ROLE OF SULPHUR IN COCONUT NUTRITION

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From the time of Justus von Leibig (1840) sulphur has been known to be an essential element for plant and animal growth. It is a well known constituent of amino acids such as cystine, cysteine and methionine; and the vitamins such as thiamine, biotin and co-enzyme A. Sulphur is also an important constituent of penicillin and gliotoxin. It is present in the volatile form as glucosides in mustard oil, allyl and vinyl sulphides and the mercaptans. It is a constituent of certain enzymes and is concerned in the radox system in the process of respiration and in the activation of ferments. It is essential for the conversion of the atmospheric nitrogen fixed by the root nodules of legumes into protein nitrogen.

Sulphur not only affects the yield of agricultural crops but also the biological value of crop yields. The importance of sulphur-containing amino acids in the human and non-ruminant animal nutrition is well known. The lack of sulphur containing amino acids is reported to be the factor that limits the biological value of proteins. Studies conducted on the nutritional value of food from various sources and countries have indicated that the sulphur containing amino acids are more important than the lysine content of proteinaceous foods. Further it is reported that a large segment of the world's population is living on a diet that is strongly deficient in methionine.

The earth's crust contains about 0.06 per cent of sulphur. It is present in soils in both organic and inorganic forms and the total sulphur of field soils ranges from 0.01 to 0.20 per cent. In the inorganic forms it is mainly present as sulphides and sulphates. In arid and semi-arid soils most of the total sulphur is present as sulphates of calcium, magnesium, potassium and sodium while in humid region soils the organic forms of sulphur constitute 80 to 90 per cent of the total sulphur. The inorganic forms of humid region soils are mainly the sulphides of metals like iron, zinc, copper and cobalt and varying amounts of gypsum and epsom salts. It may be remembered in this connection that sulphate is one of the most abundant ions present in sea water. The original source of sulphur was the sulphides of metals present in the plutonic rocks. During the weathering of these rocks, the sulphides were oxidised and released as sulphates. Part of the released sulphates found their way to the sea in drainage waters.

An important source of soil sulphur is the atmosphere. The combustion of fossil fuels, especially coal, and other sulphur containing products around centres of industrial activity, the burning of coal in the railroad industry and that of wood and coal for domestic heating release considerable amounts of sulphur dioxide and other gaseous sulphur compounds into the atmosphere. Near sea shores salt spray adds sulphur in significant quantities into the atmosphere. Further contributions of sulphur to the atmosphere come from volcanoes, sulphur springs and bogs. However, the content of sulphur in the atmosphere is often directly related to the distance from industrial centres. Part of the atmospheric sulphur is absorbed directly by growing plants which is utilised by the plant in its normal metabolic processes. It is not surprising to know that, if the soil sulphur is low, most of the sulphur requirement of the plant can be met from the atmospheric sulphur provided the atmospheric content is high. At the same time too high a concentration of atmospheric sulphur may even cause injury to plants. The sulphur dioxide and other gaseous sulphur compounds also pass into the soil by diffusion, but the major portion of the atmospheric sulphur is brought down by precipitation. It has been reported that the quantity of sulphur brought down by rain from the atmosphere varies from as low as 1 lb/acre per year in areas far off from industrial centres to more than 100 lb/acre per year near areas of high industrial activity. Sulphur deficiency can usually occur where the amount of sulphur in rain water is very low amounting to less than 10 lb. per acre per year.

Sulphur is also added to soil as an incidental component of commercial fertilizers like ammonium sulphate, superphosphate and sulphate of potash, and also as organic residues. The plant nutrient contents of some common sulphur containing fertilizer materials are given in the following table (Bixby *et al* 1964).

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Fertilizer materials	Plant nutrient content (%)			
	S	N	P_2O_5	K_2O
1. Ammonium sulphate	24.2	21.00	..	..
2. Ammonium nitrate—Sulphate	5.0	30.00	..	..
3. 'Ammo-Phos B'	15.0	16.5	20.0	..
4. Basic Slag (Thomas)	3.0	..	15.6	..
5. Gypsum (hydrated)	18.6	..	..	..
6. Magnesium Sulphate (Epsom salt)	13.0	..	..	..
7. Sulphate of potash	17.6	..	..	50.0
8. Superphosphate —normal	13.9	..	20.0	..

Adequate attention has not been given so far to sulphur as a nutrient in fertilizer treatment. This is probably due to the fact that the sulphur requirement of the crops has largely been satisfied by incidental means, especially in areas near industrial centres. But in recent years the use of sulphur-free fertilizers like urea, rock phosphate and muriate of potash has limited the addition of sulphur in the soil as an incidental component. The soil reserves of sulphur are not great enough to stand the drain of intensive cultivation over a long period of time especially in areas of high rainfall where the leaching loss of sulphates is considerable. Prolonged use of sulphur-free fertilizers will eventually induce sulphur deficiency in crops. Moreover, the production of high yielding crops will further aggrevate the deficiency of sulphur.

The amount of sulphur in plants varies in different genera and families, usually ranging from 0.1 to 1.0 per cent on a dry weight basis. It is removed in amounts similar to phosphorus, but certain crops are known as high sulphur consumers. These include sugar beet, cabbage, clover, onion, and cotton which commonly remove 15 to 40 lb. per acre per year. In general, legumes will have higher sulphur requirement than cereal crops.

