МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
ОДЕСЬКИЙ ДЕРЖАВНИЙ ЕКОЛОГІЧНИЙ УНІВЕРСИТЕТ

Методичні вказівки для СРС та навчальний матеріал з англійської мови для студентів ІІІ курсу заочної форми навчання

Напрям підготовки – гідрометеорологія
Спеціальність - агрометеорологія

"Затверджено"
на засіданні робочої групи методичної
ради "Заочна та післядипломна освіта"

ОДЕСА – 2004

Методичні вказівки для СРС та навчальний матеріал з англійської мови для студентів III курсу заочної форми навчання.

Напрям підготовки – гідрометеорологія
Спеціальність - агрометеорологія

Укладач: Кемарська Т.Г. - Одеса - ОДЕКУ, 2004 р., 32 с.

Передмова

Практичне володіння англійською мовою при заочній формі навчання означає вміння самостійно за допомогою словника читати літературу за фахом англійською мовою, знаходити корисну для роботи інформацію, а також перекладати тексти за фахом рідною мовою.

Метою запропонованих методичних вказівок для самостійної роботи студентів (СРС) та навчального матеріалу з англійської мови для студентів ІІІ курсу заочної форми навчання, напрям підготовки – “гідрометеорологія” є:

– виробити у студентів навички читання та перекладу науково-технічної літератури англійською мовою за фахом “агрометеорологія”;

– розвинути вміння розуміти зміст прочитаного;

– виробити навики постановки запитань до тексту англійською мовою;

– підготовити студентів до складання іспиту з англійської мови.

Навчальна програма для студентів ІІІ курсу заочної форми навчання розрахована на 144 годин СРС та на 22 години аудиторної роботи.

Програма з дисципліни англійська мова для студентів ІІІк. заочної форми навчання

№ п.п	Назва теми заняття	Кіль-кість СРС	Види контролю
1	Деякі особливості перекладу науково–технічної літератури. Розмовна тема “About myself”. Самостійний переклад текстів за фахом – 5 тис.др.зн.	13	УО
2	Особливості перекладу видо-часових форм дієслів (Active Voice, Passive Voice). Розмовна тема “My future speciality”. Самостійний переклад текстів за фахом – 5 тис.др.зн.	13	УО
3	Особливості перекладу модальних дієслів. Розмовна тема “Ukraine”. Самостійний переклад текстів за фахом – 5 тис.др.зн.	13	УО
4	Особливості перекладу інфінитива. Розмовна тема “Kiev”. Самостійний переклад текстів за фахом – 5 тис.др.зн.	13	УО
5	Особливості перекладу дієприкметників. Розмовна тема “Odessa”. Самостійний переклад текстів за фахом – 5 тис.др.зн.	13	УО
6	Особливості перекладу герундія. Розмовна тема “Great Britain”. Самостійний переклад текстів за фахом – 5 тис.др.зн.	13	УО
7	Особливості перекладу дієслів з післялогами. Особливості перекладу суспільно-політичного тексту. Розмовна тема “London”. Самостійний переклад суспільно-політичного тексту – 5 тис.др.зн.	13	УО

№ п.п	Назва теми заняття	Кіль-кість СРС	Види контролю
8	Особливості перекладу іменників в функції визначення. Розмовна тема “The political system of Ukraine”. Самостійний переклад суспільно-політичного тексту – 5 тис.др.зн.	13	КР№8
9	Особливості перекладу прикметників з прийменниками. Практика у перекладі. Розмовна тема “The political system of Great Britain”. Самостійний переклад суспільно-політичного тексту – 5 тис.др.зн.	13	КР№9
10	Найбільш вживані скорочення, прийняті в англо-американській технічній літературі. Самостійний переклад текстів за фахом – 5 тис.др.зн.	13	КР№10
11	Практика у перекладі суспільно-політичного тексту та тексту за фахом. Самостійний переклад текстів за фахом – 5 тис.др.зн.	14	УО

Навчальний посібник складається з двох частин. В першій частині надаються 8 неадаптованих текстів, взятих з оригінальної літератури по спеціальності “агрометеорологія”.

Ці тексти за вказівкою викладача використовуються як матеріал для практичної роботи на заняттях під час сесії, чи як позааудиторне читання, метою якого є знайомство з іномовною оригінальною літературою, накопичення слів та висловів, характерних для данної галузі, та надбання навичок перекладу перед виконанням контрольних робіт №8, 9, 10, які додаються в другій частині посібника і є контролем СРС.

При перекладі текстів студентам рекомендується користуватися загальними та спеціалізованими перекладними словниками.

Критерії оцінки виконання контрольної роботи:

– **“зараховано”** – студент переклав не менш ніж 80% тексту без суттєвих граматичних помилок, склав запитання до змісту тексту та показав знання основних термінів щодо фаху “агрометеорологія”, які зустрічалися у контрольних роботах;

– **“незараховано”** – студент переклав менш ніж 80% тексту контрольної робіти, припустив більш 10 граматичних помилок при перекладі текстів та складанні запитань, та не показав знання основних термінів за фахом “агрометеорологія”, що зустрічалися у контрольних роботах.

Text 1 BRIEF HISTORICAL REVIEW

It should be emphasized that the development of agrometeorology depends upon the understanding of biological responses of plants and animals to the physical environment, not upon the knowledge of that physical environment alone. Any progress made in the study of biological responses contributes more to agrometeorology than does an advance made in meteorology.

In 1919, Garner and Allard discovered “photoperiodism”, which is the responses of plants to day-length or light-duration. Other studies related to photoperiodism involve the investigation of the effects of light intensity or light quality together with light-duration on plant life, known as “photoperiodic induction”. Much work has also been done on “thermoperiodism” and “photoperiodicity”. The former is a study of plant responses to temperature and day-length combinations, while the latter is a study of the effects of day-length, and sometimes day-length and temperature, on animals.

In 1935, Lysenko postulated the theory of phasic development. He theorized that plants respond different to the physical environment during various phases or stages of their life cycle. Thus, a distinction between growth and development was established, and differential responses of various stages in the life cycle of the plant were emphasized.

In 1949, Went developed a special installation known as “phytotron”, comprised of a series of light- and temperature-controlled rooms in conjunction with several air-conditioned greenhouses, in which he could achieve considerable control of plant growth and development. His phytotron experiment has laid a cornerstone for the scientific development of modern agrometeorology. Since then, several facilities containing almost totally controlled environments for both animals and plants have been established in the United States and abroad. At the same time, many investigations involving the control of physical environment in a limited area of the open field have been conducted. These studies, mainly applications of micrometeorological principles, have drawn worldwide interest. This type of research will continue to be of importance, because through this the quantitative relations between living organisms and their natural environment can be established.

In the last two decades, the use of radioisotopes in the study of physiological processes of plants has contributed much to the better understanding of the physical environmental effects upon growth and development of plants. It has been found, for example, that considerable amounts of both mineral nutrients and organic substances are removed from the above-ground parts of plants when there is a steady, light rainfall. It follows then that when studying rainfall effects on plant growth, it is necessary to consider both the duration and intensity, and perhaps the time of day at which it occurs. This type of research has opened new horizons for the development of plant science.

Discoveries on the biological transformation of energy form one of the most exciting chapters in modern biological science. Many scientists have conducted and are still working on important basic research on various aspects of photosynthesis. Processes of solar energy storing by green plants and of energy transformation by microbes and animals into living tissues and other products need to be fully understood. The fixation of energy expressed in terms of the total net gain of organic matter by the earth's ecosystem, known as the "biomass measurement", has been developed in recent years. Several studies in this area, though still in the early stages, have great potential value as progress toward future steps in understanding and management of natural food resources.

