Available online at www.banglajol.info/index.php/BJSIR

Bangladesh J. Sci. Ind. Res. **59(3)**, 179-190, 2024

BCSIR

BANGLADESH JOURNAL OF SCIENTIFIC AND INDUSTRIAL RESEARCH

ISSN. 0304-9809

Integrated effects of cow dung, poultry manure and soil mixing on the growth and nutrient content of red amaranth

S. B. Soliaman, M. B. Hossain*, R. Mandal and H. R. Khan

Department of Soil, Water and Environment, University of Dhaka, Dhaka-1000, Bangladesh

ARTICLE INFO

Received: 14 July 2024

Revised: 13 August 2024

Accepted: 18 August 2024

eISSN 2224-7157/

DOI: https://doi.org/10.3329/bjsir.v59i3.74798

Abstract

A pot experiment was conducted to study the impacts of two types of organic manure on the growth parameters and status of nutrients of red amaranths raised in the manipulated soils obtained by mixing acid and calcareous soils at 3:1 ratio. The experiment was carried out using control, cow dung (3, 6 and 9 t/ha) and poultry manure (2, 4 and 6 t/ha). The results showed that the best plant growth occurred in the manipulated soil (control) than individual calcareous and acid soils. The maximum plant height, fresh weight, N, K and P content of plants were found in case of the medium dose of poultry manure T5 (4 t/ha) while the highest rate of cow dung, T3 (9 t/ha) produced the highest dry weight, N, Ca, Cu, Fe, Mn contents of red amaranth among all organic treatments. The observations of this study revealed that soil manipulation obtained by mixing two problem soils (calcareous and acid soil) could be a viable amelioration procedure, while the application of animal manures could boost soil health suggesting that the process of reclamation and application of organic manures acted synergistically.

Keywords: Problem soils; Soil mixing; Red amaranth; Cow dung; Poultry manure; Growth and nutrition

Introduction

Agriculture in Bangladesh confronts massive challenges of producing crops from its limited lands to meet up the huge necessity of foods for its growing population. Crop production here is now facing with several unavoidable concerns, namely nutrient deficiency, soil acidity, alkalinity, indiscriminate utilization of synthetic fertilizers and amendments, limited or zero use of organic manures etc. (Ghosh *et al.* 2017). Bringing new land under cultivation is very close to impossible. Therefore, management of lands particularly which are deficient in nutrients is of immense necessary (Rahman and Azam, 2005).

Soil acidity is a vital threat to crop production in approximately 27% of agricultural lands of Bangladesh (Hossain *et al.* 2021). Acidic soils, characterized by low pH levels, often pose limitations to plant growth and nutrient uptake, necessitating ameliorative measures for successful crop cultivation. Plants grown in acidic soils may lack of essential nutrients, for instance K, Ca, Mg etc. and can possess toxicity of Al, Mn, H etc., and fixing of applied elements of fertilizer (Brady and Weil, 2002; Akinrinade *et al.* 2006). On the contrary, soil calcareousness has been identified as a threat to crop production in about 27,000 sq. km land coverage (FRG, 2012). Calcareous soils being abundant in calcium carbonate can exhibit their own set of challenges, including detrimental influence of $CaCO_3$, low of organic matter content, N, P, S and other micronutrient, specially, Fe and Zn (Lucas and Knezek, 1972). Addressing the complexities associated with these contrasting soil types requires tailored interventions that can mitigate their adverse effects and optimize agricultural productivity. Mixing the acid with calcareous soils provides an improved soil with relatively neutral point soil pH and can assure all essential nutrients present in the available forms (Hossain *et al.* 2021; Soliaman *et al.* 2022; Zhang *et al.* 2002).

*Corresponding author's e-mail: bayazid@du.ac.bd

In the quest for sustainable, effective and eco-friendly agriculture amid the reality of global population burgeons, the utilization of organic fertilizers stands out as a promising avenue towards fostering soil health, enhancing crop productivity, and mitigating environmental degradation. The choice of organic fertilizers—cow dung and poultry manure—stems from their widespread availability, cost-effectiveness, and potential to enhance soil fertility through the replenishment of organic matter, essential nutrients and improvement of soil physical condition. Both cow dung and poultry manure are renowned for their nutrient-rich composition, comprising nitrogen, phosphorus, potassium, and an array of micronutrients vital for plant growth and development (Mondal *et al.* 2019; Ewulo, 2005). Moreover, they offer a sustainable alternative to synthetic fertilizers, aligning with the principles of eco-friendly agriculture (Saha *et al.* 2022; Soliaman *et al.* 2022).

