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COMPETITION FROM SYNTHETIC PRODUCTS

By Dr. I. E. Coop, Professor of Agriculture (Animal Husbandry).

New Zealand is such a small country and so remote from the centres of world activity that we sometimes find it difficult to keep pace with developments overseas. We are apt to lose sight of the fact that our agriculture is governed not from within New Zealand, but by prices and market conditions overseas, and in Britain in particular. In other words, our prosperity is dependent only partly upon developments in New Zealand, and mainly upon developments in Britain. In this connection the agricultural industry will be called upon in the coming years to face two major problems arising from such developments in Europe and America. These are the expanding and ever-increasing use of synthetic fibres for clothing material and the use of margarine in place of butter.

Synthetic Fibres

We have been hearing a good deal about wool recently, and it is well that we should be reminded of its virtues. It still holds its own as the best clothing material in the temperate and cold climates. It has certain properties which render it particularly valuable for this purpose. It is a protein fibre especially elaborated by the sheep, and possesses unique properties of elasticity, of warmth, and of moisture absorption. These properties permit us to make garments which are both warm and durable. Against these advantages may be mentioned such disadvantages as the low yield of wool per acre, and the long and costly process of scouring, combing and spinning in preparation for weaving.

Whilst the outlook for wool is assured in the immediate future, one must admit that on a long-range view the industry will be called upon to face some major problems. Of these the greatest is the challenge from synthetic fibres.

It is not my purpose to discuss in detail the steps we might take to prepare ourselves for this, but rather to indicate to you what these synthetic fibres are and what the challenge is. The synthetic fibre industry has become, over the last 25 years, one of the principal industries of the world. The output of these fibres in 1940 was over 1 million tons, as compared with about 1$\frac{1}{2}$ million tons of wool. The situation is even more serious than these figures would indicate, owing to the very rapid rate at which the synthetics are increasing—from $\frac{1}{4}$ million tons in 1930 ot $\frac{1}{2}$ million in 1936, to 1 million in 1940. During this time wool production has remained stationary. As regards price, that of the synthetics is between a third and a half of that of natural wool. For instance, in 1938 synthetic fibre was being sold at 10d per lb, as against 32d per lb for clean scoured 60's wool.

These few figures will give you some idea of the magnitude of the competition from fibres. While costs of all commodities have increased rapidly over the last few years, the price of wool to-day is less than the average price from 1920-1930. Perhaps this is the indirect effect of a decreased demand resulting from supplies of synthetics being available.

In general there are two types of synthetic fibre—the so-called cellulose fibres or rayons produced from wood, and the protein fibres produced from milk, soya beans and peanuts. It is the rayons with which we are at present most familiar. They were originally designed as an artificial silk, but their uses have now expanded very greatly. The starting materials in producing rayons are wood pulp or cotton linters. These materials are dissolved in special solutions and then squirted through very fine nozzles or spinarettes into a coagulating bath, where they are converted into very fine threads. The threads are wound on to formers, dried and cut into suitable lengths or staples. The process has the advantage that the raw material is cheap and plentiful. the fibres can be squirted in any desired diameter or fineness, and can be cut in any desired length. Both the diameter and length are uniform, which is not the case with wool. Finally, the fibres come out clean and parallel, and so do not necessitate expensive processes of scouring and combing.

The fibres are very strong, stronger than wool, but they are not elastic and do not stretch, and are not very warm. Nevertheless, manufacturers have begun incorporating some of these fibres with wool in about a 50-50 mixture, where a compromise is made between the cheapness of the synthetic and the good qualities of the wool. Materials of this nature are being sold all over the world, even in New Zealand, both for ladies' and men's wear, where previously 100% wool was used. In other countries, for instance, in Germany during the war, all so-called woollen garments, such as suits and coats, have been made of about 80% fibre from wood and straw, and 20% natural wool. Whilst no one would agree that the German garments compare in quality with 100% wool, it illustrates the point that the practice of blending is already well established all over the world.