Aside from the progress in biological sciences, developments in the physical sciences – particularly electronic aids to instrumentation and advances in microclimatic research – give a better understanding and interpretation of the physical environment. Success in measurements and studies of the physical environment, together with the progress of biostatistics, have paved an avenue for the development of agrometeorology. Appreciable contributions toward effective agricultural operations will result from the improvement of remote sensing techniques such as aerial photography and/or various electro-optical detectors whose sensors are mounted on aircrafts or even satellites.

There are many agrometeorological textbooks in French, German, Italian, Japanese, Russian, and several other European and Asiatic languages. Common drawbacks of textbooks in agrometeorology are: (1) they are regional – pertaining to material of a certain locality; (2) they are descriptive – lacking in quantitative expressions; (3) they duplicate materials appearing in general textbooks of meteorology, ecology, physiology, and sometimes crop geography; and (4) they include little information on livestock. Several new agrometeorology books in English have been published with substantial improvements and elimination of some of these drawbacks. The Agricultural Meteorology (An International Journal) published by the Elsevier Publishing Company since 1964 is the only comprehensive journal on the subject in English. The readers will find a list of agrometeorology texts at the end of the present chapter.

Answer the following questions:

1. What does the development of agrometeorology depend upon ?
2. When was "photoperiodism" discovered ?
3. What is the difference between the terms "thermoperiodism" and "photoperiodicity" ?
4. Do plants respond differently to the physical environment during various stages of their life cycle ?
5. What is a "phytotrone" ?

Text 2 THE PHYSICAL ENVIRONMENT

The Environment

The environment of plants and animals is the biological and physical system of the medium surrounding them – the biological including microbes, plants, and animals, and the physical including air, soil and water. In this chapter, we are concerned with the physical and biological materials of the environment and the factors controlling them.

Physical medium

Normally, the physical material surrounding crops and livestock is a mixture of air, water, and soil. Air and water are found in the soil; water and soil particles are found in the air. Aeration and soil moisture are phenomena of air and water in the soil, while atmospheric humidity and dust are those of water and soil in the air. The degrees of association of the various constituents comprise different types of physical environments. For example, too much water in a field of crops may cause waterlogging or even a flood, while too little produces drought. Therefore, fundumental concepts of the physical and chemical properties and the interaction of air, water, and soil in association with various forms of energy should be understood.

(a) ***Air***. The air has long been recognized as a colorless, odorless, and tasteless fluid. It is a mixture of gases, present both as single elements and as compounds, and comprises the earth's atmosphere. Some of these gases are inert, others active. The chemical and physical properties of each individual gas differ widely. Information on these can be found in textbooks on physics and chemistry. Here, the composition and distribution of the air in the physical media of crop and livestock will be described briefly.

In the first 3.5 miles above the earth's surface – predominant life-zone –, the natural atmosphere is generally fresh but not dry or pure. In this life-zone, the dry atmosphere, when measured by volume, is composed of about 78% nitrogen, 21% oxygen, and 1% of a combination of several chemically inert and rare gases (argon, neon, and helium, etc.), and chemically active trace gases (methane, nitrous oxide, ozone, etc.). A description of dry composition expressed in percent and parts per million (ppm) by volume near sea level is shown in Table 2-1 in which non-toxic, toxic, and radioactive elements and compounds are differentiated. The elements and compounds listed in the table are typical of static conditions, but as the atmosphere is dynamic, these constituents and their concentrations are variable. The degree of variability depends upon the type of chemical elements present, in association with the physical conditions of the atmosphere (radiation, temperature, wind, humidity, etc.). Water vapor, for example, is highly variable. It varies from as little as 0.001 to as much as 0.01 percent in a volume of air. When expressed by weight, it varies from few milligrams to 40 grams per kilogram of dry air. Also, its variation with time and space is much greater than any single constituent of the atmospheric air. Other variable constituents are ozone, nitrogen dioxide, sulfur dioxide, hydrogen sulfide, ammonia, carbon monoxide and a few other elements. The major constituents, namely oxygen and nitrogen, are appreciably constant.

Liquid and solid substances of both organic or inorganic compounds are foreign matters of the atmosphere. There are numerous varieties of such foreign matters, ranging from airborne bacteria and fungi to sea-salt particles and ammonium sulfate. Although they are not included in Table 2-1, the effects of some of them on animal and plant life will be discussed from time to time.

The average composition of air is different under the surface of the soil, in the water, and in the upper atmosphere (about 30 miles above mean sea level). The vertical gaseous exchange between the interface of the atmosphere and its lower boundaries (the soil, water and vegetation) and its upper boundary (the upper atmosphere), goes on constantly within space and time. Much of the gaseous exchange in the lower boundaries involves living organisms. Some of the exchanges are through such physical mechanisms as turbulence and diffusion. All of these exchanges involve matter in gaseous, liquid, and solid states.

Answer the following questions:

1. Is there any difference between the biological and physical systems of the medium surrounding plants and animals ?
2. What does the physical material surrounding crops and livestock include ?
3. What is air ?
4. What is dry atmosphere life-zone composed of ?
5. Does gaseous exchange in the lower boundaries involve living organisms ?

Text 3 GROWTH AND DEVELOPMENT IN PLANTS

It is necessary to differentiate the word “growth” from “development”, for the two differ basically. Growth refers to an increase in weight or volume of a certain organ of a plant, or a plant as a whole, within the time interval of a certain phase or an entire life span. Development is the appearance of a phase or series of phases during a plant’s life cycle. For example, the flowering of a plant is “development”, while the elongation of a stem is “growth”. In considering the plant-growing season, one can recognize that growth is a continuous function and that development is a discontinuous one. With respect to the chemical and physical changes in plant composition, growth gives quantitative changes but not profound qualitative changes. Development, on the other hand, indicates the progress of a series of qualitative changes (with or without external changes) throughout all different stages until death. Thus, it follows that the growth of a plant can be measured by the elongation of stem and shoot, the increase of dry and fresh weight, and so forth; while development is usually observed by the dates of germination, initiation of floral primordia, inflorescence, and fruiting. In other words, a study of the development of a plant is generally morphological and phenological in approach, but that of growth is generally physiological and ecological.

Plant physiologists may consider growth a complex phenomenon and a process hard to define. For growth connotes all and any of these aspects: reproduction, increase in dimensions, gain in weight and cell multiplication, and others. It depends upon the kind of individual organ taken as a measure of growth. In the case of germinating seeds and sprouting tubers, the total dry weight of the young seedling and seed combined, or of the sprout and tubers, is less than the weight of the original seed or tuber for a short period, due to respiration. However, Miller (1938) has defined growth as a permanent increase in weight, attended by a permanent change in form, induced primarily by an increase in the quantity of protoplasm. In agrometeorology, the best definition of growth is: the increase in weight or dimension of an organ which is most sensitive to environmental changes. In common agricultural practice, vernalization, winter chilling, and the breaking of dormant seeds or buds are problems of development and not growth. When the number of an organ per unit field-area is concerned, it may be considered as either a growth or a development problem, depending upon the kind and stage of the organ. While flower count or fruit count is commonly considered as an indication of the growth, the appearance of the number of leaves at each stage indicates the development. Usually, though physiologically not sound, the number of economic organ available is considered as a growth problem. In short, the number of an organ per unit area is perhaps not a good indicator for differentiating the growth from the development.

