extended by lowering seed moisture and storing at low temperatures.

Seed Collections. Pear plants require mild winters and summers for optimum growth. They grow well in deep, well-drained, sandy loam soil. Trees bear fruit five to six years after planting. Many pear cultivars are self-incompatible and need suitable pollenizers. Bees bring about pollination. Fully matured, healthy fruits are collected for seed purposes. Seeds are easily extracted after softening the fruit. They are washed thoroughly, dried, cleaned, and suitably packed for storage or stratified for immediate sowing to raise seedlings for rootstocks.

Seed Germination. Fresh pear seeds do not germinate readily and need longer stratification to stimulate the germination process. Seed dormancy is removed by storing moist seeds at low temperature. Seeds stored at 5°C for 150 days showed high germination in many pear cultivars. The inhibitor contents decrease and auxinlike substances increase in seed coat and embryo during stratification. The duration of stratification varies from 15 to 180 days in different species. The stratification period also depends on the location from which fruits are collected. Seeds from warm winter climates require less chilling than those from colder climates. Seed germination is high after removal of the seed coat because this causes the excised embryo to germinate quickly. The seedlings initially show abnormal growth if seeds have not been stratified. It is reported that moist seeds placed at 4°C for four weeks, and subsequently at the soil surface in the presence of dim light, gave higher germination. Seed germination is also improved with seed soaking in gibberellic acid (150 ppm) and thiourea (5,000 ppm), followed by 28 days of stratification.

Storage Conditions. Pear seeds readily absorb moisture from the atmosphere. High seed moisture reduces storage life of seeds. It takes eight days for seed moisture to decrease from 50 (fresh seeds) to 5 percent. Low moisture (5 to 6 percent) is ideal for seed storage. The drying of stratified seeds results in low germination due to the induction of secondary dormancy. Seeds germinate fully when stratified. Pear seeds are dried at low temperature (15°C) and low relative humidity (10 percent RH) for long-term storage. Seed viability is preserved for two years when seeds are packed in sealed bottles or stored in desiccators over calcium chloride at 2 to 10°C. Seed longevity was extended further to seven years by preserving seeds at –3 to –5°C. Seeds preserved in liquid nitrogen (–196°C) maintain viability for three years. Seed viability was successfully preserved for 22 years at –5°C. For better and longer storage of pear seeds, it was suggested storing fruits initially at 5°C for a short period prior to seed extraction, then reducing moisture content to 5 percent before packing in suitable moisture-proof containers and storing at subzero temperature (–18°C).

PLUM (Prunusspp.)

Introduction. Plum is a delicious juicy fruit grown in temperate regions. Fruits are used for table purposes, canned, dried, and processed for jam, jelly, squash, and confectionery. Plums are a rich source of sugar and contain high quantities of vitamins A, thiamine, and riboflavin and minerals such as calcium, iron, and phosphorus. Trees are planted in home gardens for ornamental purposes. The different types of cultivated plums include American plum (Prunus americana), cherry plum (P. cerasifera), damson plum (P. insititia), European plum (P. domestica), and Japanese plum (P. salicina). Plum originated in North America, China, and Europe. The major plum-growing countries are Austria, Bulgaria, China, France, Germany, Hungary, Italy, Japan, Mexico, Romania, Russia, Spain, Turkey, and the United States.

Morphology. Plum belongs to family Rosaceae and has somatic chromosome number 2n = 16. Tree is small; leaves are ovate; flowers are white; fruit is oblong to ovoid and variously colored. Most plum cultivars are self-incompatible and require pollenizers. Bees bring about pollination. Ripe, healthy, and firm fruits are selected for seed purposes. Seeds are removed from pulp, washed thoroughly with water, dried, and packed in suitable containers for storage. Propagation is commonly achieved by budding; seeds are used in raising rootstocks.

Seed Storage. Seed Germination. Seed germination is slow and it takes longer for seedlings to emerge. Fresh seeds show dormancy. Germination is improved by removal of the seed coat. Prechilling of imbibed seeds also helps to break seed dormancy. Seed exposure to high temperature (20°C) for 14 days followed by chilling at 3 to 5°C hastens the germination process.

Storage Conditions. Plum seeds show orthodox storage behavior. Dry seeds preserve high viability for long periods at cooler conditions. It is recommended to preserve seeds under moist conditions at 7 to 10°C. Seed germination was 98 percent after 26 months and 16 percent after 53 months of storage. It is recommended seed drying at 15°C and 10 percent RH to 4 to 6 percent mc. Dried seeds are packed in moisture-proof containers and stored at –20°C for long-term seed conservation.

CHERRY (Prunusspp.)

Introduction. Cherry is commonly cultivated in temperate regions. Primarily two types of cherries are grown, namely, sweet cherry (Prunus avium) and sour cherry (P. cerasus).Sweet cherry is mainly used for table purposes, but also in salads and juice preparations and for canning. Sour cherry is largely used for processing purposes, such as wine or juice making, canning, and freezing; it is also sun dried. Fruit is rich in sugar, calcium, potassium, magnesium, iron, zinc, and vitamins A and C.

Morphology. Cherry has its origin in southeast Europe. It belongs to family Rosaceae, and its diploid chromosome number is 2n = 16, 32. Trees are tall; flowers are white and perfect. Fruits are globular or oblong and red, with a fleshy outer layer surrounding the hard stones that contain the seeds. Cherry is propagated by budding and grafting. Seeds are used for raising rootstocks. Many cherry cultivars are self-incompatible and require pollenizers. The compatible cultivars are grown side by side. Honeybees bring about pollination. Fruits are harvested when they change color. Seeds are extracted from fully ripe fruits, washed thoroughly with water, dried, and packed for storage.

Seed Storage. Seed Germination. Fresh cherry seeds do not germinate due to the presence of innate dormancy. Seedling emergence is delayed due to the presence of a hard endocarp, and it improves with removal of the endocarp. Seed exposure to pre-chilling at 3 to 5°C hastens the germination process. The percentage of germination was higher at alternate temperature regimes of 3/5°C or 5/20°C for 16 and 8 h, respectively, than at a constant temperature of 3 or 5°C. Warm stratification before chilling is beneficial for promoting higher seed germination. Exposure of cherry seeds 14 days at 20°C prior to prechilling at 3°C promotes germination. Repetitions of the warm and cold stratification cycle result in full germination of seeds.

Storage Conditions. Cherry seeds are orthodox and remain viable for longer periods at low moisture and low-temperature conditions. Seeds with 12 percent mc stored at 3 to 5°C preserved viability for five years. Seeds stored in hermetically sealed bottles at –3 to –5°C maintained 91 to 97 percent germination for seven years. Seeds lost viability rapidly when stored in sealed bottles at 20 to 25°C. Subsequently, high seed viability was preserved for 15 years at –5°C. Storage of dry seeds (4 to 6 percent mc) in moisture-proof containers at subzero temperature (20°C) preserved viability for a longer period.

RASPBERRY (Rubusspp.)

Introduction. Raspberry is a hardy plant widely cultivated in temperate areas of the northern hemisphere. Red (Rubus idaeus), black (R. occidentalis), and purple raspberry (hybrid of red and black) are cultivated in different locations. Fruits are eaten fresh, canned, and used in the preparation of jam, jelly, syrup, and wine. Leaves are used for medicinal purposes. Raspberry is native to North America, Asia, and Europe. It is predominantly cultivated in England, Hungary, Russia, the United States, and Yugoslavia.

Morphology. Raspberry belongs to family Rosaceae, and its diploid chromosome number is 2n = 14. Plant is erect and about 1 to2minheight. Suckers are commonly used for its propagation. Seeds are used for evolving new cultivars through hybridization. Flowers are small, few, and white. Fruit is oblong, conical, and dark red. Ripe and healthy fruits are selected for seed purposes. Seeds are extracted from the fruit, washed thoroughly with water, dried, and packed for storage.

Seed Storage. Seed Germination. Fresh raspberry seeds show poor and delayed germination, attributed to the presence of a hard seed coat. Seed scarification and removal of the seed coat hasten the germination process. It is reported that raspberry seeds germinated fully when scarified seeds were exposed to prechilling, alternate temperatures, or light or treated with potassium nitrate, thiourea, or kinetin. Further, gibberellins, sodium hypochlorite, calcium hypochlorite, and prolonged warm stratification promote the germination of intact seeds. Seed treatment with potassium hydroxide, sulfuric acid, or gibberellic acid stimulates germination. Seed germination was higher with potassium hydroxide, and seeds soaked in concentrated sulfuric acid for more than 20 min were damaged.

Storage Conditions. Raspberry seeds show orthodox storage behavior. Low seed moisture and low storage temperatures are beneficial for extending storage life of seeds. Seeds stored in polyethylene bags at 1°C remained viable for three months.

BLUEBERRY (Vacciniumspp.)

Introduction. Blueberry is an important small fruit in North America and Europe. It is cultivated for the edible fruits. Fruits are consumed fresh as well as processed. Products such as jam, jelly, sauce, pie, and wine are prepared. Plants are also used for ornamental purposes in home gardens. Fruits are a rich source of sugar, citric acid, vitamin C, phosphorus, calcium, iron, and potassium. Blueberry is native to North America. It is cultivated predominantly in Bulgaria, Canada, Chile, Denmark, Finland, Japan, the Netherlands, New Zealand, Poland, Russia, and the United States.

Morphology. Blueberry belongs to family Ericaceae and has chromosome number 2n = 24. The commonly cultivated blueberries are highbush (Vaccinium corymbosum), lowbush (V. angustifolium), and rabbiteye (V. ashei) blueberry. The plant is a deciduous shrub, growing up to6minheight. Flowers are small, borne in clusters, and white or tinged with pink. Fruit is blue and sweet. Seeds, grafting, and cuttings are used to propagate blueberry bushes. Lowbush and rabbiteye blueberries are self-incompatible and require crosspollination for higher fruit set. These are mainly pollinated by honeybees. Fruit becomes blue on full ripening. Fruit with larger seeds develops faster than fruit with smaller seeds. Healthy and fully ripe fruits are collected for seed purposes. Seeds are removed, washed thoroughly with water, dried in shade, and packed in moisture-proof containers for storage.

Seed Storage. Seed Germination. Blueberry seeds germinate readily on immediate extraction from ripe berries. Seed stratification at 3 to 4°C for 30 days promotes seed germination. Seed germination was higher when berries were stored at –23°C and seeds were stored in berries at –2°C or 1°C. The berries become moldy with Botrytis-spp. and germination percentage is reduced considerably. Mature and large seeds give higher germination than immature and small seeds. Seed soaking in gibberellic acid (100 to 500 ppm) stimulates the germination process. Light also hastens the germination process in fresh seeds.

Storage Conditions. Blueberry seeds preserve well under ambient conditions. High seed viability is preserved for two years at 5 to 7°C. Further, seeds preserved at 4.4°C gave higher germination (86.2 percent) after 12 years of storage.

Unit 6
POTATO AND SWEET POTATO
POTATO (Solanum tuberosum L.)

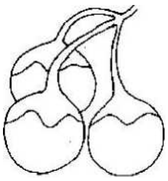
Introduction. Potato is a vegetable crop with global importance. It has been acknowledged as a staple food crop in many countries and ranks fourth after rice, wheat, and maize in production. It is cultivated in temperate, subtropical, and tropical regions for its underground edible tubers. Potato is a good source of carbohydrates and proteins and also contains high quantities of potassium and vitamins such as niacin, thiamine, and riboflavin. It has industrial importance in the manufacturing of starch, and also in the making of potato chips.

Origin and Distribution. Potato is native to South America. Its genetic diversity in terms of landraces and wild species occurs in Bolivia, Colombia, Ecuador, Peru, and Venezuela. Potato cultivation is distributed between 40°N and 20°S latitudes. It grows well in temperate regions, especially in Europe and North America. In the tropics, it does better at higher elevations. Besides North America, it is cultivated in Belarus, China, France, Germany, India, Japan, Kenya, Malaysia, the Netherlands, the Philippines, Poland, Russia, Sudan, Ukraine and United Kingdom.

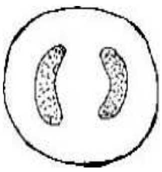
Morphology. Potato is an important member of the Solanaceae family. Plants are a dicotyledonous, perennial herb that is cultivated as an annual; the food is stored in tubers at the end of the stolons. Tubers vary in size, shape, color, and depth of eyes, which are characteristics of the different cultivars. They are bulky, perishable, and difficult to transport and store for long periods. Potato stems are weak; leaves are alternate and pinnately compound with ovate leaflets. The cultivated potato is tetraploid (2n = 48) and diploid (2n = 24), while hexaploid (2n = 72) potatoes are also found. Flowers are small and white, yellow, blue, or purple and are borne in clusters. Fruit is a berry, globose, green or purplish green, and not edible.

It contains more than 300 seeds. Seeds are small (1.5 mm), yellow or brown, flat or kidney shaped, and poisonous. One thousand seeds weigh roughly 0.6 g.

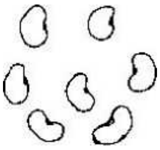
Seed Storage. Potato is propagated commercially by tubers, normally called seed tubers, to maintain the identity of the varietal characteristics, whereas true seeds are used in crop improvement and genetic conservation. Of late, cultivation through true potato seeds (TPS) is becoming popular in many potato growing areas, due to non availability of sufficient quantity of quality seed tubers, high transport costs, and problems in tuber storage. Potato seeds how orthodox storage behavior. These tiny seeds can be dried to a low level of moisture and stored at low temperatures for fairly long periods without affecting seed quality.



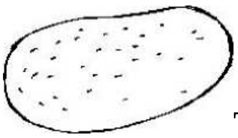
FRUITS



CROSS SECTION OF FRUIT



SEEDS



TUBER

Seed Collections. Potato is a cool-season crop, requiring low temperatures for optimum growth and tuberization. It is cultivated as a summer crop in temperate regions but is grown during the winter in the tropics and subtropics. It needs well-drained sandy loam soils. Soils rich in nutrients such as nitrogen, phosphorus, and potassium are favorable for high crop production. Potato flowers profusely and sets more fruits (berries) during long days. Both self- and cross-pollination occur, but many cultivars do not produce a sufficient quantity of pollen. However, a few set moderate to abundant amounts of pollen. Normally, potato is hand pollinated twice for better seed setting. Fruit matures in six to seven weeks after anthesis. Ripe healthy fruits are harvested for seed purposes, and seeds are separated, cleaned, dried, and stored.

Seed germination. Seed germination is epigeal and takes three to four weeks to complete. Seed germination is better at a constant temperature of 20°C and under diffuse light. Seed coat removal and exposing seeds to 16 to 118°C for 12 days increases germination percentage. Fresh seeds exhibit dormancy, which can be removed by after-ripening of seeds for 6 to 24 months at room temperature

Seed dormancy. Fresh seeds from fully developed berries show prolonged dormancy, and seeds of early harvested berries are less dormant and show poor viability. Dormancy is beneficial, especially in delaying the germination process, and enables longer storage of seeds under ambient conditions. Seeds of tetraploid plants are more dormant than seeds of diploid plants. Dormancy can be overcome by storing seeds for seven months. The endogenous gibberellic acid level increases during the first 120 days of storage, and simultaneously the quantum of abscisic acid (ABA) decreases. The proportion of GA and ABA regulates seed dormancy. However, the residual dormancy persists for two to eight years in potato seeds. The external application of gibberellic acid (1,000 ppm) removes seed dormancy.

Storage Conditions. Potato seeds are viable for relatively long periods, and they do not require specialized and expensive storage structures, as in the case of tubers. Seeds require dry, cool conditions for maintaining high seed quality in terms of viability and vigor. Seeds with 5 to 7 percent mc stored at 6 to 10°C over calcium chloride remain viable for eight years. Further, about 70 percent of seeds are viable even after ten years of storage at fluctuating temperatures (5 to 45°C). High seed viability is maintained for 10 to 13 years when seeds are stored at 0°C (Clark, 1940). At lower temperatures (0 to 5°C), seeds remain dormant for 5 to 13 years. Seeds that are low in moisture when stored in sealed containers at 1.1°C maintain high viability and vigor for nine years.

SWEET POTATO (**Ipomoea batatas (L.) Lam**.)

Introduction. Sweet potato is also called Spanish potato. It is cultivated throughout the tropics and subtropics for its edible tuberous roots. Tubers are rich in carbohydrates and beta-carotene, and they contain a high percentage of sugars, predominantly sucrose, about 3 to 6 percent. Tubers are boiled, baked, fried, and canned. Potato flour is used in the preparation of starch, glucose, pectin, and industrial alcohol. The tender foliage, which is rich in vitamins A and C, is used as a leafy green vegetable.

Origin and Distribution. Sweet potato originated from Ipomoea trifida in tropical South America. It is largely cultivated in Argentina, Brazil, Columbia, Ecuador, India, Indonesia, Japan, Malaysia, South Korea, and the Philippines.

Morphology. Sweet potato belongs to family Convolvulaceae and has a chromosome number of 2n = 90. It is a hexaploid, dicotyledonous perennial plant with long trailing vines that is cultivated annually. Roots are tuberous, fusiform, or globular, and there are four to ten per plant. Tubers vary in size and color, ranging from white, tan, and yellow-orange to salmon orange or red. Leaves are alternate and vary in shape. Sweet potato flowers readily in the tropics.

Flowers are single and axillary; the calyx is five lobed; the corolla is funnel shaped and purple in color; stamens number five; the ovary is bilocular.

Fruit is a dehiscent capsule that contains one to four seeds. Seeds are black, angular, and 3 mm long with hard testae. A large number of seeds set when tops are grafted on roots of cultivated morning glory plants.

Seed Storage. Stem cuttings are normally employed for propagation. Seeds are largely used in breeding programs and for conservation of genetic diversity in the gene bank. Seeds are stored for fairly long periods under ambient conditions. They show orthodox storage behavior, can tolerate desiccation, and store well at chilling temperatures.

Seed Collections. Sweet potato is a warm-season crop. It grows well in hot climates and needs plenty of sunshine. Low temperatures (less than 15°C) affect plant growth. Short days are congenial for flowering and root development.

Sweet potato requires deep, friable, sandy loam soil. The soil should be well drained. It is cultivated through root and vine cuttings (30 to 45 cm long).

Later, it is transplanted on ridges in the main field. Crops should be provided with adequate nutrition, irrigation, and plant protection measures for healthy and optimum growth. Sweet potato is self-incompatible, and crosspollination is brought about by insects. Matured dry fruits are collected for seed purposes and are extracted for storage.

Seed Germination. Sweet potato seeds possess a hard seed coat that delays the imbibitions process. Therefore, seed scarification with concentrated sulfuric acid is helpful in encouraging early and increased seedling emergence.

Storage Conditions. In sweet potato, seed deterioration is greater under high seed moisture and high storage temperatures. However, low-moisture seeds stored in moisture-proof containers under cool conditions retain viability for longer periods. Some scientists stored seeds at 18°C and 45 to 50 percent RH for 21 years, and 90 percent of sweet potato seeds germinated.

Unit 7
EGGPLANT, TOMATO AND PEPPERS

EGGPLANT (Solanum melongena L.)

Introduction. Eggplant is one of the most popular vegetable crops in all the tropical and subtropical countries. Eggplant is also called brinjal or aubergine. The name eggplant is derived from the egg-shaped fruit. It is a popular vegetable cultivated for its edible fruits. The immature fruit is cooked as a vegetable, fried, stuffed, or boiled.

Origin and Distribution. Eggplant is native to India, where wide genetic diversity exists. Its wild type and landraces, which are distributed in large areas, are spiny and bitter. It is largely cultivated in China, Egypt, Ghana, India, Indonesia, Italy, Iraq, Japan, Kenya, Malaysia, Nigeria, the Philippines, Puerto Rico, Spain, Syria, Thailand, and Turkey.