Red amaranth is renowned for its rich nutrient profile, containing essential vitamins, minerals, and antioxidants, making it a valuable addition to diets worldwide (Miah *et al.* 2013). Understanding how organic fertilizers affect its growth and nutritional quality not only holds implications for optimizing agricultural practices but also for promoting food security and human health. Red amaranth has been observed showing positive response in case of growth and yield when treated with poultry manure and cow dung (Sanni, 2016; Adekiya *et al.* 2019). Some researchers experimented the impact of utilizing animal manures including poultry manure and cow dung on different varieties of amaranth in Bangladesh (Ghosh *et al.* 2017; Miah *et al.* 2013; Sattar *et al.* 2007). But there is study done yet to focus on the mineral nutrient status along with the overall growth of red amaranth amended with poultry manure and cow dung in the combination of acid and calcareous soils.

The present study endeavors to unravel the effects of two animal manures, namely poultry manure and cow dung on the growth and nutrient element status of red amaranth cultivated in a mixed soil. By delving into the intricate interactions between soil properties, organic fertilizers, and crop responses, this research aspires to offer evidence-based insights into optimizing organic fertilizer usage for enhancing crop productivity and nutritional quality in Bangladesh's diverse agroecosystems. The main objective is to evaluate the impact of poultry manure and cow dung upon the growth parameters (e.g., plant height, weight) and nutrient content of red amaranth cultivated in acidic and calcareous soil mixtures. In addition, the mixing effect of acid and calcareous soils on the overall growth and nutrient content of red amaranth is another core objective of this study.

Materials and methods

Soil sample collection

The experiment was performed in the Net House of the Department of Soil, Water and Environment, University of Dhaka to unearth feedbacks of the mixed soil regarding overall growth of red amaranth and thereby determining the nutrient status in plants. In addition to that, the impact of poultry manure and cow dung on the growth and nutrition of the plant were also assessed. For mixing, acidic soils were gathered from a village of Dinajpur Sadar upazilla called Binnapara, locating at $25^{o}42^{/}52.58^{//}$N and $88^{o}39^{/}36.07^{//}$ E. Collected acid soils belong to Non-Calcareous Brown floodplain soils. Meanwhile, the calcareous soils were collected from Poschim Gangabardi, a village of Sadar upazilla, Faridpur. The GPS coordinates of the sampling site was $23^{o}34^{/}59^{//}$N and $89^{o}47^{/}17.9$//E. The calcareous soils belong to Calcareous Dark Grey Floodplain type.

Soil sample preparation

Collected soils were let to be dried in air for 5 days on a clean sheet of polythene. Visible root and debris were eliminated off. After drying in air, gentle hammering by wooden hammer was performed to crush the relatively larger aggregates. After that, samples were screened through a stainless sieve of 2 mm size was. Later than, sieved acid and calcareous soils were mixed together in a proportion of 3:1. The ratio was determined by an incubation study conducted in the laboratory of the Department to observe the mixing effect of acid and calcareous soil at different ratios. Different physical and chemical features of the acid, calcareous and mixed soils were diagnosed which have been documented in Table I. Besides, a portion of sample soils was ground and was screened through a 0.5 mm sieve and preserved for further analyses.