The protein fibres are much more closely related to natural wool. The protein from soya beans, peanuts or milk, is obtainable in yields of hundreds of pounds per acre, as compared with only a few pounds of wool per acre, and in the case of soya beans and peanuts being a by-product from the vegetable oil industry, is therefore very cheap. It is dissolved in alkali and squirted through nozzles into an acid bath to form the threads, which are then cured in formalin, dried and cut into required lengths. These synthetic fibres, whilst weaker than natural wool and without any marked felting properties, are nevertheless much closer to wool than were the rayons. They are elastic and stretch like wool, they are crimped, and are warm. They represent a stage nearer to real wool. The protein fibres were developed later than the rayons, and production is as yet not very great, though it is sure to increase rapidly. They will be used in admixture with wool on a 50-50 basis. The synthetic is by itself still inferior, but when mixed with wool produces a fabric cheaper than the 100% woollen fabric, and not greatly inferior to it in quality.

It is stated by many synthetic fibre manufacturers that the synthetics will actually increase the sale of wool by reducing the price of the garments containing the mixture. In the long run more wool would be used as new markets were opened to these cheapened fabrics. Whilst this may be true, one cannot help feeling that the synthetic fibre manufacturers will not be satisfied with a 50-50 mixture, but will attempt to produce a fibre which can stand on its own without any admixture with wool. When this happens it will be an ill day for us. What is certain is that synthetics can undersell wool, and therefore it is just a matter of how long it will take to produce a fibre which is actually as good as wool. It is difficult to predict how long this will be. If they do not succeed, it will not be for want of trying. Synthetic fibre firms are spending very much more effort on improving their products than we are on improving wool. They have made great strides in the last 25 years. Will their rate of progress continue? We can expect that it will.

On the other hand, we should be striving to maintain the position of wool. The wool-producing countries should be striving above all to maintain by research the undoubted superiority of wool, though this superiority seems to be declining. Secondly, we should keep production costs as low as possible so as to be able to compete on a price basis; and thirdly, we should be looking for new uses for wool.

Some of these things are under investigation in New Zealand, but the battle will be fought out in larger countries than ours—in Britain, America and Australia, where financial, laboratory and scientific resources are so much larger. A sign of the times and of our awakening to all this is that Australia has recently decided to spend £600,000 per annum on wool research.

(Next month Dr. Coop will discuss the competition between margarine and butter.—Editor.)

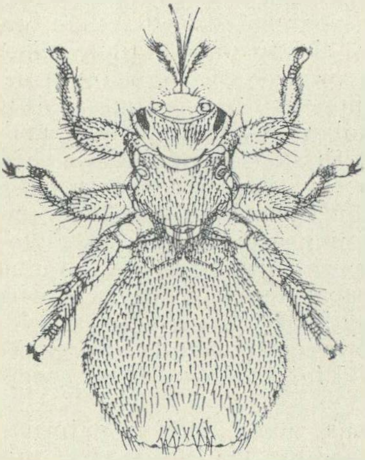
SHEEP KED

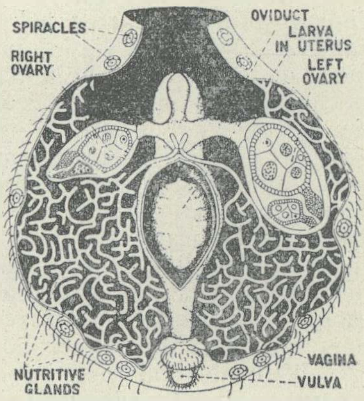
MELOPHAGUS OVINUS (LINNE, 1758)

An Example of an External Parasite

L. Morrison, B.Sc.(Agric.), Lecturer in Entomology

The sheep ked is a common external parasite of sheep, and occasionally goats, in all countries throughout the world where sheep and goats are kept. It is a degenerate louse-like fly which has completely lost its wings. Since it is a true fly and belongs to the insect order Diptera, it is quite erroneous and leads to endless confusion to designate it "tick," as is widely done in this country. A tick, such as the cattle tick of the North Island, or the Sheep and Dog tick of Europe, or the Texas fever tick, is not an insect at all, but a close relative of spiders and mites. The sheep ked is by no means the only wingless fly which occurs; in fact, winglessness may be encountered throughout most orders of insects. There are wingless aphids, wingless ants, and





THE SHEEP TICK OR KED

Left—Dorsal view of adult, about eight times natural size; note mouth parts, shielded by the maxillary palps, the compound eyes, and, in front of them, the concealed antennae; and, along the sides of the thorax and abdomen, the spiracles. (Drawn by Kathryn Sommerman).

