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Editorial

Need for Determining the Effects of Sulphur Fertilization on the Amounts of Organic Sulphur Compounds in Plant Foods

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Abstract

A large number of field trials are being conducted in India and across the globe on the yield response and uptake of sulphur (S) in a number of crops and most results show a good yield response. However, none of the studies bring out the effect of S fertilization on S containing amino acids viz. cysteine, methionine and vitamin like Thiamine, which are essential for human life and are to be obtained only from plant foods. It is due to lack of awareness and also poor infrastructures in terms of biochemical analysis of the agricultural produce in most of the developing countries including India. Therefore, there is an urgent need to establish food quality analysis laboratories in the leading institutes of the country for initiating analysis of plant foods for S-containing organic compounds

Keywords: Sulphur compounds, S-containing amino acids, S-fertilization

1. Description

Human body mainly consists of flesh (mostly proteins) and bones. These are produced from the food they consume, the major constituents being carbohydrates and fat (made up of C, H and O) for providing energy for every day work and proteins (made up of C, H, O, N and S). Thus, proteins differ from carbohydrates and fats in that they contain N and S. Carbohydrates, fats and proteins are obtained from plant foods. Proteins are also obtained from animal food, but the animals, in turn obtain these from plants. Thus, plants must be adequately fertilized with N, P and S in addition to other essential plant nutrients (K, Ca, Mg, Zn, Fe, Mn, B and Ni). Plants have the capacity to produce carbohydrates, fats and proteins using chemical elements from soil or applied fertilizer and manure and obtaining C, H and O from CO_2 in air and soil water. Until about 19th century, plants were supplied with the essential nutrients by manure made up of plant residues and animal excreta. The first N fertilizer to be discovered was sodium nitrate, also known as Chilean nitrate in South America, which existed as deposits near sea shores. The first shipment of Peruvian saltpeter to Europe arrived in England in 1820 or 1825. The first phosphate fertilizer was patented by Lawes and Gilbert in England in 1842, while the first K deposits were discovered in Germany in 1856. Ammonia synthesis, which is the base of most nitrogen fertilizers now, was developed by Fritz Haber in Germany in the second decade of 20th century (Prasad, 1998).

In India, the first fertilizer made was superphosphate in 1906 at Ranipet

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in Tamil Nadu, followed by manufacture of ammonium sulphate at Jamshedpur in Jharkhand in 1933. In 1959 urea was produced at Sindri in Bihar (Tandon, 2014). In 1947 when India gained its freedom and sufficiency in food production was the top priority of the Government of India, it was realized that fertilizer application was an important way to gain this. In 1950 a series of on-farm trials were conducted under Simple Fertilizer Trials Scheme on the recommendation of Dr. A.B. Stewart of Macauley Institute of Soil Science, Scotland. However with the then varieties of rice and wheat, even 60 kg N ha^{-1} was not economical. Real consumption of fertilizer started with the introduction of dwarf high yielding varieties of Mexican wheat. These varieties needed more than 100 kg N ha^{-1} and responses to P and K were also recorded (Mahapatra and Prasad, 1970). Concomitant with this development, fertilizer industry started production of high analysis fertilizers. In 1974, a plant at Udyogmandal, Gujarat started producing Di-ammonium phosphate (DAP 18–46–0). DAP now is responsible for about two-thirds of total P consumed in India and of 10% of N consumed in India. This is ideally suitable for pulses as per fertilizer recommendations for them as well as for basal fertilizer application in cereals. Urea production also increased in the country. A number of NPK complex fertilizers were later added to the list. These high analysis fertilizers were good for the crops and increased fertilizer consumption in the country. However, like single super phosphate and ammonium sulphate, they did not contain sulphur. With high yields of crops and spread of multiple cropping systems, such as, rice–wheat (Prasad, 2005) sulphur depletion of soils occurred and today nearly half of the cultivated area in the country is affected by sulphur deficiency. Sulphur deficiency was first reported in rice by Aiyar (1946) followed by in groundnut by Kanwar (1963) from Indian soils. After this, trials with S fertilizers were started, which gained impetus with the initiative of TSI (The Sulfur Institute of USA) programme. A large number of trials on the farmers' fields were conducted with several crops during 1997–2006 (Tewatia et al., 2014) and a good response to S application was reported by Aulakh and Pasricha (1997), Singh (2001), Maity and Giri (2003), Tandon (2011), Prasad et al. (2014), Shivay et al. (2014) and Tewatia et al. (2014). The response (kg grain increased kg^{-1} S) was in the order: cereals > oilseeds > pulses. In term of returns on S fertilization oilseeds was the best responsive amongst above all crops. But for the oil content in oilseeds crops, none of the researchers provided information on quality of crops, hence the present editorial highlight its need. However, in view of world-wide spread of Fe and Zn deficiency and agronomic effects to fortify cereal grains with these nutrients (Prasad et al., 2014). Shivay et al. (2016) pointed out that S fertilization increased Fe, Zn, Mn and Cu concentration in wheat. There are no reports from India on the effect of S fertilization on organic S components in plant foods.

