Availability of Calcium, Magnesium and Sulphur and Their Uptake by *Amaranthus* as Influenced by Composts and Fertilizers

M. R. Shaibur, T. Shaibur, A. H. M. Shamim* and S. M. Imamul Huq**

Department of Agro-bioscience, Iwate University, Morioka 020-8550, Japan
*School of Agriculture and Rural Development, Bangladesh Open University, Gazipur- 1705, Bangladesh
**Bangladesh-Australia Centre for Environmental Research; Department of Soil, Water and Environment, University of Dhaka, Dhaka-1000, Bangladesh
E-mail: abulhasnats@yahoo.com

Abstract: An investigation was done to evaluate the effects of composts, *viz*. aerobic compost (AC) and barrel compost (BC) on the availability of Calcium (Ca), Magnesium (Mg) & Sulphur (S) and their subsequent uptake by *Amaranthus.* The crop was grown for 42 days. The soils [Melandaha (Silt loam) and Dhamrai (Silty clay loam)] were treated with composts, composts plus fertilizer and only fertilizer. The 1st, 2nd, 3rd and 4th sets of experiment received 0 t ha^{-1}, 1 t ha^{-1}, 1.5 t ha^{-1}, and 2 t ha^{-1} compost, respectively. The 5th, 6th, and 7th sets of experiment received compost + urea + TSP. The last set of experiment received only urea and TSP fertilizers. In most of the cases the NH_4OAc extractable (available) Ca & Mg decreased due to application of composts while the availability of S increased. However, the uptake of Ca, Mg and S increased significantly due to application of composts or compost plus fertilizers. [Researcher. 2009;1(5):7-11]. (ISSN: 1553-9865).

Key words: *Amaranthus*, compost, fertilizer, Ca, Mg, and S

1. Introduction

To produce at optimum yields, all crops must have an adequate supply of all of the 16 essential plant nutrients. If one or more is lacking in the soil, crop yields will be reduced even though an adequate amount of the other 13 elements are available. This is somewhat analogous to the fact that a wooden bucket will hold no more water than its shortest stave. Crop yields may be limited by the element that is in shortest supply. However, there are relatively few that focus on nutrients such as Ca and S (Egrinya-Eneji, et al., 2003). The elements Ca, Mg and S are known as macro and secondary nutrients. Ca is the third most used nutrient element and it comes from the weathering of a number of common minerals and rocks including feldspar, apatite, limestone and gypsum. Mg also weathers from minerals as a cation. Most soil S comes from the decomposition of organic matter; some comes from weathering of sulphate minerals like gypsum ($CaSO_4$. $2H_2O$) and pyrite (FeS_2). Although there are many inorganic sources of sulphur, 70-90 % of the total soil S is found in organic matter (Miller and Donahue, 1992). Unlike S, the main source of Ca and Mg is inorganic. Their availability largely depends on total supply, soil pH, CEC, percent base saturation and ratio of them in soil solution (Tisdale *et al.*, 1993). The objectives of this study were to observe the changes in the availability and uptake of Ca, Mg and S due to application of composts or composts plus fertilizers.

2. Materials and Methods

Soils of Melandaha (Silt loam) and Dhamrai (Silty clay loam) series were collected from 0-15 cm depth in a composite manner. Two kg of air-dryed (passed through 5 mm sieve) soil was taken into a series of small earthen pots. The experiment was conducted at the Soil Fertility Research Laboratory of the Department of Soil, Water and Environment, University of Dhaka. The duration of the experiment was from January 2000 to June 2001. The experiment consisted of 14 treatments with three replications. The pots were arranged in a completely randomized block design. The 1st, 2nd, 3rd and 4th sets received 0, 1, 1.5 and 2 t ha^{-1} compost, respectively. The 5th, 6th, and 7th sets of experiment received additional urea and TSP fertilizers along with composts. The last set of the experiment received only urea and TSP fertilizers. For Melandaha soil, 96.2 kg ha^{-1} N and 28.13 kg ha^{-1} P_20_5 were required on high yield goal basis but for Dhamrai soil it was 77.13 kg ha^{-1} and 30.75 kg ha^{-1}, respectively. The rates were determined with the help of Fertilizer Recommendation Guide (BARC, 1997) for the field but we used this rate for our pot experiment. The compost or compost plus fertilizers or only fertilizers (urea and TSP) were mixed properly with the soil. *Amaranthus* seeds were sown and after emergence 5 seedlings were kept in each pot until harvest at 42 days. Water was also added to bring the soil at field capacity condition. After harvest, the plant and soil samples were analyzed for Ca, Mg, and S contents. Available

