Copper Development Association

Copper in Farming

CDA BK 2, November 1971

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Acknowledgements

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Copper Development Association

Copper Development Association is a non-trading organisation sponsored by the copper producers and fabricators to encourage the use of copper and copper alloys and to promote their correct and efficient application. Its services, which include the provision of technical advice and information, are available to those interested in the utilisation of copper in all its aspects. The Association also provides a link between research and user industries and maintains close contact with other copper development associations throughout the world.

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Animal Nutrition

Copper is an indispensable constituent of all living tissues. It is one of the many elements, found in the cells of plants and animals, which in trace amounts are essential for their normal growth and well being. In animals it plays a part in the utilisation of iron for haemoglobin formation.

An insufficiency of copper in an animal's tissues can occur in two ways. It can be a simple straightforward copper deficiency, brought about by an actual deficiency of the element in the fodder, or it can be of the complex type, in which the diet contains the normal amount of copper but some other factor or factors obstruct in some way its assimilation by the animal. A good example of this is molybdenum, an excess of which depletes the animal's copper reserves and the animal develops copper deficiency symptoms unless given additional copper.

Symptoms of copper deficiency in animals

An inadequate amount of copper in an animal's diet manifests itself in a number of ways. These include a general unthriftiness, retarded growth, loss of appetite, anaemia and diarrhoea. The animal has an unhealthy unkempt appearance. With sheep the wool may grow straight and straggly. With cattle the coat is rough, harsh and lacking in lustre; the colour of the hair tends to fade - in black breeds it assumes a rusty red appearance and there is greying around the face and eyes, while red breeds have a dirty yellowish appearance; there is some shedding of hair particularly around the eyes; milk yields drop.

A lack of copper has an adverse effect on the functioning of the ovaries and much evidence has accumulated which points to the necessity of an adequate intake of copper if a high level of fertility is to be achieved in a dairy herd.

A number of diseases are associated with a deficiency of copper either alone or in combination with some other element, such as a deficiency of cobalt or an excess of molybdenum. One of the early discoveries of copper deficiency in livestock was observed in Holland in 1933, when it was found that administering copper sulphate to cattle grazing on copper deficient reclaimed land prevented a disease known as ‘lecksucht’ (licking disease). Similar disorders have been observed in copper deficient pastures in the U.S.A., Australia, New Zealand and Great Britain, and known variously as ‘salt sickness’, ‘falling disease’, ‘coast disease’, etc.

Among sheep, ‘swayback’ in lambs in Britain and a similar affliction in Australia and New Zealand known as ‘enzootic ataxia’ are the result of an insufficiency of copper in the ewes' diet.