Morphology. Eggplant belongs to family Solanaceae, and its chromosome number is 2n = 24. It is a weak, erect, branching, spiny, pubescent, dicotyledonous, perennial herb. It is normally cultivated as an annual. Plants are moderately tall, growing up to 1 m in height. Foliage is dark green with large thick ovate or ovate-oblong leaves. Flowers are violet colored, single or in clusters of two to five. The calyx is long, woolly, often spiny, and it is persistent on the fruit even after maturity. Petals number five and are gamopetalous; stamens number five, are yellow, and stand erect. The ovary is superior and bilocular. Fruits vary in size, shape, and color and have many seeds. They are oblong or obovoid; smooth and shiny; and yellow, green, white, purple, or black. Seeds are small and numerous, kidney shaped, and light brown in color. One thousand seeds weigh about 4 g.

Seed Storage. Seeds are used for commercial cultivation of the crop. They are also used in genetic conservation, owing to ease of handling, are capable of maintaining genetic stability, and are inexpensive. Seeds show orthodox storage behavior. They require dry, cool conditions for better storage.

Seed Collections. High viability and vigor are ideal qualities for seed storage. These help to withstand unfavorable storage conditions. Vigorous seeds remain viable for longer periods under both favorable and unfavorable storage conditions. Seeds should be bold, clean, and free from debris as well as from insects and other microorganisms for better storage. Quality seeds are thus produced when optimum cultural practices are followed during seed production, and these seeds can then be collected for storage. Eggplant is a warm-season crop and therefore needs high temperature for optimum growth. Variations in temperature affect plant growth. The optimum soil temperature for seed germination is 30°C. Comparatively, seeds of long-fruited cultivars better withstand extremes of heat. The crop grows best in rich, deep, well-drained, sandy loam soils. Seeds are sown in raised nursery beds. Healthy seedlings are transplanted in the field after four to six weeks. In high rainfall areas, crops are grown on raised beds. Optimum spacing, fertilization, irrigation, and other cultural practices should be followed. Eggplant is a self-pollinated crop. However, cross-pollination occurs to a certain extent. Thus, an isolation distance of 50 m is provided to safeguard against contamination. Plants are checked for being true to type, especially during the flowering and fruiting stages, and any off types are removed. Fruits are harvested about 90 days after planting. Fruit color changes on maturity and its glossy appearance is lost. Simultaneously, seeds mature and become ready for harvest. Seeds are extracted from dry ripe fruits either manually or by wet extraction, whereby fruits are crushed and the pulp and seeds are soaked in water overnight. Later, the seeds are separated, dried, cleaned, and suitably packed for storage.

Seed Germination. Fresh seeds of eggplant do not germinate satisfactorily, requiring more time for germination, and thus show a certain amount of dormancy. Dormancy can be overcome by partially soaking seeds in potassium nitrate (4 percent) and subjecting them to an alternate temperature (20/30°C) regime. Seed treatment with gibberellic acid (100 ppm) eliminates dormancy.

Seed germination is epigeal and takes two weeks to complete. Germination is better at a constant temperature of 25°C or at alternate temperatures of 20/30°C. It is reported that seeds stored at room temperature or under low temperature for three years germinated well at 15 to 30°C, while some scientists suggested that eggplant seeds require alternate temperatures for full germination. Temperatures of 30/23°C for 8/16 h, respectively, are sufficient to promote germination in fresh and one year-old dormant seeds. Seed germination is higher in heavier seeds than in lighter ones, and this is attributed to better seed filling. Seed weight is positively correlated to protein content and, in turn, to seedling vigor. Further, higher seedling vigor from heavier or larger seeds is attributed to better availability and metabolism of reserve food. Eggplant seeds germinate better under dark conditions. However, seeds are sensitive to salt, and germination is affected in saline soils.

Factors Affecting Seed Longevity. Eggplant seeds can be stored fairly well under ambient conditions. High seed moisture at higher temperature affects seed longevity.

Genetic factors. Seed longevity varies within the genus among the different species. Certain cultivars withstand unfavorable storage conditions and remain viable for limited periods. Such cultivars also do not require special conditions for short-term storage.

Fruit maturity. Eggplant fruits take 30 to 40 days to mature following anthesis. Seeds extracted from fully ripe fruits give high seed quality, as seed maturity coincides with that of fruit. Mature seeds retain viability better than immature seeds.

Fruit storage. Eggplant fruits are stored for a week under ambient conditions. Further storage causes shriveling of fruits, affecting seed quality. Seeds from under ripe fruits are particularly susceptible to freezing temperatures and become dormant; warming improves germination. Storing fruits at low temperatures or below 0°C reduces germination. Storage of mature fruits for seven days increases the germination percentage.

Seed position in fruit. Seeds from the basal portion of fruits give early and high germination. These seeds preserve their high quality on storage. Similarly, fruits borne on the lower portion of the plant give quality seeds and higher germination. Size of fruit and seed weight are reduced in later-formed fruits.

Storage pests. Quite a few insects and fungi are associated with storage of eggplant seeds. Many of the pests can be eliminated under drier storage conditions. Drugstore beetle (Stegobium paniceum L.) causes considerable seed damage and affects seed viability. It is controlled by fumigation with methyl bromide. The viral activity inside the seed is entirely lost after seven months of storage at room temperature, without an appreciable reduction in germination. Fungi are controlled by a combination of activated clay and carbendazim. Application of thiram or Delsan-30 protects the seeds over a period of 18 months, without affecting the germination. Seed dressing with organomercurial compounds severely reduces seed viability.

Storage conditions. Seed longevity is primarily dependent on temperature, relative humidity, and, to a lesser extent, oxygen. Extremes of temperature and relative humidity result in a rapid decline in seed viability and seedling vigor, and an increase in leaching of electrolytes. Seed deterioration and invasions by fungi are greater at higher levels of seed moisture. The moisture is regulated by atmospheric humidity under open storage. It is reported that seed viability was affected by high humidity during storage (76 percent RH for 64 weeks).

Seeds stored at relative humidity of 10 to 40 percent maintained 50 to 60 percent viability after five years of storage under ambient conditions. Seed moisture content of 5 to 7 percent is ideal for long storage.

Storage Methods. Well-dried eggplant seeds maintain high viability under cooler conditions. Seeds are protected from extraneous factors, including humidity, by providing suitable moisture-proof packaging. Polyethylene bags are ideal for short storage, whereas laminated aluminum foil pouches are effective for longer storage.

Seed storage with silica gel. Seed storage with silica gel is beneficial in lowering the moisture content, thereby prolonging storage life. Silica gel is an inactive, inexpensive, and useful self-indicator material for seed storage. Seeds stored with silica gel in aluminum foil under ambient conditions recorded 50 percent germination after 30 months of storage, as compared to seeds stored without silica gel, which had 50 percent germination at 12 months of storage.

Cold storage of seeds. Seed viability and vigor preserve well under low temperatures. It is reported that seed viability declines rapidly under warm, humid conditions. While seeds with 7 percent mc maintain viability of 92 to 98 percent at –18 to 20°C for 112 days, seeds stored in laminated aluminum foil pouches at 5°C and –20°C maintain high viability and vigor for ten years. Viability decreases to 50 percent during the second year of ambient storage.

Seed storage in modified atmosphere. High atmospheric oxygen is injurious to seed viability, especially at higher levels of seed moisture. Eggplant seeds stored in laminated aluminum foil pouches along with carbon dioxide exhibited high seed germination after four years of storage under ambient conditions.

Invigoration of Stored Seeds. Seed deterioration is a gradual and irreversible process resulting in loss of seed quality. Imposing certain treatments slows down this process. In one-year-old seeds, germination is improved by naphthaleneacetic acid (NAA) (100 ppm) application. Similarly, in five-year-old eggplant seeds, germination and vigor are improved by seed priming with gibberellic acid (50 ppm) and potassium nitrate (0.01 M). Midstorage application of disodium phosphate to eggplant seeds is shown to improve seed germination, crop growth, and yield.

TOMATO (Lycopersicon esculentum Mill.)

Introduction. Recent years have witnessed a dramatic rise in tomato cultivation in many areas of the world. Tomato is an important solanaceous fruit vegetable that ranks fifth in production after potato. The fruits are edible and are eaten raw or cooked as a vegetable. Ripe fruits are used in the preparation of puree, soup, juice, ketchup, paste, and powder. Green tomatoes are cooked as a vegetable and made into pickles. Tomatoes are a rich source of minerals and vitamins A and C. Seeds contain a fairly high amount (24 percent) of edible oil.

Origin and Distribution. Tomato is native to South America. Large genetic diversity is observed within the coastal areas of Chile and Ecuador. Tomato is cultivated in the tropics, subtropics, and temperate regions. Fruits grown in cooler climatic conditions possess greater flavor and quality than those from tropical climates. Tomato is largely cultivated in Algeria, Brazil, China, Egypt, Greece, India, Indonesia, Iran, Italy, Japan, Malaysia, Mexico, Morocco, the Philippines, Spain, Turkey, and the United States.

Morphology. Tomato belongs to the Solanaceae family and has chromosome number 2n = 24. Plant is weak and erect or climbing; it shows indeterminate, semi-determinate, or determinate type of growth. It grows up to 2 m in height, and branches heavily with compound leaves. Leaves are dark green and hairy, with a characteristic odor. Flowers are yellow, perfect, and borne in clusters of four or more. Flower is composed of a short calyx tube; corolla rotate with six petals; six stamens that form on the corolla tube; and a pistil with several locules (five to nine). Fruit is a soft fleshy berry with various shapes, sizes, and colors. It may be round, pear, oblate, somewhat square, or flattened, with a smooth or ribbed surface. The skin color changes to red or yellow on ripening, but it remains green in fruits of Lycopersicon peruvianum, L. chilense, and L. hirsutum. Seeds are many, small, light brown, hairy, and kidney shaped, with a curved embryo embedded in the endosperm. One thousand seed weigh about 2.5 to 3.3 g.

Seed Storage. Tomato seeds are tiny structures capable of withstanding adverse storage conditions, to a certain extent. They show orthodox storage behavior, wherein desiccation of seeds and storage at low temperatures increase seed longevity. Seeds are primarily used in propagating tomato and in breeding and genetic conservation. Farmers prefer to preserve viable seeds for short periods, such as until the next growing season, whereas breeders demand the fairly long storage for germplasm conservation. Therefore, suitable storage methods have been developed to suit these requirements.

Genetic Factors. Tomato seeds maintain their viability for long periods, and this is attributed to genetic factors. Tomato seed longevity is primarily controlled by genetic means, and the magnitude of viability and germination potential is higher in hybrids than in inbred plants. Seed longevity differs within the genus among species and cultivars. Seed germination percentage varies among different cultivars stored for four years under ambient conditions.

Seed Collections. Tomato is a warm-season crop and cannot survive at very hot or very cold temperatures. It prefers deep, fertile, well-drained soil. The optimum soil temperature for germination is 30°C, with a minimum temperature of 10°C. Seeds are sown in nurseries or on raised beds or ridges, and after four to six weeks, the seedlings are transplanted to the field. Seedlings are supported with stakes, especially the indeterminate types. Proper fertilization, timely irrigation, and plant protection measures should be followed. Tomato is a self-pollinated crop. An isolation distance of 50 m is maintained to avoid accidental cross-pollination by insects. Plants are examined for cultivar characteristics during the flowering and fruiting stages, and the off types are removed. It takes about 60 to 90 days from planting to harvesting, depending on cultivars. Extreme temperatures, especially higher than 38°C, affect the fruit set. Ripe fruits are harvested (see Figure 34.2). Seeds are removed by cutting the fruits; they are then washed in water and dried. Pulp is also separated by fermentation or by using dilute hydrochloric acid.

Normally, medium to large fruits are picked for seed purposes. Seeds of these fruits give higher germination and vigorous seedlings.

Fruit maturity. Tomato seeds reach acceptable quality on maturity of fruits. The seeds mature between 35 and 41 days after anthesis, at which time seed moisture will be about 53 to 72 percent. Seeds taken 21 days after flowering are capable of germinating but do not store long. Seed germination, vigor, and storage protein increase, and seed moisture decreases, with advances from mature green to the ripening stage. Fruit color changes on maturity, when fruit becomes dark red and seed dry weight and vigor reach the maximum. It is noted that seed germination and vigor are unaffected in fruits showing pale pink to dark red coloring. Seeds of mature green fruit give low germination, and rate and intensity of germination increase from the color breaker stage. Seeds attain maximum viability in the ripe stage of fruit development and show greater seedling vigor. However, fruits can be plucked at the color breaker stage for an early seed crop without hampering seed viability. Likewise, some scientists obtained 95 percent germination in seeds of fruits turning red and in red ripe fruits, as compared to only 64 percent in seeds of mature green fruits. Further, seed quality is affected in seeds of overripe and diseased fruits.

Fruit storage. Storing fruit for a short period provides ample time for preparation and processing of seed material for storage. Fruits of different stages retain good seed quality for various periods. Seed viability decreases with an increase in fruit storage time. Red ripe tomatoes stored in a refrigerator (11.5°C and 57 percent RH) retain seedling vigor for six weeks and show the highest vigor during the third week of storage, as compared to the low vigor shown when stored for a short period at room temperatures (27.7°C and 75 percent RH).

Seed drying. Tomato seeds have 60 to 70 percent mc at harvest, and this must be reduced to 9 percent during storage for better seed quality (Harrington, 1960). Seeds dried in sun and shade (alternately for 2 h) and mechanical drying with air at 40°C are optimal for safe drying of seeds for better storage.

Seed Germination. Seed germination is epigeal and takes about one week to complete at higher temperatures. The optimum temperature is from 25 to 30°C. Tomato seeds show considerable dormancy. Secondary dormancy is induced by chilling, warm stratification, and exposure to far red light. Seed priming is reported to improve the germination percentage.

Seed size. Medium-sized seeds are reported to give higher germination, and seed size of about 0.8 mm is found to give higher field emergence and higher yield.

Plant extracts. Plant extracts contain certain growth substances that either promote or inhibit the germination process. Tomato juice inhibits germination, an effect attributed to the presence of abscisic acid. Similarly, tomato seed germination is inhibited by mandarin juice and Emblica officinalis fruits. Plant extracts of Ceratophyllum demersum, Eichhornia crassipes, Marsilea minuta, Salvinia natans, and Spirodela polyrrhiza stimulate germination, whereas extracts of Cannabis sativa, Crinum asiaticum, Holarrhena antidysenterica, Nelumbo nucifera, and Sansevieria roxburghiana inhibited germination.

Fungal extracts. Tomato seed germination is optimum in normal soils, rather than in sterilized and saline soils. Seedling growth improves with the addition of rhizosphere microflora suspension of respective plant species to the soil prior to sowing. Seed coating with spores of Aspergillus niveus, A. rugulosus, A. tamarii, Penicillium spp., and Trichoderma lignorum controls pre- and postemergence losses.

Growth substances. Seed treatment with growth substances such as GA, IAA, and NAA and short exposure to light and magnetic stimulus enhance the seed germination process. Seed soaking in GA4+7 in addition to osmotic priming (–1.0 MPa polyethylene glycol [PEG] 6000) increases germination of tomato seeds.

Storage of germinated seeds. Pregerminated and germinated seeds remain viable for shorter periods under ambient conditions. They retain their viability for five days at

5°C. Further storage reduces viability and vigor due to the degradation of enzymes and functional structures and an increase in free fatty acids. Likewise, pregerminated seeds could effectively be preserved in moist cheesecloth, with emergence percentage and emergence rate index unaffected. These seeds can also be preserved well in vacuum storage or in nitrogen at 7°C for 63 days and register excellent plant growth.

Some scientists preserved germinated tomato seeds for five days at 0° or 5°C by suspending the seeds in two fluid drilling gels, namely Natrosol-250 and Laponite-445.

Storage Conditions. Tomato seeds preserve well under ambient conditions. Higher temperatures and relative humidity are not favorable for storage. Seeds stored at 50°C and 77 percent RH showed slow and less germination. The optimum temperature and RH for storage are close to 0°C and not exceeding 70 percent, respectively. Low seed moisture, 5 to 7 percent, is ideal for longer storage, even if higher temperatures are maintained. Tomato seeds survive in outer space conditions for several years without adverse effects on germination, emergence, and fruit yield. Seed vigor depends on initial status of seed quality and the storage conditions. During storage, seedling vigor declines earlier and more rapidly than viability. Further, disintegration of cell membranes causes excessive leaching of electrolytes, soluble sugars, and free amino acids. The process of deterioration slows under favorable storage conditions.

Storage fungi. Good healthy seeds maintain their viability for longer periods. Seed health is affected under unfavorable storage conditions. Storage fungi are active at higher levels of seed moisture, causing discoloration of seeds. This is checked either by proper seed drying or by using suitable fungicidal treatment. Seed treatment with captan (2.5 g·kg –1) is effective in controlling storage fungi, and it helps retain high viability for 18 months under ambient conditions.

Storage Methods:

Seed storage with desiccants. Seed moisture plays a major role in deterioration. Even seed exposure to high levels of relative humidity reduces viability and vigor and affects membrane integrity. Desiccant-like silica gel is useful in maintaining an optimum level of seed moisture. Tomato seeds stored over silica gel preserved high viability and vigor for three years under ambient conditions.

Seed storage at low temperatures. Tomato seeds retained high seed viability and vigor for three years under ambient conditions. Thereafter, seed viability decreased; however, the seeds were economically viable until the eighth year of storage. Some scientists reported that tomato seeds maintain viability for 13 years at room temperatures and for 18 years at –5°C, and stored seeds behaved similarly to fresh seeds. Seeds maintain high viability and vigor at low (5°C) and subzero (–20°C) temperatures for ten years, as compared to four years at ambient temperatures (16 to 35°C). Well-dried seeds remain viable for longer periods at lower temperatures. However, seeds should be suitably packed in moisture-proof containers to safeguard against high relative humidity and extraneous pests.

Invigoration of Stored Seeds. Seed storage under unfavorable conditions reduces the rate of germination, uniformity, and total germination and increases the number of abnormal seedlings. Such low-vigor seeds can be reactivated by physical and chemical stimuli. Prestorage humidification and seed hydropriming impart resistance to deterioration. Seed priming with PEG 8000 at 20°C for seven days increases the rate of germination and maintains high viability at lower temperatures (10 and 20°C). It is also reported that primed tomato seeds stored at 4°C showed maximum seed viability. Prolonged high temperature (35°C) storage of primed seeds reduces the germination rate and total germination. Repriming of primed seeds has some benefit but does not entirely reverse the detrimental effects of high-temperature storage. Further repriming is ineffective when seeds show greater loss of viability. However, a slight gain in early germination is reported.

Midstorage soaking of seeds in water or chemicals hastens the germination process by leaching certain toxic substances and activates the enzyme network involved in germination. Soaking tomato seeds in water followed by drying improves the germination and seedling vigor. Hydration is also achieved by exposing seeds to 100 percent RH for 24 h followed by redrying, promoting germination. One of the agronomists soaked tomato seeds in water for 24 h followed by drying at 12°C for ten days; this resulted in higher percentage of germination, higher fruit yield, and a greater number of heavier fruits.

The beneficial effects of prestorage humidification and hydropriming related to metabolic activities induced by partial hydration; the adverse effects of osmopriming were caused by a decrease in DNA repair activity due to progression in the cell cycle. Priming enhances seed germination but simultaneously lowers resistance to deterioration. Primed seeds are vigorous but have a reduced storage life. It is reported that aging of tomato seeds involves glutathione oxidation. Priming reduces the oxidized form of glutathione. Hydration in conjunction with dilute solutions of sodium chloride (10–3 M) or sodium orthophosphate (10–4 M) improves field performance and productivity. Seed quality of eightmonth-old tomato seeds was improved by disodium and that of one-year-old seeds by naphthaleneacetic acid (50 ppm).

PEPPERS (Capsicum annuum L.)