Right—Dissection of the abdomen of the female, ventral view, to illustrate the viviparous reproduction. At centre is a larva lying in the uterus, with its mouth toward the small nipple through which the nutritive fluid is passed from the elaborately branched, cylindrical glands that furnish the only food of the insect until the adult stage is reached. This larva originated from an egg produced in the right ovary (on the reader's left); while another egg is being produced by the left ovary, the two functioning in turn. When full grown the larva will pass from the vulva. (Drawn by Kathryn Sommerman, in part after Pratt).

even wingless moths, as, for example, the female "Case Moth," which lives inside a tough, parchment-like case often attached to macrocarpa or pine trees.

The ked crawls about over the skin among the wool, and feeds by thrusting its sharp, lance-like mouth parts into the flesh and sucking blood. It causes the sheep to rub, bite and scratch at the wool, thus spoiling the fleece. Animals which are heavily infested with keds are unthrifty and unprofitable. Keds are especially severe on lambs, to which they migrate readily from the ewes, particularly at shearing time. The financial loss to New Zealand through the presence of keds on flocks must be exceedingly heavy when one considers the unthrifty condition caused by irritation, the damage to the fleece, the lowered value of the wool due to staining, and the cost of materials and labour entailed in dipping every year. It is estimated that this country spends approximately £130,000 per annum on dipping materials alone.

Appearance

Two life stages, the adult and the pupa, are commonly found on sheep at any season of the year. The adults are greyish brown, wingless, six-legged, and have a broad, leathery, somewhat flattened, unsegmented, purse-like or sac-like abdomen covered with short spiny hairs. The thorax and head are much narrower. The legs are wide spread so that the front pair appear to come out at the sides of the head . The body is about ¼-inch in length, and is closely covered, legs and all, with short spiny hairs. This dense covering of hairs, together with a pair of strongly developed, curved, sharp claws on the end of each leg, ensures against the parasite becoming accidentally dislodged from its host. This is a very necessary precaution, for a permanent parasite to become separated from its host will in all probability lead to the death of the parasite. Well-developed organs of attachment are prominent features of most parasites, both external and internal, and this is well exemplified in the sheep ked.

With the aid of a hand lens many of the external features can be made out quite readily. On the front of the head are the slender, curved mouth parts, shielded by a pair of sensory maxillary palps. The mouth parts are composed of three stylets, an upper, a middle, and a lower member. The lower one, which is much stouter than the others, is actually a trough within which lie the more delicate piercing and sucking members. Unless the upper and middle stylets are forced out of the groove of this trough, the mouth-parts appear to be a single curved structure projecting from between the hairy palps. The middle stylet is sharp, and can be driven through the skin to reach the blood. This middle stylet is hollow, and saliva can be passed along the centre channel. The food channel up which the blood is sucked is formed by the upper stylet, which is shaped like an inverted U resting on the flat middle stylet.

A pair of compound eyes are situated on the sides of the head. The eye is narrow and elongate, and runs obliquely forwards from the upper to the lower side of the head. Each eye shows a relatively small number of individual facets. The compound eye is composed of a number of eye tubes, and each facet is the outer face of one of these tubes. A pair of feelers are present on the head, and lie one in front of each eye. Long, segmented feelers, which is a characteristic feature of most insects, would be out of place in an insect whose life is passed wandering through wool, hence it is found that the feeler has been reduced to a single segment and concealed in a depression. The spiracles, or outer entrances of the air tubes, are placed along the sides of the body, two pairs on the thorax and six pairs on the abdomen.

Adult keds, bear in mind, are fully grown, and size is no true indication of age. If the abdomen appears bulky, this may indicate a recent meal of blood, or if the individual is a female, that a young ked is being carried in the uterus. There is an appreciable difference in size, however, between the sexes, the females being considerably larger than the males.