The following illustration serves the purpose: Wang (1958, 1960) has studied the morphological development of the subterranean ears of sweet corn at the early vegetative stage in connection with their maturity date. Emphasis was placed in the choice of a significant element out of a group of environmental factors as well as that of a significant period around the seedling stage of sweet corn. A test was set up for ten different sweet corn varieties for a period of 13 years (1938-50) on Ames, Iowa. It was found that the subterranean ears initiated underground on the stem became functioning ears if environmental conditions were favorable. Thus, (a) the time interval for the first 12 days after planting would be the significant period; (b) the soil temperature should be one of the significant elements; and (c) a family of curves, obtained by plotting the mean soil temperature during the significant period against the number of days of growth for each year and for each individual variety, serves as the predictor. In fact, each curve characterizes the varietal differentiation. In short, this method attempts to predict the maturity date of sweet corn about two months or more ahead of time by virtue of the concept of the physiological predetermination through the developmental process. A comparison of this method with that of the heat unit approach has been worked out by Wang (1958); who pointed out that the former is superior to the latter in its accuracy, earliness, and simplicity.

Answer the following questions:

1. Is there any difference between the words “growth” and “development” ?
2. What does the word “growth” refer to ?
3. What does development indicate ?
4. What is the best definition of growth in agrometeorology ?
5. The number of an organ per unit area is not a good indicator for differentiating the growth from the development, is it ?

Text 4 RADIATION

The intensity, duration, and quality of light are the three major factors of radiation, which affect the growth and development of plants. More work has been done on the duration of light (or photoperiodic effect) than on intensity and quality of light.

The direct solar radiation is commonly referred to as “sunlight”, and the radiation scattered from the sky is called “daylight”. A combination of the two received by the earth is known as “global radiation”, indicating the incoming radiation. The outgoing radiation consists of the radiation from the earth’s surface and that scattered back to space from the atmosphere. The difference between the incoming and outgoing radiation is called the net radiation. When the incoming radiation surpasses the outgoing, a positive net radiation results; and the reverse will result in a negative net radiation. An equilibrium between the radiation received by a surface and that emitted by the same surface is called the heat balance of the surface. For the earth’s surface, the heat balance is the major factor governing the microclimate, such as heating and cooling of the air, and the process of dew formation in the microlayer. It follows then that solar radiation is the prime source of energy which determines the weather of the earth, and in turn, the plant response.

Problems of energy transfer in the atmosphere by conduction and convection processes are a concern of dynamic meteorology; those of radiation, physical meteorology. Studies of heat and moisture in the air and soil are the major topics of thermodynamics and hygrology, respectively; plant and animal response studies, as related to all physical environmental factors, are subjects of agrometeorology. Synoptic meteorology, on the other hand, deals with the application of physical laws of the air to weather forecasting. Studies of all meteorological factors next to the ground or at the air-soil, air-water, or even air-vegetation interface are subjects of micrometeorology. Since most crops are in the realm of microenvironment, microclimatic study is the fundamental approach to agrometeorology.

Intensity of light

Photosynthesis, which has long been recognized as the major physiological process of plant growth, is governed principally by the intensity of light. When light intensity is low, respiration dominates; when high, photosynthesis dominates. In the process of chlorosis, plants etiolate at an extremely low light intensity. On the other hand, floral initiation is inhibited by an excess of light. Extremely high light intensities exert an inhibitory effect on photosynthesis through the process of photooxidation. When the rate of photosynthesis balances that of respiration, the evolution of carbon dioxide and the absorption of oxygen by plants reaches equilibrium. This equilibrium is known as the compensation point. Two compensation points (e.g., the lower and the upper) should be established for each individual plant. The determination of these limits in terms of light intensity is a complicated problem, for the rate of photosynthesis as related to light intensity is affected by a number of environmental and physiological factors:

(1) Solar radiation includes the ultraviolet spectrum which is harmful to most plants, as well as the visible spectrum which is useful. As the intensity increases, both the harmful and the useful spectrum will be increased. Their joint effects have to be determined according to the phase of development of plants.

(2) Solar radiation also includes the infrared spectrum, which gives practically no photosynthetic effect, but which does give a thermal effect. In fact, all solar radiation contributes thermal effects to plants at various degrees. To differentiate the light intensity effect from the thermal effect of solar radiation is almost impossible. It can be partially achieved through laboratory techniques, such as with a phytotron. Complete separation of light and temperature is not yet possible, for cold light sources are not available at present.

(3) More research should be directed toward the study of photosynthesis-respiration relationships of crops in association with solar intensity. In this connection, instrument design is extremely important. An ideal instrument would be able to cover an area-wide record of at least a few hundred acres of land, to integrate these records into one figure for a period of time (e.g., one or two days), to specify the type of radiation (e.g., sunlight or daylight), and to differentiate the quality of radiation (e.g., infrared, ultraviolet, and visible radiation).

(4) In determining the rate of photosynthesis, it is necessary to consider the interrelationships of complex environmental factors, in conjunction with solar

intensity on the growth and development of a plant. Through research, some available methods have been established with agrometeorological techniques.

Answer the following questions:

1. What are the tree major factors of radiation ?
2. What is meant by the words “sunlight” and “daylight” ?
3. When is the net radiation positive and when is it negative ?
4. Why is microclimatic study the fundamental approach to agrometeorology ?
5. Is it possible to differentiate the light intensity effect from the thermal effect of solar radiation ?

Text 5 MOISTURE

The term “moisture” is used to designate the presence of water in its vapor, liquid, and solid forms both in the atmosphere and in the soil. Water in solid form, such as ice (hailstones, for example) and snow, represent potential moisture. Snow is usually measured according to the depth accumulated on the ground. According to the U.S. Weather Bureau, one inch of freshly fallen snow is equivalent to one-tenth of an inch of water, but according to the Royal Meteorological Office of Great Britain, one foot of snow is equivalent to one inch of water. Because of the great variation in the density of snow, this conversion is only an approximation. Several samplings of the actual water equivalent (w) of freshly fallen snow (i.e., measured in inches of water after melting) must be made over a large area. Since the density of snow changes as time goes by, the water equivalent changes correspondingly. The amount of freshly fallen snow yielding one inch of water may vary from 5 to 20 inches. The variation is further increased by evaporation, compaction, wind, thawing, and freezing. A measurement of snow density, D_S, as defined below, is sometimes useful:

$$D_S = \frac{\text{actual water equivalent of snow}}{\text{depth of freshly fallen snow}} = \frac{w}{h}$$

A successive weekly accumulation of the actual water equivalent during the period previous to the growing season would be useful for winter evaporation and soil moisture studies. Wang (1961) has made such a study for Wisconsin. Various diagrammatic presentations have also been prepared. The total snowfall and rainfall accumulated during the winter prior to the planting as well as the snow-rain ratio have been established. When snowfall accumulation alone is considered, the snow threshold probability at various time intervals is easily computed. Snow cover is both beneficial and detrimental to agriculture. It usually serves as a natural mulch if the duration of coverage is long and persistent. But at the same time, it may cause agricultural hazards as well. The study of hail, its distribution and intensity, is another important aspect of research.

Moisture in the plant, on the other hand, has been studied more extensively by plant physiologists. Studies of water movement within plants are promising guides to research in agrometeorology. As far as crop-weather relationships are concerned, moisture in the soil is a far better indicator of the available moisture than is precipitation. This is because considerable moisture is lost as percolation, surface and subsurface runoff, evaporation, and interception by the leaves of plants.

Water in the atmosphere, in its liquid form, can be received by the earth either as dew or as rain. Dew, which is not regularly measured, is an important source of moisture, particularly in arid and semi-arid areas. Rainfall is usually expressed as the depth of rain accumulated in a definite interval of time. It may be expressed in inches, to hundredths of an inch, in English-speaking countries. Thus one inch of rainfall to the acre is equivalent to 101 tons of rainfall. The daily rainfall, for instance, is the number of inches of rain which has fallen during a 24-hour period. Effective rainfall, that portion of the total rainfall used by plants, is another important expression, but one difficult to estimate. A rainy day is customarily defined as one on which 0.01 inches or more of precipitation has fallen. Since this simple definition does not take plant responses into account, a more appropriate criterion is necessary. The crop-rainy day R_C criterion has been devised by Wanq (1956).