Preventative diagnosis

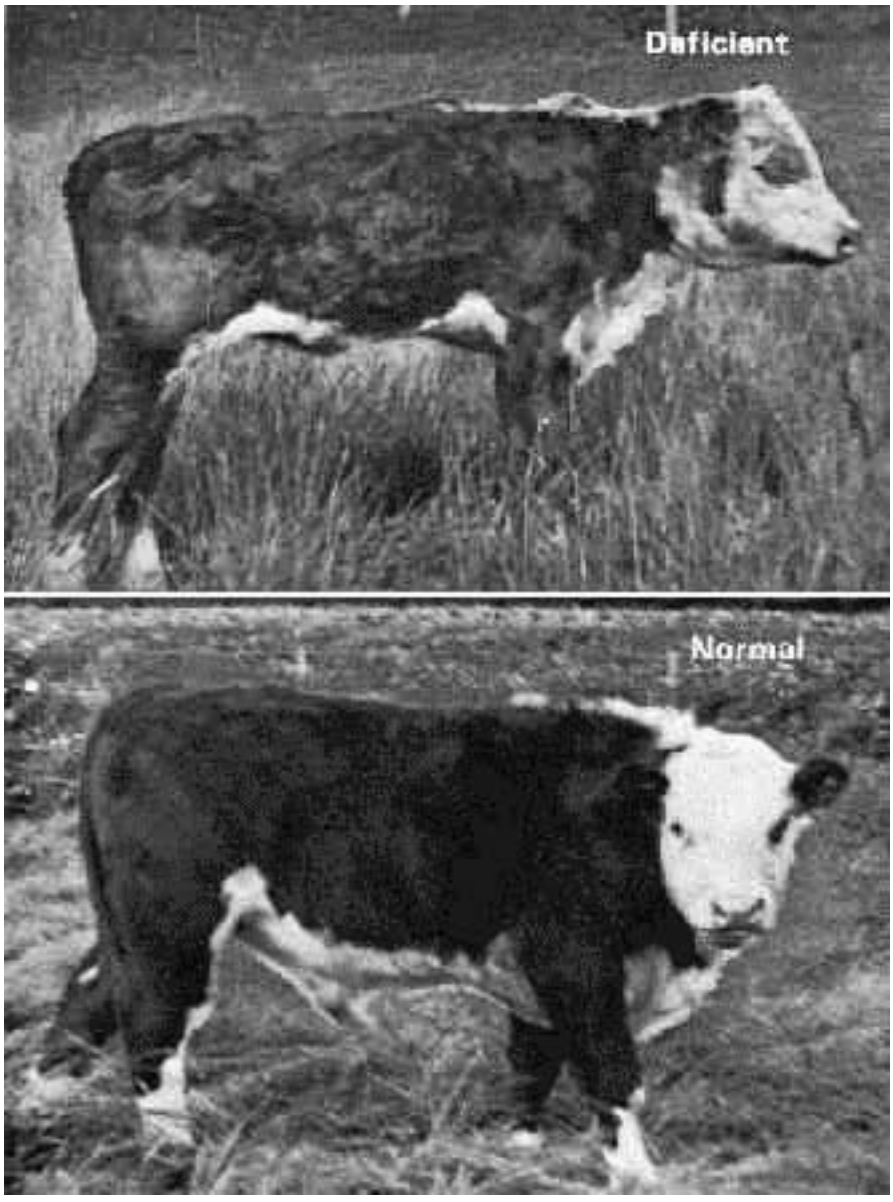
The liver acts as a storehouse for copper. When diets are deficient in copper, the copper stored in the liver is used until the liver reserves are exhausted to the extent that the liver can no longer provide the blood with all the copper it needs to keep the animal functioning properly, and copper deficiency symptoms appear. These symptoms usually begin to appear when liver copper drops below 20 parts per million (ppm). Copper deficiency can thus be diagnosed by estimating the copper content of either the blood or the liver. It is now a comparatively simple matter for a veterinary surgeon to take portions of the liver from living animals without causing them undue distress. The advantage of the liver analysis method of diagnosis is that copper deficiency can be detected long before any change in the blood takes place.