The other exposed stage of the ked is the pupa or "nit," quite wrongly termed the egg. It is an oval, slightly flattened, chestnut brown, seed-like object, about $\frac{1}{8}$-inch across the long diameter. On the slightly flattened faces are two parallel rows of depressions. The posterior stigmal plates of the larva are retained, and a small projection arising from that area emphasises the resemblance to a crimson clover, kidney vetch, or even dark-coloured broom seed. The pupæ are glued securely to the wool fibres, especially about the lower side of the neck towards the brisket, the lower part of the sides, and about the belly and crutch. These pupæ are never attached at skin level, even when the wool is only about $\frac{1}{4}$-inch long. In long wool the pupæ are usually placed well up the fibre, about $\frac{1}{2}$-inch to 1 inch from the tip. This explains why practically all are removed at shearing time with the exception of a few on the underside of the neck, where the wool may be less closely shorn.

Life History

Although individual keds have been recorded to live for as long as six months, the average length of life of the female is probably about 100 days and that of the male about 80 days. When the adults emerge from the pupæ they require some time to reach sexual maturity. This period is believed to be about six days in the case of the female and about ten days in the case of the male. Mating must take place before offsping are produced. The method of reproduction in the sheep ked is rather remarkable. Instead of laying eggs, like most insects, the ked is viviparous. This in itself is not remarkable, for although most insects are oviparous, quite a few are viviparous; for example, aphids and the tse-tse fly, and some blowflies. In other viviparous forms, however, the egg is hatched immediately before the larva is deposited, but in the case of the ked the egg is hatched and the larva is retained in the uterus until it is fully fed and about to pupate. Only one larva is produced at a time. It lies in the uterus with its mouth towards a small nipple through which a nutritive fluid is passed from elaborately branched glands in the body of the parent. This is the only nourishment the insect receives until it becomes an adult and draws blood for itself from the host animal. Although two ovaries are present, only one egg is produced at a time, the two ovaries functioning in turn. The time required for the larva to complete its feeding and become fully grown is usually from 6 to 8 days. When born, the larva is whitish in colour, oval, about $\frac{1}{8}$-inch long, and is a maggot without any appendages. The female secretes a gelatinous substance which glues the larva to the wool fibre. Within 12 hours the skin turns brown and forms a hard case or puparium within which pupation takes place. From 19 to 23 days as a rule, but occasionally after a longer time, a circular cap is pushed off from the end of the hard brown case and the adult ked creeps out. Subsequent pupæ are produced at intervals of about 8 days, and one female rarely produces more than 12 pupæ during her lifetime. In spite of the small number of offspring produced by one female, the relatively short time required to complete the life cycle leads to rapid multiplication, so that a male and female ked may be responsible for a population of 700 in one year.

Unlike the flea or the tick, which are temporary parasites, and merely attach themselves to the host animal to feed and leave it to breed elsewhere, the ked is a permanent parasite, spending its whole life on the host, feeding and breeding. It is not adapted to live for any appreciable length of time away from the host. If separated from the host, an adult ked may live for a week, or sligtly longer in warm weather, but most of them die in 3 or 4 days. The pupæ, however, may survive apart from the sheep, and even hatch out in warm weather. At Lincoln College a fleece with live keds was removed from a sheep and placed in a laboratory for observation. Live keds were present on this fleece 37 days after removal from the sheep. The original adults may have lived for a week and deposited pupæ, which would require 21 days to emerge, or longer under the reduced temperature of the laboratory compared with the body of the sheep, and the newly emerged adults may have survived a week without feeding.

There is considerable evidence to show that breeding is continuous throughout the year, and that in colder climates it is slower in winter, but in warmer climates, such as parts of New South Wales, breeding is slower in summer than in winter.

An insect which is parasitic on an animal is much more troublesome to study alive than an insect which attacks a plant. The life history of the white butterfly can be studied with ease by growing cabbages in pots in a room or covered with scrim, and placing adults on the plants. Provided the plants are kept watered and healthy, the insects are likely to breed freely on them. An insect which is parasitic on the sheep cannot be studied satisfactorily away from the sheep. It is not possible to create an artificial environment similar to that which occurs among the wool fibres. The moisture and temperature in the fleece of a sheep vary from one point to another and from time to time. For example, at Lincoln College a sheep with 2½in of wool growth, on a day when the shade temperature was 52.8°F. and the atmospheric humidity 86%, showed a temperature ranging from 96.6°F. on the skin under the wool to 84°F. at a point in the wool ¼-inch away from the skin. while the humidity varied from 40.7% on the skin to 61.6% ¼-inch away from the skin. The ked may accommodate itself to the conditions which suit it by remaining close down to the skin in cold weather, and moving out towards the tips of the fibres on very hot days.