Ca and Mg contents of soil were extracted with 1 N NH_4OAc (pH 7.0) as described by Jackson (1962). Available S content was extracted by 500 ppm P solution [from Ca $(H_2PO_4)_2$. $2H_2O$] and was determined turbidimetrically with the help of $BaCl_2$ and Tween-80 mixture in an acid medium (6 N HCl) by Spectrophotometer at 420 nm wavelength (Page 1990). For plant Ca, Mg and S, the plant samples were digested with HNO_3 and $HClO_4$ (HNO_3: $HClO_4$= 2:1). The Ca and Mg contents were determined directly by Atomic Absorption Spectrophotometer. Data were analyzed by analysis of variance (SAS Institute 1988).

3. Results and Discussion

3.1Effect of compost on Ca availability: The control treatment of Melandaha and Dhamrai soils contained 1292 mg kg^{-1} and 1668 mg kg^{-1} available Ca, respectively. This content changed due to application of compost or compost plus fertilizers or only fertilizers (Table 1). The availability was found to be 1112 mg kg^{-1} and 1561 mg kg^{-1} in Melandaha and Dhamrai soils, respectively due to fertilizer application (Table 1). Application of aerobic compost (AC) showed decrease in the availability in Melandaha soil at AC_1 (1220 mg kg^{-1}) treatment, increase at $AC_{1.5}$ (1327 mg kg^{-1}) and did not show any change at AC_2 (1292 mg kg^{-1}). Fertilizers along with AC decreased the availability significantly for $AC_{1.5}F$ (1184 mg kg^{-1}) and AC_2F (1112 mg kg^{-1}) (Table 1). After treating with BC, the availability decreased at BC_1 (1220 mg kg^{-1}) and $BC_{1.5}$ (1238 mg kg^{-1}) treatments but increased at BC_2 (1327 mg kg^{-1}) in the same soil. Fertilizers along with BC decreased the availability in BC_1F (1148 mg kg^{-1}) but increased in $BC_{1.5}F$ (1740 mg kg^{-1}) and BC_2F (1776 mg kg^{-1}) treatments (Table 1). The availability increased significantly at AC_1 (1740 mg kg^{-1}) and decreased for other treatments due to AC or AC plus fertilizer in Dhamrai soil (Table 1). Following treatment with BC, the availability of Ca in Dhamrai soil decreased significantly at BC_1 (1633 mg kg^{-1}), $BC_{1.5}$ (1579 mg kg^{-1}) and BC_2F (1579 mg kg^{-1}) treatments but did not show any change at BC_2 (1668 mg kg^{-1}), BC_1F and $BC_{1.5}F$ treatments (Table 1).

Table 1. Changes in the availability of Ca, Mg and S due to application of compost and fertilizer.

Treatments	Melandaha Soil (mg kg^{-1})			Dhamrai Soil (mg kg^{-1})		
	Ca	Mg	S	Ca	Mg	S
Control	1292 c	433 c	8.07 a	1668 b	431 b	9.70 a
AC_1	1220 b	415 b	6.45 a	1740 c	436 b	10.50 b
$AC_{1.5}$	1327 d	422 b	9.70 b	1650 a	437 b	10.50 b
AC_2	1292 c	423 b	8.87 b	1525 a	437 b	9.70 a
AC_1F	1292 c	364 a	9.70 b	1597 a	422 a	8.07 a
$AC_{1.5}F$	1184 a	357 a	8.07 a	1615 a	431 b	8.87 a
AC_2F	1112 a	363 a	7.27 a	1507 a	430 b	8.07 a
BC_1	1220 b	434 c	8.87 b	1633 a	424 a	8.07 a
$BC_{1.5}$	1238 b	435 c	9.70 b	1579 a	415 a	8.87 a
BC_2	1327 d	430 c	9.70 b	1668 b	429 b	8.87 a
BC_1F	1148 a	426 b	8.87 b	1668 b	426 a	8.07 a
$BC_{1.5}F$	1740 e	405 b	8.87 b	1668 b	440 c	10.50 b
BC_2F	1776 e	419 b	10.50 b	1579 a	426 a	10.50 b
F	1112 a	424 b	7.27 a	1561 a	441 b	8.07 a