Correcting copper deficiency

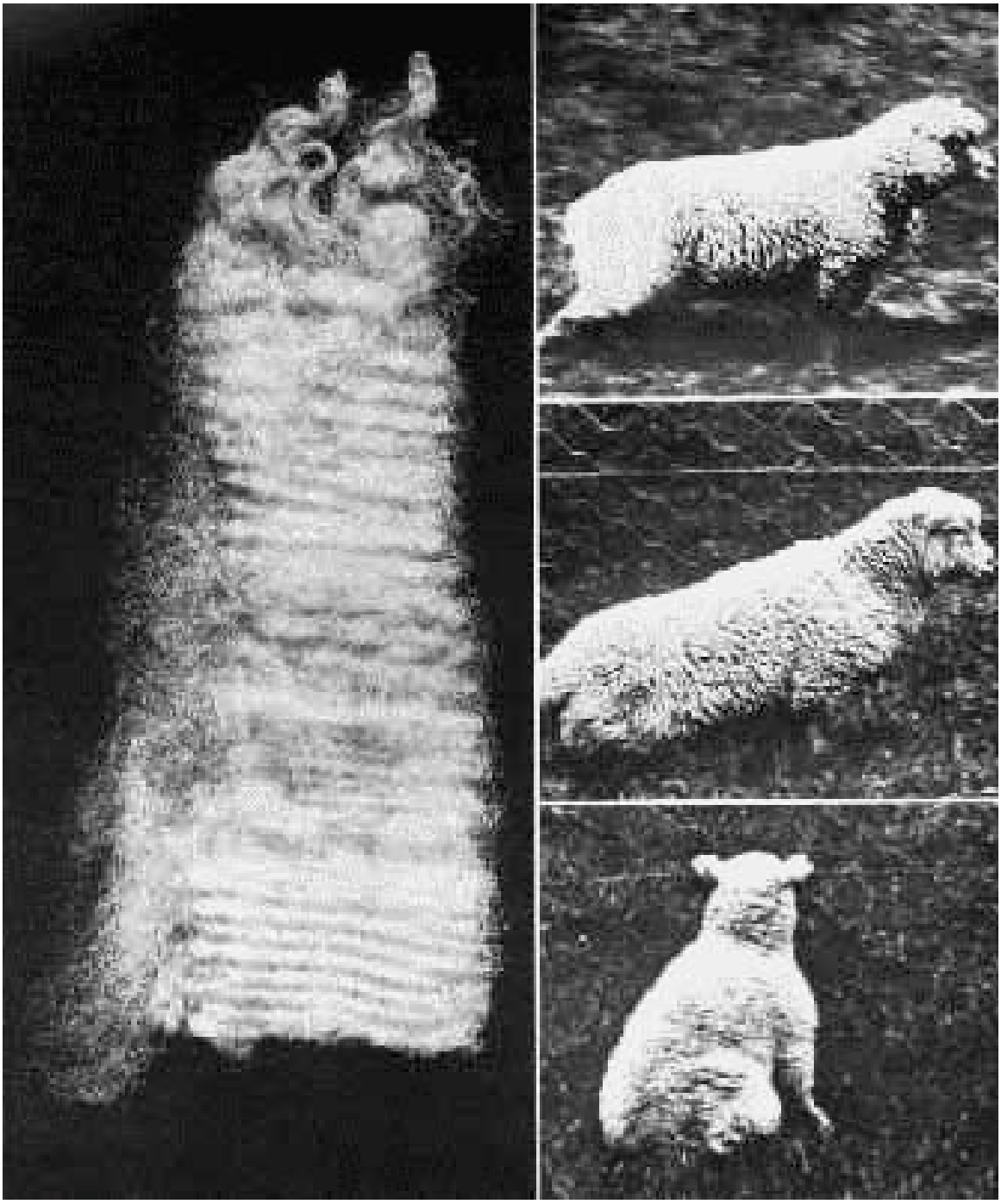
Among the methods of correcting a copper deficiency in livestock is firstly to rectify a soil deficiency by spraying or spreading copper sulphate or other copper compounds. In copper

deficiency trials in England calves, from a pasture sprayed during the summer with 5 kilograms of copper sulphate in 1000 litres of water per hectare, had an average weight of 573 kilograms at 30 months compared with an average of only 433 kilograms by the group of calves on the untreated copper deficient pasture. In Australia and New Zealand 'swayback' in lambs is being prevented by top dressing copper deficient pastures, with 5 to 10 kilograms of copper sulphate per hectare, some time before lambing begins.

Other methods include treatment of the animal by injecting with an organic copper salt, drenching periodically with copper sulphate; incorporating copper sulphate in salt and other mineral licks, or by what is probably the most general and satisfactory method, incorporating copper sulphate along with other minerals and vitamins in the form of carefully blended supplements in the feeding stuffs. Today concentrates fed to a large percentage of livestock, particularly in the more progressive countries of the world, contain some added copper as an insurance against an insufficiency of the element in animals' diets.



A comparison of calves of similar age, showing the effect of copper deficiency



Copper deficiency in sheep

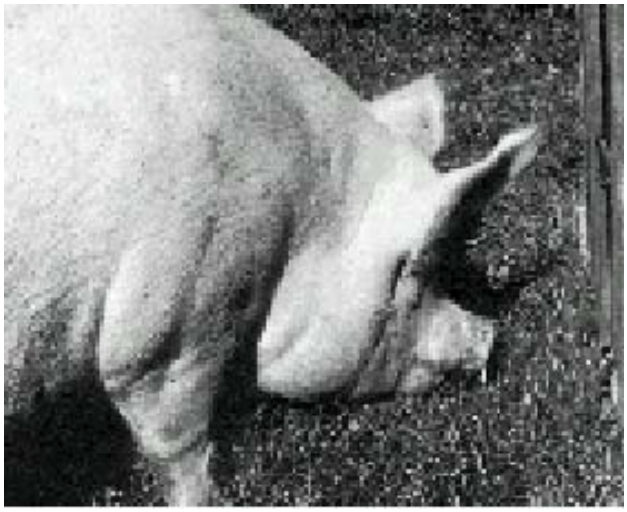
Left: Straight 'steely" wool from a copper deficient sheep
Right: Swayback (enzootic ataxia) in a copper deficient lamb