If one or a few keds are to be kept under observation on a sheep it is practically essential to confine the parasites to a small area. Many different types of cages have been employed for this purpose, but few have proved satisfactory. The following method may be worth trying: In order to confine keds to an observable area of the fleece, a strip 2in wide should be shorn within ⅛in to ¼in of the skin on the flank of the sheep so as to enclose an area of the fleece approximately 4in square. On the shorn area a sleeve of "mutton cloth" (made by knitting cotton yarn with a plain stitch built upon itself) is secured by means of a resin-beeswax mixture (80% resin and 20% beeswax). The open end of the cage so formed can be closed by means of a zip-fastener. The area of the sheep chosen should be one which is not likely to be disturbed by limb movement. These cages should prove "ked-proof" for a period of about 8 weeks, after which time the cage may have to be re-attached.

Provided one or more infested sheep can be kept in close proximity to a school, pupils may verify for themselves much of the detail given above. They may also determine how long newly emerged keds and older keds which have fed, and pupæ of different ages, can live away from the sheep at different periods of the year and under different conditions of exposure, such as on bare ground, in a tuft of wool in the shade, or in the sun and on grass.

(In a subsequent number an article will deal with the control of sheep ked in New Zealand.—Editor.)

SOIL ACIDITY

B. L. Elphick, B.Sc. (Hons., London), A.N.Z.I.C., Assistant Lecturer in Chemistry.

"Those paddocks up there on the rise are as sour as can be. I'll never get a decent pasture there until I can manage to give them a really heavy dose of lime." With this remark Mr Smith turned to show his visitor what he could do on the more fertile parts of his farm. His explanation of the poverty of that upper end of his farm was probably a sound one, but what exactly did he mean? He meant that that soil was highly acid—after all, had not his English word "sour" the same derivation as the present German word "sauer," meaning acid? Whether he realised this

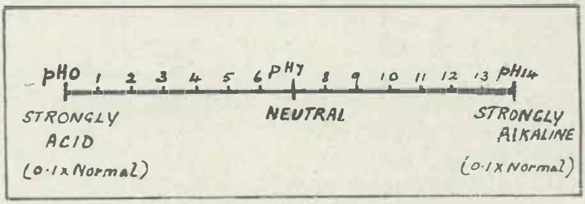


Fig. I.—The pH scale.

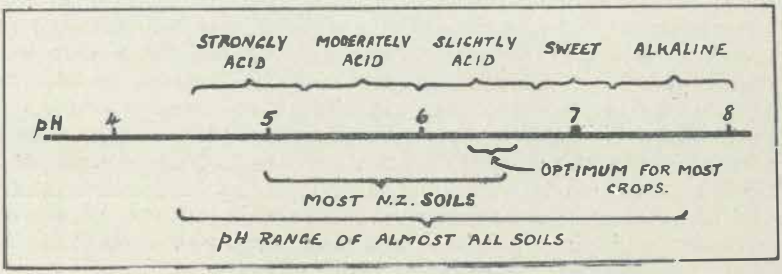


Fig. II.—The position of soils on the pH scale.

or not, he inferred correctly that this soil acidity in some way or other was preventing the satisfactory growth of his pastures and crops. What is this soil acidity, how does it arise, and how does it affect the growth of plants?

In the first place, soil acidity is a **natural phenomenon.** It is not the result of using chemical fertilisers, or not using compost, or any of the other human acts or omissions which are so often (but not always correctly) held responsible for mankind's troubles in the shape of poor health, faulty teeth, etc. Acidity develops naturally in soils to a greater or lesser extent wherever the climate is temperate and moist, as it is in New Zealand. It tends to develop wherever the downward movement of water through the soil appreciably exceeds the upward movement due to transpiration and evaporation of water vapour back into the air. In other words, it is a result of the **leaching** or washing out of the chemical bases, such as lime, magnesia, soda, etc., from the top soil through the sub-soil into the natural drainage system. One would surmise from this that a heavier average rainfall and a more porous subsoil would result in an intenser degree of acidity developing in the top soil. This is generally true. For example, the soils of Westland are, generally speaking, more strongly acid than those of Canterbury. Regions with a rainfall of 25 inches or more usually have a high percentage of acid soils.

