Journal Crop and Weed, 11(2):132-137(2015)

Effect of micronutrients on some biochemical constituents and yield of ginger

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Received : 09.01.2015, Revised : 11.06.2015, Accepted : 01.08.2015

ABSTRACT

An investigation laid out in RBD design with five replications was carried out at Horticultural Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal during the year 2007-2008 to find out the effect of micronutrients on some biochemical attributes vis-à-vis yield of ginger rhizome .The treatment consists of spray of zinc sulphate (0.5%), copper sulphate (0.5%) and ammonium molybdate (0.1%) along with control on 60 and 90 days after planting (DAP) and laid out in RBD with five replication. Rresults reveal that each of foliar micronutrient spray caused a significant increment of micronutrients while those for each zinc and copper sulphate; there was a significant rise of starch and ascorbic acid level over that of control in ginger rhizome. Whereas, spray of ammonium molybdate effectuated a significant enhancement in the level of soluble protein over that of control which was also significant in addition to total sugar and oleoresin for that of zinc sulphate. All in all, the foliar spray of zinc sulphate resulted in the highest generation of micronutrients and the impact of them was reflected though not significant yet in the highest yield besides a better biochemical environment in ginger rhizome.

***Keywords*:** Biochemical constituents, ginger, micronutrients, yield

Ginger (*Zingiber officinale* Rosc) is one of the most valuable and important spices in many tropical countries. It is widely used in food, beverage, confectionery and medicine while India is the largest producer, consumer and exporter of this crop. So, it is imperative to maximize the output of ginger besides quality. But, in spite of the best inputs, the output per unit area of ginger is not sufficiently large. This signals the deterioration of soil health due to imbalance of nutrients especially of those required in a very small amount known as micronutrients but vital for the optimum metabolic mechanisms of the crop. Micronutrients play an active role in plant metabolism, starting from cell wall development to respiration, photosynthesis, chlorophyll formation, enzyme activity, hormone synthesis, and nitrogen fixation in addition to so many other functions vital for plant life (Marschner, 2003., Millan *et al.,* 2005., Yruela, 2009 and Jimenez *et al.,* 2013) which in turn regulate yield and quality. Among the micronutrients, zinc, copper and molybdenum are very important for their role in bringing stability and sustainability in production system (Das, 2007). Zinc is the structural constituent of few enzymes including RNA polymerase (Marschner, 2003) and carbonic anhydrase (Hafeez *et al*., 2013) besides activating a large number of enzymes influencing metabolisms of carbohydrate, protein (Hafeez *et al*.,2013) and auxins. (Marschner, 2003, Carrette, 2013). On the other hand, copper enzymes are important in photosynthesis, respiration, detoxification of super oxide radicals and lignification (Pilon *et al.,* 2006, Yruela, 2009). The function of molybdenum is, however, linked with electron transfer reactions in plants (Mendal and Kruse, 2012). As of now, very little research has been carried out with regard to the impact of micronutrient sprays on the economic output of ginger, more so, on the quality of rhizome. Therefore, an attempt was made in the present investigation, to study the influence of each micronutrient spray- zinc sulphate, copper sulphate and ammonium molybdate- on the yield of ginger. In addition, the impact of those micronutrient sprays on the level of micronutrients (zinc+ copper + molybdenum), starch, sugar, protein, fat, oleoresin and ascorbic acid in ginger rhizome was also taken into account.

MATERIALS AND METHODS

The experiment was carried out at the Horticultural Research Station, Mondouri, Nadia, during May, 2002 to February, 2003. The soil of the experimental site was *Gangetic* alluvium (Entisol) with sandy clay loam texture, having good water holding capacity, nearly neutral pH and of medium fertility status. The physicochemical properties soil at 0-15 cm depth before the cultivation of ginger crop was as follow: taxonomy- *Haplaquent*, sand 38.4%, silt 24.3%, clay 35.3%, water holding capacity 54.6%, saturated hydraulic conductivity 0.14 cm hr^{-1},