Copper as a growth stimulant for pigs

An observation in the 1940s by Dr R Braude of Reading University that pigs in a newly erected piggery were licking certain copper fittings, led to the important discovery that copper had growth promoting properties. Braude frequently saw the pigs fighting for access to the copper rings which had been fitted in place of steel to prevent rusting. After a year no rings were left - they had simply been licked away. To prove that the pigs actually craved for copper, small plates of six different metals (aluminium, brass, copper, magnesium, nickel and tin) all painted alike, were next placed in the pens.

The pigs soon uncovered first the copper and then the brass (copper-zinc alloy) plates, leaving the others untouched.

Braude next replaced the metal plates with six mineral salt licks, to which he respectively added copper, cobalt, manganese, nickel, tin, and zinc as fine powder, but again the pigs were only interested in the lick containing copper. Pigs were next given the choice of two identical diets except that one contained added copper sulphate. Here, yet again, the pigs preferred the meal which contained the copper supplement and consumed about four times as much of it as of the 'no-copper' meal.



Pigs thrive on a copper-fortified diet - In a test involving six different metals, pigs quickly uncovered copper, followed by brass and systematically ignored the other metals

Ever since Braude's discovery that pigs craved for copper, scientists all over the globe have been experimenting with the feeding of copper sulphate to growing pigs. Carefully controlled trials in a number of countries over the past two decades have now firmly established that the inclusion of 250 ppm copper, i.e. 0.1% or 1000 ppm copper sulphate (copper sulphate contains 25.0% copper), in the diet of fattening pigs may be expected to produce, on average, an increased growth rate of around 100% with an improvement in feed conversion of nearly 8.0%. Looked at another way 1 kilogram of copper sulphate put into one metric ton of meal can result in pigs reaching bacon weight nearly two weeks earlier, with a saving of approximately 25 kilograms of meal. This means that for the expenditure of from £0.05 to £0.10 for 300 grams of copper sulphate, it is possible to save up to £0.75 on the feeding cost of a bacon pig. Today many, many millions of pigs all over the world are being fed from weaning to slaughter on copper sulphate fortified diets.

How does copper sulphate promote growth?

Although several hypotheses have been advanced, the precise manner in which copper stimulates growth in pigs has not yet fully been established. It is of course known that copper has a role in haemoglobin formation and is essential for the proper functioning of certain enzymes but the copper requirements for these purposes are thought not to be much in excess of 10 ppm copper in the diet.

One explanation, for the growth promoting effects of feeding high levels of copper to pigs, is that it is due to the anthelmintic properties of copper and it has been suggested that growth is stimulated simply by the copper sulphate, which has long been known as a most efficient vermifuge, controlling the round worms.

Another explanation is that the response to copper is due to the action of copper sulphate on the micro-flora in the digestive tract in a manner similar to antibiotics.

Yet another explanation is that the copper sulphate reacts with the toxic hydrogen sulphide produced in the intestines by certain micro-organisms, thereby promoting growth by removing the poison as insoluble copper sulphide.

Whether the real explanation is a combination of all the above prognoses or whether there is a totally different mode of action, the fact remains that the feeding of high levels of copper sulphate stimulates appetite and results in faster growth and better feed conversion.

Copper sulphate v antibiotics

In recent years many trials have been conducted to compare the separate effects of copper and antibiotics as growth promoters for pigs. The results, in the large majority of trials, have shown copper sulphate to give by far the better response. This coupled with the fact that the cost of copper supplementation is only a fraction of that of antibiotics, has made copper sulphate the more favoured choice as growth promoter. Consideration must also be given to the possible long term effects, on health, of feeding antibiotics.

Feed levels for pigs

Copper sulphate has over the years shown, by its consistent effect on growth rate gain and feed conversion, that it is a most reliable growth promoter for pigs when fed at the rate of around 1 kilogram per 1000 kilograms of meal.