It follows, therefore, that the mineral content of natural waters, in springs, rivers, etc., is partly a result of this removal of bases from the soils, and the leaching process going on in the soils is seen to be a continuation of the agelong process of chemical rock weathering. There is an important difference, however, between the removal of bases from rocks by chemical weathering and the removal of bases from soils by leaching, since the bases are held differently in the two cases. In rocks the bases are largely combined in distinct silicate minerals, such as felspar and hornblende, which by hydrolysis break down into colloidal clay and the soluble salts of the bases. In soils, however, we start off with the already highly weathered material. It is true that there is often in the soil a residue of partially weathered silicate minerals, found mainly in the fine "silt" fraction, and that these continue their slow breakdown, gradually yielding up their bases into soluble forms available to plants. But by far the greater part of the available plant nutrients in a soil is held in quite a different manner by the **colloidal** constituents of the soil, namely, the clay and the humus. In order to understand the nature of soil acidity, its development and correction, it is necessary to know something of the behaviour of these soil colloids.

Base Exchange

The soil colloids, clay and humus, are by their nature weakly acidic materials. The clay is a complex of compounds such as hydrated alumino-silicic acid, while the humus is a complex of many different organic compounds, including the so-called humic acids. These weak acids are insoluble in the usual sense of the term, yet being in an extremely fine (sub-microscopic) state of division, they display a remarkable reactivity on account of the relatively immense surface their particles expose to the soil solution. At this surface they are able to ionise, as all acids do, liberating positively charged hydrogen ions, which are mobile, yet retained in attendance, as it were, near the ionising surface by the attraction of the negatively charged colloid. It is the existence of this attendant layer of partially mobile ions all over the immense surface of the colloidal particles that makes possible the important phenomenon generally known as **base-exchange,** or more correctly, **ionic-exchange.** Next to photosynthesis, this is probably the most important chemical reaction in the realm of agriculture.

The positively charged ions of the common bases always present in the soil solution, soda, potash, lime and magnesia, are able to change places in chemically equivalent amounts with the hydrogen ions of the attendant layer, so that the colloidal material, or the **exchange complex** as it is called, is constantly in equilibrium with the soil solution. If, for example, the concentration of calcium or sodium in the soil solution is increased, as it would be by the addition of lime or nitrate of soda, a base- or ionic-exchange immediately occurs, calcium or sodium ions entering into the exchange complex replacing others (possibly hydrogen ions) till a new equilibrium is established. The equilibrium is always such that only a very small proportion of the total available bases is actually in solution at any one time, the bulk being held absorbed on the colloids. In this manner a fairly large reserve of these chemical plant nutrients is held in an exchangeable or available condition by the soil colloids, while the soil solution remains suitably dilute, and the stock of nutrients is prevented from leaching away into the drainage channels.

Soil Acidity

It will now be clear that any addition of bases to the soil solution will serve to replace and neutralise part of the acidity (the hydrogen ions) held on the surface of the exchange complex. On the other hand, weak acids, chiefly carbonic acid, are constantly being formed by the vital activities of the soil organisms, and these acids tend gradually to replace the absorbed bases by hydrogen, leaving the complex more and more acid as the bases so liberated are leached away. Thus the acidity of the soil solution (its **hydrogen ion concentration,** as the chemist would say) is a reflection of the extent to which the attendant ionic layer at the surface of the colloids consists of hydrogen rather than basic ions. If the exchange complex is highly saturated with bases, the soil solution will not be acid; it may even be alkaline. On the other hand, the more **unsaturated,** or lacking in bases the complex becomes, the more strongly acid will the soil solution be.