Introduction. Peppers are known by several names in different regions, such as bell pepper capsicum, cayenne, chilli, paprika, red pepper, and sweet pepper, according to their shape, color, and pungency. Immature and mature fruits are eaten raw as salad vegetables, and various vegetable dishes are made from them. Sweet peppers are nonpungent, have a mild flavor, and are thus widely used in salad. Ripe chilli fruits are pungent, and their dry powder is commonly used as spice in cooking various foods. Hungarian type paprika are more pungent, whereas Spanish and European types are less pungent.

The pungency in the fruit is due to capsaicin (C18 H27 NO3) content, which is mainly confined to the septa and placental tissue. Peppers are a rich source of vitamins A and C.

Origin and Distribution. Peppers originated in Central and South America, more particularly in Mexico and surrounding countries. It is widely grown in the tropics, subtropics, and temperate regions. Some of the leading pepper-growing countries are Algeria, Argentina, Bulgaria, China, Hungary, India, Indonesia, Japan, Kenya, Mexico, Malaysia, Nigeria, the Netherlands, the Philippines, Spain, Sudan, Thailand, Turkey, the United States, and Yugoslavia.

Morphology. Peppers belong to family Solanaceae, and their chromosome number is 2n = 24. They are short-lived, dicotyledonous, perennial plants in the tropics, but they are cultivated as an annual. Plants consist of a strong root and shoot system and grow up to 1.5 m in height. Plant stems are hard and branched, with simple, ovate, light green to dark green leaves. Flowers are small, axillary, and single or two to three in cluster at the node; the calyx is five lobed; the corolla is white or greenish, campanulate, and five petaled; the five stamens have bluish anthers; the ovary is two celled. Fruit is a podlike berry, erect or drooping, indehiscent, and many seeded. It varies in shape (heart, cylindrical, round, cherry, long and thin, or square), size, and color. Initially, fruits are green or purple in color and later become red, orange, yellow, brown, cream, or purplish on ripening. Seeds are somewhat circular, yellow, light in weight, and 3 to 5 mm long. One thousand seeds weigh about 3.5 to 5 g, depending on variety and growing conditions.

Seed Storage. Pepper seeds show orthodox storage behavior. Seeds are predominantly used in crop production and for genetic conservation. Seeds are genetically stable in long-term conservation. Seeds remain viable for two to three years in ambient conditions. High atmospheric humidity and high temperatures shorten the storage life of seeds. The germinating energy in stored seeds decreases more rapidly than germination capacity, and it is lost completely by three years when stored at room temperatures.

The seed storage life is primarily dependent on genetic factors. Seed longevity differs among the different cultivars during storage and is influenced by storage temperatures and cultivation conditions. Some genotypes withstand aging to a certain extent and remain viable for relatively longer periods under ambient conditions. Such genotypes produce improved seed longevity in hybrids when used as parents.

Seed Collections. Peppers grow well in warm, humid climates. High temperature induces flowering, while excessive rainfall damages the crop, affecting the fruit set and causing fruit rotting. Peppers prefer deep, fertile, well-drained soils. Seeds are sown in nurseries on raised beds and subsequently transplanted to the field four to six weeks after sowing. In the field, adequate spacing, fertilization, weeding, and suitable plant protection measures must be followed to get a healthy crop. Though peppers are a self-pollinated crop, about 5 to 40 percent are cross-pollinated. Normally, bees, thrips, and ants cause cross-pollination. To prevent pollen contamination, an isolation distance of 400 m is adopted. Plants are inspected for vegetative, flowering, and fruiting characters during the flowering and fruiting stages, and off types are removed. Fruit matures four weeks after anthesis. Red ripe and disease-free fruits are plucked for seed purposes. Seeds are extracted manually or by machine, the latter giving better recovery at less expense.

Fruit maturity. Mature bold seed maintains high seed quality during storage. Seed maturity coincides with that of fruit maturity and is expressed by change in fruit color. Early harvested fruits give poor-quality seeds with low viability and vigor. Fruits harvested at color breaker stage have high viability. Some agronomists reported that seeds extracted from fruits 48 days after anthesis have higher viability and vigor. Further, seeds extracted from second and third fruit pickings retain high viability after 12 months of ambient storage.

Seeds are fully capable of germination and impart tolerance to desiccation just before or at mass maturity. The maximum potential longevity occurs after 10 to 12 days of mass maturity. Seeds harvested at the ripe stage show higher germination and high seedling vigor, and can be stored longer under ambient conditions. Some scientists noted that seeds extracted from mature green fruit did not germinate and required 14 days of storage for germination. Seeds from red fruits (50 days after anthesis) and over mature red fruits (60 days after anthesis) possessed higher germination capacity and greater dry weight. Seeds are generally allowed to mature for a short period within the fruits after harvest for better seed quality.

Fruit storage. Dry pepper fruits can be stored for various periods, depending on the climatic and storage conditions. Fruit seeds stored up to six months exhibited higher germination. Pepper fruits preserve well in cloth bags or paper bags, as these allow free exchange of gases and water vapor from the fruits. Seeds of these stored fruits gave 75 percent germination for three years, whereas seeds of fruits stored in sealed conditions in aluminum foil did not germinate.

Seed position. Seed viability is influenced by the position of seeds inside the fruit. Seeds from the basal portion of the fruit have higher potential for viability and vigor as compared to those from the middle and tip.

Seed Germination. Fresh seeds do not germinate readily and show the presence of dormancy. Seeds require six weeks of after-ripening to germinate. Several by-products, such as alcohol, aldehydes, ketones, esters, hydrocarbon, and furans, are released from seeds during after-ripening. Pepper seeds germinate well at a constant temperature of 25 to 35°C and are inhibited below 20°C, which can be overcome by seed priming (PEG 6000 or potassium nitrate [KNO3] + potassium orthophosphate [K3PO4]). Seed germination is epigeal and takes about six to ten days to complete. Seeds of cultivars derived from other species, such as Capsicum baccatum, C. chinense, and C. pubescens do not germinate at a constant temperature and require an alternate temperature regime. Pepper seeds are sensitive to salinity, and germination is affected by high levels of salts, more than 4,000 ppm. Seed germination is rapid and higher when a little fruit pulp is retained along with the seed during drying. This aids better translocation of metabolites from pulp to seed at higher temperatures. Seed germination is enhanced by the use of plant stimulants such as atonik, and such treated seeds can also be stored for longer periods. Application of growth substances such as GA and IAA improves seed germination.

Storage of germinated seeds. Germinated seeds are more perishable and do not store long. However, when such seeds are placed in polyethylene bags (0.025 mm) with a vacuum seal or in nitrogen at 7°C they remain viable for 63 days.

Storage Conditions. A high seed quality is essential for longer storage of seeds, and seed losses are minimal under ideal storage conditions. Initial seed quality, especially high vigor, contributes to longer storage life. Prevalence of high relative humidity and temperature shorten storage life. Chemical composition of seeds and atmospheric relative humidity determine the seed moisture content, thereby deciding seed longevity. The low level of seed moisture is maintained and protected from atmospheric humidity by suitable packaging. It is reported that 10 percent moisture is optimum for better storage of Capsicum frutescens seeds. In a study conducted by some scientists, pepper seeds (8 percent mc) were stored at 10.7 to 23.8°C and 45.7 to 85.7 percent RH for eight years in cloth bags, glass containers, polyethylene boxes, plastic bags, and tins. Among all, seed viability was highest in glassware-stored seeds, while in others, viability was lost gradually, and more rapidly in seeds stored in cloth bags. In one study, seeds remained viable for seven years when packed in sealed jars or plastic bags and stored at 5 to 10°C.

However, seed lost viability rapidly under unsealed conditions. Under fluctuating temperatures from 2 to 26°C, seed viability decreased from 92 to 29 percent during five years of storage. Ultra-low-temperature storage of seeds at –70°C did not improve the storability over that of –12°C. On aging, seeds became brown and lost vigor and viability. Such seeds lose more electrolytes and soluble sugars on imbibitions through leaching.

Seed storage at low temperatures. Pepper seeds preserve well at low temperatures. Seed deterioration is less at 5°C storage. High seed viability and vigor were maintained in seeds stored at 5 or –20°C after five years of storage, as compared to three years only when seeds were stored at ambient temperatures. In bell pepper, too, high seed viability was maintained at low (5°C) and subzero (–20°C) temperatures for fifteen years, while under ambient conditions, bell pepper seeds remained viable for two years. The loss of viability was associated with greater leaching of electrolytes, soluble sugars, and free amino acids from the seeds. Seeds with 4 percent moisture stored at 32.2°C maintained viability for at least three years. Further, seeds preserved viability for five years at 5°C and for ten years at –4°C in sealed containers. Furthermore, high seed viability was maintained in laminated aluminum foil pouches stored at 5 and –20°C for ten years.

Modified atmospheric storage of seeds. Seeds stored in partial vacuum under ambient conditions remain viable and vigorous for three years. A higher concentration of carbon dioxide inhibits germination and preserves viability for five years under ambient conditions.

Storage fungi. Pepper seeds associate with certain fungi under conditions of high seed moisture and high atmospheric RH. Alternaria, Aspergillus, Chaetomium, Colletotrichum, Fusarium, Penicillium, and Rhizopus species affect seed quality during storage, and these are effectively controlled with fungicidal applications. Fungicides, such as captan, carbendazim, copper oxychloride, and mancozeb are effective in maintaining good seed health. Sodium hypochloride and captan at 2.5 percent give effective control of storage fungi and high seed germination during storage. The Ocimum oil is more effective than synthetic fungicides, and it does not show any adverse effect on seed germination or seedling growth during storage.

Invigoration of Stored Seeds. Seed loses germinating capacity during storage. Such low-vigor seeds regain their quality to a certain extent when treated with growth substances or other physical stimuli. Seeds of cv. California Wonder showed improved germination after soaking in water for 72 h followed by gibberellic acid (50 ppm) application. Likewise, seed quality improved with the application of potassium dihydrogen phosphate (3 percent) to four-year-old seeds, whereas repriming of primed seeds stored at 5°C caused reduction in seed germination.

Unit 8
BULB CROPS

ONION (Allium cepa L.)

Introduction. Onion is a popular bulb vegetable crop in temperate, tropical, and subtropical regions. Both immature and mature bulbs are eaten raw, cooked, or used in the preparation of different vegetable dishes. The green leaves are also used in salads, and cooked as a vegetable. Onion contains high amounts of carbohydrates, calcium, phosphorus, vitamins A and B, and the volatile substance allylpropyl disulphide. Onion has medicinal value in that it possesses antibacterial properties.

Origin and Distribution. Onion originated in Central Asia comprising Afghanistan, Iran, Tajikstan, Turkey, and West Pakistan. It is cultivated in Argentina, Brazil, China, Colombia, Egypt, Ghana, India, Indonesia, Iran, Italy, Japan, Korea, Malaysia, Mexico, Morocco, Myanmar, the Netherlands, Nigeria, Pakistan, the Philippines, Poland, Russia, South Africa, Spain, Turkey, and the United States.

Morphology. Onion belongs to the family Alliaceae and has chromosome number of 2n = 16. It is a monocotyledonous biennial herb but is cultivated as an annual. Stems are short with poorly developed root systems, and adventitious roots emerge from the base of the stems. Leaves are alternate, hollow, and arranged in a circle, forming a bulb. Bulbs are flat, globular, or cylindrical in shape. Bulb color varies, being either white, yellow, brown, pink, red, or green. Inflorescence is a terminal umbel consisting of 50 to 2,000 tiny flowers. Number of seed stalks varies from 1 to 20, depending upon bulb size, cultivars, and growing conditions. Flowers are white, with six stamens and a protoandrous superior ovary, and trilocular. Fruit is a capsule that splits longitudinally and contains one to two seeds. Seeds are black, shiny, and wrinkled. Embryo is crescent shaped or curved and embedded in the endosperm. One thousand seeds weigh about 3.5g.

Seed Storage. Onion is propagated by seeds. Seeds are short-lived under ambient conditions. Seeds are also used for evolving new varieties in breeding programs, and for long-term conservation of genetic diversity. Onion seeds exhibit orthodox storage behavior; they can withstand loss of moisture and have extended longevity under low-temperature storage conditions. Seed longevity of several crop species was studied under different atmospheric conditions; and onion seeds were found to be the most short-lived. It is also reported that onion seeds lost viability more rapidly than seeds of other crops. Onion seeds preserve viability for 6 to 12 months under ambient conditions.

Seed longevity is primarily governed by genetic means. However, it is also regulated by storage conditions. It varies in different genotypes, species, and cultivars. Good-storer cultivars withstand relatively higher temperatures and relative humidity. Some agronomists identified certain good and poor-storer cultivars. Poor-storer types showed greater cellular damage during storage, as evidenced by excessive leakage of electrolytes and soluble sugars. These cultivars are useful in studying inheritance of seed storability and in hybridizing for better storage quality.

Location of Seed Storage. Extreme climatic conditions affect seed longevity. Areas where dry and cool climates prevail during most of the year are suitable for safe seed storage. Some scientists identified the places suited for short-term seed storage based on prevailing temperatures and relative humidity during a year. It was suggested that the combination of temperature (°F) and relative humidity (percent) should not exceed 100 for better storage.

Seed Collections. Onion is a cool-season crop that requires low temperatures for bulb formation and flowering. It withstands frost. Plants grown under low temperatures (15 to 16°C) yielded more seeds than those grown under high temperatures (22 to 23°C). Heavy rainfall areas are not suited for cultivation. Deep, fertile, sandy loam soil with good drainage is ideal for onion cultivation. Onion has a shallow root system and needs frequent irrigation.

Onion is propagated by seeds. Seeds are sown in a nursery, and four week-old seedlings are transplanted to the field. Soil sterilization is useful, especially in nursery bed preparation, for reducing pink root rot disease and for higher seedling vigor. Seeds are produced by the bulb-to-seed or seed-to-seed method. In the former method, mature healthy bulbs are planted for seed production. Bulbs are stored for four to five months before planting for curing. Bulbs stored at 10°C for 90 days flowered earlier, produced more flowers, and had the highest seed yield. Likewise, bulbs stored for 12 weeks at 10°C resulted in higher yield.

Onion yield increases with increased seed size. Onion is a cross-pollinated crop, and pollination is mainly brought about by bees. An isolation distance of 1,600 m is used to maintain genetic purity. Plants are adequately fertilized, and protected against pests and diseases. Plants with double bulbs and thick necks are removed to maintain varietal quality. Heads are collected when fruits open and expose the black seeds. Later they are cured for two to three days and then threshed; seeds are separated, cleaned, dried, and suitably packed for storage.

Seed maturity. Bold, uniform, healthy, and high-vigor seeds are best suited for storage. It was opined that seeds attained maximum dry weight during maturity. These mature seeds store longer than immature seeds. Some scientists observed that seeds harvested one week prior to full maturity gave normal percentage of germination, while germination decreased in seeds harvested two weeks early. Further, a delay in harvesting affects seed quality by risking rain damage or seed shattering.

Seed drying. Seeds are capable of exchanging moisture with the atmosphere. The process is faster in seeds rich in storage proteins, and it is slower in onion seeds. Seeds absorb moisture from the atmosphere when the vapor pressure is lower in seeds, and they lose moisture when the vapor pressure is lower in the atmosphere. When the two vapor pressures are equal, no movement of moisture vapor occurs, and the system is in equilibrium. Seeds dry on the movement of water vapor out of the seeds into the atmosphere by creating a moisture gradient. Seed structure will be damaged at a higher rate of evaporation. Thus, seeds are preferably dried at low temperature and low humidity. Drying seeds with dehumidified air at 25 to 40°C did not affect the germination percentage. Seeds are dried by various means, such as natural drying; sun drying; heated, unheated, and dehumidified air drying; drying with desiccants; and vacuum and freeze-drying. Each has advantages and disadvantages. Seeds are protected against heat damage during drying. Seeds dried in scorching heat and sun showed reduced germination. It was noted that drying too rapidly at a high temperature was injurious to seed life. The reduction of seed moisture from 10.0 to 6.5 percent is more beneficial for preserving high viability than nondrying of seeds. Drying with silica gel is optimum for maintaining high seed viability for a longer period. Earlier, some agronomists believed that onion seeds should be dried to one-third to one-half of their original moisture content for satisfactory storage at room temperatures.

There are different opinions about ultralow-mc drying of seeds: It damages the cell structure and contents, thus affecting viability and seed storability, and also it is unsuitable for storage of large quantities of seeds. Freeze-drying for one day increases the seed. Freeze-dried seeds showed 61 percent germination after one year of storage at 50°C in sealed containers. Further excessive drying is to be avoided, as water in the protective monolayer should not be removed (Woodstock, 1975). Furthermore, freeze-dried seeds (4.1 percent mc) stored in desiccators over zeolite at 40°C gave 79 percent germination after six years of storage. Freeze-drying of seeds improves storability at higher temperatures. Seeds with 2.0 to 3.7 percent (ultradry) moisture preserve higher viability than those with 5.5 to 6.8 percent (dry) at 20°C storage, while no difference was observed at –20°C storage. It appears that ultradrying of seeds is useful, especially for seed storage under ambient conditions.

Seed moisture. High seed moisture is injurious to the storage life of seeds. The rates of seed deterioration and fungal damage are greater at higher moisture contents. Seed moisture is higher at the initial stages of seed development, and it decreases on maturation and ripening. Seed moisture content depends on seed composition, air temperature, and relative humidity. At any given moisture level, seed viability and vigor decrease more rapidly at higher temperatures. Seedling vigor exhibits a rapid decline earlier than seedling viability. It was reported that the seed longevity period doubled for every 1 percent decrease in moisture content. Low-moisture seeds are viable for longer periods. According to some scientific works, loss of seed viability is rapid between 13 and 15 percent moisture content and slower at 11 percent. Low moisture decreases the seed deterioration, as it is unsuitable for the growth of pathogens.

Seed Germination. Seed germination is rapid and high in onion at 20°C, whereas in another species, Allium unifolium, germination was high at 5°C, and seeds did not germinate at 15°C. Fresh seeds show a certain amount of dormancy. According to scientific data, after-ripening of two months is required to eliminate the dormancy. Thus, dormancy tends to delay germination rather than completely prevent it. The cotyledon tip elongates during germination, carrying the radicle and plumule out of the testa. The elongated cotyledon forms a sharp bend that pushes to the soil surface, becomes green and straight, and produces foliage. It was reported that large seeds give better field emergence than small seeds, and their yield also is higher by 18 percent. Higher concentrations of carbon dioxide inhibit germination.

Storage Conditions. Storage conditions such as temperature, relative humidity, oxygen, light, and pathogens contribute to seed deterioration.

Temperature. Seed longevity decreases with an increase in storage temperatures. According to some agronomists, seed longevity decreased by half for every 5°C rise in storage temperature. The temperature is closely related to seed moisture, and the combination of these two factors seriously affects seed deterioration. High-moisture seeds at higher temperatures deteriorate rapidly. It is reported that onion seeds lose viability faster under variable temperatures and relative humidity. A number of scientists noted a greater decrease in seed viability at 20°C and 80 percent RH.

High-vigor seeds tolerate such effects. Different workers have reported various longevity periods at room temperatures. It is observed that onion seeds are viable for 60 days or less under ambient conditions, and also noted a shorter storage life for onion seeds, which remained viable for less than 60 days at 26.7°C and 75 to 80 percent RH. According to scientific data, onion seeds remained viable for 12 months in an aluminum can, whereas some agronomists reported that seeds remained viable for four years at room temperatures when relative humidity was less than 10 percent. Seeds having 6.2 percent moisture remained viable for 13 years at room temperatures. Further, the reduction of seed moisture to 1.2 percent is beneficial for longer storage life (nine years) at room temperatures. In another study, seeds having 6 to 8 percent moisture, packed in polypropylene film or triple-laminated aluminum foil, and stored at 22°C and 40 to 60 percent RH remained viable for 65 months.

