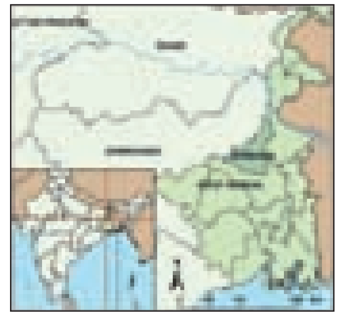
Balancing Sulfur and Magnesium Nutrition for Turmeric and Carrot Grown on Red Lateritic Soil



By P. Bose, D. Sanyal, and K. Majumdar

Increasing rates of S and Mg improved the yield and quality of turmeric and carrot in the depleted red lateritic soils of West Bengal. This trend reversed once the optimum rate of S and Mg application was exceeded, probably due to antagonistic effect of Mg on K uptake.

The deficiency of secondary nutrients, namely S and Mg, is increasing in India. One survey found 240 districts to be generally deficient in S, and the problem is spreading (Sakal et al., 1981; Singh, 1998). A recent effort by the Fertiliser Association of India, The Sulphur Institute, and the International Fertilizer Industry Association (FAI-TSI-IFA) studied 27,000 samples distributed over 12 states and found that over 40% of samples were deficient in available S and another 35% potentially deficient. More than 70% soil samples taken from Uttar Pradesh, Madhya Pradesh, Maharashtra, Orissa, Jharkhand, West Bengal, Andhra Pradesh, and Karnataka were low to medium in available S (Biswas et al., 2004). The main reasons behind such widespread deficiency are over-dependence on "S-free" fertilizers, depletion of soil S with continuous cropping, sizable areas (around 27% of the country's gross cropped area) under pulses and oilseeds that have a higher requirement for S, loss of soil S due to leaching, soil erosion, lack of organic manure addition, and low awareness of farmers towards use and importance of S in agriculture.

Similarly, Mg deficiency can be a problem in India. Cases are found in the acid laterite soils of Kerala, the Malnad area of Karnataka, Nilgiris in Tamil Nadu, certain areas of Andhra Pradesh under cotton, citrus, and banana, in Goa, parts of Himachal Pradesh, the red lateritic zone of West Bengal and throughout the northeastern region of India. Magnesium can be leached more easily compared to Ca, making acid, sandy soils particularly vulnerable to Mg deficiency. The deficiency also becomes severe under intensive cultivation. With heavy use of NPK fertilizers and manures, sometimes a depressing effect of K application on yield is the result of Mg deficiency. While possibly not a problem at low yields, Mg deficiency can become a problem at high yield levels, as in the case of tea estates in southern India (Verma, 1993). The Mg content of soils depends upon the nature of the parent material, the degree of weathering, soil texture, rainfall, intensity of cropping, and management practices. Magnesium deficiency is actually more widespread than is realized due to inadequate scientific data about the effect of applications of Mg fertilizers on crops, particularly in India.

Birbhum district of West Bengal is located within the leached red and lateritic soil belt and has wide-spread N, P, K, S, and Mg deficiencies. The agro-climatic conditions in Birbhum are highly suited for cultivation of carrot and turmeric, but its soils require careful nutrient management for optimum yield. Two experiments were undertaken to study the effect of soil test based fertilizer application, with special reference to S and Mg, on growth, yield, and quality of carrot (cv. Early Nantes) and turmeric (cv. Lakadong, Shillong).

Inspecting the turmeric experimental plot are, from left, Dr. Majumdar, Mr. Bose, and Mr. Roy, the cooperating farmer.

Turmeric (*Curcuma longa)* is a herbaceous, rhizomatous spice crop, native to tropical Southeast Asia. India is the largest producer of turmeric in the world, with 75% of world output. Turmeric is a heavy nutrient using crop and responds well to fertilizer application. Carrot (*Daucus carota* L.) is one of the major vegetable crops of India. It is grown in the spring-summer season in temperate regions and during winter in tropical and subtropical parts of the world.