Water of the atmosphere, in its vapor form, may be represented in several ways: vapor pressure (e), relative humidity (r), vapor pressure deficit (d), absolute humidity (a), specific humidity (q), mixing ratio (m), dew point temperature (T_d), wet-bulb temperature (T_w), and the virtual temperature (T_v). These expressions may be defined as follows:

Vapor pressure (e) is the pressure of water vapor in the air during the transformation of water to vapor or ice to vapor. The former is known as vapor pressure over water, and the latter as vapor pressure over ice. Vapor pressure over water is always greater than over ice. When saturated, it is known as saturation vapor pressure (e_s), which is determined by the air temperature. The higher the air temperature, the larger the saturation vapor pressure. Values of saturation vapor pressure over water and over ice with respect to various temperatures can be obtained, for example, from the Smithsonian tables.

Answer the following questions:

1. What does the term moisture designate ?
2. How is snow density defined ?
3. What is considerable moisture lost through ?

4. What ways may water of the atmosphere, in its vapor form, be represented in ?
5. Vapor pressure over water is always greater than over ice, isn't it ?

Text 6 THE AVAILABLE MOISTURE IN THE SOIL

Moisture is among the most difficult problems for meteorologists and agrometeorologists today. In spite of numerous studies, many problems are still unsolved. It is more so for soil moisture than for moisture in the air, because soil moisture is subject to change in a smaller area, whereas air moisture represents comparatively large areas, even though the air moisture gradient is large. Moreover, in terms of accuracy and representativeness, soil moisture is difficult to measure. Shaw & Arble (1959) have compiled a bibliography on soil moisture measurement in which a large number of measuring techniques were introduced. and yet soil moisture measurements are still uncertain. However, the most fundamental problem involved in the water requirements of a crop is a knowledge of the presence of available soil moisture.

Studies of soil moisture with respect to agrometeorology cover a multitude of subjects but can be grouped into four principal categories:

(1) Studies relating to the growth and development of plants: photosynthesis, respiration, transpiration, chloroplast formation, plant structure, chemical composition, photoperiodism, maturation, reproduction, fruiting, seed setting, germination, root development and distribution, permanent wilting point, quality, and yield.

(2) Studies relating to the physical properties of soil: field capacity, moisture deficit, moisture equivalent, hygroscopic coefficient, water and vapor movement, capillary action, drainage, infiltration, leaching, dispersion, exchange of ions, pH, soil moisture tension and stress, mineral availability, salinity, soil porosity, tillability, and ground water.

(3) Studies relating to weather-soil relationships: soil moisture and rainfall, evaporation, evapotranspiration; diurnal, seasonal and long-range variations in soil moisture; prediction of soil moisture and improvement in observations and instrumentation.

(4) Studies relating to agricultural practices: mulching, maintaining fertility, and control of soil moisture.

This vast field may be illustrated in the following two aspects: plant response to normal and hazardous soil moisture, and the water budget of a crop field and crop itself.

Soil Moisture Excess, Deficit, and Normal Condition. In view of plant response, soil moisture studies may be divided into three categories:

(1) moisture excess at its maximum – a flood; (2) moisture deficit at its maximum – a drought; and (3) normal moisture condition – a field capacity.

It is evident that under the prolonged retention of excessive moisture, plants are affected by (i) lack of aeration, which results in a high carbon dioxide and low oxygen concentration (Permeability of plant roots to water is decreased through the reduction of root respiration. The absorption of nutrients by plants is retarded.); (ii) loss of soil fertility, which results from the processes of infiltration, percolation, and runoff; (iii) depression of microbiological activity, which is caused by lack of oxygen and low soil temperature; and (iv) increase of plant diseases and the retardation of root development. In short, either high water tables or wet soils affect soil aeration, and consequently root growth, microbial activity, nutrient availability, and nutrient entry. Except for aquatic plants, the physiological processes of most plants, such as photosynthesis, respiration, cell enlargement, and divisions, would be influenced by excessive moisture. Therefore, when soil is either flooded by heavy rainfall or by irrigation for a critical duration, the condition is detrimental to plant growth and development. The physiological adaptations of crops to excessive moisture vary with species and variety. More studies have been done on drought resistance than on excessive moisture resistance because the former occurs more frequently. In agricultural fields, excessive moisture is usually associated with either an intensive heavy rainfall in a short time or a prolonged light rainfall, or both. Sometimes, in the case of a very heavy downpour of rain, water erosion results and in turn the agricultural crop would definitely be destroyed. In this connection, some mechanical damages may also occur, such as interference of flowering and pollination. The compaction of the soil by raindrops prevents the uniform emergence of seeds. This gives poor stands and poor quality in production. Small grains are often waterlogged by rain so that harvesting becomes difficult. Waterlogged grain is susceptible to spoilage and disease. The effect of rain on the hay harvest and the storage of grains is a problem. In case of a light rainfall of long duration, which generally occurs in conjunction with gloomy, cloudy and humid weather, the spread of diseases and a delay of flowering or maturity of crops are to be expected. These are the indirect effects of excessive moisture conditions. The worst case is a dry spell followed by an intensive wet spell, or vice versa. Numerous evidences demonstrate effects harmful to development crops.

Answer the following questions:

1. Is it easy to measure soil moisture ?
2. What four principal categories can studies of soil moisture be grouped into ?
3. What are the results of excessive soil moisture ?
4. What are the indirect effects of excessive moisture conditions ?

5. When is the spread of plant diseases to be expected ?

Text 7 SNOWFALL

Snowfall prior to the normal growing season is one of several physiological preconditioning factors necessary for plant growth.

The total accumulated snow and rainfall during the freezing season (i.e., The period other than the growing season), which begins from the first day of the normal freezing season of the previous year and continues to the end of that same season, is normally considered as the amount of moisture reserved for plants at the time of sowing. Mallik (1955) studied the pre-sowing rainfall and germination of wheat in India, and Salom Calafell (1951) indicated that years of snow are the years of prosperity. That a good year of snow is an indication of abundant harvest has been common knowledge to most farmers and growers for centuries. This probably result from the contribution of the available moisture, the reduction of insects and diseases, and the increase in fertility. Strictly speaking, this is not true because evaporation, percolation, and runoff are the dominating factors in soil moisture depletion. In other words, the total accumulation of precipitation minus depletion from these factors would give the actual amount of available moisture prior to planting. If the soil is frozen continuously throughout the freezing season without any thawing days, the difference in snow depths would facilitate the computation of evaporation over snow surface. Thus the remainder indicates the actual available moisture. For example, if the snow water equivalent is D_S (in inches of water) at a specific date and after t days it is D'_S (with no snowfall during the period of t), then the rate of evaporation (E_S) over snow surface is

$$E_S = (D_S - D'_S) / t,$$

where E_S is expressed in inches per day.