2. Organic S Components in Plant Foods

Sulphur is a constituent of some amino acids and vitamins. It is also a constituent of some important metabolites (Prasad, 2014). These are discussed briefly.

3. Amino Acids

There are two S-containing amino acids, namely, methionine and cysteine. Methionine is an essential amino acid and human body cannot synthesize it. Therefore, it must be obtained from plant food. Beans, soybean and sesame seeds in plant food and eggs are good sources of methionine. Methionine helps in lowering damage to lever leading to lever cirrhosis due to excess alcohol intake. It is also effective in reducing Parkinson's disease and acute pancreatitis (Uden et al., 1990).

An important metabolite of methionine is SAMe, which is involved in many metabolic processes in human body. Deficiency of SAMe can lead to depression (Kagan et al., 1990). In plants methionine is the precursor of ethylene, which is responsible for ripening in fruits, such as, apple, pear, peach, mango, banana, and avocado. Jarvan et al. (2008) from Ethiopia reported that an application of 10 kg S ha^{-1} with 100 kg N ha^{-1} increased methionine content from 1.26 to 1.98 g kg^{-1} in wheat grain.

The other S-containing amino acid is cysteine, which can be synthesized by human body. A derivative of cysteine is acetylcystein or N-acetylcysteine, which is an essential medicine needed in a basic health system (WHO, 2013). It is used for the treatment of excess intake of paracetamol (Green et al., 2013) and as a mucous loosener in bronchitis, pneumonia and tuberulosis (Poole and Black, 2001). The promise of N-acetylcystein in neuropsychiatry is also reported (Berk, 2013). RDA for SAAs (methionine + cysteine) is 13 mg kg^{-1} body eight in adults; the requirement is much higher (58 mg kg^{-1}) in infants of 3–4 months (Parcell, 2002). Thus, an adult of 50 kg weight will require 650 mg of SAAs every day.

4. Vitamins

Sulphur is a constituent of thiamin (vitamin B1) and biotin (vitamin H). Thiamin is an essential vitamin and human body cannot synthesize it. Plant foods are the only source of thiamin. Cereal grains are an important source of thiamin. Thiamin deficiency leads to *beriberi* disease and also to bilateral visual loss (Shills et al., 2006). RDA for thiamin is 1.4 mg kg^{-1} day^{-1}. Biotin is involved in the synthesis of fatty acids. In humans intestinal bacteria can synthesize it and therefore there is no RDA for biotin. Green leafy vegetables are a good source of biotin. Järvan et al. (2008) reported that an application of 10 kg S ha^{-1} with 100 kg N ha^{-1} increased it from 2.23 g to 2.91 kg^{-1} grain in wheat.

5. Metabolites

Sulphur is also associated with several metabolites in plants. The important ones are: i) Glutathione (GSH) an antioxidant in animals and plants involved in the destruction of cells caused by reactive oxygen (Pompella et al., 2003), ii) Glucosinolates (GSLs) present in brassicas, such as rapeseed, mustard,

broccoli, cauliflower and cabbage, which were considered as a problem constituent, but recently they have been reported to be involved in mitigating cancer (Das and Tyagi, 2000), and iii) Alliin, is responsible for producing allicin on cutting of garlic cloves and onion bulbs. Alliin is important, because it produces alliicin, which is anti-bacterial (Block, 1999) and is helpful in reducing cholesterol absorption and in reducing blood pressure (Nijjar et al., 2010). This is why garlic cloves are used in heart problems.

6. Agenda for Action

Hundreds of field experiments are conducted by Agronomists and Soil Scientists each year all over the country to study the effect of S fertilization on yield of crops but no efforts are made to study the effect of S fertilization on useful S organic compounds due to lack of facilities for such analysis as well as awareness of the subject. It is high time that Ministries of Agriculture & Farmers' Welfare and Food and Consumers Affairs should take serious steps to develop food technology laboratories at least in top agricultural institutes, such as, Indian Agricultural Research Institute at New Delhi, National Dairy Research Institute, Karnal and at some leading agricultural universities, which will also train future chemists in the analysis of agricultural products for organic compounds responsible for human health. This will also create additional jobs for analytical chemists in the country. Food products labelled with the content of health related organic compounds will also increase their export capability, since most food products sold in USA and other advanced countries carry a food quality label giving the content of important ingredients.

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