Both the experiments were laid out in a randomized block design with seven treatments and three replications. In the case of turmeric the plot size was 7.0 m x 5.0 m, while for carrot the plot size was 3.5 m x 3.0 m. Uniform cultural practices and plant protection measures were undertaken for all the treatments. Randomly collected soil samples (0 to 15 cm depth) were analyzed and yield target-based recommendations were developed following Agro Services International, Inc. analytical methods (Portch and Hunter, 2002).

All the plots in the turmeric experiment received 150 kg/ha N and 50 kg/ha P_2O_5 and 190 kg K_2O/ha on the basis of soil test values. For carrot, a constant level of 80 kg/ha N and 50 kg P_2O_5/ha and 120 kg K_2O/ha were applied to all the plots on the basis of soil test values. Variable rates of S (0 to 66 kg/ha) and Mg (0 to 33 kg/ha) constituted the seven treatments for both the crops (**Table 1**). No S and Mg were applied in the control plots.

Turmeric received the full dose of P during land preparation while half the N and K were applied one month after transplanting. The remaining N and K were applied 4 months after transplanting. Sulfur and Mg were applied in two equal

Abbreviations and notes for this article: N = nitrogen, P = phosphorus, K = potassium, Mg = magnesium, S = sulfur, Ca = calcium.

Table 1. Turmeric rhizome characteristics as influenced by different levels of S and Mg treatments.

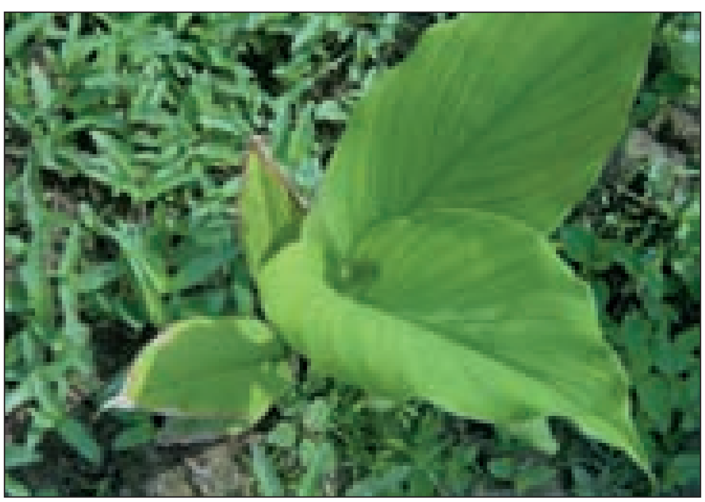
Treatments	No. of mother rhizome/plant	Weight of mother rhizome, g	No. of primary fingers	Length of primary finger, cm	Weight of primary finger, g
S_0Mg_0#	4.3	66.9	9.3	4.8	72.2
$S_{11}Mg_{5.5}$	4.7	69.2	15.7	4.8	108.0
$S_{22}Mg_{11}$	4.7	74.9	17.3	5.0	109.7
$S_{33}Mg_{16.5}$	5.0	76.1	18.7	5.1	126.4
$S_{44}Mg_{22}$	5.3	150.3	24.0	5.7	204.1
$S_{55}Mg_{27.5}$	4.7	138.7	21.3	5.4	202.9
$S_{66}Mg_{33}$	4.3	119.3	20.0	5.4	200.1
C.D. (at 5 %)*	NS	30.1	NS	NS	39.4

values in subscripts are applied rates of S and Mg in kg/ha; * NS – not significantly different.

splits at one and four months after transplanting. The full dose of P, half N and half K were applied to carrot at land preparation. The remaining N and K were applied one month after transplanting. Sulfur and Mg were applied in two equal splits at land preparation and one month after transplanting.

The Total Soluble Solid (TSS) content of carrot was determined with an ERMA hand refractometer, calibrated at 20º C (A.O.A.C, 1984; Mitra and Sanyal, 1990). The data were corrected as per the standard temperature correction table. The values obtained were recorded as ºBrix, which are essentially percent soluble solids present in the extracted juice. Since 90% of soluble solids in the juice are sugar, a high TSS content in carrot suggests better quality. The curcumin content of turmeric was determined following the method as described by Sadashivam and Manikam (1992).