Snow cover, which is a good insulator, acts as a blanket of natural mulch for the root and stocks of vegetation during the winter and has been studied by a number of authors. The physical and physiological aspects of snow cover are explained thus: Snow is almost a blackbody for infrared radiation at a wavelength of 10 microns, and is a good reflector for visible radiation. As shown in Table 4-1, the albedo of freshly fallen snow is 81 percent. Thus by day it reflects most of the short-wave radiation and receives little heat for storage. By night it radiates strongly, thus lowering the surface temperature. However, the direct solar and sky radiation can penetrate through the snow just as well as through water. the little storage heat will gradually built up and give considerable heating. This heating increases with the combination of a clear day and cloudy night. Observations show that the soil under snow is very much warmer than the air immediately above the snow. The temperature of the ground under snow has been observed to be above the freezing point of water, and this causes the overlying snow to melt from below. The heat enters the snow layer by infiltrating water from melting or so-called pseudo-conduction, while heat transmits upward through snow by true conduction. It is well known that snow is a poor conductor; thus a heat wave attributes more heat to snow than cold can take away from it. Also, the former is a much faster process than the latter. Moreover, the cooling process which takes place during the night by long-wave radiation is confined to only a thin top layer of the snow, as is also true for evaporative cooling during the day. Short-wave radiation, on the other hand, penetrates deep into the snow. When alternation of freezing and thawing occurs, thin ice sheet layers are formed. In this case, snow is still acting as a natural mulch, but it is harmful to vegetation because air circulation is retarded. This is detrimental to plant growth because of suffocation, due to the presence of concentrated carbon dioxide, rather than to the freezing. The other harmful effect of snow is due to mechanical damage by the dead weight of the snow. During bright sunny days in the winter the physiological drought, a result of low ground temperature, is still another aspect of alternation in the freezing and thawing snow. When the snow is completely melted on successive days and frozen at night, the frost penetration goes deep into the ground.

Answer the following questions:

1. What is one of several physiological proconditioning factors necessary for plant growth ?
2. Why is a good year of snow an indication of abundant harvest ?
3. Is snow cover a good or a poor insulator ?
4. What is the albedo of freshly fallen snow ?
5. When is snow harmful to vegetation ?

Text 8 INSTRUMENTATION AND OBSERVATION

General considerations

The purpose of this article is to introduce some useful agrometeorological instruments for physical and biological measurements as related to crops and livestocks. The instrument specifications, including accuracy, sensitivity, range, limitation, and stability will be emphasized; and theories, principles, mechanisms and structures of instruments will be mentioned only when necessary. Before the discussion of agrometeorological instrumentation, a brief summary of the basic consideration in atmospheric instrumentation, and other instrumentation in general, is in order.

An atmospheric instrument is designed to measure, directly or indirectly, the energy or mass in the atmosphere. In instrumentation, an atmospheric property to be measured may be considered an atmospheric signal. Signals such as solar radiation, air temperature and wind velocity represent the energy flow in the atmosphere, while the three states of water and numerous airborne substances are the mass in the atmosphere. These signals are identified and measured quantitatively by the sensing element of the instrument, generally referred to as the "sensor" (also known as the "sensing device", "sensing element", or "sensitive element").

There are two ways in which a signal is measured: point source measurement and remote sensing. In the point source measurement, the sensor makes a close contact with the medium (e.g., immersing a thermometer bulb into the water). In the remote sensing, the sensor reacts to a signal from a distance either as a passive receiver (e.g., a camera registering the image of an object transmitted through lightwave), or through an active signaling process (e.g., a radar sending out radio waves and receiving an echo they create). The instruments designed for point source measurements are called the contacting type, and those for remote sensing are known as the non-contacting type.

For a representative and valid measurement, the sensor must interact with the signal precisely and immediately, and should be capable of detecting the entire spectrum of the signal with a consistency in its calibration. Therefore, the accuracy (precision), sensitivity (time response), range (capacity), and stability (calibration consistency) are the four basic considerations of an instrument. A mercury-in-glass-thermometer, for example, may be read to 1°F and can be estimated to 0.1°F, but its accuracy is limited to 0.2°F at best, due to the physical property of the glass. Also, the response time of the mercurial bulb is 1 to 2 minutes, and thus, it cannot react immediately to a sudden change of temperature. A wind speed of over 10 mph, however, tends to shorten the time considerably (to less than 1 minute). The capacity of the mercury thermometer ranges between –38°F and 300°F. The lower limit is, therefore, -38°F (the freezing point of mercury), and the upper limit is 300°F, beyond which the stability of the sensor will be altered.

The interaction of the sensor with a signal is often interfered by some unwanted signals (noise), which must be eliminated or minimized. For a thermometer, while the radiation heating may raise the mercury several degrees higher than the true air temperature, the evaporation cooling tends to lower it appreciably if the bulb is wet. Thus, both radiation and evaporation represent unwanted signals to a thermometer. Also, an atmospheric instrument must be durable to withstand the weather hazards and various mechanical impacts.

The representativeness in atmospheric-signal measurement depends not only on the accuracy, sensitivity, and stability of the sensor, but also on the realiability in sampling of the space and time variations of the signal. For a reliable representation of the spatial distribution of temperature, humidity, and rainfall, whose spatial variation is large, a dense-station network (high spatial resolution) would be necessary. Similarly, a high time-resolution would be required for the measurement of signals with high time variability. Other considerations in sampling are: the location of the instrument (exposure, position, etc. in relation to the topography and vegetative coverage) and movability of the instrument platform (fixed or mobile).

Answer the following questions:

1. What is an atmospheric instruments designed to ?
2. Name two ways in which a signal is measured.
3. What are the four basic considerations of an instrument ?
4. Why are radiation and evaporation unwanted signals to a thermometer ?
5. What does the representativeness in atmospheric – signal measurement depend on ?

CONTROL PAPERS

Control Paper 8

Variant 1

1. Translate the text in writing:

AGRICULTURAL METEOROLOGY – ITS SCOPE AND AIMS

Aims. The primary aim of agricultural meteorology is to extend and fully utilize our knowledge of atmospheric and related processes in order to optimize sustainable agricultural production with maximum use of weather resources and with minimal damage to the environment. This entails improving the quantity and quality of agricultural crops, timber and other forest products (e.g. natural rubber), vegetable fibres (e.g. cotton, flax, sisal), and animal products and by-products (e.g. hides).

A secondary aim concerns the conservation of natural resources. The climate may place constraints upon a particular resources. The climate may place constraints upon a particular form of land-use at a given place and time. An agricultural meteorologist should be (but often will not be) consulted when questions are being examined of land-use, of the exploitation of resources and of the deployment of technological processes. For example, the short-term benefit from the cultivation of semi-arid grassland has often (e.g. in the former Soviet Union) been gained at the expense of long-term damage from erosion by wind and water. Meteorologists have the advantage of being able to take into consideration processes on very different time-scales.

Range of subject matter.

The subject includes:

(a) The Earth (physical) sciences – specifically the physics of the atmosphere, i.e. meteorology and climatology, but also soil physics and hydrology;

(b) Certain biological sciences – specifically physiology, ecology and pathology of plants and animals, and associated "technologies" of agriculture.

A more detailed statement is given in the opening paragraphs of the WMO Guide to Agricultural Meteorological Practices (WMO-No.134):

"Agricultural meteorology is concerned with interaction between meteorological and hydrological factors, on the one hand, and agriculture in the widest sense, including horticulture, animal husbandry and forestry, on the other hand. Its object is to discover and define such effects, and thus to apply knowledge of the atmosphere to practical agricultural use. Its field of interest extends from the soil layer of deepest plant and tree roots, through the air layer near the ground in which crops and woods grow and animals live, to the highest levels of interest to aerobiology, the latter with particular reference to the effective transport of seeds, pollen and insects.

In addition to natural climate, and its local variations, agricultural meteorology is also concerned with artificial modifications in environment (as brought about, for example, by windbreaks, soil management, irrigation, glasshouses, etc.); in climatic conditions storage, whether indoors or in field heaps; in environmental conditions, in animal shelters and farm buildings; and during the transport of agricultural produce by land, sea or air."

This compendium considers the relationship between weather and agriculture, and touches upon subjects that may be conveniently classified under seven main headings: soil and water, plants, farm animals, diseases and pests of crops and animals, farm buildings and equipment, farm operations, and artificial modification of the meteorological and hydrological regime. Each of these will be briefly discussed in this chapter.