Pot experiment

A pot experiment was carried out choosing red amaranth as the experimental plant. Each pot got 2 kg of manipulated and air-dried soils. Urea, Muriate of Potash (MP), Triple Super Phosphate (TSP) and Gypsum fertilizers were utilized as basal doses of N, K, P and S respectively (FRG, 2012). Total amount TSP, MP, Gypsum and half portion of Urea were used during soil preparation for pots. Rest half of Urea was applied

Table I. Different physical and chemical properties of calcareous, acid and manipulated soils

Characteristics	Calcareous soil	Acid soil	Manipulated soil
Texture	Loam	Silt loam	Silt loam
pH	8.30	4.50	6.38
EC (µS/cm)	176.0	447.0	509.0
C.E.C (cmol/kg)	12.50	6.46	9.86
OM (%)	1.54	1.86	0.173
OC (%)	0.89	1.08	1.005
Available N (mg/kg)	108.0	192.50	117.0
Available P (mg/kg)	18.80	5.50	12.95
Available K (mg/kg)	103.28	58.53	80.39
Available S (mg/kg)	15.83	30.95	18.90
Available Na (mg/kg)	62.50	25.0	6.78
Available Ca (mg/kg)	3615.0	300.50	500.0
Available Mg(mg/kg)	208.0	97.50	179.0
Available Fe (mg/kg)	15.38	103.10	49.40
Available Mn (mg/kg)	15.70	37.52	27.70
Available Cu (mg/kg)	1.03	0.67	0.514
Available Zn (mg/kg)	1.30	2.44	1.118

on the15th day of sowing seeds. Cow dung was added at a rate of 3, 6 and 9 t/ha and poultry manure were applied at three different rates such as 2, 4 and 6 t/ha respectively. These organic amendments were applied a week prior to sowing for uniform mixing and proper decomposition. The analyzed %OC, % N, %K, %P, %S, %Mg and %Ca of cow dung and poultry manure were found like 6.65, 8.96; 0.4, 1.33; 0.31, 0.80; 0.20, 0.60; 0.09, 0.12; 0.15, 0.30 and 0.30, 0.62 respectively. Certified seeds (BARI-1) of red amaranth were purchased from a registered nursery and were sown at a rate of 10 seed per pot.

There were total 9 treatments and each had 3 replications.

T_C= Calcareous soil

T_A= Acid soil

T_{0M} = Manipulated or mixed soil (Control)

T_1 = cow dung at 3 t/ha in the manipulated soil

T_2 = cow dung at 6 t/ha in the manipulated soil

T_3 = cow dung at 9 t/ha in the manipulated soil

T_4 = poultry manure at 2 t/ha in the manipulated soil

T_5 = poultry manure at 4 t/ha in the manipulated soil

T_6 = poultry manure at 6 t/ha in the manipulated soil

Plant sample preparation

After growing for 45 days, plants were harvested as root and shoots. Just after then, the fresh weight was measured by electric balance. Later, the plant samples were chopped into smaller fractions, air-dried and were further dried at $70^0 \pm 5^0$C for 48 hours in an oven. After drying in oven, samples were ground with the help of mortar and pestle and pulverized samples were screen through a stainless sieve of 0.5 mm. After sieving, samples were transferred into plastic bottles to store for chemical analysis.

Chemical analysis

The particle size analysis of soil samples was determined by Hydrometer method and textural classes were done by Marshall's triangle (Black, 1965). The pH value of the samples was determined by a glass electrode pH meter and the solution was made at 1:2.5 ratio of soil and water. The organic carbon (OC) was evaluated by following the wet oxidation method described by Walkely and Black (Jackson, 1973). Van Bemmelen's factor (1.724) was multiplied with %OC to calculate organic matter content.

Available N was measured by extracting with 1N KCl, then distillation by a Micro-Kjeldhal's distillation unit.and, finally, titrated against standard diluted solution of H_2SO_4 (Huq and Alam, 2005). Bray and Kurtz method was used to extract available P in soil with pH less than 7 and for soils with pH more than 7, Olsen method was chosen. Determination of available P was performed by a spectrophotometer (Shimadzu UV-VIS) at 880 nm. The available K in soil was extracted by 1N solution of Ammonium acetate at pH 7.0 and was estimated with the help of a Jenway PFP7 flame photometer with filters of 769 nm (Jackson, 1973). Availability of S in soil was evaluated by creating $BaSO_4$ turbidity utilizing Tween-80, after that a Shimadzu UV-1800 spectrophotometer was used to estimate the available S at 420 nm (Jackson, 1973). The CEC of the soil samples was measured by extracting the soil with 1N NH_4OAC solution followed by replacing NH_4-N by 1N NaCl fixing pH at 7. The substituted NH_4-N was undergone alkali distillation (40% NaOH) and emitted NH_3-N was collected in 4% H_3BO_3 having mixed indicator and then titrated against standard H_2SO_4. (Huq and Alam, 2005). Cu, Fe, Zn and Mn were analyzed by a Varian AA240 atomic absorption spectrophotometer.

