0273-2289/01/9601-3/0167/$11.50

Biochemical Evaluation of Sulfur and Nitrogen Assimilation Potential of Mustard (*Brassica juncea* L. Czern. & Coss.) Under Application of Slow-Release Sulfur Fertilizer

Altaf Ahmad, Gerard Abraham, and M. Z. Abdin*

Centre for Biotechnology, Hamdard University, New Delhi 110062, India, E-mail: root@hamduni.ren.nic.in

Abstract

Pot experiments were conducted to study the efficacy of a slow sulfur-releasing fertilizer, sulfur glass fritz (SGF 1), on growth, photosynthesis, and sulfur, and nitrogen assimilation potentials of brown mustard (*Brassica juncea* L. Czern. & Coss. cv. Pusa Jaikisan). Growth as indicated by biomass accumulation slowed down in response to the application of sulfur glass fritz. A similar trend was observed in the case of photosynthesis rate. The activity of two marker enzymes, ATP-sulfurylase and nitrate reductase, showed very low levels of activity, indicating poor assimilation of sulfur and nitrogen by the plant under sulfur glass fritz. It is therefore concluded that the release of sulfur by sulfur glass fritz is too slow and that the initial nonavailability of sulfur to the plants could lead to suboptimization of both sulfur- and nitrogen-assimilating enzymes. These factors may contribute to low rates of photosynthesis and poor growth.

Index Entries: Mustard; gypsum; sulfur glass fritz; biomass; photosynthesis; ATP-sulfurylase; nitrate reductase; slow release sulfur fertilizer.

Introduction

Sulfur is one of the six macronutrients required by plants, and it is the principal constituent of amino acids such as cystein and methionine. The level of sulfur in the soil is one of the critical factors determining the growth and yield of plants *(1)*. However, in recent years widespread deficiency of sulfur in the soil of crop fields has been noticed in many parts of India, and

*Author to whom all correspondance and reprint requests should be addressed at the Centre for Environmental Management for Degraded Ecosystems, University of Delhi, South Campus, Benito Juarez Road, New Delhi 110 021, India.

one of the reasons for the low status of sulfur in soil is leaching *(2)*. In the West strict environmental legislations have led to a shift toward sulfur-free fertilizers *(3)*. In India such a situation could be expected in the near future. To check leaching and ensure better utilization of nutrients, nutrient-releasing compounds are available that release nutrients at slow rates *(4)*. However, it is extremely important to analyze critically the utilization efficiency of these fertilizers by crop plants before they are recommended as an alternative to the most widely used and cheapest sources of sulfur such as gypsum.

In the present study, the efficiency of a slow sulfur-releasing compound, sulfur glass fritz (SGF 1), on biomass, rate of photosynthesis, and sulfur and nitrogen assimilation potential of mustard (*Brassica juncea* L. Czern. & Coss. cv. Pusa Jai Kisan) was analyzed.

Materials and Methods

Mustard plants were grown in ceramic pots (38 × 72 cm) containing sandy loam soil. The pots were kept under net house conditions. A basal application of N, P, and K was given at the rate of 50, 30, and 30 kg/ha, respectively. Six plants were maintained throughout. Treatments included one level of sulfur in the form of gypsum (T_1) and SGF 1 (T_2) at 40 kg/ha. The content of S in SGF 1 is 5.6% compared to 13–18% in gypsum. Plants were periodically watered, and sampling was done on 30, 45, 60, 75, and 90 d after sowing.

Photosynthetic rate of the intact leaves was measured using a portable photosynthetic system (model LICOR 6200). In vitro ATP-sulfurylase activity was measured following the method of Wilson and Bhanduruski *(5)*. In vivo assay of nitrate reductase activity of the leaves was measured according to the method of Klepper et al. *(6)* and as modified by Nair and Abrol *(7)*. Nitrite was estimated by using the method of Snell and Snell *(8)*.