Turmeric—Application of different levels of S and Mg did not have any significant effect on the vegetative growth of the plants. Though maximum number of mother rhizomes and primary fingers, as well as highest length of primary fingers, was noted at 44 kg/ha of S and 22 kg Mg/ha, the effects were not statistically significant (**Table 1**). There was a significant increase in the weight of the mother rhizome at the above dose, which then declined with further increases in S and Mg levels. Significant variation in weight of primary fingers was observed due to S and Mg applications, also peaking with 44 kg S/ha and 22 kg Mg/ha.



Potassium deficiency in tumeric at an early stage in the experimental plot.

Results show that inclusion of S and Mg in the fertilization schedule dramatically improved the fresh yield (**Table 2**). Maximum fresh yield of 26 t/ha was obtained with 44 kg S/ha and 22 kg Mg/ha, along with soil test based N, P, and K application rates. The average yield of dry turmeric in West Bengal is around 1.5 t/ha. Assuming dry yield to be about 20 to 30% of the fresh yield, the maximum dry yield in this study was more than 6 t/ha. No significant effect was found on percent dry weight or curcumin content.

Carrot—Different levels of S and Mg did not have any significant influence on the vegetative parameters of the carrot. No perceptible variation was observed in fresh weight of leaves at different levels of S and Mg application. There was also no significant variation in root characteristics of carrot due to S and Mg application. However, a significant variation in yield per plant as well as projected yield per hectare was noted at various levels of S and Mg application in carrot (**Table 3**). The variety of carrot grown in this experiment has a yield potential of about 15 t/ha under West Bengal conditions, but the average yield in farmers' plots were about 5 to 6 t/ha. The current experiment showed that S and Mg strongly influenced carrot yield, which nearly doubled after addition of the first increment of S and Mg (**Table 3**). Maximum yield of 13.6 t/ha was obtained at 44 kg S and 22 kg Mg/ha, which is probably the optimum rate under the experimental conditions. Any further increase in S and Mg rates caused a sharp decline in yield.

Root and tuber crops exhibit a distinct source-sink competition between vegetative growth and storage tissue growth for a fairly long period. The effects of mineral nutrient supply on crop yield response characteristics are often a reflection of sink limitations imposed by either a deficiency, or an excessive supply, of mineral nutrients during certain critical periods

Table 2. Yield and quality of turmeric as affected by different levels of S and Mg.

Treatments	Fresh yield/plant, g	Fresh yield, t/ha	Dry weight, %	Curcumin, %
S_0Mg_0#	197.1	13.8	23.5	4.8
$S_{11}Mg_{5.5}$	203.1	14.6	26.0	5.1
$S_{22}Mg_{11}$	208.9	14.2	25.4	5.2
$S_{33}Mg_{16.5}$	223.4	15.6	24.7	5.2
$S_{44}Mg_{22}$	369.9	25.9	26.3	6.4
$S_{55}Mg_{27.5}$	351.9	24.6	26.6	6.1
$S_{66}Mg_{33}$	336.4	23.6	23.1	6.1
CD (at 5 %)*	52.4	3.4	NS	NS

values in subscripts are applied rates of S and Mg in kg/ha; * NS – not significantly different.

Table 3. Yield and TSS content of carrot as affected by S and Mg application.

Treatments	Fresh yield/plant, g	Projected fresh yield, t/ha	TSS content, °Brix
S_0Mg_0#	22.9	5.6	9.1
$S_{11}Mg_{5.5}$	41.8	10.1	9.5
$S_{22}Mg_{11}$	46.3	11.3	9.7
$S_{33}Mg_{16.5}$	49.9	12.1	10.3
$S_{44}Mg_{22}$	56.1	13.6	10.7
$S_{55}Mg_{27.5}$	44.4	10.8	11.1
$S_{66}Mg_{33}$	36.3	8.8	11.0
CD (at 5 %)	4.7	1.2	0.2

values in subscripts are applied rates of S and Mg in kg/ha.

of plant development. The current experiment showed that yield of both the crops declined with any further increase of S and Mg rates beyond 44 kg/ha of S and 22 kg/ha of Mg. This could be due to the antagonistic relations between K and Mg. In the literature, the antagonistic effect of K on Mg is widely reported. Potassium induced Mg deficiency in Arabica coffee was reported by Rao (1968) at leaf K levels of 2.48%, Mg levels of 0.21%, and at a K:Mg ratio of 11.8. Reports of antagonistic effects of Mg on K are few. However, Mg-induced K deficiency was observed in coffee by Rao (1968) at 0.4% leaf Mg and 1.2% leaf K level under field conditions with continuous use of dolomite as an amendment along with concurrent foliar sprays of magnesium sulfate. Probably such antagonism was significant in this study at application rates of more than 22 kg/ha of Mg, which reduced K uptake and caused losses in yield. Similar antagonism between Mg and K was found in mature tea experiments at Annamallais, South India (Verma, 1993).