Means followed by different letters in each column are significant (p=0.05) according to Ryan-Einot-Gabriel-Welsch Multiple Range test. A=aerobic compost, C_1=compost @ 1 t ha^{-1}, $C_{1.5}$=compost @ 1.5 t ha^{-1}, C_2=compost @ 2 t ha^{-1}, B=barrel compost, F=fertilizers.

Table 2. Uptake of Ca, Mg and S (mg/100 plants shoot or root) by *Amaranthus* in Melandaha soil as affected by composts and fertilizer.

Treatments	Calcium		Magnesium		Sulphur	
	Shoot	Root	Shoot	Root	Shoot	Root
Control	177 a	19.03 b	163 a	19.90 b	30.61 b	4.33 b
AC_1	213 b	20.41 b	222 b	15.40 b	34.45 b	4.30 b
$AC_{1.5}$	250 c	24.23 b	277 c	20.04 b	49.22 c	5.83 c
AC_2	197 a	12.42 a	265 c	12.96 a	56.26 c	3.01 a
AC_1F	190 a	18.23 b	217 b	12.50 a	45.23 c	2.54 a
$AC_{1.5}F$	489 e	40.56 d	782 e	32.76 c	95.87 d	8.68 c
AC_2F	250 c	29.90 c	293 c	20.54 b	23.92 a	4.34 b
BC_1	312 d	22.08 b	374 d	18.96 b	54.29 c	4.01 b
$BC_{1.5}$	276 c	13.20 a	302 d	22.96 b	48.02 c	4.79 b
BC_2	291c	18.17 b	365 d	13.98 a	49.59 c	3.89 b
BC_1F	331 d	20.66 b	433 d	18.15 b	50.12 c	5.23 c
$BC_{1.5}F$	311 d	13.80 a	394 d	14.40 a	49.86 c	5.01 c
BC_2F	333 d	13.80 a	420 d	23.70 b	48.63 c	7.50 c
F	402 e	15.64 a	600 e	27.41 c	88.44 d	8.68 c

Means followed by different letters in each column are significant (p=0.05) according to Ryan-Einot-Gabriel-Welsch Multiple Range test. A=aerobic compost, C_1=compost @ 1 t ha^{-1}, $C_{1.5}$=compost @ 1.5 t ha^{-1}, C_2=compost @ 2 t ha^{-1}, B=barrel compost, F=fertilizers.

3.2Effect of compost on Mg availability: The control treatment of Melandaha and Dhamrai soils contained 433 mg kg^{-1} and 431 mg kg^{-1} available Mg respectively (Table 1). The availability changed to 424 mg kg^{-1} and 441 mg kg^{-1} in Melandaha and Dhamrai soils, respectively for fertilizer application (Table 1). AC decreased the availability in Melandaha soil and was more pronounced in the presence of fertilizer as compared to control and compost treatments. The highest value was found for AC_2 (423 mg kg^{-1}) and the lowest was for $AC_{1.5}$ (357 mg kg^{-1}) (Table1). Application of fertilizers along with BC decreased the availability as compared to control and compost treatments and the lowest value was observed for $BC_{1.5}F$ treatment in the same soil (Table 1). In Dhamrai soil the availability increased (though not significant) due to AC and decreased when fertilizers were added along with AC (AC_1F). For this case the highest value was found for $AC_{1.5}$ and AC_2 (437 mg kg^{-1}) and the lowest was for AC_1F (422 mg kg^{-1}) treatments. In most cases (except $BC_{1.5}F$) the availability decreased significantly due to application of BC or BC plus fertilizers in Dhamrai soil (Table 1).