After grinding, plant samples were digested by of HNO_3 and $HClO_4$. Plant nutrient contents were analyzed from the digest. N content in plant was determined by Micro-Kjeldahl's method (Jackson, 1973). P content in plant was determined by utilizing a Shimadzu UV-VIS spectrophotometer in colorimetric method fixing a range of 400 to 490 nm wave length as described by Jackson (1973). Plant´s K content was determined from the digest with the help of a flame photometer (Jackson, 1973). The digest was also used to evaluate the S content of plant samples by turbidimetric method (Huq and Alam, 2005). After the wet oxidation with $HClO_4$ and HNO_3; plant Ca, Mg, Mn, Fe, Cu and Zn were determined according to the procedures for soil which have been mentioned earlier.

Statistical analysis

One-way analysis of variance (ANOVA) was applied to figure-out the significant difference between treatments. Least Significant Difference (LSD) test was done along with. SPSS (v 20) at > 95% confidence level ($p < 0.05$) and Microsoft Excel (2019) were used for statistical analysis.

Results and discussions

Growth parameters of red amaranth

Growth is the progressive development of an organism which is generally described to give some quantitative expressions to the amount of growth by a plant during a given period of time. Of the various parameters plant height, fresh shoot weight (at maturity), dry weight was considered for the present investigation (Table II and III).

Plant height

The height of red amaranth plants was recorded as better (25 cm) in manipulated (control, T_{0M}) than individual acid (T_A) and calcareous (T_C) soils (Fig. 1 and Table: II). This might due to the pH obtained is close neutral range (6.38) in manipulated soil after mixing calcareous and acid soils, which might facilitate better nutrient availability to plants (Solaiman *et al.* 2022) and thus better plant height happened.

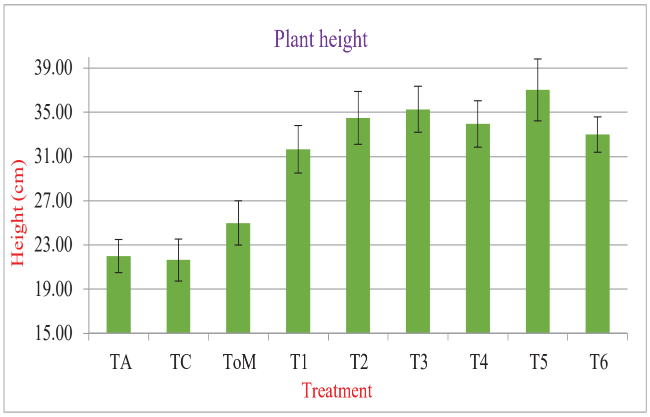

Fig. 1. Impacts of soil manipulation, cow dung and poultry manure application upon the height of red amaranth

Application of poultry manure and cow dung in manipulated soils increased the height of red amaranth plants with the increasing rate and the highest (37.03) was documented in the T_5 treatment (Fig. 1) where poultry manure was applied at 4 t/ha. Increasing doses of cow dung treatments resulted consistent increase of plant height over control (T_{0M}) and the highest dose of cow dung (9 t/ha) caused the tallest plant (35.38cm) among all cow dung treatments (Fig. 1). On the other hand, poultry manure also showed an increase in plant height up to 4 t/ha (T_5) and thereafter decreased with the highest rate of 9t/ha (T_6). These results indicate that the second dose (4 t/ha) of poultry manure ranked first and the highest dose (6t/ha) showed negative effect compared to the second dose and the poultry manure was superior to cow dung as long as the height of red amaranth is concerned (Fig. 1). However, the increase of plant heights over control with both treatments was not statistically significant (Table: III).