Soil and water. Weathering is an important factor in creating and then determining the nature of a soil, the organisms it contains and its capacity for retaining and releasing heat, nutrients and moisture. Rainfall not only adds chemical components to the soil, but it also washes out ("leaches") soil nutrients.

The mechanical state of the soil – as it affects the cultivation, pest control and harvesting of crop plants, management of pastures (stocking density, etc.) is greatly influenced by local weather conditions. In these matters the cooperation of environmental scientists is vitally important: meteorologists must not simplify too much the surface aspects of their work, while on the other hand hydrologists should not assume full knowledge of all weather and climate factors. All in all, cooperation between meteorologists, hydrologists and soil scientists needs to be improved.

The water reservoir for plant growth and development is contained in the soil. The amount of water available in soil depends on the effectiveness of precipitation or irrigation, on the one hand, and on soil's physical properties and depth on the other hand. The rate of water loss from the soil depends on the climate, and on the physical properties of the soil and the root system of the plant community. Efficient utilization of soil water and cultivation techniques for preservation of soil moisture are of major concern to agrometeorology, especially in semi-arid areas.

Erosion by wind and water depends on regional and local weather factors. The extent to which a given tract of land suffers from erosive agencies is, moreover, determined by the presence and vigour of the vegetative cover. Excessive concentration of salt at the soil surface may occur in areas especially where there is significant evaporation and drainage is not adequate, particularly when irrigation water is poor quality.

In all regions with a marked seasonal variation in weather, seasonal changes influence soil conditions and hence the farming programme ('calendar') – e.g. the beginning and end of rainy seasons in (sub) tropical countries; in wet climates, the period during which the water content of the upper soil layers exceeds the 'field capacity' ; or the duration of frozen ground in high latitudes.

2. Put five questions to the text.

Control Paper 8
Variant 2

1. Translate the text in writing:

PLANTS AND CROP MICROCLIMATE

Development and growth of plants depend on environmental conditions at every stage (Woodward, 1987). An understanding of the interrelation between the structure of the environment (ground cover, surface slope, degree of shelter, etc.) and the local microclimate, in the crop and around the crop, may result in actions aimed at the long-term improvement of the growth situation.

Even before planting the influence of the weather should be considered. The quality of the seed sown depends on meteorological conditions during the year in which it was produced. The productivity of long-rotation crops, e.g. vines, fruit and forest trees, can also be affected by weather experienced over many previous seasons.

Post-harvesting operations, such as drying grass and other crops, and the capacity to maintain the quality of stored farm crops are affected by seasonal weather. Weather and climate are important in the occurrence of forest, bush and grass fires, and knowledge of them is important for the defence against such hazards.

Farm animals (farm livestock). Weather affects animals in all stages of growth and condition, regardless of whether they are well-fed and healthy, or ill-fed and diseased. Primarily it acts directly on their feeding, growth, health and offspring production, e.g. by drought or through the effect of extremely high or low temperatures (Mount, 1979). In addition, weather influences livestock through their food supply (grass, crops) and the state of soils on which they are kept. Climate determines geographical distributions of animals. Yield and quality of animal products, and their processing and storage and transport are also weather-dependent. Keane (1986) deals at length with many aspects of weather influences on animals.

Diseases and pests of crops and animals. Weather influences the degree to which plants and animals (i.e. the ‘victim’ and/or ‘host’) are attacked by pests and diseases, or harbour them. It also affects the biology of insects and disease organisms, and determines the nature, numbers and activity of pests (and of the predators on pests), and extent and virulence of diseases. In crop and livestock protection, the spread and aerial transport of pests and diseases, and the effectiveness of applied control or eradication methods depend upon atmospheric agencies. Examples of this include: the wind–dependent distribution of chemical sprays; the effects of temperature on the chemical activity of pesticides, or on the vulnerability of pests to such treatments; the dependence of fungi on the presence or absence of liquid water is climate sensitive, be it rainfall or dew.

Farm buildings, equipment and operations. Climatic conditions must be taken into account in the planning of farm buildings and, particularly, in the design of animal housing and stores for agricultural produce. The choice of farm machinery, harvesting technique and the deployment of labour is also climate sensitive (Dalton, 1974). One important aspect is the climatological probability that the soil will be sufficiently strong to support machinery at the time it is needed.

The farmer’s best choice of work priorities depends on relevant forecasts sufficiently far ahead – even plans for a single day call for forecasts for several days; and those forecasts must include some parameters not normally included in public forecasts.

Artificial modification of meteorological regimes. Irrigation, windbreaks, shelterbelts, mulches, storage and conservation of snow and water, as well as soil cultural practices, have an important influence on certain aspects of local environment, such as soil moisture, wind velocity and atmospheric humidity.

The greatest degree of control of environmental conditions is exercized in the use of glasshouses and in intensive animal housing. Varying degrees of independence from external environmental conditions can be achieved (at times to a very high degree). However, the cost of the materials and the energy needed to achieve this independence tend to increase as the difference increases between desired internal climate conditions and actual weather and climate outside the structure. Meteorological support in the design and management of such artificial climates plays an important part in keeping their cost-benefit ratios economically acceptable.

Climate change. There is considerable research on the agricultural effects – both qualitative and quantitative – of climate change aided by or triggered by man's activity (e.g. changes in carbon dioxide content of the atmosphere due to the consumption of fossil fuels, such as coal and oil, or the production of methane by animals and vegetation). However, this compendium will not discuss the question of climate change at any length for several reasons. The first is, that climate change is likely to be a rather slow process, so agriculture might often manage to adapt to environmental changes known in advance. The second is, that processes related to climate change are still subject to much research, so that explicit statements on their consequences might have to be reappraised within a few years. In particular, global temperature changes can lead to climate changes of varying sign and magnitude at regional or local scales.

For example – higher temperature could mean increased evaporation (not always), with possible increase in aridity or increase in cloudiness – and the latter would decrease incoming radiation and might (or might not) increase precipitation. Higher temperatures combined with sufficient radiation would increase photosynthesis, but the simultaneous *increase* of metabolism might shorten growth seasons, leading maybe to a net *decrease* in production. In temperature latitudes in spring, earlier high temperatures might mean early flowering, at a time when the risk of frost is still very high. There are many more such meteorological side effects (Fajer and Bazzaz, 1992).

Control Paper 9
Variant 1

1. Translate the text in writing:

USE AND PROVISION OF AGROMETEOROLOGICAL INFORMATION

To illustrate the variety of information requirements in agrometeorology, we will list a few of the categories of users that meteorologists are expected to support, showing how their needs vary. These user groups are not listed in any order of importance and their characteristics, situation and requests may differ from country to country.

Owners of large farms of one km^2 or more are often faced with large investments to be made, in mechanization and sometimes also in (part-time) labour. Generally speaking, they grow a limited number of crops, progressing in some cases to monoculture. In order to run such agricultural factories professionally, they may require extensive weather and climate information for planning, sometimes in a computer-compatible form.

A horticulturist, dealing with high-value crops grown over a very small area, usually controls the climatic conditions as much as possible in a greenhouse or in plastic tunnels. In order to make the necessary adjustments to regulate the radiation passing through his roof and the ventilation air entering below it, he must have quantitative information on e.g. local humidity and cloudiness as a routine matter.

Intermediate in scale between the two above-mentioned market-directed types of farming are family farms. Their main products are usually animals or regional staples – viticulture, cereal, grain or rice, grasses, beans or beets, fruits, sugarcane, vegetables – and some supporting minor crops or animals besides. These farmers are usually avid customers of agro-weather broadcasts (particularly on hazards such as frosts) which guide their short-term operational decisions.