Results and Discussion

The biomass accumulation and rate of photosynthesis of *B. juncea* plants grown on SGF 1 declined considerably compared with plants grown on gypsum (Fig. 1). The biomass accumulation at T_1 attained a peak value at 105 d after sowing, whereas a five times lower biomass was accumulated by plants at T_2. Photosynthetic rate was also reduced at T_2 and followed the same trend as biomass (Fig. 2). The levels of both sulfur and nitrogen are very important for plants to built up photosynthetic capacity and, consequently, biomass accumulation. When plants are grown with a limited sulfur supply, nonprotein nitrogen accumulates and growth is retarded *(9)*. Peoples et al. *(10)* observed that maintenance of active photosynthesis by leaves throughout the growth period is a requirement for high yield. The present study is of immense importance because a critical evaluation of SGF1 is necessary before it is recommended for field trials. There exists a

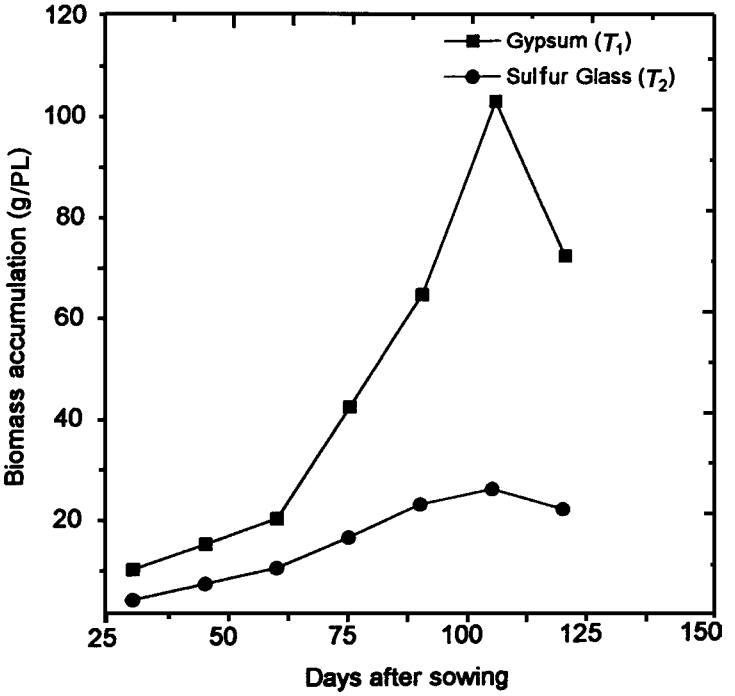

Fig. 1. Effect of sulfur glass fritz and gypsum application on biomass accumulation in mustard.

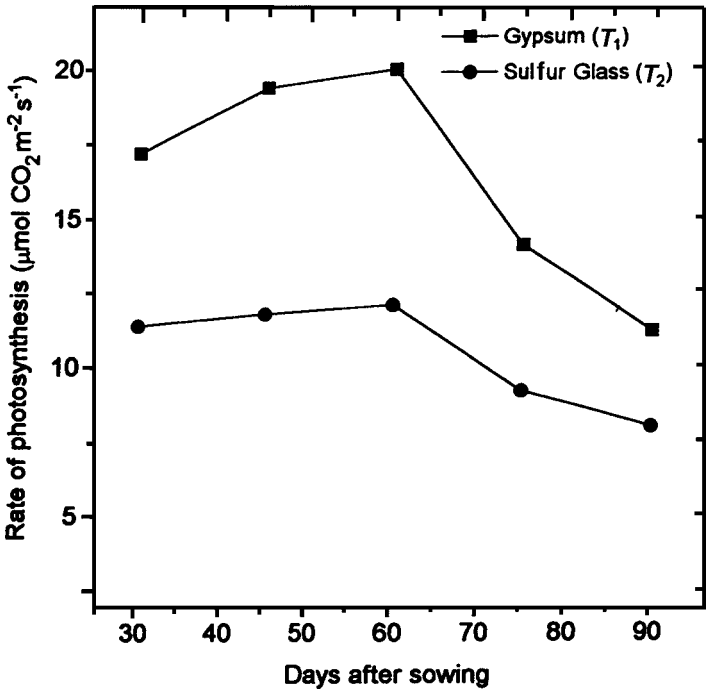

Fig. 2. Effect of sulfur glass fritz and gypsum application on photosynthetic rate of mustard.