Several levels of copper sulphate feeding have been tried, the concentrations varying from 125 ppm copper to 500 ppm copper and higher. At the 125 ppm copper level the response obtained has generally only been about half that obtained at the 250 ppm copper level. At the 375 ppm level the response has, on the whole, been a little lower than at the 250 ppm copper level, which is now universally accepted as the best concentration to employ having regard to safety and other factors. Hundreds of trials have been done with copper sulphate at the 250 ppm copper level over the past 20 years and many millions of pigs have been fed with it since, with considerable economic benefit to the farmer.

Safety precautions

Only when the pig's diet is very low in iron and zinc and very high in calcium, is there any danger of copper toxicity developing. A high level of calcium in the basal diet will induce zinc deficiency, which in turn, along with a deficiency of iron, favours the development of copper toxicity. Where this occurs, correcting these factors will greatly extend the safety of copper supplementation. Experiments at the Rowett Research Institute, Aberdeen, have shown that,

while in the absence of iron and zinc supplements 425 ppm copper produced copper toxicity symptoms, the simultaneous addition of iron and zinc eliminated all signs of toxicity.

Under normal conditions, toxic symptoms generally only begin manifesting themselves at levels of around 500 ppm copper. There is thus a fairly wide margin for errors, to meet most mixing conditions. Further, copper sulphate has a bitter taste and pigs will tend to refuse a meal containing a toxic dose. Copper sulphate has thus a sort of automatic safety device against gross overdosing through errors in mixing.

Whereas fattening pigs thrive on as much as 250 ppm copper in their diet, other animals, if fed on such high levels of copper for any length of time, may conceivably be poisoned. Care must therefore be taken to ensure that other livestock, especially sheep, do not have access to such a high copper containing diet. Care must also be taken to ensure that the copper sulphate is adequately mixed with the feed, so that each animal receives the intended proportion of copper sulphate in its diet.

Plant Nutrition

How to grow two ears of corn where one grew before is a problem that is with us all the time. Copper can help towards increasing yields and raising the productivity of the land, to keep pace with the rise in population.

Over a century ago attention was first focussed on what we now know as the major plant nutrients - nitrogen (N) phosphates (P) and potash (K). It was not until many decades later, as improved analytical methods became available, that it was realised that, in addition to NPK, numerous other micro or trace elements are just as essential to the growth and well being of plants - a deficiency of any one element acting as a limiting factor.

Copper, an essential trace element

When land was plentiful and the demand for food was not as great as it is at present, only the most fertile soils were cultivated. The increasing world population has necessitated the utilisation of more and more of the less productive lands. The role that traces of copper have to play in raising the fertility of such soils is only now beginning to manifest itself. In many countries marginal land, thought at one time unsuitable for growing crops or maintaining livestock, is being converted into rich fertile farm land, by the addition of but a few pence worth of copper sulphate per hectare.

A classic example of thus comes from Australia, where the ‘ninety mile desert’, before it was transformed from barrenness to fertility with just a few kilograms per hectare of copper sulphate together with other nutrients, barely carried one sheep per four hectares, today is carrying five sheep to each hectare and the productive value of the land has risen from £1.00 to over £20.00 per hectare per annum.

Replacement of copper in the soil

In Britain the bringing under the plough of poor marginal land during and since the war, the extensive employment of NPK fertiliser to boost yields, the discontinuation of copper seed dressings and a reduction in the use of copper containing fungicides are all undoubtedly contributing to an insufficiency of available copper. There are now distinct signs that the bumper crop yields, being taken off the land by an ever increasing use of nitrogenous fertilisers which contain no copper, are beginning to exhaust the soil of its reserves of readily available copper.

In the days before artificial fertilisers, when farmers had to depend entirely on farm yard manure (FYM), there was a closed cycle returning part at least of the copper taken up by the crop. Whereas a rotational dressing of about 40 metric tons of FYM per hectare may be expected to replace as much copper as is removed by the crops, the NPK fertilisers supply no worthwhile quantities.