Cattle farmers need weather information to provide winter forage their herds, e.g. to find out when they can make hay. In latitudes without winter, farmers are interested in early warning about impending disasters such as floods or storms.

Government planners (say, from the Ministry of Agriculture) may have the task of forecasting the yield of the next national staple crop harvest, as an ‘early warning’ of crop failures is necessary information for economic measures. This means that the meteorologist must know about the reliability of existing weather-related crop development models. Another subject for government advice is the climatological suitability of various regions for growing new types of crops.

Agricultural product factories, and other related business involved in processing or transporting food for the market, can use long-term forecasts and climatic information for planning purposes – provided that they are able to use predictions phrased in terms of probability. They prefer statistical climate studies to climate models (Changnon, 1992).

Investigators specialized in related subjects like hydrology and agronomy often ask for meteorological datasets. This should be used to start cooperation.

Agrometeorological service. In order to cope adequately with such varied requests, it is essential to establish an agrometeorological unit – preferably in a National Meteorological Service where, together with forecasting services and a national database, the necessary infrastructure for data collection and analysis is already in existence. In 1980 a WMO working group recommended three subsequent development stages after the establishment of such a unit:

(1) A 'passive' pre-operational stage using available infrastructure, supplying simple climatic information for agriculture more efficiently by assigning this task specifically to a few members of a climatological service. At this stage a national agrometeorological committee, supported by WMO and FAO, should identify local weather-sensitive problems;

(2) A more 'active' stage, in which derived information (e.g. growing degree days, leaf-wetness duration) is provided by a specialized unit. Some countries might stop here;

(3) An operational stage, where advisory services and forecasts are provided, and the necessary research is done to support such problem-oriented services.

Agrometeorology and agroclimatology can assist in two categories of problems which could be designated as the tactics and the strategy of food production. Strategic considerations cover the choice of crop, selection of farm animals, design and extent of farm machinery, and methods of soil cultivation. Strategic planning. in particular, includes the correct choice of land use, production facilities and genetic issues. Likewise, a statistical study of past climates, their variability, the range of possibilities – particularly extremes and sequences which the atmosphere can generate – can prove useful in risk assessment of nature proposals.

Tactical items relate to short-term timing of farm operations, and all that goes to make up good husbandry. Weather forecasts can play a tactical role, always provided that such predictions are reliable and accessible, that they do not omit farming-related weather parameters – and that agricultural effects of approaching weather are either understood by weatherwise farmers, or stated clearly in the forecast.

A forecast can only be useful if there is some action that the recipient can undertake, either to take advantage of favourable circumstances, or to reduce adverse effects. All too often farmers are powerless to act – an aircraft can change course to avoid a hailstorm, but farmers cannot shelter their crops.

2. Put five questions to the text.

Control Paper 9

Variant 2

1. Translate the text in writing:

DIURNAL AND ANNUAL VARIATIONS OF SOIL TEMPERATURE AND MOISTURE

Periodic fluctuations of soil temperature are caused by the daily and yearly fluctuations in solar radiation received at the surface. The maximum temperature of the surface is reached when the flow of heat into the soil is exactly equal to the flow outward, and so depends not only on the incoming radiation but also on heat transfer in the soil and in air above the surface. Thus it is not surprising that the incidence of the maximum temperature on the surface occurs some time after local noon. At night the surface usually continues to cool until the fall of temperature is checked by the input of solar radiation after dawn, when the curve of temperature takes an abrupt upward turn. Observations even over a period limited to a calendar year clearly reveal that:

(a) There is a diurnal variation of temperature to a depth of about 0.5m, below which changes become too small to measure with conventional equipment;

(b) This diurnal variation is superimposed on a seasonal variation. Providing there is sufficient depth of soil, the seasonal variation becomes negligibly small at depths between roughly 5 and 20m depending upon the soil type and condition – an average figure of 10m would be reasonable to assume;

(c) Plots of both the daily and the seasonal march of soil temperature shows that:

(i) The amplitude of the fluctuation decreases with increasing depth; typically, it is halved for each 0.1m of descent into the ground.

(ii) With increasing depth, the times at which the maximum and the minimum are registered lag increasingly behind time events at the surface. This is most clearly shown in the annual curve, and least clearly for the diurnal minimum.

(iii) Depending on soil type and structure, soil temperatures remain constant at depths of about 10 metres or more. Ground water with a water table below this depth has a constant temperature, which is approximately the annual mean temperature at the relevant station.

Observations at fixed hours may have a different physical significance according to the time of the year they are taken. At 0.1m depth an observation at 1400 hours (local time) will generally be at, or near, the diurnal maximum. But the minimum is reached some time after sunrise, when the effect of surface warming penetrates downwards and arrests the fall of temperature. Therefore observation made at 0800 hours (local time) will be close to the diurnal minimum in early spring and late autumn – but in summer in temperature latitudes, when sunrise may be at 0400 hours (local time) or earlier, an 0800 hours observation will take place well up on the rising portion of the temperature curve.

In addition to the diurnal and annual courses, temperatures in the upper layers of the soil also show irregular variations due to weather. The exchange of air between atmosphere and soil cannot influence soil temperature much, because of the low density (and hence heat capacity) of air compared with that soil, but the day-to-day variations of radiation are certainly felt in the upper soil.

Also, a sudden fall of soil temperature can be caused by heavy rain or showers. When rain or showers occur, the decrease of the soil temperature in the layers below the water front is more due to the decrease of net radiation than to water. In heavy soils, the percolation speed is only about 0.2-0.3 mm h^{-1}, so only the uppermost soil layers can be cooled directly by rain water. But in sandy soils, where water is able to percolate faster, a cooling effect of rain is frequently measurable, especially after dry spells. The cooling effect of rain lasts often as long as the soil moisture and thus the heat capacity of the soil is changed. The diffusivity for a good moist horticultural soil will be about $0.45mm^2s^{-1}$, that for a peat soil about $0.15mm^2s^{-1}$, and for dry organic matter $0.1mm^2s^{-1}$. In so-called ‘good’ soil, temperature fluctuations reach deeper levels, and more rapidly, than in peaty soils or in organic mulch. Also, given the same net energy at the surface, the surface and near-surface temperature of the dry organic layer (i.e. the layer with poor thermometric conductivity) may reach higher maximum and lower minimum than the ‘good’ soil.

Soil profiles often exhibit markedly different layers. On a daily basis, calculations based on homogeneous soil characteristics may not be useful when, for example, the topsoil has a markedly higher organic content than the subsoil. Similar problems also arise in the analysis of seasonal fluctuations, e.g. when a shallow layer of soil lies on rock, or when a water table occurs at a few metres depth.

When the soil is covered with vegetation, the upper side of the canopy forms a new surface, which absorbs a considerable portion of incoming radiation. The remaining part of radiation goes through the plant cover and is absorbed by the lower leaves, the rest by the soil surface. The radiation reaching the soil surface below a dense plant cover can be diminished to a few per cent of the total. The amount of reduction depends on the so-called ‘leaf area index’, i.e. the ratio of the whole leaf area (one side) to the soil surface.

2. Put five questions to the text.

Control Paper 10

Variant 1

1. Translate the text in writing:

WATER AND VEGETATION

Almost every process occurring in plants is affected by water. However, four main functions can be distinguished in which water plays a major role:

(a) Water is the major constituent of physiologically active plant tissue;

(b) Water is a reagent in photosynthesis;

(c) Water is the solvent in which salts, sugars and other solutes move from cell to cell, and from one part of the plant to another;

(d) Water is an essential element for the maintenance of plant turgidity (hydraulic) inflation
necessary for cell enlargement and growth.