The results of this research clearly show that S and Mg were deficient in the carrot and turmeric crops at this location. However, over application of these nutrients can result in yield declines, demanding that careful attention be paid to the effect of soil test S and Mg levels when determining fertilizer additions. BC

Mr. Bose and Dr. Sanyal are with the Department of CIHAB, Institute of Agriculture, Visva Bharati University, West Bengal, India. Dr. Majumdar is Deputy Director, IPNI-India Program, Kolkata, West Bengal; e-mail: kmajumdar@ipni.net.

Acknowledgment

This research was supported by Mosaic India. The authors also thank the cooperating farmer, Mr. Birendra K. Roy.

References

A.O.A.C. 1984. Association of Official Analytical Chemists, Washington, D.C.

Biswas, B.C., et al. 2004. Fert. News, 49(10), pp. 13-33.

Mitra, S.K. and D. Sanyal. 1990. Gartenbauwissenschaft, 55(2), pp. 83-84.

Portch, S. and A. Hunter. 2002. Special Publication No. 5, PPI/PPIC China Program.

Sadashivam, S. and A. Manikam. 1992. Biochemical Methods for Agricultural Sciences, Wiley Eastern Ltd, New Delhi.

Sakal, R., et al. 1981. Madras Agric. J. 68, 343.

Singh, M.V. 1998. 28th Progress report of 1996-98 for the AICRP OF Micro- and Secondary Nutrients and Pollutants in Soils and Plants. Indian Institute of Soil Science, Bhopal. pp. 137.

Rao, W.K. 1968. Indian Coffee, 32, 1-2.

Verma, D.P. 1993. *In* Fertilizer Management in Commercial Crops (Ed. H.L.S. Tandon), FDCO, New Delhi, pp. 148-175.

Posters Feature Forage Legumes and Grasses/ *Southern Forages* Book Now in Fourth Edition

Two educational 24 x 30-in. posters, *Forages Legumes* and *Forage Grasses*, are now available from IPNI. Each poster features color photographs of 30 species of important forage plants, along with descriptive text on seeding/establishment, fertility needs, pest considerations, and other practical tips.

The posters were prepared by the authors of the popular book, *Southern Forages*. They are Dr. Don Ball, Auburn University; Dr. Carl Hoveland, University of Georgia; and Dr. Garry Lacefield, University of Kentucky. The book was first published in 1991 and has become a standard among farmers, educators, horse owners, individuals managing wildlife plots, and many others.

"The new posters provide one more level of information accessibility for the many people interested in forage grasses and legumes. We have seen the popularity and usefulness of the *Southern Forages* book for many types of audiences and believe the posters will effectively enhance understanding of forage production and management," noted IPNI President Dr. Terry Roberts. Many of the species included on the posters are grown across large areas of North America and some in other countries.

The posters would be appropriate for display in classrooms, seed outlets and farm stores, Extension and soil/water conservation meeting rooms, farm offices, and various other settings. A single poster is available for purchase at US$3.00 plus shipping. The cost for a set including one of each poster is US$8.00 sent folded or US$9.00 rolled in a mailing tube.

The Fourth Edition of the book *Southern Forages* was published by IPNI in early 2007 and is now available for US$30.00 plus US$4.00 shipping and handling for a single copy. Discounts are available on larger quantities.

For more information and cost details, contact: Circulation Department, IPNI, 3500 Parkway Lane, Suite 550, Norcross GA 30092-2806; phone 770-825-8082; fax 770-448-0439; e-mail: circulation@ipni.net; website: **www.ipni.net/sf**. BC