These colloidal acids, clay and humus, which we have seen are always more or less neutralised by absorbed bases, must not be thought of as anything resembling the corrosive unpleasant acids of the chemical laboratory. Their acidity is extremely feeble, far weaker, for example, than are the digestive juices of the human stomach. As Emil Truog, an eminent soil-scientist, says, "The exchange acids (humic and alumino-silicic) are not detrimental or toxic substances. They form, in fact, the backbone of good soil. Physically they make possible the granulation of soils; chemically they serve as a storehouse for bases that may easily be drawn upon in exchange for hydrogen as needed."

Active and Reserve Acidity

Let us now consider two soils, the one a heavy loam well supplied with clay and humus; the other a light sandy soil, poorly supplied with these colloids. Suppose that the exchange complex in both soils is equally unsaturated. The two soils will be more or less equally acid, i.e., the hydrogen ion concentrations of the two soil solutions will be roughly the same; but the total quantity of acid will be much greater in the case of the heavy soil, in proportion to its greater content of colloidal material. In practice this would mean adding a proportionately greater amount of base (e.g., lime) in order to neutralise or sweeten the heavier soil. In other words, when we set out to neutralise soil acidity we have not merely to neutralise the hydrogen ions of the soil solution, that is its **active acidity,** we must also neutralise the very much greater reserve acidity of the colloidal materials, for these two are in intimate equilibrium with each other. This explains why the lime-requirement of soils rich in clay or humus is much greater than that of light soils poor in these colloids.

The Measurement of Soil Acidity

It is customary in most chemical work to express acidity in terms of "normality," a normal solution being one that contains 1 gram of acid hydrogen per litre. When we come to measure and express the acidity of soils (and other biological media, such as bacterial culture solutions), we are dealing with very weak acids and such extremely low concentrations that our unit, the normal solution, is inconveniently large. For example, the acidity of a slightly acid soil solution would be about one-millionth x normal, while that of a strongly acid soil would be about one hundred-thousandth x normal. Here we have a minute difference, awkward to express in the usual manner, yet an exceedingly important difference in its effects on living organisms. This difficulty is overcome by the use of the **pH scale** (Fig. 1). The pH scale (1) expresses hydrogen-ion concentration on a simple scale of 14 units. It will be noticed that the lower the pH the higher or stronger is the acidity, rather in the same way as the "gauge" of a wire is lower as the wire becomes thicker. The important but minute difference in acidity, clumsily referred to above on the "normality" scale, can now be expressed as the difference between pH6 and pH5.

The range of acidities encountered in soils is shown in Fig. II. Hardly any plants can tolerate a soil more acid than pH4, or more alkaline than pH9. There are only a few very exceptional soils that reach such extremes of acidity or alkalinity, and they would be barren and infertile. The great majority of the productive soils of the world fall within the range pH4.5-pH7.5, while most New Zealand soils lie within the still narrower range pH5.0-pH6.5.

The measurement of the acidity or pH of soils is possible in two ways. The more accurate of the two is the **electrometric method,** based on measurement of the electric charge developed on a platinum electrode immersed in the soil-water suspension. The simpler method makes use of **indicator solutions.** A large number of synthetic compounds are available, resembling litmus and methyl orange, in that their colours change as the pH of their solution changes. Each indicator has its own characteristic zone in the pH scale within which its gradual colour changes occur. For example, the following three indicators (2) would between them cover all soil acidities likely to be encountered in New Zealand soils:—

Brom-cresol-green changes from yellow at pH 4.0 to blue at pH 5.6
Brom-cresol-purple changes from yellow at pH 5.2 to purple at pH 6.6
Brom-thymol-blue changes from yellow at pH 6.0 to blue at pH 7.6

Each perceptable change in colour between the two extremes corresponds to a definite pH. Litmus solution, or even litmus paper, would show whether a soil was highly acid or not. In fact some older text-books prescribe the use of litmus paper for this purpose. But it is not sensitive enough, and the other indicators mentioned are much more reliable.

(1) Readers who have a little knowledge of mathematics will perceive that this is a logarithmic scale. Thus pH6 = 10 to the power of —6 x normal. pH4 = 10 to the power of —4 x normal. Note however that these figures refer to actual concentration of Hydrogen ions and not to total quantity of acid. There is an important difference here. We may have chemically equal amounts of two acids, yet one being a strong acid (e.g. sulphuric acid) will be highly ionised giving a high concentration of H ions, while the other being a weak acid (e.g. carbonic acid) will be so feebly ionised that the actual concentration of H ions is very low. It is the concentration of H ions that is important to living organisms, and it is this that the pH scale measures.