The total copper content in British soils is within the range of from 2 to 100 ppm copper, which represents about from 5 to 250 kilograms of copper per hectare in the top 300 millimetres of soil. Arable crops remove each year, on average, about 80 grams of copper per hectare from normal soils. It might therefore at first sight appear that there are sufficient reserves of copper in British soils for more than from 50 to 2500 years. Unfortunately, there is at present no certain method of ascertaining what proportion of the total amount of copper present in a soil will be in a form available to the crops, or, more important, how much will be available at the time it is needed. There is thus a sound logical basis for generally advocating putting back into the soil whatever copper is removed annually by the crop, even on those soils well endowed with total copper. This could probably best be done by fertiliser manufacturers incorporating the copper in their nitrogenous fertilisers, especially as it is well known that there is an interaction between nitrogen and copper - heavy dressings of nitrogenous fertilisers can depress yields in the absence of available copper; nitrogen gives increased yields only so long as there is an adequate supply of copper available.

Symptoms of copper deficiency in plants

The minimum copper requirements of plants appears to vary with each species and even within varieties of the same species. Deficiency symptoms only become apparent when the deficiency is very acute. Generally, long before any visible signs appear, crop yields will have dropped to such an extent that the land will have been labelled as being unsuitable for growing a particular variety or species of plant.

The reproductive stage of the plant's growth is generally the first to be affected by an insufficiency of copper. Characteristic symptoms in cereals, which usually grow normally until they are about 150 millimetres high, are stunted growth, withering of the tips with a spiral formation of some of the leaves and the flowers failing to fertilise resulting in many of the ears remaining unfilled. Grasses from copper deficient pastures have a lower protein content and are not as palatable to livestock as grasses from pastures with an adequate amount of copper. Beans and peas are stunted, paler in colour and produce underdeveloped seeds. Spinach grows normally for a few weeks, after which the outer leaves develop yellowish-white patches and shrivel up. Carrots make normal growth for the first few weeks after which little further growth takes place - the plant remains stunted and no carrot is formed. Maize grows to a height of only about one metre, the outer leaves have a marked yellowish-white striping and the cobs fail to produce any seed at all or are only partly filled. Fruit trees grown in copper deficient soils may develop a marginal chlorosis of the tips of the young leaves, which wither and drop off, followed by the dieback of the shoot, the bark becomes loose and the capacity of the tree to fruit is decreased. There may also be excessive gumming with stone fruits.

Symptoms of copper deficiency in maize

Preventative measures

Although our knowledge of the extent of the problem is still far from complete, it appears that clay soils are generally sufficiently endowed with copper. A deficiency of the element is normally found on peat, in soils of high humus content, on very sandy soils with a low humus content, and also on heath, scrub or moor land. Crops, grown on any of these types of soil, which in the presence of adequate water fail to respond to the major NPK nutrients, should be suspected as being deficient in available copper. This, of course, does not mean that the factor limiting plant growth will necessarily always be found to be copper. Indeed it may well be any one or a combination of the trace elements, such as boron, magnesium, manganese, molybdenum, zinc, copper, etc.

Experimental techniques are now available for supplying all the major and trace nutrients, except the one to be tested, thus making it possible to assess which particular nutrients are lacking in the soil. A simple, rough and ready test of the availability of copper in a soil, is to apply small amounts of copper sulphate, in strips about 5 metres wide across the field, along with the normal NPK fertilisers and observe the effect on suitable indicator plants such as oats, maize, spinach, carrots, etc.

Correcting copper deficiency

Although there is undoubtedly a fairly big margin of safety, the indiscriminate addition of copper to soils is to be deprecated for, as with lime, nitrogen or any other plant nutrient, a gross excess will have the opposite effect of that desired. Where copper deficiency has been confirmed either by soil analysis or field diagnosis, it can be corrected by applying 50 kilograms of copper sulphate per hectare in the form of fertiliser before sowing or by spraying the foilage

of the cereal plants, when they are between 150 and 200 millimetres high, with 750 grams of copper sulphate (dissolved in from 400 to 2000 litres of water) per hectare or 2 kilograms of copper oxychloride or other copper fungicide (in an appropriate amount of water) per hectare. The soil application has generally given the best results and has the advantage that it will persist for 10 years or more. The foliar application has to be given to each crop.