Seed deterioration is rather slow at lower storage temperatures, which are also noncongenial for insect and pathogen activities. Seed viability was lost more rapidly under higher storage temperature in high-moisture seeds than in low-moisture ones. In another study, seeds with 8 and 15 percent mc were packed in muslin cloth and in aluminum foil and stored at 5 and 30°C. Seeds in muslin cloth experienced moisture loss from 15 to 7 percent under high temperature and preserved high seed viability, but seed germination was zero within one week of storage in high-moisture seeds packed in aluminum foil pouches stored at 30°C. Therefore, high-moisture seeds should be stored either in moisture-pervious containers or in unsealed conditions, especially under ambient storage conditions. It is maintained onion seed viability for seven years by storing them at 0°C. Subzero (–20°C) temperatures are most suitable for longer storage. Some agronomists preserved onion seeds for 15 years at 5 and –20°C. A higher percentage of germination was recorded in seeds stored at –20°C than in those stored at –5°C, particularly when seeds were stored in laminated aluminum foil pouches. Seedlings that emerged from stored seeds did not show any abnormalities, and they were on par with seedlings from fresh seeds for seed quality and morphological traits. Seeds stored for ten years at 5°C showed reduced germination percentage from 94 to 68 percent. It was noted greater seed deterioration at 5°C than at –18 or –196°C. Seeds stored at higher temperatures (40 to 50°C) and relative humidity (75 percent) showed certain unacceptable changes in seedlings, such as higher frequency of chromosomal aberrations. The disturbance of genetic stability was associated with loss of seed viability.

Relative humidity. Humidity around the seeds regulates the seed moisture. Dry seeds gain moisture rapidly in high humidity conditions. Further, a high level of humidity favors the growth of storage fungi. When some scientists stored seeds at 44, 66, and 78 percent RH, percentage of germination was 73, 37, and 0 after 250 days of storage. Likewise, the others reported that onion seeds lost viability rapidly at 55 and 70 percent RH, and they preserved high viability at 35 percent RH. Humidity fluctuation from 55 to 76 percent is more injurious to seed viability. To prevent the ill effects of high humidity, seeds were stored at a low humidity level and suitably packed in moisture-proof containers. Seeds stored at 10 percent RH gave 46 percent germination after five years of storage at 20°C, and they lost viability rapidly at RH of 40 percent and above. It was suggested storing dry seeds in sealed containers at room temperature with the enclosed air saturated with acetylene.

Air. The removal of air from storage containers enhances seed longevity. Seeds stored in partial vacuum gave 54 percent germination, as compared to those stored in air for 18 months under ambient conditions, which showed 27 percent germination, while no difference was noted when seeds were stored in air or partial vacuum at 34 to 40°C for 62 months. According to some data, the deleterious effects of high relative humidity decrease when onion seeds are stored under reduced atmospheric pressure for 14 weeks, and the moisture absorption is reduced by packing seeds in partial vacuum.

Light. Light hastens the germination process in certain vegetable crops, but darkness increases the germination percentage in most of the vegetable crops. This is attributed to the role of phytochrome. A 2 h exposure of seeds to fluorescent light every day prevents germination. The same seeds could be made germinable by subjecting them to dark conditions. Some scientists believed that intermittent light prevents the germination process more than continuous light, and inhibition is greater at higher light intensity. This is beneficial, especially in preserving seeds for a shorter period, because it inhibits sprouting during unfavorable storage conditions.

Storage fungi. Seeds are carriers of several pathogens on their surface and inside their tissue. The growth of these organisms is enhanced by the presence of high seed moisture and high relative humidity. It was observed a greater number of mold fungi colonies at relative humidity above 70 percent and at 20°C storage. These pathogens cause seed discoloration, produce much of the heat in seeds, and reduce the germination percentage. The fungi associated with onion seeds are Alternaria alternata, Aspergillus flavus, A. niger, A. ochraceous, Chaetomium globosum, Curvularia lunata, Drechslera australiensis, Fusarium spp., Penicillium cyclopium, Rhizopus stolonifer, and Stachybotrysatra. The production of fungal metabolites reduces seed viability and vigor during storage.

Use of fungicides effectively controls storage fungi. It is reported that onion seeds remained viable (49 percent) up to a period of 40 months when treated with Ceresan and thiram (0.2 and 0.3 percent) followed by mancozeb (0.2 percent). Maintenance of low seed moisture (8 percent), low temperature (10°C), and RH less than 70 percent is beneficial for longer retention of pathogen-free seeds.

Seed Storage Methods. Different storage methods, such as the use of desiccants, low temperature, and modified-atmosphere storage, maintain high viability and vigor for various periods. The methods should consider the principle factors associated with seed deterioration, such as temperature, humidity, oxygen, and pathogens, during storage. The choice of methods depends on the period of seed storage, kind and quantity of seed material to be stored, and cost. Maintaining genetic stability is the most important factor, apart from the retention of high viability and vigor in seeds. Seed storage begins with selection of bold, well-matured, healthy, and vigorous seeds for storage.

Storage with desiccants. In this method, seeds are stored in moisture proof containers, such as glass bottles, plastic boxes, or aluminum cans or pouches, along with a known quantity of desiccant, such as silica gel. The desiccant absorbs excess moisture and maintains a low moisture level throughout the storage period. On moisture absorption, blue silica gel turns white. Drying in the sun or in an oven further dehydrates it. Silica gel has added advantages; it is easy to use, less expensive, and more effective in maintaining low seed moisture. According to some data, silica gel should be added at the rate of 20 percent of seed weight for each 1 percent reduction in moisture content, while some scientists recommended application at the ratio of 1:10 (silica gel to seed quantity) in an airtight jar. Seeds preserved with silica gel retained higher viability for seven years when stored at both 5 and –20°C. Silica gel is more useful at 5°C than at –

20°C. Onion seeds stored in desiccators under warm conditions preserved viability for nine years in spite of fluctuations in temperature. Likewise, some scientific works opined that addition of silica gel to the storage container maintains seed viability under adverse storage conditions, while a number of agronomists believed that the presence of a desiccant did not affect seed quality and that germination rate remain unchanged. However, silica gel does improve the seed quality in the presence of fluctuating storage temperatures. Calcium oxide and dry rice are other desiccants used in onion storage. Dry rice preserves the onion seeds for three years at ambient temperatures. Seed packaging and sealed storage. Packaging is essential to protect the seeds from high humidity by providing a suitable moisture barrier structure.

Many packaging materials, such as craft paper bags, muslin cloth bags, glass containers, polyethylene pouches, aluminum cans, and laminated aluminum foil pouches, are used for seed storage. The choice depends on the kind and quantity of seed material, temperature, and period of storage. Cloth bags and craft paper bags are suitable for short periods of seed storage. For longer storage, moisture-proof containers and low temperatures are employed. It was reported that aluminum foil or tin cans are completely resistant to moisture penetration. Here, fluctuation of moisture occurs due to frequent opening and closing of the containers. Seeds of “Yellow Bermuda” onion remained viable for a longer period in sealed containers than in unsealed containers. In sealed storage, low moisture seeds preserve their viability, while high-moisture seeds (13 to 15 percent) could not maintain viability beyond 104 days when stored at 25°C. Onion seeds stored in sealed jars at 15 to 20°C maintained storability longer than those stored in unsealed containers. Aluminum foil pouches are completely impermeable to moisture, and seeds stored in them retain initial viability for 22 months. It is recommended that onion seeds be stored in aluminum foil pouches at 5°C. These pouches are handy, occupy less space, and can be shaped to any size; they can be heat sealed and reused, and they do not release toxic compounds during storage.

Some agronomists preserved onion seeds at 32 percent RH, and viability was unaffected by packaging or temperatures, whereas germination was significantly affected at 75 percent RH when seeds were stored in jute-woven polyethylene or cloth bags, but not in polyethylene film covered with jute or cloth bags. Seed moisture content increases if seeds are stored in jute or cloth bags.

Onion seeds having 6.5 percent moisture content and packed in paper packets and in laminated aluminum foil pouches were stored under ambient conditions (16 to 35°C and 25 to 90 percent RH). Seed viability is well preserved in sealed storage and decreases rapidly under unsealed conditions. Laminated aluminum foil pouches and polyethylene bags are effective in preserving high seed viability for five years at 5 and –18°C. Viability was further extended to a period of 15 years by storage at –20°C. A well-dried onion seed can be stored for a longer period in sealed storage.

Low-temperature storage. Low-temperature storage is the most ideal method for onion seed storage. Seeds remain viable for fairly longer periods at low temperatures.

The storage temperature is selected based on purpose and length of seed storage. High-quality seeds are preserved at subzero or ultralow temperatures for longer periods, while for bulk storage, seeds are stored above 0°C with a dehumidifier for shorter periods. Seeds are to be well dried for subzero temperature storage; otherwise, they will be affected by chilling injury. Moisture-proof containers such as metal cans, glass containers, and aluminum foil pouches are used for these purposes.

Seed deterioration is significantly reduced at lower temperatures. Cold storage of onion seeds is a very satisfactory method for conservation of high seed viability for longer periods. Onion seeds were successfully preserved at –20°C for 15 years without decline in viability and vigor, and there were no morphological variations in the seedlings that emerged from cold-stored seeds. According to some works, seed germination and seedling emergence are improved following sealed storage at –14 to –20°C. Some scientists stored onion seeds at –4°C for 20 years. Likewise, the others observed high viability at 0 and 10°C up to 60 percent RH, and –20°C is superior to 0 or 5°C. Some agronomists stored onion seeds in sealed glass containers at –1 to –2°C for three to four years.

Modified-atmosphere storage. Seed viability is preserved well in the absence of oxygen. Replacement of oxygen with other inert gases, such as carbon dioxide or nitrogen, is beneficial in maintaining high viability, especially at lower seed moisture levels. A high quantity of oxygen during storage affects seed viability. According to some data, the deleterious effects of oxygen are more pronounced at high levels of seed moisture. It is reported that onion seeds deteriorated faster when stored in oxygen, and slower when stored in nitrogen. Seeds stored in a nitrogen atmosphere showed high seed viability, and longevity improves with seed storage in nitrogen, more so than in carbon dioxide. However, onion seed storage in carbon dioxide is more beneficial than storage in air. It was reported that carbon dioxide-stored seeds preserved high viability for six years. Gaseous storage is effective for short-term storage and beneficial in the absence of a cold-storage facility.

Invigoration of Stored Seeds

Seed deterioration. Onion seeds are highly perishable, and reductions in germination and seedling vigor are the major criteria for the physiological manifestation of seed deterioration. Physical and chemical changes associated with deterioration are discoloration of seed coat, delayed germination, decreased tolerance to suboptimal environmental conditions during germination and storage conditions, reduced germinability and seedling growth, and increased number of abnormal seedlings.

Biochemical changes include an increase or decrease in enzyme activity, a decrease in oxygen uptake, an increase in leaching of organic and inorganic constituents from seeds, an increase in free fatty acids, a decrease in total soluble sugars, an increase in reducing sugars and a decrease in total soluble sugars, a decrease in proteins, and an increase in amino acids, and changes in carbohydrates, organic acids, and protein metabolism.

The exact cause of seed deterioration is not known. It was observed that as long as the cells concerned with assimilation and transportation of food and the meristematic regions are alive, the seeds remain viable and are capable of germinating. Cell structure gets disturbed on deterioration, resulting in excessive leakage of electrolytes, soluble sugars, and potassium. In onion seeds, with increasing storage period, the palmitic and stearic acids increase and the oleic and linoleic acids decrease. According to some works, seed viability is negatively correlated with saturated fatty acid content and positively correlated with unsaturated fatty acid content. Seed vigor, an essential component for crop production and better storage, decreases on deterioration.

Normally, high seed vigor is estimated by percentage of germination. It was developed a rapid technique for estimating seed quality. Seeds are kept in gauge bags placed in boiling water for 30 min. The number of seeds producing radicles is directly proportional to seed viability. Based on estimated storage conditions, some scientists developed seed viability equations to predict seed storability. The others showed that such equations are less accurate at higher levels of moisture and for longer storage periods. The possibility of using ATP (adenosine triphosphate) content as an indicator of onion seed quality was also studied.

A high positive correlation exists between ATP content and viability. ATP content is greater for seeds stored at 3°C than for those stored at 30°C. Likewise, dehydrogenase activity, which is directly related to seed viability, is greater in seeds stored at low temperatures than in those stored under ambient conditions. Exposing seeds to accelerated aging (42 or 45°C at 100 percent RH) for 72 h can help predict seed quality. Seed quality can be improved to a certain extent by imposing the following treatments.

Seed priming. Seeds have to be treated with osmotic solution to hasten the germination process. This gives rapid and uniform seedlings and delays aging. PEG is most effective in this regard. Primed seeds are dried to their original level of moisture and stored. This gives higher germination than unprimed seeds, a result attributed to the cellular repair process during the imbibition state. According to some data, prestorage dry treatments, such as acetone permeation of antiaging chemicals and low concentrations of halogens (iodine, chlorine, and bromine) and alcohol (methanol, ethanol, and isopropanol), improve the storability of dry-stored seeds.

The intricacies involved in the invigoration of seeds are not clear. It appears that prevention of damaging oxidative reactions, such as free-radicalinduced peroxidation reactions involving unsaturated lipid molecules of lipoprotein biomembranes, and the repair of age-induced damage to vital bioorganelles by the cellular repair system are associated with seed invigoration.

Midstorage treatment with water or saline solution helps in retaining the original vigor and viability of seeds. A number of agronomists reported that hydration and dehydration improve the storage life and vigor of seeds. This improvement is associated with enhanced activity of dehydrogenase and peroxidase, with a simultaneous reduction in lipolytic activity and breakdown of fat contents. Onion seeds were soaked in water and other solvents, such as ethyl alcohol, acetone, xylene, dichloromethane, and petroleum ether. Seeds soaked in water followed by drying gave higher germination than other solvents. Highmoisture onion seeds (15 to 25 percent) were stored at high temperatures (45°C); the loss of viability was less for seeds having moisture of 20 to 25 percent than for those having 15 percent moisture. It is suggested that activation of the cellular repair process is due to imbibitions. Addition of monosodium hydrogen phosphate (10–4 M) and sodium sulfate (10–4 M) to water used for soaking gives minor additional advantages.

Chemicals. Chemical treatment of seeds is beneficial in delaying the aging process. Impregnation of acetone with vitamin E (20 units/milliliter [ml]) and butylated hydroxytolule (10–1 M) improves the storability of onion seeds. Natural and synthetic antioxidants can also be used, either alone or in combination with drying, to extend seed longevity. Six-month-old onion seeds treated with certain chemicals, such as EDTA (ethylenediaminetetraocetic acid) (0.1 M), potassium metabisulfite (KMS) (0.02 M), oxalic acid (0.01 M), ascorbic acid (0.02 M), PEG (0.5 M), and saturated glucose can be stored under ambient conditions (16 to 35°C and 25 to 90 percent RH).

Seed germination and vigor improved with the treatment. These seeds were viable for a longer period than untreated seeds during ambient storage. These chemicals act as antioxidants or prevent free-radical formation. Leaching of toxic metabolites from seeds occurs during imbibitions. According to some works, leaching of inhibitors is greater in the presence of dilute salt. EDTA prevents the formation of radical centers on unsaturated fatty acids and prevents the deterioration of seeds. EDTA also extends seed storage life and vigor through the cellular repair system during the hydration phase.

Growth regulators. Seed quality improves with the application of growth regulators. Kinetin improved germination percentage and seedling vigor even in seeds stored under unfavorable storage conditions, while ABA lowered seed viability and vigor.

Magnetic stimulus. Electromagnetic treatment of seed causes morphological, physiological, and biochemical changes in seeds. Five-year-old onion seeds stored at 5°C can be exposed to electromagnetic fields (36 to 144 oersteds). Seed germination is improved with exposure to a 108 oersteds electromagnetic field for 30 min. This also improved seedling length and dry weight, and leaching of metabolites decreased as compared to untreated control. Magnetic stimulus promotes the biological mechanism by slowing down the process of seed deterioration and stimulates the seedling growth rate.

LEEK (Allium ameloprasum var. porrum L.)

Introduction. Leek is a robust plant popular in the Middle East and Northern Europe. It does not form bulbs; instead, the long green leaves are cooked as a vegetable. The blanched stems and leaves are boiled or fried. It is a rich source of minerals such as phosphorus and iron.

Origin and Distribution. Leek originated in the Mediterranean region. It is cultivated in Belgium, China, Denmark, France, Malaysia, the Netherlands, the Philippines, Spain, and the United Kingdom.

Morphology. Leek belongs to family Alliaceae and has chromosome number of 2n = 32. It is a monocotyledonous biennial plant. Leaves are flattened and variable in length. Inflorescence is a terminal umbel with many pinkish flowers. Fruit is a capsule. One thousand seeds weigh about 3.75 g.

Seed Storage. Seeds are generally used in the propagation of leek. Also, seeds are used in crop improvement and in long-term conservation of genetic diversity. Seeds show orthodox storage behavior; they can tolerate desiccation and store well at chilling temperatures.

Seed Collections. Leek is a cool-season crop. It grows well in low-temperature areas and at higher altitudes. It needs vernalization and long days for induction of flowering. It requires deep well-drained soil for optimum growth. The seeds are sown in the nursery, and then seedlings are transplanted in trenches in the field. Seed-to-seed or bulb-to-seed method is used to produce seeds. Leek is a cross-pollinated crop, and bees bring about pollination. An isolation distance of 1,000 m is maintained between two different varieties. Normal cultural practices, such as fertilizer, irrigation, and plant protection, are followed. Off-type plants are removed. Mature heads are collected, dried, and threshed; seeds are separated, cleaned, and packed for storage.

Seed Germination. Seed germination is rapid at low temperature. It is highest at 20°C and is affected at 30°C. Likewise, it was reported that the optimum temperature for germination was between 15 and 20°C. Fresh seeds exhibit dormancy that persists for several months. Prechilling of seeds and exposure to an alternate temperature regime (20/30°C for 16/8 h) promotes germination.

Storage Conditions. Leek seeds are short-lived under ambient conditions. Seed viability and vigor decrease with an increase in storage temperature and relative humidity. Seeds stored at 26.7°C gave 65 percent germination after six years of storage, and storage at 43.3°C further reduced seed viability. Some scientists preserved high viability for two years at 2°C and 10 percent RH. Further, seeds with 7.7 to 13.8 percent mc stored at –20°C retain their original viability for five years. The stimulatory effect of priming persists after drying and subsequent storage with silica gel up to 15 months.

Unit 9
ROOT CROPS

RADISH (Raphanus sativus L.)

Introduction. Radish is a popular vegetable crop in Asia and Europe. It is mainly cultivated for the young tuberous root, which is used in salad. Tender and nonpithy roots are cooked as a vegetable and also made into pickles. The foliage is also used as a leafy vegetable in Asia. The immature pods and leaves of another species, Raphanus caudatus, are eaten raw and/or cooked as a vegetable. Radish increases the appetite and gives a cooling effect. Roots are rich in minerals and vitamins A and C. The pungency of radish root is due to a volatile substance called isothiocyanate. Radish has medicinal properties, especially in curing ailments of the liver and gall bladder, headache, diarrhea, piles, and jaundice.

Origin and Distribution. Radish probably originated in Western Asia, including the greater portion of China, where wide genetic diversity exists. Later, its cultivation spread to temperate and tropical regions. It is grown in Brazil, Germany, Hungary, India, Indonesia, Italy, Japan, Malaysia, the Netherlands, the Philippines, Spain, the United Kingdom, and the United States.

Morphology. Radish belongs to family Cruciferae and has chromosome number 2n = 18. It is dicotyledonous annual or biennial herb. Its hypocotyls and swollen primary roots are used in salad. Root size, shape, and color vary in different cultivars. They are round, tapering, and cylindrical, either red or white, and flesh is white. Leaves are pinnate and partly divided. Flowers are small, white, or pink, self-incompatible, and pollinated by insects. Fruit is an indehiscent silique, with a long beak, and contains 6 to

12 seeds. Seeds are small, 3 mm in diameter, yellow or brown, and globose. One thousand seeds weigh about 10 g.