(2) These indicator solutions together with the appropriate colour standards, also the B.D.H. "soil indicator" can be obtained from the usual firms supplying scientific apparatus and chemicals.

Methods

All that is necessary to determine the pH of a soil sample is to place about half an inch of the pulverised soil sample in test tube, add an equal amount of Barium Sulphate (this heavy insoluble material causes the soil suspension to settle out quickly), then add to the contents of the test-tube an equal volume of the appropriate indicator solution and shake vigorously. After settling 5-10 minutes there will be a clear layer of solution whose colour may be matched against a standard colour chart for that particular indicator. The pH of the soil can then be estimated to within 0.2 - 0.3 on the pH scale.

Where a rapid though less accurate test is desired, a special "Soil Indicator" solution (2) may be used. This is a mixture of several indicators, covering a wide range of pH. Its colour changes are red-orange-yellow-green-blue as the soil reaction changes from strongly acid to mildly alkaline, green indicating neutrality. All that is necessary is to place about half a teaspoonful of the slightly damp soil in a white porcelain basin or crucible (even a white china cup will do), wet the soil with a few drops of the soil indicator, and after a minute or two allow some of the solution to drain away from the soil. Its colour then enables the soil reaction to be classified as strongly, moderately or slightly acid, neutral or slightly alkaline. This is quite sufficient for most practical purposes.

There is a third method which, though it does not measure acidity directly, nevertheless gives with most a soils a useful indication of the degree of acidity. This is the **Comber Test,** named after Professor N. M. Comber, of Leeds University. It depends on the fact that the more acid the soil solution is the more soluble are the iron compounds present, and the test is virtually a chemical test for soluble iron in the oxidised or ferric state. Place about one inch of the fairly dry pulverised soil in a clean test-tube, add an equal volume of Comber test solution, (3) shake vigorously and allow to settle. The resultant colour of the clear liquid is interpreted as follows:—

Deep blood red coloration indicates strongly acid soil
Moderate red coloration indicates moderately acid soil
Pale pink coloration indicates slightly acid soil
Colourless indicates sweet soil

The test is not reliable, however, with volcanic soils, peaty soils or with soils that have received more than 10 cwt. limestone within the past 3-4 years.

How soil acidity affects the growth of plants, and how it is corrected by the application of lime will be the subject of a further article.

(3) The Comber Test solution is prepared by dissolving 4 grams of potassium thiocyanate in 90 ccs. rectified spirit + 10 ccs. acetone.

ANSWER TO CORRESPONDENT:

PASTEURIZATION OF MILK AND CREAM

The official definition of pasteurized milk and cream states that they shall be milk and cream respectively which has been efficiently heat-treated either by the holding method or by the high-temperature short-time method hereinafter described, which has not been more than once heated as so described, which has not otherwise been treated by heat and which is free from living coliform bacilli (that is there should be none in 1/10th of a millilitre).

By the holding method the temperature of the milk or cream is raised to not less than 145°F. (62.8°C.) and not more than 150°F. (65.6°C.) and retained at not less than 145 or more than 150 for at least 30 minutes, and immediately and rapidly reduced to 50°F. (10°C.) or less and maintained with protection from contamination at 50° or less until the milk or cream is removed from the premises for delivery. By the high-temperature short-time method, the temperature of the milk or cream is raised to not less than 162°F. (72.2°C) and retained for at least 15 seconds at that temperature and immediately cooled and held as above.

No milk or cream shall be deemed to be efficiently heat treated within the meaning of the regulations if, when subjected to the phosphatase test, it gives a reading exceeding 2.3 Lovibond blue units. Raw milk gives a reading of 30 units. 2.4 —6 units represents milk insufficiently heat treated. Readings of greater than 6 indicates that the milk has been grossly under treated.

(The phosphatase test is not generally suitable for use in schools but details will be furnished to anyone interested. —The Editor.)