The present finding is closely associated with Ghosh *et. al*. (2017), who reported that cow dung application increased the plant height of red amaranth significantly. Similar

Table II. Effects of soil manipulation on the height, fresh and dry weight of red amaranth

Treatment (t/ha)	Height (cm/plot)	Fresh matter (kg/ha)	Dry matter (kg/ha)
T_A	22.00±1.95	9.77±0.87	0.55±0.06
T_C	21.64±2.12	9.23±0.94	0.52±0.04
T_{0M}	25.00±2.67	12.03±1.09	1.21±0.07

Table III. Height, fresh and dry weight of red amaranth as influenced by cow dung and poultry manure

Treatment (t/ha)	Height (cm)	Fresh matter (kg/ha)	Dry matter (kg/ha)
T_{0M}	25.00	12.03	1.21
T_1	31.66	20.33	2.39
T_2	34.50	21.76	2.53
T_3	35.28	24.56	2.61
T_4	33.95	24.07	2.25
T_5	37.03	26.99	2.37
T_6	32.99	25.68	2.23
LSD at 5%	NS	4.25	0.65

results in *A. hybridus* were also reported by Sanni (2016). In addition, Mondal *et al.* (2019) claimed that different manures including poultry increased the height of red amaranth over control treatment which is also falls in line with the results of Kahu *et al. (2019),* Saha *et al.* (2022) and Islam *et al.* (2011).

Fresh weight and dry weight of red amaranth

The fresh and dry weights of red amaranth were the highest (12.03 and 1.21 kg/ha respectively) for T_{0M} (manipulated soil) comparing to the acid (T_A) as well as calcareous soil (T_C) (Fig. 2 and Table: II). This could be because of the favourable soil pH obtained from mixing of calcareous and acid soils together.

Different treatments containing poultry manure and cow dung influenced the fresh weight of red amaranth. The results showed an increase in fresh weight significantly ($p \leq 0.05$) over the control (T_{0M}) in case of treatments (Table: III). Application of cow dung in the manipulated soil increased the fresh weight of plants steadily with the increasing doses and the highest (24.56 kg/ha) was found in the highest (9 t/ha) dose (T_3) among all cow dung treatments. On the other

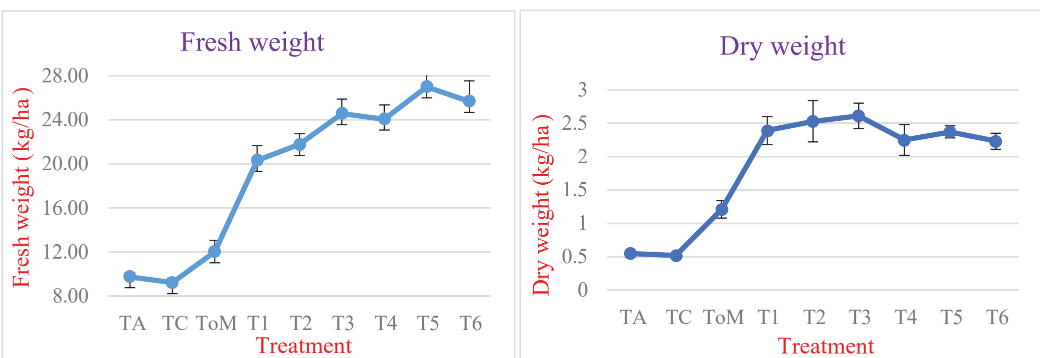

Fig. 2. Fresh weight and dry weight of red amaranth affected by soil manipulation, cow dung and poultry manure

hand, treatments of poultry manure showed an increase with increasing doses for T_4 (2 t/ha) and T_5 (4 t/ha) and the highest fresh weight (26.99 kg/ha) was obtained in T_5 treatment of poultry manure. However, there was a slight decrease of fresh weight (25.68 kg/ha) for T_6 (6 t/ha) of poultry manure comparing to T_5.

The dry weight of red amaranth plants increased significantly ($p \leq 0.05$) over the control (T_{0M}) in all the treatments (Table: III). Results showed (Fig. 2) that application of cow dung (T_1, T_2 and T_3) at increasing rates (3, 6 and 9 t/ha) increased the shoot dry weight consistently and the maximum dry weight (2.61 kg/ha) was attained at T_3 treatment (9 t/ha) among all the treatments of poultry manure and cow dung. Meanwhile, treatments of poultry manure first tended to increase the dry weight for increasing doses namely, T_4 (2 t/ha) and T_5 (4 t/ha), reached its peak (2. 37 kg/ha) at T_5 and then decreased (2. 23 kg/ha) even less than T_4 (2 t/ha) in the highest dose treatment, T_6 (6 t/ha). These indicate that the dry weight of red amaranth increased more according to increased treatments of cow dung than poultry manure application.