Seed Storage. Radish is raised commercially through seeds. Seeds show orthodox storage behavior and are capable of maintaining high viability, vigor, and genetic stability on long-term conservation. Radish seeds are fairly good storers under ambient conditions.

Seed Collections. Radish is a cool-season crop. Asian types are suited to tropical conditions; European ones are less pungent and grow well in tropical plains, and produce seeds in hilly regions. Small radishes are adapted to temperate climates, and larger ones can tolerate fluctuations in temperature. Low temperature is congenial for development of root texture, flavor, and size. High temperature leads to premature bolting. Radish prefers loose, fertile, and well-drained soils. Seeds are produced either by root-to-seed or seed-to-seed method. In root-to-seed method, the matured roots, called stecklings, are removed and replanted by cutting the tops. Seed size and weight decide seed quality. With increased seed size, the field emergence increases. Large seeds also give higher yield than smaller seeds. Proper cultural practices, such as adequate spacing, nutrition, irrigation, and plant protection measures, are to be followed for production of quality seeds. Radish is a cross-pollinated crop, and bees and other insects bring about pollination. Thus, a minimum isolation distance of 1,600 m is maintained between cultivars. The off-type roots are rogued based on shape and color. The crop is harvested when pods become brown and seeds near maturity. Dried pods are collected and threshed; seeds are removed, dried, cleaned, and packed for storage.

Seed Germination. Fresh seeds show dormancy, and six weeks of after-ripening eliminates the dormancy. Further, germinating seeds using an alternate temperature regime of 10/20°C for 18/6 h breaks the dormancy. In radish, seed germination is epigeal and takes five days to complete. Fresh seeds absorb more water and germinate more slowly than older seeds. Seed germination improves by application of gibberellic acid (5 to 10 ppm), naphthaleneacetic acid (10 to 20 ppm), potassium nitrate, and acidulated water (pH 4.5) with nitric acid, and it is inhibited by exposing seeds to far-red light.

Storage Conditions. Radish seeds retain their viability longer than other cruciferous seeds. The economic life of spring and winter radishes is 9 to 12 years. Seed germination decreased to 50 percent after 7 years of storage under ambient conditions. Prolonged seed storage increases the percentage of substandard produce and the risk of invasion by many diseases. Bold and well-matured seeds retain better viability than immature seeds. Seed drying to lower moisture helps in better retention of seed viability. Well-dried seeds stored for 9 to 12 years at 10–1 to 10–2 millibar (mb) preserve high seed quality without loss of viability. A number of scientists stored low moisture seeds (4.2 percent) in plastic bags at –20°C for ten years. There was little change in moisture content, and initial germination (86 percent) remained unchanged. Likewise, seeds with 6 percent moisture packed in polyethylene bags and laminated aluminum foil pouches and stored at 5 and –20°C maintained viability for 15 years. The retention of viability during storage is better at –20°C than at 5°C. These stored seeds when sown in the field did not show any morphological abnormalities for root and shoot characteristics.

Storage fungi. Storage fungi such as Alternaria alternata, Aspergillus flavus, and Fusarium moniliforme associate with seeds during storage, especially under high levels of seed moisture or relative humidity. Seed treatment with captan, thiram, or carbendazim controls the fungi.

Invigoration of Stored Seeds. Seed viability is lost gradually during storage. However, loss of vigor precedes the decrease in viability. Viability can be revived to a certain extent by exposing stored seeds to physical or chemical stimuli. Seed soaking in water followed by drying improves germination and seedling vigor. Soaking leaches out certain toxic substances and activates the enzymes involved in germination. Some scientists attributed this to the counteraction of free radicals that damage cellular components.

CARROT (Daucus carota L.)

Introduction. Carrot is a popular root crop in temperate, tropical, and subtropical regions. It is cultivated as a fresh produce item and also processed, canned, and dehydrated. Tender carrots are used in soups, stews, curries, and confectioneries and cooked as a vegetable. Carrot juice is a popular drink in developed countries. Carrots are rich in carbohydrates, fiber, minerals, especially iron, and vitamins, such as alpha- and beta-carotene. Carrot roots, particularly black cultivars, are fed to cattle. Carrot seed contains an essential oil that acts as a carminative and stimulant and has wide usage in the treatment of kidney ailments.

Origin and Distribution. Carrot genetic diversity exists in Africa, Europe, and West Asia. It probably originated in Afghanistan. It is cultivated in almost all countries. Some leading producers are Argentina, Brazil, Canada, China, France, India, Indonesia, Italy, Malaysia, Mexico, Morocco, the Netherlands, Nigeria, the Philippines, Poland, Russia, the United Kingdom, and the United States.

Morphology. Carrot belongs to family Umbelliferae and contains chromosome number 2n = 18. It is a dicotyledonous biennial plant with a short stem and well developed roots. Its swollen roots, which are either short and blunt or long with a tapering cone, are edible. It is cultivated as an annual vegetable and as a biennial for seed production. The stem elongates and gives inflorescence during the second year. The inflorescence is a compound umbel that is flat or round. Flowers open from the outer orbit and proceed toward the center. Flowers are perfect and white, with five stamens and an inferior ovary with two locules. Fruit is oblong-ovoid, ciliate, and indehiscent and contains a single seed, which contains essential oil. One thousand seeds weigh about 0.8 g.

Seed Storage. Carrot is cultivated by seeds. Seeds are also used in crop improvement and in conserving genetic diversity through seed storage. Seeds show orthodox storage behavior; they can withstand desiccation and chilling during prolonged storage. Well-dried seeds retain viability for longer periods at low storage temperatures. Seeds with less than 10 percent moisture remain viable for six months under ambient conditions. Further, sealed storage preserves seeds for eight years.

Seed Collections. Carrot requires a cooler climate for growth and development. The Asian types produce seeds in plains, while European types require vernalization of six to eight weeks at 8°C for induction of flowering. However, seeds are normally produced in hills, having higher altitude and a cooler climate. Carrot grows well in deep, sandy loam, well-drained soil. Seeds are produced either by seed-to-seed or root-to-seed method. The latter is a widely accepted practice, requiring the selection of good roots for planting. Plants are spaced properly, adequately fertilized, timely irrigated, and protected against pests and diseases. Planting full-size roots, with one-half or two thirds top, gives higher seed yield. A closer spacing of 45 × 20 cm also gave higher seed yield. Flowering occurs at eight-day intervals in different orders of. Individual flowers are protoandrous, and insects, especially bees, bring about cross-pollination. An isolation distance of 1,600 m is maintained between varieties. Off-type plants showing variation for root and shoot characteristics are removed. The primary and secondary umbels are selected for seed purposes, as they give good-quality seeds. Seeds from primary umbels are heavier than those from secondary ones. The crop is harvested when the third-order umbels turn brown. Plants are cut at the base and stored for curing. Subsequently, seeds are separated, cleaned, dried, and packed for storage.

Seed Germination. Fresh carrot seeds show a considerable amount of dormancy, which is attributed to underdeveloped embryos and immature seeds. Mature seeds also show dormancy. According to some scientists, an after-ripening period of three months eliminates seed dormancy. Comparatively, wild relatives of carrots show more pronounced dormancy than cultivated ones. Seed germination is higher at a constant temperature from 15 to 25°C or at an alternate temperature of 20/30°C for 16/8 h, respectively. Seed germination is greater in vigorous seeds, which complete the germination process in a short time. Seeds with low vigor take longer for seedling emergence and exhibit greater variability in plant characteristics. Likewise, seed germination is lower and delayed in immature as compared to mature seeds.

Seed size. Seed size also affects seed germination. It was reported that field emergence is greater for large seeds. Likewise, large seeds (1.66 mm) have greater storability. The crop yield is also increased by 40 percent when large as compared to smaller seeds are sown.

Chemicals. Seed germination is improved by soaking seeds in naphthalene acetic acid (100 ppm). Seed soaking in water exudates certain chemicals, including toxic ones. According to a number of works, these exudates contain a high amount of inhibitors that affect the germination process. The amount of exudates mainly composed of water-soluble sugars is negatively correlated with seed viability.

Seed priming. Seed priming promotes germination in fresh and old seeds. Seeds soaked in polyethylene glycol (6000) at 15°C for ten days resulted in early and higher germination.

Storage Conditions. Low-temperature storage. Seeds attain full viability and vigor on maturity. Such seeds retain their viability for a longer period than immature seeds. Seed germination and seedling vigor decrease when seeds are stored at 20°C and 80 percent RH. Seeds lose viability rapidly at higher temperatures and relative humidity. The ideal storage conditions for longer storage life are temperature close to 0°C and 70 percent RH. Loss of seed viability is more rapid in dry seeds than in ultra dry seeds at 20°C. Seeds with 2.0 to 3.7 percent mc (ultra dry) and those with 5.5 to 6.8 percent mc (dry) retained viability for five years at –20°C, while seeds with 7 percent moisture exhibited 60 percent germination in unsealed, and 80 percent in sealed, conditions after two years of ambient storage. Seeds stored in moisture-proof containers at room temperature remained viable for 22 months. Seed stored in polyethylene bags maintained higher viability than those stored in paper bags. Seed viability was maintained for eight years at 5 and –20°C storage. Likewise, it is reported that seeds stored in plastic bags maintained viability for 11 years at –20°C storage.

Storage with desiccants. Desiccants are effective in lowering seed moisture. Seeds stored with silica gel retained viability for 36 months under ambient conditions. Some scientists reported that desiccants are ineffective at a constant storage temperature of 0°C and they improve seed storage quality in the presence of fluctuating temperatures between 5 and 30°C.

Modified-atmosphere storage. A higher level of oxygen in the storage container affects seed viability. Several volatile compounds, such as methanol, ethanol, acetone, and acetaldehyde, are released from dry seeds during storage. The quantity of volatile compounds released increases with increasing storage period and temperature. Lowering the oxygen level and/or replacement with inert gases, such as nitrogen or carbon dioxide, maintains high germination during ambient storage.

Storage of pelleted seeds. Storage of pelleted seeds enhanced germination by 4 to 8 percent compared to nonpelleted seeds. Further, the yield from pelleted seeds is greater by 10 percent.

Storage fungi. Storage fungi are largely associated with improper storage, especially when high seed moisture is retained during ambient storage. Fungi are effectively controlled by seed treatment with thiram, which also promotes seed germination. It was suggested coating seeds with resins and incorporating fungicides during storage to protect seeds from fungal attack.

Invigoration of Stored Seeds. Soaking stored carrot seeds in water or in dilute chemicals, such as sodium thiosulfate (10–5 M) or disodium phosphate (10–4 M), for 2 h followed by drying reduces physiological deterioration during subsequent storage.

Even hydration by saturated atmosphere for 24 to 48 h followed by drying is effective in reducing loss of seed viability. Midstorage hydration-dehydration is effective in improving seed viability and vigor.

BEETROOT (Beta vulgaris L.)

Introduction. Beetroot is an important salad crop in temperate regions. It is also known as garden beet. Here, the edible portion includes the swollen hypocotyls and a smaller part of the taproot. The foliage is also used as greens and cooked as a vegetable. Apart from its usage in salad, beetroot is boiled, pickled, or cooked as a vegetable. It is a good source of carbohydrates, calcium, phosphorus, potassium, and vitamin C. Its foliage is rich in iron and vitamin A.

Origin and Distribution. Beetroot originated in Asia Minor, the Mediterranean region, and southern**.** Europe. It is a popular vegetable crop in Europe, the Middle East, and North America. It is cultivated in Canada, China, Denmark, Germany, India, Indonesia, Italy, Malaysia, the Netherlands, the Philippines, the United Kingdom, and the United States.

Morphology. Beetroot is a biennial glabrous herb that is cultivated as an annual for vegetable purposes. It belongs to family Chenopodiaceae and has diploid chromosome number 2n = 18. The food is stored in the root, which is flat, conical, or tapering; red; and swollen. The red pigment is due to the presence of betacyanins. Foliage is dark green or red and ovate, forming a rosette. Inflorescence is a three- to four-flowered cyme; it grows up to 1 m in height. Flower is small, with a green calyx, no corolla, and five stamens, with one ovule per ovary. Fruit is an aggregate formed by the partial fusion of two or more fruits. In this, the calyx continues to grow after fertilization; becomes hard, uneven, and corky; and encloses the seed. It is referred to as beet seed or glomerule and normally contains two to six seeds. True seeds are small, brown, 3 mm long, and kidney shaped. One thousand seeds weigh about 17 g.

Seed Storage. Beetroot seeds show orthodox storage behavior. The retention of high seed quality, viability, and vigor is the desired end in seed storage. Seeds with high initial vigor maintain viability for a longer period. Seeds are viable for two to six years under normal storage conditions.

Seed Collections. Beetroot is a cool-season crop, requiring a cool and humid climate for optimum growth. It needs deep, fertile, well-drained, sandy loam soils. eavy soils are unsuitable for cultivation, and it is sensitive to water logging. Beetroot is propagated by seeds. Plants require vernalization for nduction of flowering, and an altitude over 1,000 m is congenial for seed roduction. Seeds are commonly produced by the root-to-seed method, which allows root inspection during transplanting. Sometimes the seed-to-seed method is also used. The first healthy and true-to-type stecklings are selected and stored for a short period before replanting. Proper fertilizer dosage and irrigation, especially during the dry period, are applied to the seed plots. Plants are protected from pests and diseases. Beetroot is cross-pollinated, predominantly by wind, so an isolation distance of 1,600 m is maintained between cultivars for maintenance of genetic purity. Off-type plants are removed based on foliage and root characteristics. Fruits become brown on maturity. Plants are cut when the fruits on lower branches are mature, then they are heaped and stored for a short period.

Later, the dried fruits are threshed; seeds are separated, cleaned, dried, and suitably packed for storage.

Seed Germination. Seed germination is slow and erratic and takes longer to complete. Fruit surface contains an inhibitor that affects the germination. Simple washing or soaking in water or in plant extracts of certain seaweeds, which appear to possess cytokinin-like substances, improves seed germination. Some agronomists reported that osmoconditioning of seeds with 1.2 MPa of PEG (6000) followed by a two-minute water rinse is effective in improving germination.

Storage Conditions. Beetroot seeds remain viable for a fairly long period under room temperatures. However, they deteriorate rapidly at higher storage temperatures and humidity. Lowering of seed moisture is beneficial for prolonging storage life and maintaining high seed quality. Seed moisture is reduced by 1 percent through the addition of sodium sulfate at the rate of 1.5 percent of seed weight basis. Seed storage at lower temperature reduces the metabolism and slows the process of seed deterioration. Seeds stored at 10°C and 50 percent RH maintained high seed viability for 13 years.

TURNIP (Brassica rapa L.)

Introduction. Turnip is an important cruciferous vegetable crop in temperate regions that is, of late, becoming popular in tropical regions as well. It is cultivated for its fleshy roots and foliage. Tender roots are used in salad and are cooked as a vegetable. It is a good source of iron and vitamins A and C.

Origin and Distribution. Turnip originated in the Mediterranean region and is cultivated throughout the world. It is grown in Afghanistan, Canada, Denmark, France, Germany, India, Italy, Japan, Malaysia, the Philippines, Russia, the United Kingdom, and the United States.

Morphology. Turnip belongs to the Cruciferae family, and its diploid chromosome number is 2n = 20. It is a biennial dicotyledonous herb that is cultivated as an annual for vegetable purposes. Food is stored in the taproot, which is flat, globose, or a long globe. Its color above ground is red, purple, white, or yellow, and the underground portion is white or yellow. Foliage is light green and hairy, with lobed leaves. Flower is perfect and bright yellow, with five sepals, five petals, five stamens, and a three-celled superior ovary. Fruit is a dehiscent silique; seeds are round; black, red, or brown; and 1.5 to 2 mm in diameter. One thousand seeds weigh roughly 4.3 g.

Seed Storage. Seeds are used in the commercial production of turnip. They are also employed in evolving new genotypes and in maintaining genetic diversity for longer periods. Seeds show orthodox storage behavior and remain viable for longer periods under dry, cool storage conditions.

Seed Collections. Turnip is a hardy cool-season crop that can withstand frost. It grows well in deep, fertile, well-drained, sandy loam soils. Seeds are produced either by seed-to-seed or root-to-seed method. The latter is commonly used and provides easy selection of desirable types of roots for high seed quality.

Healthy true-to-type roots are transplanted. The inflorescence is a terminal raceme. It is a cross-pollinated crop, and honeybees are the main pollinators. It is easily crossable with Chinese cabbage, radish, and mustard.

Thus, an isolation distance of 1,600 m is provided to safeguard against genetic contamination. Roguing is done at different times to remove off-type plants. Normal and timely cultural practices, such as fertilizer application, irrigation, and suitable plant protection measures, are followed during seed production. Pods turn yellow on maturity, and the whole flowering stalk is cut, heaped, and allowed to cure for four to five days. Pods are threshed, and seeds are separated, cleaned, dried, and packed for storage.

Seed Germination. Seed germination is epigeal and higher at a constant temperature of 20°C or at alternate temperatures of 20/30°C for 16/8 h. Seed size varies from 1 to 1.7 mm; large to medium-sized seeds give early and higher germination than smaller seeds.

Storage Conditions. Turnip seeds store well under ambient conditions. Higher storage temperatures and relative humidity are injurious to seed longevity. It is reported that seeds stored at 18 to 22°C and 60 to 80 percent RH remained viable for 12 to 13 years. Economic seed longevity is about two to three times less than biological longevity. Seed moisture is lowered and kept at a safe limit through the use of chemical desiccants. According to some works, calcium chloride is a satisfactory desiccant for longer seed storage. Another desiccant, sodium sulfate, applied at the rate of 1.5 percent of seed weight reduces the seed moisture by 1 percent and keeps seed viable for a longer period. It also protects seeds from pathogens. Resins are used in storage to prevent premature germination and to facilitate storage by extending storage life.

Unit 10
COLE CROPS

CABBAGE (Brassica oleracea var. capitata L.)

Introduction. Cabbage is an important winter vegetable crop widely cultivated in Europe and North America. It is also popular in the tropics and subtropics. It is cultivated for its tender, modified edible leaves, which form a compact structure called a head. Leaves are used for salad purposes, processed for pickles, sauerkraut, and cooked as a vegetable. Cabbage is a rich source of amino acids, vitamins A and C, and minerals such as phosphorus, calcium, potassium, sodium, and iron.

Origin and Distribution. Cabbage originated in the Mediterranean region. It is grown in China, Colombia, Czechoslovakia, Denmark, Egypt, France, Germany, India, Indonesia, Italy, Japan, Korea, Malaysia, the Netherlands, the Philippines, Poland, Russia, South Africa, Spain, Taiwan, Ukraine, the United Kingdom, and the United States.

Morphology. Cabbage belongs to family Cruciferae and has a chromosome number of 2n = 18. It is a biennial but is cultivated as an annual. The stem is short and encircled by compact foliage. Cabbage heads are round, flat, or pointed. Leaves are red, green, smooth, or wrinkled. Flowering is induced on vernalization. Flowers are small, hermaphrodite, and yellow, with four sepals and petals, six stamens, and an ovary with two locules. Fruit is a silique that dehisces on maturity and contains 12 to 20 seeds. Seeds are small, smooth, brown, and globular. One thousand seeds weigh about 3.3 g.

Seed Storage. Cabbage seeds are short-lived under ambient conditions. They show orthodox storage behavior and can withstand drying as well as chilling temperatures on storage. Seeds are stored for short periods for growing of crops, and for longer periods for the conservation of genetic diversity. A high plant population is a prerequisite for successful crop production, and achieving the required plant density depends on seed quality. Thus, to meet the requirement, suitable storage practices have to be followed for maintaining high viability and vigor during storage.