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pH (1: 2.5) 6.8, electrical conductivity 0.29 dS m^{-1}, bulk density 1.48 g cc^{-1}, CEC 12.8 cmol (p^{+}) kg^{-1}, organic carbon 6.8g kg^{-1}, total nitrogen 0.3g kg^{-1}, ammoniacal nitrogen 11.4 mg kg^{-1}, nitrate nitrogen 5.84 mg kg^{-1}, available phosphorus 2.46 mg kg^{-1}, available zinc 0.096 mg kg^{-1}, available copper 0.075 mg kg^{-1}, available molybdenum 0.06 mg kg^{-1}, microbial biomass carbon 38.12 mg g^{-1}. Dithane M-45 (0.3%) treated rhizomes (25-30 g) of ginger cv. *Gurubathan* were planted at 20 X 20 cm spacing in 3.0 X 1.0 m raised beds during the last week of May, 2007 and harvested during middle of February, 2008. Crop was mulched immediately after planting with paddy straw. The experiment was laid out in RBD with five replications. The treatments comprised of zinc sulphate [ZnSO4 $7H_2O$ @ 0.5%], copper sulphate [$CuSO_4$ $5H_2O$ @ 0.5%], ammoniun molybdate [$(NH_4)_6$ Mo_7O_{24} $4H_2O$ @0.1%] and control. Foliar spray of micronutrients was executed on 60 and 90 days after planting (DAP).

Irrespective of treatments, recommended doses of manures (FYM @ 25 tonnes ha^{-1}) and fertilizers (100 kg N, 60 kg P and 60 kg K in the form of urea, single super phosphate and muriate of potash, respectively) were applied, of which whole of the phosphorus was applied at the time of planting while half of both nitrogen and potash were applied at 45 DAP and the rest at 90 DAP. Earthing up and mulching were given after each split application of fertilizers. Plant samples (rhizomes) were collected from five randomly selected plants on 150, 180 and 240 DAP for the analysis of zinc, copper and molybdenum, starch, sugar, protein, fat, oleoresin and ascorbic acid. Zinc and copper were estimated through atomic absorption spectro-photometer following wet digestion of oven dried plant (rhizome) in the mixture of acids- HNO_3, H_2SO_4 and $HClO_4$ in the ratio of 10:1:4 (Jackson, 1973) while for molybdenum, oven dried rhizomes were digested in AR grade acid mixture (HNO_3+ $HClO_4$) by following the procedure outlined by Purvis and Peterson (1956) and estimated colorimetrically by chlorostannous reduced thiocyanate amber colour method as described by Johnson and Arkley (1954). After estimation, the level of zinc, copper and molybdenum were compounded for the presentation of the impact of each micronutrient spray. Starch and sugar were determined in accordance with the procedure described by Sadasivam and Manickam (1998) where as the methods of Jackson (modified Kjeldahl, (1973) and Lowry *et al*., 1951) was adopted for assessing crude and soluble protein**,** correspondingly. AOAC method (1984) from chapter 31 and 45 was taken into account for the measured fat and ascorbic acid, respectively. Oleoresin was estimated as proposed by Winterton and Richardson (1965).

RESULTS AND DISCUSSION

An insight of table- 1 reveals that irrespective of treatment, there was a gradual and significant decrease in the level of micronutrients (Zn + Cu + Mo) from 150 DAPS to 240 DAPS in ginger rhizome. The depletion in micronutrients of rhizomes with the age of the crop was because of the translocation (Tiffin, 1972) of micronutrients to metabolic sinks in commensuration with the progressive demand of crop for the betterment of overall metabolism through enzymatic participation including growth and efficiency of root system besides the stimulation in and accentuation of resistance to overcome adverse situation (Das, 2007). However, there was a differential accumulation of micronutrients in ginger rhizome. In this respect, the influence of foliar zinc sulphate spray was the highest in respect to the accumulation of micronutrients followed by those of ammonium molybdate and copper sulphate, respectively and the impact of micronutrients was reflected through the yield. As a consequence, foliar spray of zinc sulphate resulted though not significant but in the highest yield of ginger rhizome (Table 9), corresponding to nearly 14.1 per cent increase over control followed by those of copper sulphate (8.9% increase over control) and ammonium molybdate (4.0 % increase over control), correspondingly. The results, thus, manifest the favourable impact of micronutrient spray, in general, and zinc sulphate spray in particular. Micronutrients are important components of enzymes and hence vital for growth and development of plants. Some of them even regulate the metabolism of other nutrients in plants. As an instance zinc is directly related to phosphorus and calcium nutrition so also with the availability of nitrogen (Shear, 1948). Consequently vegetative and reproductive processes are accelerated by zinc nutrition in plants (Potarzychi, 2009). Sharma *et al.,* (1974) found that good availability of zinc in soil resulted in better growth and development of plants and the virtues were probably translated through the highest yield of ginger rhizome. As of then, the level of starch (Table 2) in ginger rhizome augmented significantly, on and on, irrespective of treatment, up to the harvest of ginger rhizome. But the level of increment differed in accordance with the