Organic manures probably increased the amount and availability of nitrogen in soil that might have positive effects on plant vegetative growth and consequently, increment in fresh and dry weight of shoots. Noor *et al*. (2007) mentioned the maximum fresh weight of red amaranth was achieved by 5 t ha-1 poultry manure, which also supports the outcomes of this study. Okokoh and Bisong (2011) found that higher yield of fresh leaf and fresh stem in amaranth were obtained when poultry manure was used. Similar observations were claimed by Saha *et al.* (2022), Adekiya *et al.* (2019) and Miah *et al.* (2013). On the contrary, significant ($P \leq 0.01$) variation in fresh and dry weight of Indian spinach and red amaranth were observed due to the effect of cow dung by Ghosh *et al.* (2017). Some of other researchers including Mondal *et al.* (2019) and Sanni (2016) reported that cow dung application increased the fresh and dry weight of plants.

Major nutrient status of red amaranth

The N, P, K, S, Mg and Ca content in red amaranth plants were presented in Table IV and V.

Nitrogen

The concentration of N was higher (1.47%) in red amaranth plants of manipulated soil (T_{0M}) than individual acid (T_A) and calcareous (T_C) soil (Fig. 3 and Table: IV). The highest content of N (1.81%) was documented in red amaranth plant amended with 9 t/ha cow dung (T_3) as well as treated with poultry manure at 6 t/ha (T_6). Cow dung treated plants showed an increase in N content ranging from 1.54% to 1.81% at 3 t/ha (T_1) to 9 t/ha(T_3) respectively but only T_3 was statistically significant ($p \leq 0.05$) over the control (Table: V). Application of cow dung at 3 and 6 t/ha (T1 and T_2 respectively) increased N contents of plant but not significant compared to control. Similarly, increased N content with the

Table IV. Impacts of soil manipulation on major element contents of red amaranth

Treatment	% N	% P	% K	% S	% Mg	% Ca
T_A	1.40±0.0	0.24±0.0	1.65±0.05	0.38±0.03	0.73±0.04	0.40±0.03
T_C	1.02±0.0	0.33±0.0	1.74±0.05	0.22±0.03	1.44±0.09	1.60±0.07
T_{0M}	1.47±0.0	0s.38±0.	1.84±0.07	0.25±0.02	0.73±0.06	0.60±0.04

Table V. The status of major element contents in red amaranth plants grown in manipulated soil as affected by poultry manure and cow dung

Treatment	% N	% P	% K	% S	% Mg	% Ca
T_{0M}	1.47	0.38	1.84	0.25	0.73	0.60
T_1	1.54	0.40	1.93	0.27	0.88	0.68
T_2	1.59	0.53	2.30	0.34	1.02	0.77
T_3	1.81	0.57	2.50	0.30	0.94	0.83
T_4	1.55	0.58	2.12	0.29	0.98	0.70
T_5	1.76	0.62	2.52	0.34	0.86	0.81
T_6	1.81	0.46	2.31	0.39	1.11	0.81
LSD at 5%	0.16	0.09	0.33	NS	NS	0.10

increasing amounts of poultry manure was observed. Poultry manure applied at the lowest dose (T_4) showed no significant increase, while other increased doses (T_5 and T_6) produced significant increases ($p \leq 0.05$) over the control (T_{0M}). The improvement in the mineral contents of amaranth leaf as a result of the application of poultry manure was attributed to better availability of nutrients (Adekiya *et al.* 2019). Asghar *et al.* (2009) mentioned that organic waste and N fertilizer caused significant increase in N uptake by plants. Similar outcomes were also documented by Sanni (2016), Mondal *et al.* (2019) and Monira *et al.* (2007). The present results are partially agreed with above findings.