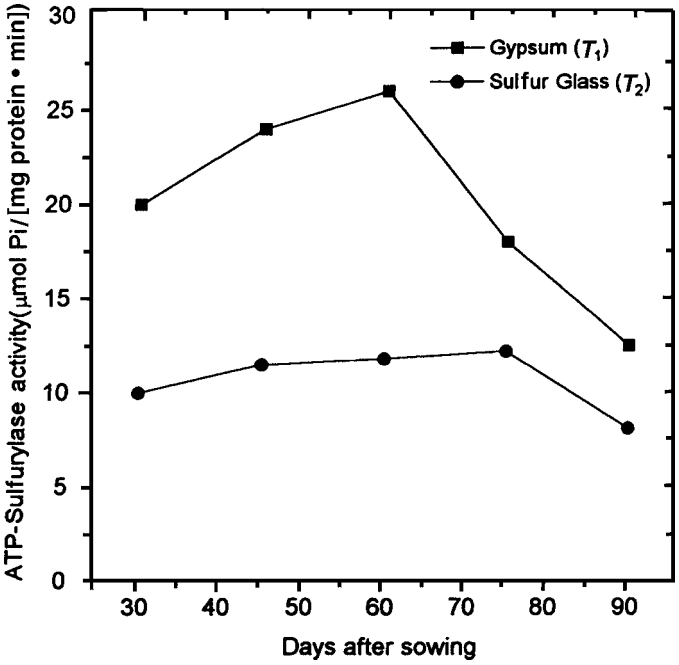

Fig. 3. Effect of sulfur glass fritz and gypsum application on ATP-sulfurylase activity of mustard.

strong correlation between ATP-sulfurylase and yield of *Brassica* genotypes *(11)*. A similar correlation exists between nitrate reductase activity and yield *(12–14)*. The activities of two important marker enzymes, ATP-sulfurylase and nitrate reductase, were significantly low in case of mustard plants grown on SGF 1 (Figs. 3 and 4). In the case of plants grown on gypsum (T_1), high rates of ATP-sulfurylase and nitrate reductase activity were observed on d 60 after sowing, and thereafter it declined. However, the mustard plants grown on sulfur glass fritz showed (T_2) a peak value for the activity of these enzymes on d 75 after sowing. Plants at T_2 exhibited very low levels of activity as compared with T_1. The low levels of ATP-sulfurylase are an indication of low levels of sulfur assimilation. ATP-sulfurylase catalyzes the first step of the sulfate assimilation pathway, and it can be used as an indicator of the state of regulation of sulfur assimilation *(15,16)*. The low nitrate reductase activity could be owing to noninduction of nitrate reductase enzyme because of an insufficient quantity of sulfur. Sulfur has a positive role in regulating the nitrate reductase activity *(17)*. Reuveny et al. *(18)* reported that in tobacco, induction of nitrate reductase activity by nitrate was proportional to the initial sulfate concentration. The assimilatory pathways of both sulfur and nitrogen are functionally convergent *(19)*, and there is a metabolic coupling between sulfur and nitrogen assimilation *(20)*.