foliar spray of micronutrients and the highest through the impact of zinc sulphate. The hike of zinc in leaves of grapes and citrus have well been documented by Sindhu *et al.* (2000) and Singh *et al.* (2002), respectively under the influence of zinc sulphate. Zinc is involved in carbohydrate metabolism especially for acceleration in the activity of the enzymes-fructose 1, 6- bisphosphatase and aldolase- involved in starch synthesis (Marschner, 2003). Aldolase is the key enzyme for the reversible biochemical transformation of fructose 1,6-bisphosphate to dihydroxyacetone phosphate and glyceraldehydes-3 phosphate while fructose 1,6-bisphosphatase is linked with the reversible transformation of fructose 1,6- bisphosphate to fructose -6-phosphate (Cox and Nelson, 2011) which, in turn, is biochemically transformed to starch (Heldt, 2004). In addition, fructose 1, 6- bisphosphatase is important in partitioning of C_6 sugars in the chloroplasts and cytoplasm while aldolase regulates the transfer of C_3 photosynthates from chloroplasts into the cytoplasm and within the cytoplasm the flow of metabolites via the glycolytic pathway. A gradual decrease in the level of sugar (Table 3) *via* a significant decrease from 180 to 240 DAP substantiates further the conversion of sugar to starch. However the spray of zinc sulphate effectuated the highest accumulation of total sugar, which corresponded to nearly 21.4% increase over control while there was no significant variation among other treatments. The highest accumulated sugar was due to the highest level of micronutrients especially zinc- an integral part of many zinc-dependant enzymes involved in carbohydrate metabolism besides its pivotal role in the carbonic anhydrase reaction (Marschner, 2003., Millan *et al.,* 2005). Zinc is also a structural component of ribosomes (Mengel *et al*., 2011) and hence important for protein synthesis (Hafeez *et al*., 2013).

Table 1: Influence of micronutrient sprays on concentration of micronutrients (mg kg^{-1}) in ginger

Treatment	Days of sampling			
	150	180	240	Mean
Zinc sulphate	25.13	22.14	21.02	22.76
Copper sulphate	13.18	6.73	4.66	8.19
Ammonium molybdate	13.0	11.42	7.67	10.69
Control	2.3	1.9	1.75	1.98
Mean	**13.4**	**10.55**	**8.77**	**1.095**
LSD (0.05)	**NS**	**0.948**	**NS**	

Table 2: Influence of micronutrient spray on the level of starch (g 100g^{-1}) in ginger rhizome

Treatment	Days of sampling			
	150	180	240	Mean
Zinc sulphate	37.44	47.86	48.88	44.70
Copper sulphate	38.22	44.88	46.5	43.19
Ammonium molybdate	36.01	39.25	44.54	39.93
Control	35.87	38.03	41.38	38.42
Mean	**36.88**	**42.50**	**45.31**	**2.189**
LSD (0.05)	**NS**	**1.896**	**NS**	

Table 3: Influence of micronutrient spray on the level of total sugar (g 100g^{-1}) in ginger rhizome

Treatment	Days of sampling			
	150	180	240	Mean
Zinc sulphate	7.75	7.17	6.02	6.98
Copper sulphate	7.33	6.51	5.63	6.49
Ammonium molybdate	7.11	6.28	5.32	6.23
Control	6.26	5.88	5.11	5.75
Mean	**7.11**	**6.48**	**5.52**	**0.83**
LSD (0.05)	**NS**	**0.72**	**NS**	