Seed Collections. Cabbage is a cool-season crop that withstands frost. Hilly regions are generally well suited for seed production because chilling temperatures are prevalent. Normally, temperatures less than 10°C for five or six weeks are required for the induction of flowering. Cabbage grows well in deep, fertile, well-drained soils. Seeds are produced by head-to-seed or seed-to-seed method. In the former method, the crop is raised for head purposes, and well-developed healthy and mature heads are selected for seed purposes and stored for a short period before replanting. Later, these are planted in the field by making a crosscut on top of the heads, without causing injury to the growing points. This facilitates early emergence of flower stalks. The crop is adequately fertilized, irrigated during dry periods, and protected against pests and diseases. In the seed-to-seed method, selected heads are left in the field and crosscuts are made to facilitate flower emergence. Cabbage is a cross-pollinated crop, and bees and flies mainly bring about pollination.

Crops are separated by a distance of 1,600 m from another varietal block. Pods turn yellow on maturity, and at this stage, they are collected, dried, and threshed; seeds are separated, cleaned, and suitably packed for storage.

Seed Germination. Seed germination is epigeal and higher at a constant temperature of 20°C. Seed germination in dormant seeds can be improved by exposing to alternate temperatures of 20/30°C for 16/8 h, respectively. Seed color changes to dark brown at maturity but lightens on seed aging. The germination percentage is higher in darker seeds than in lighter ones. According to some works, low germination and emergence rates are associated with low-vigor cabbage seeds, which are improved by soaking seeds in water followed by osmopriming with polyethylene glycol (PEG).

Storage of germinated seeds. Germinated cabbage seeds are viable for a short period. Storage life could be extended up to five days if stored in aluminum foil pouches at 5°C. Longer storage reduces seedling emergence.

The decrease in vigor is attributed to degradation of structure and enzymic activity. According to some works, germinated seeds can be stored for one week at –20°C when cooled at the rate of 2 to 6°C per min.

Storage Conditions. Initial seed vigor, seed moisture, storage temperature, relative humidity, and oxygen content regulate seed storability. Higher seed moisture and higher temperatures promote germination and deterioration. It was suggested the use of resins for preventing premature seed germination. Seed coating with resin gives better storage but does not affect the germination process.

Seed moisture. High seed moisture reduces the storage life of seeds. It is reported that seeds with low initial germination and high moisture content deteriorated faster at 11 to 19°C and 58 to 83 percent RH. Seeds having 3 percent moisture retained their viability for 22 years at –10°C. Seeds readily absorb moisture from the atmosphere; thus, they must be packed suitably to protect against high humidity.

Various kinds of packaging, such as glass jars, polyethylene bags, and aluminum foil pouches or cans, are used for seed storage. Normally, low moisture seeds are sealed in packages before storage. Some scientists reported that seeds with high moisture content packed in plastic bags deteriorated faster and lost viability after 16 months of storage, whereas low-moisture seeds maintained high viability for 54 months. Seeds attain moisture equilibrium earlier in hessian (burlap) or cloth bags than in polyethylene bags. It is noted that polyvinylidene chloride (PVDC) strengthened paper bags are effective moisture barriers, preserving seed viability for seven years.

Seed storage with desiccants. Seed moisture removal by desiccants is faster than air drying. Desiccants are effective in maintaining high seed viability under fluctuating temperatures. A number of scientific works recommended that cabbage seeds be mixed with sodium sulfate (1.5 percent) on a seed weight basis for a 1 percent reduction in moisture.

With this, high seed viability was preserved for two years, and fungal micro flora were reduced on seeds. Further, seed longevity was extended to eight years for desiccant stored seeds as compared to nine months for seeds in open storage.

Temperature. Cabbage seeds lose their viability rapidly at higher storage temperatures. They lost viability completely by four months of storage at 40°C and 77 percent RH. Seed deterioration is greater at variable ambient temperatures, but seeds preserve high viability for 86 months at 0°C. Similarly, some agronomists preserved cabbage seed viability for 7 to 15 years at 18 to 22°C and 60 to 80 percent RH. Low-temperature cabinets, such as a freezer, are effective in preserving seed viability. Accordingly, seeds stored in airtight jars at –20°C preserved their viability for 23 years.

Air. Higher oxygen levels in storage containers increase the respiration rate, resulting in quick deterioration. Cabbage seeds stored in a vacuum at 10–1 to 10–2 mb maintain viability for 9 to12 years. Also, high levels of carbon dioxide inhibit the germination process and help in preserving seed viability.

Storage fungi. Cabbage seeds associate with several storage fungi. Seed viability is affected by the presence of Alternaria, Aspergillus, Fusarium, Rhizopus, and Sclerotium spp. These can be effectively controlled through seed treatment with captan or carbendazim. Cabbage seeds treated with thiram could be stored for 12 months at 2 to 32°C, with no loss of viability, and treated seeds germinated better than untreated ones.

CAULIFLOVER (Brassica oleracea var. botrytis L.)

Introduction. Cauliflower is an important cole crop cultivated for its edible curd. The curd is made of highly metamorphosed abortive flowers on thick hypertrophied branches. It is cooked as a vegetable and eaten raw. The green foliage serves as good cattle feed. Cauliflower is rich in minerals such as potassium, sodium, iron, phosphorus, calcium, and magnesium. It grows well in temperate regions.

Origin and Distribution. Cauliflower, which evolved from wild cabbage, is native to the Mediterranean region. It is largely cultivated in Australia, Canada, Caribbean islands, China, Egypt, France, Germany, India, Italy, Malaysia, the Netherlands, the Philippines, the United Kingdom, and the United States.

Morphology. Cauliflower belongs to family Cruciferae and has chromosome number 2n = 18. It is a dicotyledonous biennial plant cultivated as an annual. It has a short, stout stem with long, dark green foliage that encloses the curd, protecting it from sun. The inflorescence is dense and terminal, with a large number of flowers. Flowers are small and have four sepals and petals, six stamens, and a bicarpellary gynoecium. Self-incompatibility exists in certain cultivars. Fruit is a silique about 8 cm long. Seeds are round and dark brown. One thousand seeds weigh about 2.8 g.

Seed Storage. Seeds are widely used in cultivation, and as such, farmers prefer to preserve seeds for shorter periods, such as until next growing season. Seeds are also used in evolving new cultivars and for long-term conservation of genetic diversity. Cauliflower seeds show orthodox storage behavior and withstand desiccation and chilling temperatures during storage. Seeds are short-lived under ambient conditions.

Seed longevity is primarily controlled by genetic factors and further regulated by storage conditions. Seed storability varies in different cultivars. On deterioration, poor-storer cultivars showed greater leakage of electrolytes and soluble sugars as compared to good-storer ones. Good-storer cultivars preserve viability for relatively longer periods under ambient conditions and do not require any special packaging or conditions for short-term storage.

Seed Collections. Cauliflower is a cool-season crop and is less tolerant to heat and dry conditions. It grows well in cool, moist, fertile, well-drained soils. Seeds are sown in the nursery, and young seedlings are later transplanted in the field.

Normal cultural practices, such as timely fertilizer, irrigation, and plant protection measures, are followed. Normally, plants with good curds are allowed in the field, and later they produce flowers and seeds. These selected plants are scattered all over the field, occupying a large cultivable area. To overcome this, selected plants are transplanted carefully to a seed production block. Curds are scooped during transplanting to facilitate flowering.

Cauliflower is highly cross-pollinated, and honeybees and bumblebees are the major pollinators. Thus, an isolation distance of 1,000 m is maintained between varieties. Off-type plants are removed. Pod ripening is non uniform, and pods on lower branches mature first. These are pooled, cured for a few days, and threshed; seeds are separated, cleaned, dried, and suitably packed for storage.

Seed Germination. Seed germination is epigeal and takes five to seven days to complete. Further, it is enhanced by exposing seeds to 20/30°C for 16/8 h and to light. Short-duration exposure of seeds to light increased the germination percentage.

Storage Conditions. Cauliflower seeds are viable for a short period under room temperatures. They remain viable for nine months under open storage Well-dried seeds (5 percent mc) packed in aluminum foil pouches could retain high viability under ambient conditions. Likewise, some scientists obtained a high germination percentage and high seedling vigor in seeds of good-storer cultivars after five years of storage in ambient conditions. It was recorded greater loss of viability at 15 to 20°C, while maintaining high viability at –20°C for five years. Seeds removed from –20°C chambers further maintained high viability for three months under normal temperatures. Seeds stored in desiccators remained viable for eight years under ambient conditions, whereas those stored in plastic containers at –20°C, for six years.

Storage fungi. Storage fungi affect seed health. These fungi grow rapidly in humid conditions. Fungi such as Alternaria alternata, Alternaria brassicicola, Aspergillus spp., Penicillium spp., and Rhizopus stolonifera associate with seeds. These fungi cause discoloration and shriveling, increase storage temperature, and reduce seed viability. Some agronomists observed 11 genera on cauliflower seeds, namely, Alternaria, Aspergillus, Chaetomium, Cladosporium, Curvularia, Drechslera, Fusarium, Gloesporium, Phoma, Rhizopus, and Stemphylium. Seed treatment with fungicides such as thiram or carbendazim is effective in controlling storage pathogens.

KOHLRABI (Brassica oleracea var. gongylodes L.)

Introduction. Kohlrabi is also known as kohl kohl. It is widely cultivated in temperate regions for its swollen edible stem, and its cultivation is expanding to the tropics and subtropics. Kohlrabi is cooked as a vegetable. It contains high amounts of calcium, magnesium, phosphorus, sodium, sulfur, potassium, and vitamins A and C.

Origin and Distribution. Kohlrabi originated in the Mediterranean region. It is largely cultivated in the Caribbean islands, Denmark, France, Germany, India, Indonesia, Italy, Malaysia, the Netherlands, the Philippines, and the United Kingdom.

Morphology. Kohlrabi is a small, dicotyledonous, biennial herb that is cultivated as an annual. Its stem is small and stout and enlarges just above the ground in a sphere shape. The swollen stem is 5 to 10 cm in diameter and white, green, or purple. Flowers are light yellow in color. Fruit is a silique that dehisces on maturity. Seeds are round, 1.5 to 2.0 mm in diameter, and brown. One thousand seeds weigh about 3.2 g.

Seed Storage. Kohlrabi is propagated by seeds. Seeds are also used in hybridization programs for evolving new cultivars and in long-term conservation of genetic variability. Kohlrabi seeds show orthodox storage behavior. Drying and cold storage do not affect seed viability. Kohlrabi seeds are short-lived under ambient conditions. They require suitable storage conditions for longer maintenance of high-quality seeds.

Seed Collections. Kohlrabi is a cool-season crop. It requires low temperature (10°C) for a week to induce flowering. Cold treatment for about 8 to 12 weeks followed by 2 weeks at 10°C initiates flowering.

Plants are earthen up or they are protected from frost by covering their swollen stems with soil, lifted and stored separately during frost. Normally, the seed-to-seed method produces seeds. Kohlrabi requires deep, fertile, and well-drained soils. Seeds are sown in the nursery, and seedlings are subsequently transplanted to the main field. Plants are fertilized properly, irrigated, and protected against pests and diseases. Uniform and true-to-type plants are selected for seed purposes, and off-types are eliminated. Kohlrabi is cross-pollinated by bees; thus, an isolation distance of 1,600 m is provided to maintain genetic purity. Mature pods are harvested, stored for a few days, and threshed; seeds are extracted, cleaned, dried, and packed for storage.

Seed Germination. Seed germination is epigeal and completes in a week. It is rapid and highest at a constant temperature of 30°C.

Storage Conditions. Kohlrabi seeds lose viability and vigor rapidly under ambient conditions. Seeds stored at 15 to 20°C lost viability rapidly. In open conditions, seeds remained viable for nine months, and longevity was extended to eight years by preserving seeds in desiccators. Seeds stored at subzero temperatures (–20°C) remained viable for six years. Further, seeds maintained viability for three months at normal temperatures after storage at –20°C, with no reduction in germination or seedling vigor.

Unit 11
LEAFY VEGETABLES

SPINACH (Spinacia oleracea L.)

Introduction. Spinach is an important winter leafy vegetable cultivated for its smooth or wrinkled edible leaves. It is cooked as a vegetable and used raw in salad. It contains protein, carbohydrates, calcium, iron, and vitamins A, B, and C.

Origin and Distribution. Spinach originated in Central Asia. It is predominantly grown in temperate regions; however, it is also cultivated at higher altitudes in the tropics and subtropics. It is a popular leafy vegetable in Canada, Denmark, Egypt, France, Germany, the Netherlands, Poland, Russia, Spain, the United Kingdom, and the United States.

Morphology. Spinach belongs to family Chenopodiaceae and has chromosome number 2n = 12. It is a dicotyledonous, dioecious, erect, herbaceous biennial plant with edible leaves. The inflorescence is a terminal panicle; male flowers are small and open earlier into pistillate flowers. Female flowers are axillary and greenish and number 6 to 12 per cluster. Fruit is single seeded. Seeds are round and smooth or prickly. One thousand seeds weigh about 10 g.

Seed Storage. Seeds are widely used in crop production. They are also used for evolving new varieties and in the conservation of genetic diversity. Seeds show orthodox storage behavior and are fairly long-lived under ambient conditions.

Seed Collections. Spinach is a cool-season crop that grows well in low-temperature areas. High temperature induces premature bolting. Young seedlings can withstand frost. Spinach is a long-day plant. Flowering is profuse under long-day and chilling conditions. The plant bears staminate, pistillate, or hermaphrodite flowers separately. It grows well in fertile, well-drained, sandy loam soil.

Crops are fertilized, irrigated, and sprayed regularly against insect pests and diseases. Stems elongate and form flowers in clusters. Spinach is cross-pollinated by the wind; therefore, an isolation distance of 1,600 m is provided between varieties. Roguing is done during the flowering and fruiting stages, and off-type plants are removed. On maturity, plants are cut and threshed, and the seeds are separated, cleaned, dried, and packed for storage.

Seed Germination. Spinach seeds show a considerable amount of dormancy. Prevalence of low temperature also induces dormancy. Such dormant seeds require after-ripening as well as higher temperatures for germination. 21 days of after-ripening was beneficial for eliminating dormancy. Seeds germinate at 5 to 27°C, and the optimum temperature is between 20 and 25°C .

Spinach seeds can also tolerate a high level of soil salinity. Seed germination is hastened by exposing seeds to a 40 MHZ radio frequency electric field.

Storage Conditions. Seed storage under improper conditions affects seed quality. Seed viability is lost rapidly in high-moisture seeds and also at high storage temperature and relative humidity. Spinach seeds remain viable for three to four years under proper storage conditions. Seeds having 5 to 7 percent moisture that are suitably packed in polyethylene bags and in aluminum foil pouches or cans and stored at lower temperatures maintain high viability and vigor during storage.

CORIANDER (Coriandrum sativum L.)

Introduction. Coriander is cultivated as spinach and mainly used in flavoring food dishes. Dry seeds are powdered and used as a spice in food preparation. It is rich in proteins, carbohydrates, calcium, iron, and vitamin A. Fruit contains a volatile aromatic oil that is used in medicines and has carminative properties.

Origin and Distribution. Coriander originated in the Mediterranean and Middle East regions. It is cultivated in Brazil, China, England, France, Germany, India, Italy, Malaysia, Morocco, Thailand, and the United States.

Morphology. Coriander belongs to family Umbelliferae and has chromosome number 2n = 22. It is an annual, dicotyledonous herb that grows up to 80 cm in height. The stem is hollow, with broad leaves at the base and narrow leaves at the top. The inflorescence is a terminal umbel with numerous small white, pink, or lavender flowers. The fruit is globular, yellow, or brown; ribbed; and about 4 mm in diameter. It is a two-seeded schizocarp. Seeds are semiglobular and contain essential oil (0.1 to 1 percent), mainly coriandrol (C10 H18 O). One thousand seeds weigh roughly 7 to 13 g.

Seed Storage. Coriander is propagated by seeds. It is also used in breeding programs and in long-term conservation of germplasm. Seeds show orthodox storage behavior. Seed viability is unaffected by drying and low-temperature storage.

Seed Collections. Coriander needs a cooler climate for optimum growth, especially at higher altitudes. It grows well in deep, fertile, well-drained soils. Seeds are sown directly in the field. Normal cultural practices are followed for high crop production. It is a cross-pollinated crop, and about 1,000 m of isolation distance is maintained to prevent genetic contamination. Off-type plants are removed. Fruit requires about 90 to 120 days from sowing to maturity. Dry, mature fruits are collected, separated, and cleaned for storage.

Seed Germination. Fresh seeds do not germinate readily, revealing dormancy. Seed germination is better at 15°C, and it takes 10 to 21 days to complete. Seed germination decreases above 30°C and lower than 10°C . Seeds selected from the second-order umbel gave higher germination and higher seedling vigor than those from the first- or third-order umbels. Germination is improved by subjecting seeds to alternate temperatures of 27/22°C for 8/16 h, respectively.

Storage Conditions. Seed viability and vigor decrease with an increase in seed moisture and storage temperatures. Low-moisture seeds are packed in polyethylene bags or in laminated aluminum foil pouches and are stored at low temperature. This maintains high viability for a longer period.

Storage pests and fungi. Higher seed moisture is congenial for insect and pathogen activity. Fumigation with methyl bromide (64 ml liter –1) or hydrogen cyanide (HCN) (48 mg liter –1) gas for 2 h at reduced pressure kills the insects inside and does not affect seed quality. Fungal damage is controlled by application of fungicides, such as brassicol, zineb, captan, and thiram, at 0.3 to 0.4 percent.

Unit 12
SALAD VEGETABLES

LETTUCE (Lactuca sativa L.)

Introduction. Lettuce is a popular salad crop in temperate regions. It is a cool-season vegetable crop exclusively cultivated for its edible leaves. It is also grown to a lesser extent and on a smaller scale in the subtropics, where it is cooked as a vegetable. It is rich in minerals such as calcium, phosphorus, and iron and vitamins A and C.

Origin and Distribution. Lettuce originated in the Middle East region composed of Iran and Turkey, where the wild species are found. It might have evolved from Lactuca serriola L. Lettuce is cultivated in Australia, Canada, China, France, Italy, Malaysia, the Netherlands, the Philippines, South Africa, Spain, the United Kingdom, and the United States.

Seed Storage. Lettuce seeds show orthodox storage behavior. Seed viability is unaffected by loss of moisture and by exposing seeds to chilling temperatures. Seeds are commonly used in commercial propagation and for long-term genetic conservation.

Morphology. Lettuce belongs to family Compositae and has chromosome number 2n = 18. It is cultivated as an annual for vegetable purposes and as a biennial for seed purposes. Lettuce is a dicotyledonous herb with a small stem that contains latex. Leaves are alternate, sessile, and spirally arranged in a rosette. Outer leaves are dark green and rough, whereas the inner ones are light green and succulent. Heads vary in size and shape and are classified as cos, butter head, or crisp and leafy type. Inflorescence is a capitulum that contains yellow perfect flowers arranged in a cluster. Fruit is a singleseeded achene, black, brown, or white in color. One thousand seeds weigh about 0.6 to 1.0 g.

Seed Collections. Lettuce is a cool-season crop. It grows well under temperate conditions and requires humus and well-drained soil. Dry conditions or water shortage induces premature bolting. It is propagated by seeds. Crops are provided with optimum dosages of nutrients, regular irrigation, and plant protection measures for the production of high-quality seeds. Lettuce is mostly a self pollinated crop; however, cross-pollination occurs to a small extent. An isolation distance of 50 m is maintained between varieties to safeguard against genetic contamination. To facilitate flowering, a slight cut is made on the head or the upper leaves are removed. Off-type plants are removed during the flowering and fruiting stages. Fruits take two weeks to mature after anthesis and are harvested when the capitulum bursts and shows the pappus.