The world-wide problem of copper deficiency in soil

An inadequate amount of copper in the soil has been traced to be the cause of the failure to grow good crops on a wide range of soils all over the globe:

Australia

In this country, which probably suffers most from a lack of available copper, thousands of tons of copper sulphate and other copper compounds are currently being used to make good some of the shortfall. Some years ago an eminent authority estimated that around 150 million hectares of land in the better rainfall areas could be made productive if trace element deficiences, which include copper, could be made good and that if the full potentiality of Australia were developed by this means, the number of livestock could be doubled.

New Zealand

Hundreds of tons of copper sulphate are being employed each year to maintain the fertility of a large acreage of copper deficient peat land where outstanding results have been obtained. In one trial, on a very acid deep peat, a top dressing of 5 kilograms of copper sulphate per hectare gave a 100.0% increase in pasture growth and produced a vigorous sward of rye grass and white clover. Crops of maize, turnips, carrots, spinach, and broad beans grown on peat, to which 70 kilograms of copper sulphate per hectare had been applied as a fertiliser before planting, have also shown outstanding improvement.

United States of America

Copper deficiency was first observed in 1927 on the raw peat soils of the Florida Everglades. Very substantial quantities of copper sulphate are annually distributed by manufacturers of fertilisers and magnificent responses have been obtained from the inclusion of this trace nutrient in fertiliser mixtures in the copper deficient areas.

From Connecticut it is reported that the addition of 20 kilograms of copper sulphate per hectare, along with the usual fertiliser application, to tobacco fields increased the yields by 175 kilograms per hectare, without any adverse effect on the tobacco's burning qualities. Copper deficiency of tung has been reported from the northern peninsula area of Florida. The addition of half a kilogram of copper sulphate per tree or spraying the foliage with Bordeaux mixture corrected the deficiency.

India

Some soils in the Bombay State have responded well to copper. As little as one kilogram of copper sulphate per hectare, applied to the soil in which rice seedlings were grown prior to transplanting, substantially improved the final yield of grain. In southern India the addition of from 5 to 10 kilograms of copper sulphate per hectare, along with the usual fertilisers, considerably increased the yield of rice. A gain, of as much as 800 kilograms per hectare over the control, has been recorded.

Egypt

The suspension of a bag, containing 5 kilograms of copper sulphate per hectare, in the water at the intake of an irrigation channel to control algae scums was observed also to have a marked stimulating effect on the growth of the rice.

South Africa

Fifteen kilograms of copper sulphate per hectare with 155 kilograms of a standard NPK fertiliser has substantially enhanced yields of wheat in the copper deficient coastal belt. The application of 50 kilograms of copper sulphate per hectare to the soil or 300 litres per hectare of a 0.4% solution of copper sulphate sprayed on to young sugar cane plants, greatly improved their appearance and within three months after treatment they were 600 millimetres taller than the untreated plants.

Kenya

Copper deficiency has been diagnosed in the Rift Valley in soils containing less than 3 ppm available copper by analysis with "aspergillus niger" and wheat in such soils responded to copper sulphate applications.

Denmark, Germany and Holland

'Yellow tip' or 'reclamation disease' which affects cereals, sugar beet and leguminous crops has been traced to a deficiency of copper. It is controlled by the application of from 25 to 50 kilograms of copper sulphate per hectare. Copper containing slags are also extensively used.

France

Copper deficiency has been found in the organic granite soils in Brittany, in sandstone soils in lower Normandy and in the sands in the Landes. Soil dressings of from 25 to 50 kilograms of copper sulphate per hectare have been employed successfully to improve the yield and quality of cereals, peas, red clover, sugar beet and maize.

United Kingdom

Copper deficiency was first identified during the late 1940's on the sandy reclaimed acid heathlands of Norfolk and eastern Suffolk and on the peaty Fen soils of Cambridgeshire, the Isle of Ely and Huntingdonshire. Later it was found on the recently ploughed shallow black soils overlying chalk in the south of England and also in the light textured soils overlying old red sandstone in north eastern England and southern areas of Scotland as well as on the acid sandy soils and peaty soils in Ireland. In Scotland it has been found that cereals, growing on soils with less than 1 ppm EDTA extractable copper, generally respond to the application of copper sulphate either as a soil dressing or as a foliar spray. Each year more and more lands deficient in copper are being discovered. It has been estimated that in East Anglia alone an extra income of at least £250,000.00 per annum could accrue to the farmers there by the use of copper where it is needed.

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