Table 4: Influence of micronutrient spray on the level of crude protein (g 100g^{-1}) in ginger rhizome

Treatment	Days of sampling			
	150	180	240	Mean
Zinc sulphate	8.38	7.54	6.70	7.54
Copper sulphate	7.95	7.18	6.27	7.13
Ammonium molybdate	8.0	7.28	6.40	7.20
Control	7.48	6.93	6.18	6.86
Mean	**7.95**	**7.23**	**6.38**	**7.18**
LSD (0.05)	**NS**	**2.02**	**NS**	

Table 5: Influence of micronutrient spray on the level of soluble protein (g 100g^{-1}) in ginger rhizome

Treatment	Days of sampling			
	150	180	240	Mean
Zinc sulphate	4.65	3.26	2.84	3.58
Copper sulphate	3.77	2.94	2.16	2.96
Ammonium molybdate	4.96	3.87	2.36	3.73
Control	3.12	2.66	1.85	2.54
Mean	**4.13**	**3.08**	**2.30**	**0.666**
LSD (0.05)	**NS**	**0.58**	**NS**	

Table 6: Influence of micronutrient spray on the level of fat (per cent dry wt.) in ginger rhizome

Treatment	Days of sampling			
	150	180	240	Mean
Zinc sulphate	6.11	5.66	4.33	5.37
Copper sulphate	6.0	5.22	4.82	5.35
Ammonium molybdate	5.42	4.84	3.92	4.72
Control	5.33	4.58	3.14	4.34
Mean	**5.72**	**5.07**	**4.05**	**5.69**
LSD (0.05)	**NS**	**0.94**	**NS**	

Table 7: Influence of micronutrient spray on the oleoresin (per cent dry wt/wt) content in ginger

Treatment	Days of sampling			
	150	180	240	Mean
Zinc sulphate	5.71	6.96	7.12	6.60
Copper sulphate	5.45	6.24	6.84	6.18
Ammonium molybdate	5.04	6.11	6.44	5.86
Control	4.93	5.78	6.23	5.65
Mean	**5.28**	**6.27**	**6.65**	**0.84**
LSD (0.05)	**NS**	**0.73**	**NS**	

Table 8: Influence of micronutrient spray on ascorbic acid (mg g^{-1} fresh wt) in ginger rhizome

Treatment	Days of sampling			
	150	180	240	Mean
Zinc sulphate	10.82	12.25	10.70	11.26
Copper sulphate	10.66	11.79	9.88	10.77
Ammonium molybdate	9.56	10.32	9.79	9.89
Control	9.02	10.12	9.27	9.47
Mean	**10.01**	**11.12**	**9.91**	**1.20**
LSD (0.05)	**NS**	**1.04**	**NS**	

Table 9: Influence of micronutrient spray on the yield of ginger rhizome

Treatment	Yield (q ha^{-1} fresh wt)
Zinc sulphate	25.68
Copper sulphate	24.52
Ammonium molybdate	23.42
Control	22.51
Mean	**24.03**
LSD (0.05)	**NS**