3.3Effect of compost on S availability: The control treatment of Melandaha and Dhamrai soils contained 8.07 mg kg^{-1} and 9.70 mg kg^{-1} available S, respectively. This content changed due to management practices (Table 1). The value was found to be 7.27 mg kg^{-1} and 8.07 mg kg^{-1} in Melandaha and Dhamrai soils, respectively due to fertilizer application. The availability increased significantly at $AC_{1.5,}$ AC_2 and AC_1F due to AC or AC plus fertilizer treatments and the value ranged from 6.45 mg kg^{-1} (AC_1) to 9.70 mg kg^{-1} ($AC_{1.5}$ and AC_1F) in Melandaha soil (Table 1). The availability also increased significantly due to BC or BC plus fertilizer application in the same soil and ranged from 8.87 mg kg^{-1} (BC_1, BC_1F or $BC_{1.5}F$) to 10.50 mg kg^{-1} (BC_2F) (Table 1). Similar results were obtained for $AC_1$and $AC_{1.5}$ in Dhamrai soil. AC along with fertilizer did not change the availability significantly and the value ranged from 8.07 mg kg^{-1} (AC_1F and AC_2F treatments) to 10.50 mg kg^{-1} (AC_1 and $AC_{1.5}$) (Table 1). BC alone in Dhamrai soil did not change the availability although there has been some increase in presence of fertilizer ($BC_{1.5}F$ and BC_2F) (Table 1).

It was found that for almost all cases, the availability of Ca decreased. Similar result was also found for Mg in Melandaha and S in Dhamrai soils (Table 1). This was most probably due to higher consumption of these elements by plants or their fixation by organic matter (Tisdale *et al.*, 1993). The main source of Ca and Mg is inorganic and the availability largely depends on the total supply, soil pH, CEC, percent base saturation, types of soil colloids, and ratio of them to other cations in soil solution (Tisdale *et al.*, 1993). In Melandaha soil S availability increased. This may be due to the mineralization of compost (organic matter) (Stevenson, 1986).

3.4Effect of compost on Ca uptake: The Ca uptake was found to be 177 mg/100 plants shoot and 19.03 mg/100 plants root in Melandaha soil (Table 2). Due to application of fertilizer the values changed to 402 mg/100 plants shoot and 15.64 mg/100 plants roots. In shoots, the uptake increased significantly due to compost or compost plus fertilizer application. The more pronounced uptake was shown for BC over AC but for individual treatment the highest uptake was for $AC_{1.5}F$ (489 mg/100 plants shoot) treatment. For root, the highest uptake was also found for the same treatment. The uptake by roots decreased for $AC_{2,}$ $BC_{1.5,}$ $BC_{1.5}F$ and BC_2F treatments (Table 2). For Dhamrai soil, the uptake increased for AC_1F, $AC_{1.5}F$ and AC_2F, BC_1, BC_1F treatments in shoots as compared to control (Table 3). In roots it increased significantly for almost all cases.

Table 3. Uptake of Ca, Mg and S (mg/100 plants shoot or root) by *Amaranthus* in Dhamrai soil as affected by composts and fertilizer.

Treatments	Calcium		Magnesium		Sulphur	
	Shoot	Root	Shoot	Root	Shoot	Root
Control	269 b	7.85 a	263 c	16.57 c	34.50 c	3.79 b
AC_1	211 a	11.50 b	182 b	20.75 c	26.45 b	2.22 a
$AC_{1.5}$	274 b	14.89 b	200 b	13.92 b	22.82 a	3.18 b
AC_2	280 b	6.91 a	305 d	10.32 b	40.63 d	6.00 c
AC_1F	339 c	15.09 b	312 d	9.91 b	51.16 e	4.68 c
$AC_{1.5}F$	355 c	16.69 bc	258 c	10.23 b	38.67 d	6.43 c
AC_2F	426 d	23.61 c	342 d	13.38 b	53.06 e	6.83 c
BC_1	305 c	16.38 bc	235 c	14.82 b	62.47 f	6.18 c
$BC_{1.5}$	268 b	9.15 a	230 c	8.85 b	68.14 f	2.79 a
BC_2	112 a	9.42 a	76 a	3.87 a	17.98 a	4.34 b
BC_1F	423 d	20.45 c	393 d	13.10 b	62.63 f	6.83 c
$BC_{1.5}F$	188 a	11.90 b	88 a	3.21 a	31.32 c	3.83 b
BC_2F	182 a	13.55 b	146 b	6.32 a	33.20 c	2.45 a
F	346 c	19.69 c	377 d	9.52 b	45.86 d	5.18 c