Phosphorus

The P content in red amaranth plant was better (0.38%) in the manipulated soil (T_{0M}) than plant grown in acid and calcareous (T_A and T_C respectively) soils (Fig. 3 and Table: IV). The reason might be the favorable pH condition in the manipulated soil for the growth of plants. All the treatments of poultry manure as well as cow dung showed positive effects on the phosphorus content of the amaranth plant and the highest (0.62%) was found in application of poultry manure at 4 t/ha (T_5). Cow dung application with increasing rate showed a consistent and significant increment ($p \leq 0.05$) of P content over the control (T_{0M}) except T_1 (Table: V). On the other hand, increase in P content in red amaranth due to poultry manure was found to be significant ($p \leq 0.05$) over the control (T_{0M}) except T_6 (Table: V). Data showed significant increment of P with increasing doses of poultry manure, peaked at T_5 and fell sharply in T_6 (Fig. 3). Asghar *et al.* (2009) reported significant increment of P content treated with compost. Using of organic manure enhanced the efficiency of fertilizer utilization (Nevens and Reheul, 2003). These findings also support the evaluations from Adeleye *et al.* (2010), Akanni and Ojeniyi (2008).

Potassium

K status in red amaranth was found to be increased (1.84%) in manipulated soil (T_{0M}) comparing to individual calcareous (T_C) and acid (T_A) soils, 1.74 % and 1.65% respectively (Fig. 3 and Table: IV). Application of cow dung at all the rates showed steady and significant ($p \leq 0.05$) increment of plant K content over the control (T_{0M}) but T_1 (3 t/ha) was not significant (Table V). Meanwhile, except the lowest dose (2 t/ha), all the poultry manure doses produced significant ($p \leq 0.05$) increase of K in red amaranth plants (Table: V). Poultry manure showed an increase in K content up to 4 t/ha (T_5) and thereafter a decrease with the highest rate (T_6) of 6 t/ha than the medium rate (T_5). Among all the treatments, the highest K content was recorded in treatment T_5, the medium dose of poultry manure at 4 t/ha (Fig. 3). Olowoake and Adeoye (2013) suggested that the organic manure increased soil K and subsequently more uptake of K. The highest K uptake was found due to an addition of organic manure than nitro-

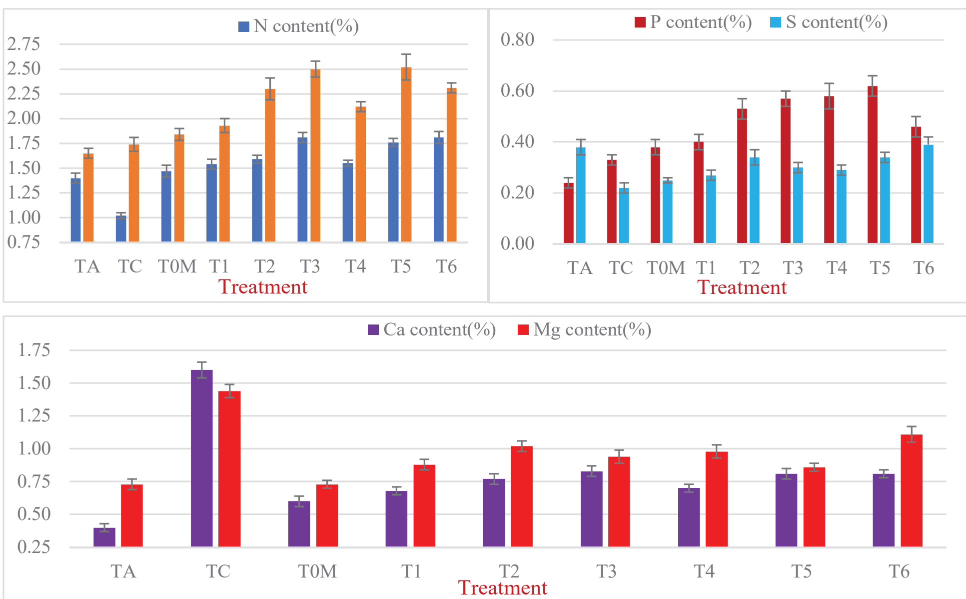

Fig. 3. Impacts of soil manipulation, cow dung and poultry manure on the N, K, P, S, Ca and Mg content of red amaranth

gen fertilizer, which partly supports our findings (Kumawat and Jat, 2005).