Consequently there was a significant rise in level of soluble protein (Table 5) over control in ginger rhizome by the zinc sulphate spray. The impact of ammonium molybdate spray was also positive and significant over control as molybdenum is a cofactor and has both structural and catalytic functions of many enzymes involved in nitrogen metabolism (Mendal and Kruse, 2012; Mendal, 2013) and hence protein synthesis (Agarwala *et al*., 1978). However, the extent of increment in soluble protein was 46.9 per cent over control by the spray ammonium molybdate while that by that of zinc sulphate; the increase was 40.9 per cent over control, in spite of no significant impact in between each of spray containing zinc sulphate and ammonium molybdate. As of then, the level of soluble and crude protein as well fat in ginger rhizome depleted gradually from 150 to 240 DAP, irrespective of treatment schedule, though not always, on and on, significant for crude protein and fat yet revealing the transport after metabolism of soluble and crude protein as well fat to the growing parts in accordance with the metabolic requirement of ginger crop. However, there was no significant variation among the treatments for crude protein and fat (Table 4). Oleoresin level in ginger rhizome progressively increased from 150 to 240 DAP through a non significant progress from 180 to 240 DAP (Table 7). On the other hand, the level of ascorbic acid decreased significantly from 180 to 240 DAP in spite of a non significant boost in the ascorbic acid level from 150 to 180 DAP (Table 8). Ascorbic acid repairs the oxidative damage in the plant system and the significant diminution in its level at last phase manifest degenerative changes in metabolic activities (Asada, 1999). However, the influence of the foliar spray of magnesium sulphate was similar to that of copper sulphate while causing a significant enhancement in the level of ascorbic acid in ginger rhizome over that of control. Copper plays a significant role in boosting the activities of respiratory enzymes in addition to the regulation of enzyme- ascorbate oxidase (Ayala and Sandmann, 1988; Yruela, 2009). Consequently, copper sulphate spray effectuated the increment of 13.7% in the level of ascorbic acid over control while that for magnesium sulphate- 18.9 over control. The reason for higher accumulation of ascorbic acid by magnesium sulphate spray is ascribed to higher generation of sugar (Table 8) for its biochemical conversion through the secondary pathway from glucose 1- phosphate to ascorbic acid *via* L- gulonate (Cox and Nelson, 2011). As of then, zinc sulphate spray brought about a significant rise in the level of oleoresin corresponding to 16.8 per cent over control. The yield data obtained from these treatments varied one another but none was significant over the others. However, the maximum yield (25.68 t ha^{-1}) was

observed in plants sprayed with zinc followed by copper sulphate (24.52 t ha^{-1}) and ammonium molybdate (23.42 t ha^{-1}). The control recorded the lowest yield of 22.51 t ha^{-1}. The increase in yield for zinc, copper and molybdenum over control was 14.08%, 8.93% and 4.04% respectively. The increase in yield by zinc treated plots might be due to better synthesis of tryptophan being the precursor for auxin synthesis. The above results are similar to the observation of Roy *et al*. (1992) in ginger whereas the beneficial effects of molybdenum and copper were reported by Gaudi *et al*. (1988).The results, thus, revealed that the spray of micronutrients effectuates the upliftment in the output of ginger and improvement in the biochemical environment of rhizome. In this respect the zinc sulphate spray caused the best impact.

REFERENCES

A.O.A.C. 1984. *Official Method of Analysis*. 2, chapter 31. Association of Official Analytical Chemist, Washington, DC. pp. 10.

A.O.A.C. 1984. *Official Method of Analysis*. 2, chapter 45. Association of Official Analytical Chemist,, Washington, DC, pp. 16.

Agarwala, S. C., Sharma, C P., Farooq, S. and Chatterjee, C. 1978. Effect of molybdenum deficiency on the growth and metabolism of corn plant raised in sand cultures. *Canadian J. Bot*., **56**: 1905-08.

Asada, K.1999. The water- water cycle in chloroplast: scavenging of active oxygen and dissipation of excess photon. *Ann. Rev. Physiol. Pl. Mole. Biol.*, **50**: 601-39.

Ayala, M. B. and Sandmann, G.1988 b. The role of Cu in respiration of pea plants and heterotrophically growing *Scenedesmus* cells. *Z. Naturforsch* **43 c**: 438-42.

Ayala, M. B. and Sandmann, G.1988. Activities of Cu-containing proteins in Cu-depleted pea leaves. *Physiol. Pl*., **72**: 801-06.

Carrette,T. 2013. Effect of natural complexing agents on zinc accumulation of navy beans. *M. Sc. Thesis*. Bioscience Engineering in Agricultural Science. Universiteit Gent.

Cox, M. M. and Nelson, D.L. 2011. *Lehninger Principles of Biochemistry*. WH Freeman and Co., New York, pp. 1158.

Das, D. K. 2007. *Micronutrients: their Behaviour in Soils and Plants*. Kalyani Publishers. New Delhi, pp. 307.