Seeds shatter if harvesting is delayed. Plants are cut and placed in small piles, dried, and threshed. Seeds are separated, cleaned, and packed for storage.

Seed Germination. Lettuce seeds germinate readily and do not show any dormancy. However, seeds exposed to conditions of extreme temperature or light show secondary dormancy. The optimum temperature for seed germination is 25°C, and germination takes four or five days to complete. Seeds do not germinate when exposed to higher temperatures. A temperature regime greater than 25°C inhibits the germination process, due to the impermeability of the seed coat to oxygen. Continuous exposure of seeds to a dark period also induces secondary dormancy (skotodormancy).

Light. Light plays a vital role in lettuce seed germination. It promotes germination activity under a set of conditions. Germination rate is higher in the presence of light than in darkness. The exposure of moist seeds to fluorescent light for 24 h alone and/or followed by 24 h of darkness accelerates the germination process. The uneven emergence of seedlings caused by higher temperature is overcome by exposing moist seeds to red light for 3 h, and this eliminates the secondary seed dormancy. While red light improves germination, far-red light inhibits it.

Chemicals. Seed germination improves by imposing certain chemical treatments, such as osmoconditioning with PEG at 10 bar, acid immersion for an hour followed by washing, and application of ethephon, gibberellic acid (50 mg liter–1) or kinetin, thiourea (1,000 mg liter–1) (Sarma and Chakraborthy, 1977), and vitamin K (50 ppm). Germination is affected by volatile toxic substances released within storage containers.

Immersion of skotodormant seeds in acid followed by either gibberellic acid application or exposure to red light improved germination. Acid treatment weakens the membrane barrier of the endosperm cells and results in better penetration by gibberellic acid, thereby inducing higher germination.

Storage of pregerminated seeds. Pregerminated seeds are viable for a very short period. However, they can be stored up to five days at 5°C in aluminum foil pouches. Further storage reduces vigor and viability due to degradation of the cellular structure and inactivation of enzymes.

Storage Conditions. Seed moisture or relative humidity, storage temperature, and oxygen play a major role in deterioration of lettuce seeds. Proper and careful regulation of these parameters is beneficial in retention of high viability on long storage. Lettuce seeds show good viability even after 15 years of storage.

Seed moisture. Seed moisture is reduced with the development of seeds. It remains constant at the physiological maturity of seeds. Further, moisture is reduced by drying seeds to a safe limit for better storage. Lettuce seeds deteriorate rapidly under high humidity and temperatures.

Seeds gain or lose their moisture from or to the atmosphere based on changes in vapor pressure. Seeds stored at fluctuating humidities at 5°C or 0 percent RH at room temperature maintain viability for four years. At highest and lowest humidity, dormancy developed in seeds and was apparently associated with seed deterioration, leading to death. The best seed viability is maintained at 46 to 58 percent RH. Some agronomists observed more abnormal seedlings when seed moisture exceeded 12 percent, and seeds were killed within a day when moisture exceeded 47 percent.

Excessive drying also affects seed quality. Crop yield decreased in seeds stored at 4.1 percent mc compared to those at 6.4 percent mc. A number of scientists preserved well-dried seeds at 10–1 to 10–2 mb for 9 to 12 years without loss of viability.

Seed packaging. Packaging creates a barrier between seeds and the external environment. It protects the seeds from high relative humidity and prevents the entry of pathogens. The selection of packaging depends on the duration of storage. Normally, low-moisture seeds are kept in sealed storage. Seeds stored in thinner-gauge bags lose their viability rapidly and exhibit more abnormalities than those stored in thicker-gauge bags. Seeds stored in polyethylene bags at –20°C lost moisture from 6.6 to 5.6 percent in 11 years of storage, and there was no reduction of seed viability during the period.

Desiccants. Chemical desiccants are effective in lowering seed moisture, thereby extending storage life. High seed quality was maintained for 86 months when lettuce seeds were stored with desiccants under fluctuating temperatures (5 to 30°C). This method is quite beneficial for short-term storage, easy to manage, and inexpensive.

Temperature. Seed longevity decreases with increasing temperature. Seeds remain viable for four years at 5 or –18°C. At 20°C, viability is lost more rapidly in dry seeds (5.5 to 6.8 percent mc) than in ultra dry seeds (2.0 to 3.7 percent mc). Ultra dry seeds maintained viability for five years at –20°C storage.

Air. High oxygen content affects seed quality during storage. Lettuce seeds retain high viability in sealed containers when stored with carbon dioxide, which maintains higher germination, reduces chromosomal aberrations, and delays aging of seeds. Low-moisture seed survival was better in nitrogen than in air, vice versa for high-moisture seeds.

Invigoration of Stored Seeds. Seed quality declines during ambient storage. Mid-storage hydrationdehydration of medium-vigor lettuce seeds effectively reduces physiological deterioration and gives better field emergence and higher yields, whereas soaking-drying is not effective in higher-vigor seeds. To improve germination, seeds are to be soaked in water for 2 h followed by storage at 4.4°C for four to six days. Seed soaking in thiourea (0.5 percent) also improves the germination percentage.

The hydration-dehydration treatment curtails the process of deterioration and minimizes chromosomal aberrations. Introduction of chemicals such as ethephon (30 ppm), potassium iodide (10–4 M), p-hydroxybenzoic acid (10–4 M), or tannic acid (10–5 M) into the seeds by dry permeation technique, using acetone as a solvent on the old seeds, reduces seed deterioration and promotes germination by counteracting the effect of free-radical damage to the stored seeds.

Moist storage. Higher seed moisture causes a rapid decline in longevity and also produces chromosomal aberrations. Seeds stored under an imbibed state do not germinate, which helps in the retrieval of high seed quality. Imbibed seeds held at 25°C in darkness retained viability up to ten months. Seeds behave differently at a higher level of moisture (15 percent), and oxygen is essential for survival. At this stage, the relative effect of temperature on decreasing longevity is slightly diminished. Seeds at 20 to 30 percent moisture do not suffer further decreases in longevity. It appears that hydration activates the repair mechanism. Seedlings grown from dry seeds stored under ambient conditions showed an increase in morphological abnormalities with an increase in storage period, whereas seedlings from imbibed stored seeds appeared normal. The repair mechanism operates only under the imbibed state, under the conditions that prevent germination during storage.

CELERY (Apium graveolens L.)

Introduction. Celery is an important salad crop in Europe and North America that is grown for its edible leaf stalks and swollen roots. It is consumed raw or cooked as a vegetable. In temperate regions, the petioles are eaten as a fresh vegetable after blanching or flavoring. Dry leaves are used as a flavoring agent and in medicine. Seeds contain 2 to 3 percent volatile oil. Celery is rich in minerals such as calcium, phosphorus, and iron and in vitamin A.

Origin and Distribution. Celery originated in Asia and Europe. It is largely cultivated in Europe and North America. Some of the major celery-growing countries are Algeria, Canada, China, Egypt, France, Indonesia, Malaysia, New Zealand, the Netherlands, the Philippines, Sweden, the United Kingdom, the United States, and the West Indies.

Morphology. Celery belongs to family Umbelliferae and has chromosome number 2n = 22. It is a dicotyledonous biennial crop. It completes a life cycle in one year under temperate conditions. Celery roots are thick and fleshy; leaves are pinnately compound with long petioles up to 40 cm. Foliage is light or dark green and possesses a strong flavor. The inflorescence consists of small white flowers in an umbel. Flowers are perfect and self-fertile. Fruit is a rigid schizocarp that contains one seed. Seeds are small, brown, and ribbed. One thousand seeds weigh about 0.5 g.

Seed Storage. Celery is propagated by seeds. Seeds are important in genetic conservation and crop improvement. Seeds are moderate storers under ambient conditions. They store well under dry, cool climatic conditions.

Seed Collections. Celery is a cool-season crop that grows well in low-temperature regions. It requires deep, fertile, well-drained, humus soil. It is raised by seeds in the nursery and transplanted in the field. Seeds are soaked in water before sowing for early and higher germination. Plants undergo vernalization for the induction of flowering. Celery is a self-fertile plant, but insects bring about cross-pollination to a limited extent. Thus, an isolation distance of 500 m is provided between varieties. Adequate horticultural practices, such as irrigation, nutrition, and crop protection measures, are followed. Crops are inspected during the vegetative and reproductive phases, and off-types plants are removed. Fruits become brown on maturity, and at this stage, crops are harvested.

Delay in harvesting causes shattering of seeds. Later, the plants are threshed, and the seeds are separated, dried, and suitably packed for storage.

Seed Germination. Seed germination is epigeal and higher at alternate temperatures of 15/22°C (Guy, 1981). In celery, the seed embryo is comparatively underdeveloped, and embryo size varies in different cultivars. About 20 percent of seeds are empty. Further, immature embryos are dormant. All these factors contribute to delayed and uneven emergence of seedlings. Seed dormancy is also dependent on the umbel order. Seeds from primary and secondary umbels were large and less dormant but gave lower percentage of germination than tertiary and quaternary umbels. This is attributed to the imbalance of gibberellin and cytokinin levels in seeds. Dormancy is also induced in seeds by exposing them suddenly to dry conditions after the imbibing state, while seed germination improves with a combination of GA and PEG. Incorporation of growth substances into PEG is more effective than soaking seeds in gibberellins and ethylene solution alone, either before or after osmotic priming.

Storage Conditions. Celery seeds maintain high viability and vigor at low temperature and lower humidity. The choice of temperature range and packaging is selected based on duration of storage. For short storage, well-dried seeds can be packed in polyethylene bags and stored at 5°C. For longer storage, seeds can be packed in moisture-proof containers, such as laminated aluminum foil pouches, and then stored at subzero temperatures.

Unit 13
CUCURBITS

CUCUMBER (Cucumis sativus L.)

Introduction. Cucumber is cultivated in tropical and subtropical regions for its edible fruits. Tender fruits are eaten raw in salad, cooked as a vegetable, and also pickled. They contain carbohydrates and are a rich source of vitamin C.

Origin and Distribution. Cucumber originated in India, and large genetic variability is observed in different parts of India. It is grown in Bulgaria, China, Egypt, Greece, India, Indonesia, Japan, Malaysia, Mexico, the Netherlands, Poland, Russia, Spain, Turkey, and the United States.

Morphology. Cucumber belongs to Cucurbitaceae family and has diploid chromosome number 2n = 14. It is a monoecious, dicotyledonous annual plant. Vines are long and trailing with stout, hairy stems. Leaves are triangular, have three to five lobes, and are cordate. Flowers are yellow; male flowers are borne in clusters and outnumber female flowers. Fruit is a pepo and varies in size and shape, from globular to oblong, and is many seeded. The skin color is whitish green to dark green, turning yellow or brown on maturity. Flesh is pale green with no central cavity. The bitterness of fruit and foliage is owing to the terepene compound cucurbitacin, which gives resistance to certain insect pests. Seeds are white and flat. One thousand seeds weigh 25 to 33 g.

Seed Storage. In cucumber, seeds are used for propagation and in breeding programs. Seeds can be stored until the next growing season or for a very long period for genetic conservation. Cucumber seeds exhibit orthodox storage behavior. They can withstand removal of moisture and can be stored at lower temperatures. High seed viability and vigor are retained at lower temperatures and lower moisture content. Cucumber seeds retain their viability for a fairly long period. They lose viability completely by 38 months of storage. Germinating power and yield reduce steadily in crops raised from seeds stored under ambient conditions. Crop yield is lower in plants raised from older seeds than in those from fresher seeds. On proper seed storage, low deterioration occurs. Such seeds give more productive plants than fresh ones.

Cucumber plants raised from two- to three-year old seeds are more productive than plants raised from one-year-old seeds. In fresh seeds, catalase activity is lower than in stored seeds, suggesting that the vigor of freshly harvested seeds is lower than that of stored seeds. Likewise, there was a delay in ethylene production in fresh seed germination. Seed vigor improves in fresh seeds following after-ripening at 75°C for 24 h. Chemical composition of seeds varies with storage period. Sugars and vitamin C tend to increase with longer storage.

Seed Collections. Cucumbers are propagated by seeds. High seed viability and vigor are essential for high plant populations in the field and, in turn, for higher crop production. Cucumber grows well in warm climatic conditions. Seed quality improves with growing plants in artificial light, limiting the number of fruits per plant, and pollinating artificially with bees. Seed yield increases and fruit size and number of fruits per plant decrease with an increase in plant population. Cucumber prefers deep, fertile, well drained soils. Seeds are directly sown in the field on ridges or on hills. Plants are regularly irrigated, properly fertilized, and protected against pests and diseases. Plants are cross-pollinated mainly by bees, and an isolation distance of 1,600 m is maintained to prevent genetic contamination. Male flowers open earlier than female flowers; the latter are favored by short-day conditions and low temperatures. Plants are to be examined for off types, especially during the flowering and fruiting stages. Ripe fruits are collected when they turn pale yellow or golden in color (see Figure 42.1). Seeds are separated by either mechanical or chemical means. The pulp along with the seeds is fermented.

Seeds that sink to the bottom are selected, and floating ones are discarded. Selected seeds are dried, cleaned, and stored.

Fruit maturity. Fruit maturity coincides with seed maturity. Seed maturity determines seed quality for sowing and storage. In cucumber, seed quality is poor in seeds obtained from immature fruits (20 days after anthesis), even after subjecting fruits to postharvest ripening. Seeds harvested at 30 days after anthesis need postharvest ripening of 7 to 15 days for better quality. The best seed quality is obtained 40 days after anthesis. Further delay affects seed quality by excessive respiration and field damages. The lipase activity and vitamin C content increase during seed germination. In seedlings raised from seeds extracted from mature fruits, lipase activity, ascorbic acid content, and other biochemical indices were at higher levels than in seedlings raised from seeds of immature fruits. Mature seeds retain viability better than seeds of immature fruits.

Seed Germination. Seed germination is epigeal and completes in five to seven days. It is influenced by fruit maturity at harvest and duration of fermentation, in seed extraction, seed storage time, seed placement, and germination temperatures. A constant temperature of 30°C is ideal for germination. The germination process is completed in the shortest time at higher temperatures. Certain cucumber cultivars germinate more quickly than others, and heritability for speed of germination is very low (0.15 to 0.20 percent).

Seed dormancy. Some scientists observed dormancy in seeds of cultivated, wild, and hybrid cucumbers that can be overcome by after ripening for one month. Seeds stored for six months at 15 and 20°C showed improved germination. Light inhibits germination, and longer exposure at 20°C induces secondary dormancy.

Seed placement. Seeds placed at 45° angles with the embryos pointed upward give high germination percentage and best seedling growth. This was attributed to better hypocotyl emergence from the soil, rapid cotyledon expansion, and earlier differentiation of leaves. However, Sowing seeds in the flat position gave higher germination at a constant temperature of 26.7°C.

Chemicals. Seed germination improves with the application of certain growth substances. Seed treatment with GA 4/7 plus ethephon or insulin or insulin-like factors I and II enhances the germination of cucumber seeds. Further, seed quality is improved by treating seeds with succinic acid.

Storage of pregerminated seeds. Pregerminated seeds can be stored for ten days in a cold-air medium. Seed viability and vigor decrease on longer storage, which is attributed to the degradation of functional structures, an increase in fatty acids content, and enzymatic degradation.

Storage Conditions. Seed viability decreases rapidly at higher storage temperature and relative humidity. Cucumber seeds fail to germinate at 20 to 30°C and 82 percent RH after three months of storage. For shorter seed storage, the optimum conditions are 25°C and 45 percent RH. Seeds stored at a constant temperature of 16 or 25°C or at varying temperatures of –7 and 20°C maintain viability for seven years. Seed viability decreases rapidly at 20°C and 80 percent RH. The optimum conditions for storage are temperatures close to zero and relative humidity not exceeding 70 percent. At lower temperature and lower humidity, such as 3°C and 38 percent RH, seeds retain 80 percent germination after ten years of storage. Further, none of the seeds germinated after 13 years of storage. Seed moisture should be low for ultralow-temperature storage. Seeds with 5 or 6 percent moisture stored at –196°C retained germination ability for two years, and germination was affected when seed moisture increased to 9 to 10 percent. The safe moisture level is 1.02 to 4.08 percent for ultra dry storage. Seeds with this moisture range retain high viability and vigor; those with moisture below this range are damaged by extreme drying, and those with moisture above this range showed reduced storability.

Seed packaging. Various kinds of packaging materials are employed in seed storage. The ideal material should protect seeds from high moisture, withstand low temperatures, and preserve viability for longer periods. Sealed airtight containers are better for storage than unsealed containers. Sealed polyethylene film of 0.125 and 0.25 mm thickness is an excellent moisture-resistant package for dry cucumber seeds. Thin polyethylene film of 0.037 to 0.05 mm was useful for a short-term marketing package, but not for long-term storage.

Storage fungi. Seed quality is affected during rainy or humid conditions. Fungi invade seeds, especially in open storage, and reduce seed viability and vigor. It is recommended seed treatment with Ceresan, thiram, or captan to protect seeds from storage fungi and also to maintain high germination.

Invigoration of Stored Seeds. Seed germination and seedling vigor decrease with an increase in storage period. Use of certain chemical treatments during mid storage revives vigor. Seed treatment with potassium orthophosphate (3 percent) improves the seed germination of four-year-old cucumber seeds. Seed coating with calcium chloride (40 millimolar [mM]) had a similar effect.

MUSKMELON (Cucumis melo L.)

Introduction. Muskmelon is widely grown in the tropics. It is also known as sweet melon, cantaloupe, or honeydew melon. It is cultivated for its edible fruits, which have a sweet and musky flavor. Fruits are commonly used for dessert purposes. They are rich in sugar and vitamins A and C. Seeds can also be eaten after removing the hard seed coat.

Origin and Distribution Muskmelon originated in tropical Africa. Subsequently, its cultivation spread to other tropical regions. It is largely grown in China, Egypt, France, India, Indonesia, Iran, Italy, Japan, Korea, Malaysia, Mexico, Morocco, the Philippines, Romania, Spain, Turkey, and the United States.

Morphology. Muskmelon belongs to family Cucurbitaceae and has diploid chromosome number 2n = 24. The plant is cultivated as an annual. It has long trailing vines, with leaves that are dark green, alternate, ovate, and three to seven lobed. Flowers are monoecious or andromonoecious. Pistillate flowers are borne singly, and staminate ones in clusters. Fruit is a fleshy pepo and varies in size, shape, and color. Fruits are globular or oblong, smooth or furrowed, green, yellow, or yellow-brown; flesh is green, pink, or yellow and has a musky scented flavor. Seeds are white or cream, black, or red-brown; flattened; and number 400 to 600 per fruit. One thousand seeds weigh about 5 to 25 g.

Seed Storage. Muskmelon seeds show orthodox storage behavior and withstand desiccation and chilling. Seeds remain viable for a long period under dry, cool conditions. High seed germination and vigor are retained for two years under ambient conditions. Seed storability varies in different cultivars. Some cultivars are more sensitive to aging than others. Low-vigor seeds have higher respiratory quotients.

Seed Collections. High-quality seeds with high viability and vigor are essential for high crop production. Crops grow well in sunny locations and during the warm season. Fruits produced under humid and rainy conditions are of inferior quality and get invaded by several diseases. Muskmelon requires deep, fertile, well-drained soil. High phosphorus content in the soil improves fruit quality and yield. Seeds are sown directly on ridges in rows or raised beds. Proper spacing, adequate nutrition, timely irrigation, and plant protection measures are followed. Muskmelon is compatible with other cucurbits and is generally pollinated by bees. To protect against genetic contamination, an isolation distance of 1,000 m is maintained. Off-type plants are removed, especially during the flowering and fruiting stages. Staminate flowers open early and outnumber pistillate flowers. Fruit color changes from green to yellow or white on maturity, and ripe ones are plucked for seed purposes. Seeds are separated from the pulp by washing and then are dried, cleaned, and packed for storage.