As with most biological conditions, the availability of water has an optimum – there can be too much, as well as too little water for good progress of the above processes. An example of this is when, after a long dry period, sudden rain may lead to bursting of cells. The roots have been working hard to provide water from the soil and do not immediately stop doing so, leading to excessive cell turgor because evaporation is no longer proceeding at the original rate.

In reviewing the physiological significance of internal water relations on crop yields, Slatyer (1969) proposed that only two valid generalizations could be made:

(a) The growth and development of most crops can only proceed fully unimpaired, and crop yield is only maximal when high water status is maintained throughout the life of the crop;

(b) The harmful effects of water deficits are usually most pronounced in tissues and organs which are in the stages of most rapid growth or development.

The second proposition implies that, as far as economic crop yield is concerned, sensitivity to water stress varies in the course of time. In this context it is very interesting to note that with some crops it is a standard practice on farms to impose stress at certain growth stages, with a view to influencing quality development and improving the economic (though not necessarily the maximum) yield – an interesting conflict between quality and quantity. Other existing dangers of over-irrigation make Slatyer's first generalization quite doubtful. Apart from the physiological difficulties in assessing effects, it seems that water/crop yield relationships can only be simple in the dry regions of the world.

Despite the great range in form, all types of vegetation share certain characteristics that are important in relation to water – yield control. Vegetative cover is made up of three parts: the canopy of living and dead stems and leaves that stands clear of the soil, the accumulation of dead and decaying plant remains that lie on or in the soil surface, and the living and dead roots and subsurface stems that permeate the soil. The canopy above the ground and the surface litter accumulation operate as barriers interposed between the atmosphere and the soil. They intercept precipitation and thus temper the delivery of water to the soil, and they retard wind movement near the soil surface. The heat-insulating properties of canopy and litter reduce the interchange of energy between soil and atmosphere – this slows the evaporation of water from the soil in daytime, and may increase it at night. This effect of canopy and litter, however, may be offset by loss of soil water through transpiration of living parts of the canopy.

At the soil surface , vegetation also obstructs the overland flow of water and the pick-up and transport of soil material. This is accomplished by stems and litter accumulations that form miniature anchored dams and diversion walls, and by roots and decaying organic matter which obstruct the soil or bind it.

Beneath the soil surface, to depths reached by roots, vegetation acts both directly and indirectly. Roots, by their growth and subsequent death and decay, permeate the soil with material that both binds it and aids the flow of water through it. Roots also absorb water and carry it to the above-ground parts of plants, thus contributing to the return of water to the atmosphere. The parts of vegetation that are below the soil surface act indirectly by creating the favourable environment for the activity of small animals, insects, fungi, moulds and bacteria. To all these organisms vegetation means shelter and favourable living conditions; to most of them it means food as well. Some of them, like worms, burrow in the soil and thus aid in keeping it permeable to water. Others break down organic matter and thus perform the same kind of function, while at the same time permeating the soil with the binding materials of their own bodies.

This brief discussion provides some indications of the hydrological effects exerted by vegetation itself. It suggests that vegetation affects water yield by slowing or diverting surface flow, by inducing water to enter the soil, and by influencing water losses through evaporation and erosion processes. In order to describe these hydrological effects in greater detail, attention must be focused upon a thin layer above and below the Earth's surface, namely the layer that lies between the tops of plant crowns and the lowermost tips of plant roots. It is within this layer that vegetation interacts, in the fullest sense of the word, with hydrological and meteorological processes.

2. Write in English a summary of the text (4-5 sentences).

Control Paper 10

Variant 2

1. Translate the text in writing:

MOISTURE CHARACTERISTICS OF SOILS

Types of soil differ in the size, shape and density of packing of their particles and aggregates, and therefore in the amount and distribution of spaces ('pore spaces') into which water and air (and also plant roots and animals) can move. Moreover there are differences in the physical and chemical properties of the surfaces of various soil materials, especially in their ability to absorb and release moisture. Such properties vitally affect the movement and retention of water in the soil. Therefore available soil water cannot be assessed sufficiently only in terms of the amount of water per unit volume of soil block, or per unit weight of 'undisturbed' soil or per unit weight of oven-dried soil. Different soil types will release different amounts of water to crops, even if their total soil moisture content S (expressed as a percentage of dry weight) is exactly the same.

The state of soil moisture can be conveniently classified into four categories:

(a) Gravitational water, which occupies the larger pores of the soil and drains away under the influence of gravity. An excess of this water can damage plants if drainage is too slow, for instance by choking the roots;

(b) Capillary water, which is held by surface forces as film around the particles, in angles between them and in capillary pores. In the form of liquid, capillary water moves slowly from thicker to thinner films and along moisture-tension or diffusion-pressure gradients. It can also move in the form of vapour. Capillary water is the only important source of water for most cultivated plants;

(c) Hygroscopic water, which is held as a very thin film on the particles by surface forces. This water is held so firmly that it can move only in the form of vapour. The moisture remaining in air-dry soil is usually regarded as hygroscopic water and is not available to plants;

(d) Water vapour, which occurs in the soil atmosphere and moves along vapour-pressure gradients. It probably is not used directly by plants.

The movement of liquid water through soils occurs predominantly under the joint action of gravity (unidirectional) and surface-tension forces (all directions), associated with the degree of curvature of water films around and between particles. Accordingly, these forces depend upon the size and the shape, i.e., the geometry of the pore spaces. Other forces, hydrostatic and osmotic, may also operate.

If water is added to a block of otherwise 'dry' soil, some of it will drain away rapidly through any relatively large cracks and channels. The remainder will tend to displace some of the air in the spaces between particles, beginning with the larger pore spaces. Broadly speaking, a well-defined ‘wetting front’ will move downwards into the soil, leaving an increasingly thick layer retaining all the moisture which it can hold against gravity; that soil block is then said to be at field capacity. The drying of soil shows similar behaviour, with a relatively sharp ‘drying front’ moving down into the soil as evaporation proceeds from the surface.

Therefore, after a period with wet and dry spells, the soil block will tend to have alternate wet and dry layers. The state of field capacity, generally desirable for agriculture, must not be confused with the undesirable situation of ‘saturated’ soil, where all the pore space is occupied by water.

When the moisture content falls below field capacity, the subsequent, rather limited, movement of water in the soil is largely in the vapour phase, and this occurs mainly by distillation, related to temperature gradients in the soil. Plant roots within the block will, however, extract liquid water from the water films around soil particles with which they are in contact. Hence it is clear that more water can be lost from a soil block carrying vegetation than from another block, identical in initial water status but without vegetation. as water is extracted and the moisture content drops further below field capacity, a point is reached at which the forces holding the moisture films to soil particles cannot be overcome by root suction – plants are starved of water, lose turgidity, as the soil moisture content has reached the wilting point.

What is important for the plant is not the absolute amount of water content, the volume percentage in a unit volume of soil – but rather how much is available to the plant, and this is strongly linked to surface tension forces in the soil. This ‘available water’ is specified by the soil potential Ψ, which is the suction energy (as measured with a tensiometer) that roots must exert to extract water from the soil. The appropriate unit for Ψ is J m^{-3}, which usually is translated into a unit of pressure called pF, equal to the logarithm (base 10) of the (negative) head of water expressed in cm.

For practical purposes the wilting point is reached for all species when the forces attaching water films to the soil particles reach a value of about 15 atmospheres or 1.52 Mpa = 155m water column pF = 4.2. This corresponds to capillary action in spaces of less than 1 μm width, while most root-hairs are at least a few μm in diameter. So the usual location of the wilting point at pF = 4.2 makes physical and biological sense.

2. Write in English a summary of the text (4-5 sentences).

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