Guidi, N., Suwandi, Y. and Hilman, I. 1988.The effects of the application of stable manure and different trace elements on garlic. *Bull. Penelitian Hortikultura*, **16**:5-13.

Hafeez, B., Khanil, Y. M and Saleem, M. 2013. Role of zinc in plant nutrition-A review *American J. Expt. Agri.,* **3**: 374-91.

Heldt, H. W. 2004. *Plant Biochemistry*. Academic Press. London, pp. 630.

Jackson, M. L. 1973. *Soil Chemical Analysis*. Prentice Hall India Pvt. Ltd., New Delhi, pp. 498.

Johnson, C. M. and Arkley, T. H. 1954. Determinaion of molybdenum in plant tissue. *Ann. Chem.,* **26**: 572-74.

Lowry, O. H., Rosebrogh, N. J., Farr, A. L. and Randale, R. J. 1951 Protein measurement with folin phenol reagent. *J. Biochem*., **193**: 265-75.

Marschner, H. 2003. *Mineral Nutrition in Higher Plants*. Academic Press, London, pp. 889.

Mendel, R.R and Kruse, I. 2012. Cell biology of molybdenum in plants and humans. *Biochem. Biophysic Acta*., **79**: 1823-68.

Mendel,R.R. 2013.Metabolism of molybdenum. *Met. Ions Life Sci*.,**12**:503-28.

Mengel, K., Kirkby, E. A., Kosegarten, H and Apple, T. 2011. *Principle of Plant nutrition*. Kluwer Academic Publisher, London, pp. 849.

Millan, A.F.L., Ellis, D.R. and Grusak, M.A. 2005. Effect of zinc and manganese supply on the activities of superoxide dismutase and carbonic anhydrase in Medicago truncatula wild type and raz mutant plants. *Pl. Sci*., **168**:1015-22.

Pilon, M., Abdel-Ghany, S.E, Cohu, C.M., Gololin, K.A. and Ye,H.2006.Copper cofactor delivery in plant cells. *Curr. opinion Pl. Biol*., **9**:256-63.

Potarzychi, W.G. 2009. Effect of zinc application on grain yield of maize and its yielding components. *Pl. Soil Environ*., **55**:519-27.

Purvis, F. R. and Peterson, N. K. 1956. Methods of soil and plant analyser for molybdenum. *Soil Sci*., **81**: 223-38.

Roy, A., Chatterjee, R., Hassan, A. and Mitra, S.K. 1992. Effect of Zn, Fe and B on growth, yield and

nutrient content in leaf of ginger. *Indian Cocoa, Arecanut Spices J*., **15**: 99-101.

Sadasivam, S. and Manickam, A. 1998. *Biochemical Methods*. New Age International Publisher. New Delhi**,** pp. 256.

Sharma, B.B., Singh, R. and Sharma, H.C. 1974. Response of sweet orange plants to zinc, urea and DBCP. *Indian J. Hort.,* **31**: 38-44.

Shear, G.M. 1948. Zinc and boron deficiency in Virginia. *Fruits*, **36**:150-52**.**

Sindhu, P.C., Ahlawat, V.P. and Nair, A.S. 2000. Effect of foliar application of urea and zinc sulphate on the growth and mineral composition of grapes (*Vites vinefera* L.).cv *Perlette*. *Haryana J. Hort. Sci*., **29**:35-36.

Singh, S., Singh. D., Bhatia, S. K. and Ahlawat, V. P. 2002. Interaction of phosphorus and zinc on leaf nutrient content of Kinnow. *Haryana J. Hort. Sci*., **31**: 171-72.

Jimenez, M.T., Ampudia, A.C., Galvan, A., Fernandez, E. and Llamas, A. 2013. Molybdenum metabolism in plants. *Metallomics*, **5**:1191-1203.

Tiffin, L. O. 1972. Translocation of micronutrients in plants. In. *Micronutrients in Agriculture* (Eds.), Soil Sci. Soc. America Inc., Madison, Wisconsin, USA, pp. 199-29.

Yruela, I. 2009. Copper in plants: acquisition, transport and interaction. *Functional Pl. Biol*., **36**:409-30.