The well-known sulphur deficiency disease in plants is the 'yellows' disease of tea (Storey and Leach, 1933). Under field conditions sulphur deficiency has also been reported in tobacco, sugarcane, soybean, citrus, subterranean clover and coconut. Sulphur, like calcium, is regarded as being relatively immobile in the plant system and under deficient conditions, there is little or no apparent translocation of this element from older to younger tissues resulting in the appearance of deficiency symptoms for the most part on the younger tissues. The sulphur deficiency symptoms resemble those of nitrogen deficiency. These symptoms include reduced vegetative growth, general paling and development of orange, red or purple pigments. Sulphur deficient plants will have an impaired photosynthesis. Since it is a constituent of certain amino acids the protein metabolism is also impaired. A point of difference between sulphur and nitrogen deficiencies is that in sulphur deficient plants the young leaves are usually affected more or before old ones.

Plant roots absorb sulphur almost entirely as the sulphate ion and the concentration of this ion in the soil is important with respect to the sulphur nutrition of a plant. It is also absorbed into the plant through the leaves as sulphur dioxide when this gas is present in the atmosphere. The sulphur present in organic residues is known to have considerable influence on the level of plant available sulphur in soils. Under aerobic conditions, the sulphur present in the organic matter is converted into sulphates by the action of micro-organism. Since most of the sulphates are highly soluble, the leaching losses of sulphates are generally large especially under conditions of heavy rainfall. The leaching losses are still great on coarse-textured soils. The nitrogen to sulphur ratio in soil organic matter is approximately 10:1 and the relative plant requirement of these elements also approximates 10:1. When sufficient quantity of organic matter is turned over to supply the nitrogen needs of a plant, a high proportion of the sulphur need of the plant is also met with incidentally. In extreme cases of sulphur deficiency elemental sulphur may be applied either alone or mixed with ordinary superphosphate. The sulphur is oxidised by certain bacteria and converted into plant available sulphates in the soil. The application of sulphur will eventually lower the soil pH which may be corrected by adequate liming. Elemental sulphur is also used for lowering the pH of alkaline soils.

Sulphur deficiency in coconut was reported recently in many widely scattered areas of Papua and New Guinea by Southern (1969). The main sulphur deficiency symptoms reported were orange yellow leaves, both young and old, and arching and weakening of the rachis followed by necrosis of leaflets. In individual leaflets, chlorosis starts from the tip, but rapidly extends until the whole leaflet including the midrib becomes chlorotic. The number of live fronds becomes fewer. The yield of nuts is reduced in number and the nuts are usually small with normal kernel thickness. On drying the kernel collapses into a thin rubbery copra processing very poor physical and chemical characteristics. It is characterised by a low oil content and a high nitrogen and sugar contents. The oil from rubbery copra had high iodine value and a low saponification value compared to the oil from normal copra. The symptoms are differentiated from those produced by nitrogen deficiency, since the latter does not affect the young leaves unless the deficiency is very severe. The nut size may become small, but they produce normal copra. The condition was corrected by the application of sulphur or sulphur containing fertilizers like ammonium sulphate and sulphate of potash. Southern had recommended the use of 2 lb. of sulphur or sulphur containing fertilisers equivalent to 2 lb. of sulphur per tree, once in two years for conditions existed in Papua and New Guinea. The response was spectacular within six months on the foliage and the copra quality had come to normal 18 months after the application of sulphur. It is obvious that sulphur deficiency may not occur where there has been regular use of sulphur containing fertilizers. It has been suggested by Southern that the sulphate content of nut water and coconut leaves would be a much better index than the total sulphur content. According to Southern 20 ppm of sulphate sulphur in the nut water and 150 ppm of sulphate sulphur in the leaf tissues (9th to 14th frond) are critical, below which sulphur deficiency is likely to occur in the coconut pålm.

Rubbery copra is found in the root (wilt) disease affected areas of Kerala (India). In certain palms in these areas, the nut size is gradually reduced and becomes abnormally small giving a total volume of about 1100 cc when the average total volume of a healthy nut is 2700 cc. The yield is not reduced in number in such palms, but premature nut fall is observed in some cases. The shape of such nuts becomes ovular with curved surface, and the husk becomes soft and thin. The size of the dehusked nut is not reduced much compared to the reduction in the size of the whole nut. The average volume of a dehusked nut from an affected palm is 520 cc while that of a healthy nut is 600 cc. but there is a considerable reduction in the weight of dehusked nut, volume of nut water, thickness of kernel, weight of copra per nut, hardness of copra, hardness of shell and the oil content of copra of the affected nut compared to a healthy nut. The quality of oil is also poor as evidenced by a high acid and iodine values. The kernel formation is quite uneven in the affected nut. This phenomenon is different from that reported by Southern that, in the case of the rubbery copra in Papua and New Guinea, the kernel thickness as well as the overall size of the dehusked and whole nut are normal looking, but on drying the kernel collapses into rubbery copra.

The possible association of sulphur deficiency on the incidence of rubbery copra observed in the root (wilt) disease affected areas of Kerala has been investigated and the result of analysis of soils. leaf tissues, nut waters and copra samples do not indicate any association of sulphur deficiency with this phenomenon. Further, sulphur deficiency does not seem to be an immediate problem for coconuts in the West Coast, but the continued use of sulphur-free fertilizers will eventually lead to a sulphur deficiency condition. Inclusion of any one of the sulphur containing fertilizers in the fertilizer schedule for coconut will be much beneficial in preventing the incidence of sulphur deficiency in coconut.

References

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