Fruit maturity. Seeds from fully matured fruits maintain high seed quality during storage. Fresh muskmelon seeds show dormancy, and an after-ripening period is required at all stages of seed development. Seeds are fully mature 60 days after anthesis. Seed germination increases in fully matured seeds after one year of storage at 20°C.

After-ripening improves seed quality and the yield of plants raised from the seeds. During fruit ripening, the quantity of oligosaccharides and vitamin C content increase and mono saccharides, total acidity, and pectin content decrease. Only fruits 35 days old or older are suitable for after-ripening.

Fruit position. The position and number of fruits per plant influence seed quality. An increase in fruit number is accompanied by a decrease in fruit weight, number of seeds per fruit, seed weight, and germination percentage.

Seed Germination. Seed germination is epigeal and completes in five days. Germination improves with pulp fermentation of 24 h. It was highest in fruits harvested at full maturity, as compared to those in the full-slip or half-slip stage. Seeds from the proximal and middle portions of the fruit germinate better than seeds from the distal end. Seed germination and emergence hasten with storage up to 15 months and then decline, which is attributed to changes in lipase-1-peroxidase activity. Osmotic priming improves seedling emergence, whereas it has a deleterious effect on storage life of muskmelon seeds.

Storage Conditions

Seed moisture. Low seed moisture increases the storage life of seeds. Moisture content of 6.6 percent or less is ideal for long storage life of muskmelon seeds. In ultradry storage, extreme drying damages muskmelon seeds, and at a higher level of seed moisture, the storability decreases, especially at room temperatures.

Temperature. Seeds lose their viability rapidly under high temperatures, especially if they have high moisture content and are kept in open storage. Seeds maintain viability for two years at room temperatures, whereas the storability extends to eight years by storing them in polyethylene bags and laminated aluminum foil pouches at low (5°C) and subzero temperatures (–20°C).

Oxygen. A high level of oxygen reduces seed viability and vigor. Seeds stored in nitrogen atmosphere under ambient conditions exhibit higher germination percentage after six years of storage.

Storage fungi. Seed quality is affected by fungal infection. Fungal activity is higher at high seed moisture and high humidity. Some of the fungi that associate with muskmelon seeds are Botrytis cinerca, Cephalosporium spp., Cladosporium herbarium, Fusarium moniliforme, Mucor spp., Penicillium oxalicum, and Trichothecium spp. Heat treatment at 45°C for 10 min eliminates several fungi, without any adverse effect on seed germination. Also, fungicides such as captan and carbendazim are effective in controlling storage fungi.

WATERMELON (Citrullus lanatus (Thunb.) Mansf.)

Introduction. Watermelon is a popular dessert fruit in the tropics and subtropics, especially in the dry regions of the world. It is grown for the edible juicy fruit. The sweet pulp, which is rich in sugars and amino acids, is eaten raw. The juice is canned and also used in the preparation of syrup. Seeds, which are rich in edible oil, are roasted with salt and eaten.

Origin and Distribution. Watermelon is native to south-central Africa. It is cultivated throughout the tropics and subtropics. It is grown in Brazil, China, Egypt, Greece, India, Iran, Iraq, Italy, Japan, Korea, Mexico, Morocco, Spain, Tunisia, Turkey, and the United States.

Morphology. Watermelon belongs to the Cucurbitaceae family and has diploid chromosome number 2n = 22. Watermelon is an annual dicotyledonous plant having vigorous spreading vines with a deep root system; thus, it can survive under relatively dry conditions. Leaves are pinnately lobed, number three to four pairs, and have hairy tendrils. Flowers are unisexual, single, axillary, light yellow, small, and less showy compared to other flowers of cucurbits. Male flowers exceed the number of female flowers. Fruit is large, oblong, globular, ellipsoidal, or spherical in shape, with a thick and fragile rind. Fruit color is green, or cream and striped. Flesh is juicy and pink to red, yellow, white or greenish white, and the central cavity is absent. Seeds are numerous, about 200 to 500 per fruit; brown, black, red, white, greenish, or yellow; and rich in carbohydrates, fats, and proteins. One thousand seeds weigh about 110 to 115 g.

Seed Storage. Watermelon is exclusively propagated by seeds. Seeds are also used in hybridization programs and in the conservation of genetic diversity. Seeds show orthodox storage behavior and are fairly good storers under ambient conditions. Seeds maintain their viability for a fairly long period. In a long-term study, seeds of several species of watermelon stored for 43 to 60 years at the National Seed Storage Laboratory, Fort Collins, Colorado, lost only 51 percent of their viability.

Seed Collections. Watermelon is a warm-season crop. It requires a hot, dry climate, plenty of sunshine, and a long growing season. It grows well in deep, fertile, well drained, sandy loam to loam soils. It is propagated by seeds. Seeds are sown directly in the field, either on hills or on ridges. Crops are suitably spaced, fertilized, watered, and protected against pests and diseases for better crop growth and seed production. Watermelon is a cross-pollinated crop, and pollination is mainly brought about by honeybees. Male flowers appear first, followed by pistillate flowers. An isolation distance of 1,000 m is provided for maintaining genetic purity. Off-type plants showing undesirable vegetative and fruit characteristics are removed, especially during the flowering and fruit development stages. Fruit takes about 80 to 110 days for maturity, and its color changes from green to pale yellow on the underside of the fruit. Seeds are located in the central areas of the fruit pulp. Seeds are removed along with pulp, washed, dried, cleaned, and processed for storage.

Fruit maturity. Fruit color changes on maturity and becomes light yellow, especially on the lower surface. During this stage, seeds also attain maturity and give higher germination. Watermelon fruit matures in 49 to 54 days. Normally, fruits are left on the vines for a comparable period after the vines become dry. In cucurbits, the seed coat completes its growth earlier than the embryo, and this may play an important role in inhibiting the germination of immature seeds. Seed coat removal increases germination in immature seeds.

Fruit storage. Watermelon fruits can be stored for relatively long periods. Seeds from stored fruits also maintain seed quality for a long period. High seed germination could be maintained for four months when fruits are stored under ambient conditions, but germination decreases on prolonged storage. Storage of mature fruits up to 48 months did not affect seed germination, but germination was affected in seeds of immature fruits.

Seed Germination. Watermelon seeds possess a hard seed coat and thus take longer to germinate. Seed germination is epigeal and slow at lower temperatures. It improves with simple washing of seeds with water and scarification of the seed coat. Seed germination and storage life improved by treating the freshly extracted seeds with 2 percent hydrochloric acid or sodium hydroxide. Seed germinates readily on full imbibitions. Very dry or excess seed moisture affects the germination process. Seed germination is suppressed at minimum and maximum levels of 5 and 29 percent moisture. Seed germination was higher under darkness, and intermittent exposure of seeds to red or far-red light affects the germination process.

Storage Conditions.

Seed moisture. High seed moisture is injurious to seed viability. Moisture content of 5 to 7 percent is safe for long-term storage. Excessive removal of moisture damages cell structure and affects seed quality. A number of agronomists recommended moisture content of 1.25 to 4.26 percent for ultra dry storage. Seed moisture less than 1.25 percent damages the cell structure, thereby reducing storability.

Seed packaging. A suitable container is required to maintain a desirable moisture level in seeds. Seeds can be stored in cloth bags, paper bags, glass containers, and laminated aluminum foil pouches, or aluminum cans, depending upon storage period and conditions. Polyethylene bags and laminated aluminum foil pouches are effective in maintaining high viability at lower temperatures. Polyethylene bags are also cheaper, transparent, and sealable. Watermelon seeds stored in polyethylene bags at 2°C and 65 percent RH retain higher viability than seeds stored in paper bags. In a hermetically sealed box, seed viability was preserved for 15 to 23 years, and seeds packed in paper bags exhibited lower germination and more abnormal seedlings after four to five years of storage.

Temperature. High temperature promotes seed deterioration. Seeds stored at room temperatures remain viable for only two years, as compared to 15 years in those stored at 5 and –20°C.

Air. Watermelon seed quality decreases during open storage under ambient conditions. A high level of oxygen promotes the respiration process. Seeds stored in nitrogen remain viable for seven years under ambient conditions.

PUMPKIN (Cucurbita moschata (Duchesne) Poir.)

Introduction. Pumpkin is an important cucurbitaceous vegetable in arid regions of the tropics. It is cultivated for its edible fruits, which have a long storage life under ambient conditions. Ripe fruits are cooked as a vegetable and also are fed to cattle. Pumpkin is rich in carbohydrates, potassium, and vitamins A and C.

Origin and Distribution. Pumpkin originated in the arid regions of Central and South America. It is grown largely in the tropics. Some major pumpkin-growing countries are Argentina, China, Egypt, India, Indonesia, Iran, Italy, Japan, Malaysia, Mexico, Peru, the Philippines, South Africa, Spain, Turkey, and the United States.

Morphology. Pumpkin belongs to the Cucurbitaceae family. It is a dicotyledonous trailing plant having chromosome number 2n = 40. Leaves are simple, large, alternate, and deeply lobed. Plant is monoecious and bears a single yellow staminate flower on a long stem, while the pistillate is borne on a shorter stem. Fruit is large and varies in size, and its flesh color ranges from yellow to orange. Seeds are brown or white with a broad rim and contain about 30 percent proteins and 40 percent oils. One thousand seeds weigh about 200 g.

Seed Storage. Pumpkin is commercially propagated by seeds, which have greater value in genetic conservation. Seeds show orthodox storage behavior, and seed deterioration decreases with decreases in seed moisture and storage temperature.

Seed Collections. Pumpkin is a warm-season crop; it tolerates hot, dry climatic conditions. It requires deep, fertile, sandy loam soils. Seeds are sown directly on ridges or hills in the field. Pumpkin is cross-pollinated by insects, mainly bees. Fruit shape and yield are affected by improper and inadequate pollination. Therefore, one or two beehives are placed near the seed production field. An isolation distance of 1,600 m from other cucurbits is maintained to avoid cross-fertilization. Roguing of off-type plants is done during the flowering and fruiting stages. Only a few fruits per vine are retained for optimum size; otherwise, fruit weight will be reduced. Heavy fruits yield bold and high-quality seeds. Below average fruits give lower seed yield, but those seeds give the highest percentage of germination. Fruit takes normally four months from anthesis to maturity. Change of fruit color to yellow or straw color is the indication of maturity. Seeds are removed along with the pulp from the matured fruit and subjected to fermentation in water for 24 h followed by washing in running water for 40 min.

Fruit maturity. Seed viability and vigor are high in seeds harvested at the mature stage. Pumpkin seeds extracted from fruits 15 to 65 days after anthesis can be stored for seven weeks. Seed germination and seedling vigor increase with increasing fruit age and storage length.

Fruit storage. Pumpkin fruits can be stored for a fairly long period at room temperatures. Seed quality improves with storage of fruits. Seeds of ripe fruits give high viability and vigor. Seed germination in unripe fruits improves after ripening. Further, storage of ripe and overripe fruits at 23°C and 50 percent RH for six weeks resulted in loss of seed vigor and/or germination.

Seed Germination. Seed germination is epigeal, and seedling emergence takes less time at higher temperatures. Seed germination is better at alternate temperatures of 20/30°C for 16/8 h, respectively.

Seed size. Large seeds produce higher yield than small or medium-sized seeds, whereas there is no relationship between seed size at planting and seedling emergence.

Chemicals. Seed germination in pumpkin improves by soaking seeds in an ammonium chloride solution (400 ppm) for 6 h.

Storage Conditions. Pumpkin seeds are viable for four years under ambient conditions, whereas high germination is retained for only two years. Seed viability and vigor are affected by higher storage temperatures and relative humidity. Some agronomists preserved pumpkin seeds for 18 months by storing air-dried seeds in cloth bags under ambient conditions. Moisture content of 1.79 to 4.07 percent is safe for ultra dry storage of pumpkin seeds. Further, reducing the moisture damages cell constituents, and higher moisture reduces seed storability. Seed storage at 5 and –20°C maintains high viability and vigor for 15 years. The loss of viability is associated with greater leaching of electrolytes, soluble sugars, and free amino acids and a decrease in dehydrogenase activity in seeds.

MARROW (Cucurbita pepo L.)

Introduction. Marrow is a popular cucurbit in the tropics and subtropics. It is also known as summer squash or vegetable marrow. It is cultivated for its edible fruits. Immature fruits are boiled or roasted, and mature fruits are cooked as a vegetable. It is a good source of carbohydrates and vitamin A.

Origin and Distribution. Marrow originated in South America. Large genetic diversity exists in Mexico. It is cultivated in Argentina, Brazil, India, Indonesia, Malaysia, Mexico, the Philippines, and the United States.

Seed Storage. Marrow seeds exhibit orthodox storage behavior. These seeds can be dried to a very low moisture content, and storing them at chilling temperatures can extend longevity. Seeds are viable for two to three years under ambient conditions and need cool, dry conditions for better storage.

Morphology. Marrow belongs to family Cucurbitaceae and has chromosome number 2n = 40. Marrow is a monoecious annual that produces both bushy and long running plants. Stems are rough with large, deeply lobed leaves. Flowers are bright yellow to orange yellow, single, and showy. Fruits differ in shape, size, and color and have a hard or soft shell. Fruits contain a large number of seeds that are easily separable from the pulp. Flesh is yellow or white. Seeds are brown, white, and large or small with a rim. One thousand seeds weigh 300 to 310 g.

Seed Collections. Marrow is a warm- and dry-season crop that withstands high temperatures. It grows well in well-drained, humus soil. It is propagated by seeds. Seeds are sown directly in the field, either on ridges or on hills. Plants are provided with adequate nutrients and watered regularly for better crop growth. Marrow is a cross-pollinated crop, and insects bring about pollination. Male flowers outnumber and appear earlier than female flowers. An isolation distance of 1,600 m is maintained to protect from cross-pollination with other cucurbits. Plants are inspected during the flowering and fruiting stages for various morphological characteristics and off-type plants are removed. Fruit color changes on maturity. Dry fruits are collected, and seeds are removed from the pulp. Seeds are washed thoroughly, dried, cleaned, and packed for storage.

Fruit maturity. Seed germination is higher in seeds of matured fruits. Marrow seeds reach mass maturity 61 to 63 days after anthesis and moisture content decreases to 40 to 48 percent. Seeds extracted from immature fruits (28 days after anthesis) did not germinate. Seeds harvested 24 to 31 days after mass maturity gave higher seed longevity.

Fruit storage. In cucurbits, fruit storage is a common practice used to improve seed quality. Storage of ripe fruits for three weeks and of immature fruits for 12 weeks at room temperature eliminates dormancy. The mature marrow fruits can be stored for 48 months with germination unaffected.

Seed Germination. Seed germination is epigeal and higher at alternate temperatures of 20/30°C for 16/8 h or at a constant temperature of 30°C. Seeds take one week to germinate under dark conditions. Seed placement at a 45° angle, with the embryo end upward, gives a higher percentage of germination and better seedling growth.

Seed dormancy. Marrow seeds exhibit dormancy to a certain extent. Seed dormancy is eliminated by after-ripening of seeds for one to two months. Decoating of seeds also overcomes the dormancy and gives 100 percent germination shortly after mass maturity.

Storage Conditions. Seed deterioration decreases at a lower level of seed moisture and at a lower temperature. Seed longevity improves with a decrease in seed moisture and temperature. Seed moisture of about 6.5 percent gives highest seed storability, and any subsequent increase in moisture reduces seed longevity. Root growth is also adversely affected at higher seed moisture. Thus, marrow seeds are dried to a lower moisture content (5 to 7 percent) and suitably packed in moisture-proof containers, such as laminated aluminum foil pouches, and are preferably kept at –20°C for long-term storage. However, seeds can be packed in polyethylene bags and stored at 5°C for relatively longer storage.

Invigoration of Stored Seeds. Seed priming improves the rate of seedling emergence, produces uniform seedlings, and gives a higher germination percentage, irrespective of the osmotic agent used or the duration of treatment.

EXERCISES

1. Answer the questions:

1. What is your field of science/research?
2. What is your particular area of research? What are you specializing in?
3. What are the latest achievements in this field of science?
4. What fundamental discoveries have been made in your field of science/ research?
5. Can you name some outstanding researchers in your field of science? What contribution have they made?
6. Do achievements in your branch of science/ research influence everyday life? In what way?
7. What further developments can you predict in your field of science/ research?

Active vocabulary

- to do/to carry out/ to carry on/ to conduct research
- to contribute/ to make a contribution to
- to influence/ to affect
- to study/ to investigate/ to explore
- to put forward an idea
- to suggest an idea/ a theory/a hypothesis
- to advance/ to develop/ to modify a theory
- to predict/ to forecast/ to foresee
- to accumulate knowledge
- field of science/ research
- latest/recent achievements/developments/advances
- an outstanding/prominent/world-known scientists/researcher

2. Complete the following sentences. Speak about your field of science/ research.

1. I do/ carry out research in the field of…
2. It is the branch of science that studies…
3. Major developments include advances in …
4. Remarkable advances have been made …
5. My current field of science/research is …
6. It is difficult/ not difficult to foresee/predict … .

Active vocabulary

- to deal with/ to consider the problem
- to be the subject of special/particular interest
- to be interested in
- to be of great/little/no interest/importance/significance/value/use
- to take up the problem
- to work on the problem
- a lot of/little/no literature is available on the problem

3. Answer the questions:

1. What is your research problem?
2. What is the subject of your research?
3. What is of special interest in the problem of your research?
4. Why has the interest in this problem increased considerably in recent years?
5. What concept is your research based on?
6. Is there much literature available on your research problem?
7. What are the main aspects of the problem that have been considered?

Active vocabulary

- purpose/aim/objective/goal/target
- a method/a technique/ a procedure
- detection/identification/observation
- measurement/calculation/computation/approximation
- consideration/generalization/deduction/assumption
- modeling/simulation
- advantages/merits
- disadvantages/shortcomings/limitations
- accurate/precise
- accuracy/precision
- reliable/valid/conventional/effective/useful/valuable
- data/results/method
- to make an experiment/analysis
- to reveal/to find/to confirm/to prove evidence
- to study/to examine
- to collect data
- to create
- to improve
- to work out/to develop/to design
- to verify/to check
- to approve/ to disapprove an assumption
- to use/to employ/to apply
- to allow/to permit/to provide
- to come into use
- results/findings/data/observations/evidence
- comprehensive/extensive
- detailed
- remarkable/encouraging/convincing
- preliminary
- sufficient/insufficient
- to collect/to get/to receive/to obtain data
- to treat the problem
- to succeed in/to make progress in/to be a success
- to fail in
- to be similar to/ to be the same as
- to coincide/ to be consistent with
- to agree with/to fit the assumption
- to support/in support of
- to conclude/to come to/to bring to a conclusion/to make conclusions

4. Answer the questions:

1. What is the subject of your current research?
2. What is the purpose of your research?
3. What method do you employ? Why?
4. What are the advantages of the method used over other methods or techniques?
5. What does the method consist in?
6. Do you find the method reliable/precise? Why?
7. How much time will it take you to complete your research successfully?
8. Have you already obtained any research results?
9. Has your research been successful?
10. Do your results coincide with those obtained by other researchers?
11. Are your results of theoretical or practical interest?
12. Do the data/results/observations/findings allow you to come to any definite conclusion(s)?
13. What conclusions have you come to?
14. How long will it take you to finish your research?
15. Are you going to publish the results obtained?

5. Complete the sentences with the words from the Active vocabulary section. Speak about the purpose of your current research, the method used and the results obtained.

1. Currently I …
2. I make the experiments/analyses in order to …
3. The purpose of my experiments/analyses is to …
4. In our current research we … the method of ….
5. The method/technique allows/permits … to ….
6. The method/ technique makes it possible to …
7. The method proves to be …
8. At present a lot of work is being done to …
9. The results we have … so far cannot be used to ….
10. The evidence appears to …
11. As a result of numerous experiments performed we have obtained sufficient data to ….
12. We have come to the conclusion that … .

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