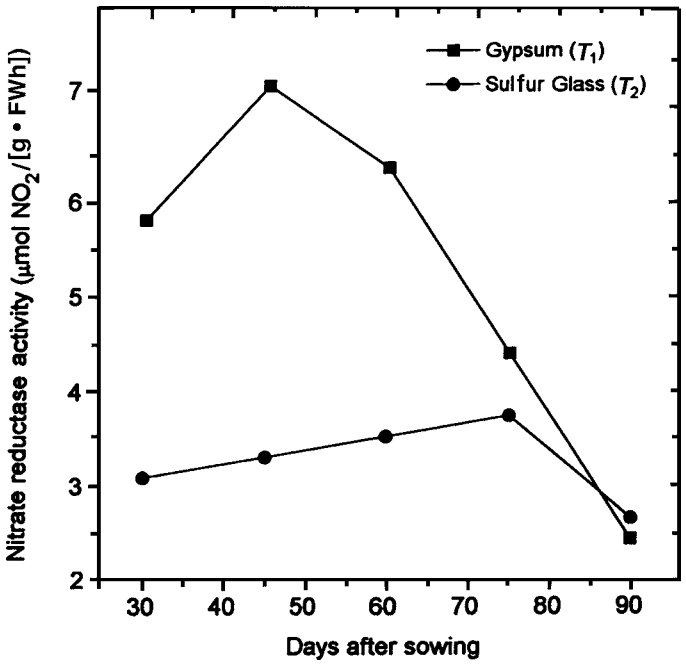

Fig. 4. Effect of sulfur glass fritz and gypsum application on nitrate reductase activity of mustard.

On the basis of the present study, it can be concluded that the release of sulfur into the soil by SGF 1 (5.6%) is too slow and that the poor availability of sulfur impairs the balance of sulfur and nitrogen assimilation. Moreover, the noninduction of both ATP-sulfurylase and nitrate reductase activities may lead to slow growth rates in mustard. The initial lag in the induction of enzyme activities coupled with the low rate of photosynthesis reduced the growth of mustard. One of the reasons for poor performance of SGF 1 may be low content of S (5.6%). Therefore, it is suggested that S content of SGF 1 should be increased.

Acknowledgments

We wish to thank Council of Scientific and Industrial Research (Technology Mission on Oilseed, Maize and Pulses) for financial help and Dr. N. Biswas for the sulfur glass fertilizer.

References

1. Lakkinent, K. C. (1997), *Fert. News* **42,** 15–17.
2. Tandon, H. L. S. (1991), in *Sulphur and Agricultural Production in India*, Sulphur Institute, Washington, DC.
3. Leustek, T. and Saito, K. (1999), *Plant Physiol.* **120,** 637–643.

4. Abrol, Y. P., Chatterjee, S. R., Anand Kumar, P., and Jain, V. (1999), *Curr. Sci.* **76,** 1357–1364.
5. Wilson, L. G. and Bhandurski, R. S. (1958), *J. Biol. Chem.* **233,** 975–987.
6. Klepper, L. A., Flesher, D., and Hageman, R. H. (1971), *J. Plant. Nutr.* **3,** 843–846.
7. Nair, T. V. and Abrol, Y. P. (1977), *Crop. Sci.* **17,** 438–444.
8. Snell, F. D. and Snell, C. T. in *Calorimetric Methods of Analysis*, 3rd ed., Academic, NY.
9. Eppendorfer, W. H. (1971), *J. Sci. Food Agric.* **22,** 501–505.
10. Peoples, M. L., Beilharz, V. C., Waters, S. P., Simpson, R. J., and Dalling, M. J. (1980), *Planta* **149,** 241–251.
11. Ahmad, A., Abraham, G., and Abdin, M. Z. (1999), *J. Agron. Crop Sci.* **183,** 19–25.
12. Reilly, M. L. (1976), *Proc. R. Ir. Acad.* **76,** 555, 556.
13. Balasubramahnyan, V., Shanta Kumari, P., and Sinha, S. K. (1977), *Ind. J. Exp. Biol.* **15(**1), 780–782.
14. Nair, T. V. and Abrol, Y. P. (1982), *Ind. J. Plant Physiol.* **25,** 110–121.
15. Brunold, C. and Rennenberg, H. (1997), *Prog. Bot.* **58,** 164–168.
16. Hatzfeld, Y., Cathala, N., Grignon, C., and Davidian, J. C. (1998), *Plant Physiol.* **116,** 1307–1313.
17. Friedrich, J. W. and Schrader, L. E. (1978), *Plant Physiol.* **61,** 900–903.
18. Reuveny, Z., Dougall, D. K., and Trinity, P. M. (1980), *Proc. Natl. Acad. Sci. USA* **77,** 6670–6672.
19. Filner, P. (1966), *Biochem. Biophys. Acta* **118,** 299–310.
20. Clarkson, D. T., Saker, L. R., Purves, J. V., and Lee, R. B. (1989), *J. Exp. Bot.* **40,** 953–963.