Means followed by different letters in each column are significant (p=0.05) according to Ryan-Einot-Gabriel-Welsch Multiple Range test. A=aerobic compost, C_1=compost @ 1 t ha^{-1}, $C_{1.5}$=compost @ 1.5 t ha^{-1}, C_2=compost @ 2 t ha^{-1}, B=barrel compost, F=fertilizers.

3.5Effect of compost on Mg uptake: The Mg uptake by plants was found to be 163 mg/100 plants shoot and 19.90 mg/100 plants root in Melandaha soil. The values changed to 600 mg/100 plants shoot and 27.41 mg/100 plants root, respectively due to fertilizer application (Table 2). The absorption increased significantly in shoots for AC, AC plus fertilizer, BC and BC plus fertilizer as compared to control treatment in Melandaha soil (Table 2). The highest value was found for $AC_{1.5}F$ (782 mg/100 plants shoot) and the lowest were for AC_1F (217 mg/100 plants shoot). For roots, the values obtained are not very prominent. In Dhamrai soil inconsistent results were obtained in almost all cases both for shoots and roots (Table 3).

3.6Effect of compost on S uptake: The S uptake by plants was found to be 30.61 mg/100 plants shoot and 4.33 mg/100 plants root in Melandaha soil. The values were 88.44 mg/100 plants shoot and 8.68 mg/100 plants root due to fertilizer application in the same soil, respectively (Table 2). In almost all cases, S uptake in shoots increased significantly due to AC, AC plus fertilizer, BC and BC plus fertilizer. The higher uptake was observed for BC but the maximum uptake both for shoots and roots were obtained for $AC_{1.5}$ F treatment (Table 2). Similar results were also found for Dhamrai soil (Table 3) both for AC, AC plus fertilizer, BC and BC plus fertilizer. For this case the highest value was obtained for $BC_{1.5}$ (68.14 mg/100 plants shoot) and the lowest value was obtained for BC_2 (17.98 mg/100 plants shoot). In root, the highest value was for AC_2F and BC_1F (6.83 mg/100 plants root) and the lowest was for AC_1 (2.22 mg/100 plants root).

In most cases, the uptake of Ca, Mg, and S increased significantly due to application of compost or compost plus fertilizer. This might be due to higher growth of plants. The growth increased due to application of compost or compost plus fertilizers; that growth increase occurs due to compost application is in report (Schegel, 1992; Eghball and Power, 1999; and Molla and Huq, 2003). In almost all cases, the maximum uptake took place when fertilizers were added along with compost. The maximum uptake occurred in Melandaha soil when it was treated with barrel compost (Table 2 and Table 3). From this result it can be said that uptake of Ca, Mg and S increased significantly due to application of compost or compost plus fertilizer.

4. Conclusion

From the present study, it can be concluded that the availability of Ca and Mg decreased but S availability increased due to application of compost or compost plus fertilizer. Ca availability increased when barrel compost was applied in Dhamrai soil indicating availability depends on soil types. The uptake of Ca, Mg and S is increased in shoots over roots indicating the elements are mostly needed in aerial parts. Better results were observed with Barrel compost but for individual treatment $AC_{1.5}F$ gave the best uptake of these elements. The best production was also obtained at this treatment (Molla and Huq, 2002).

Acknowledgements: The author desire to express his appreciation to the Ministry of Education, Science, Culture and Sports, Government of Japan for their kind support.

Received: 4/30/2009 and **Revised:** 13/08/2009

Correspondence to:
Abul Hasnat Md. Shamim, Ph. D Student
Faculty of Environmental Science and Technology
Okayama University, Okayama 700-8530, Japan
E-mail: abulhasnats@yahoo.com

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