Sulphur

The amount of S content in acid soil (T_A) containing amaranth shoot was higher (0.38%) than that of calcareous soil, T_C (0.22%). In manipulated (T_{0M}) soil, the S level was in between (0.25%) them (Table IV). Treatments of poultry manure and cow dung application increased the S content of amaranth plants but not significantly (Table V). The maximum S content (0.39%) in the amaranth plant was observed with the T_6 (6 t/ha), the highest dose of poultry manure (Fig. 3). Cow dung application at the rate of 3 t/ha (T_1) to 6 t/h (T_2) showed increase in S content of shoot from 8% to 36% compared to the control (T_{0M}). Further addition of cow dung (T_3) resulted decrease in S content than the medium dose (T_4) of it but increased 20% over the control (T_{0M}). On the contrary, Poultry manure resulted a consistent increase in S content of shoot with increasing doses (Fig. 3). Addition of 2 t/ha (T_4) to 6 t/ha (T_6) poultry manure caused an increase of S content 16% to 56% over the control (T_{0M}). The present finding corresponded with other findings. Such as in barley, the highest S uptake was also recorded in the plots receiving poultry manure (Kumawat and Jat, 2005). Similar result was mentioned by Adekiya *et al.* (2019) stated that, the effect of poultry manure increased higher uptake of S in plants which supports the present study.

Calcium

The maximum Ca content (1.60%) was found in calcareous soil containing red amaranth shoot (T_C) and the minimum (0.40%) was found for acidic soil (T_A). The T_{0M} (mixed soil) had median Ca content (0.6%) acid and calcareous soil (Table: IV and Fig. 3). Ca content of red amaranth shoot showed a significant increase ($p\leq 0.05$) over the control (T_{0M}) for all treatments except the lowest dose of cow dung, T_1 (Table: V). Cow dung treated plants showed a steady increase in Ca content ranging from 0.68% to 0.83% at 3 t/ha to 9 t/ha respectively. Maximum content of Ca (0.83%) was found in red amaranth plant treated with T_3 (9 t/ha). On the other hand, poultry manure treated red amaranth showed an increment consistently (0.71% and 0.81%) in T_4 (2 t/ha) and T_5 (4 t/ha) respectively and then remained constant (0.81%) in the highest dose, T_6 (Fig. 3). High Ca content of poultry manure and cow dung might assure the increase the Ca content in red amaranth. Saha *et al.* (2022) reported that Ca content in red amaranth plant increased significant ($p<0.05$) over the control for different organic and inorganic fertilizers. Findings from several other researches fall in line with this partially (Ewulo, 2005; Akanni and Ojeniyi, 2008 and Adekiya *et al.* 2019).

Magnesium

Mg content was found the highest (1.44%) in plants grown in calcareous soil (T_C) and in acidic soil (T_A) and manipulated soil (T_{0M}) the value was 0.73% (Table: IV and Fig. 3). Treatments of both type manure failed to create consistent and statistically significant impact on Mg content of red amaranth shoot (Table: V). Result showed that among the three doses of cow dung from 3 to 9 t/ha, content of Mg varied from 0.88 to 0.94% and the highest (1.02%) was found in T_2 (6 t/ha). Meanwhile, poultry manure showed an overall increase of Mg content with increasing amount of poultry manure (Fig. 3) and the highest Mg content (1.11%) was recorded in plant treated with T_6 (6 t/ha). Almost similar findings were outlined by Agbede *et al.* (2008) who observed that, the increased uptake of Ca and Mg from soil occurred due to application of the manure. The evaluation also resembles to Ewulo *et al.*, (2008) who noted positive effect of manure applications on leaf Ca and Mg concentrations of tomato. Findings from other researches also support them (Adeleye *et al*. 2010; Akannni and Ojeniyi, 2008).

Micronutrient contents of red amaranth

Copper

The highest copper (Cu) content in red amaranth (6.55 mg/kg) was found in calcareous soil (T_C) whereas the lowest (2.30 mg/kg) in acidic soil (T_A) and plants grown in manipulated soil (T_{0M}) remained in between (4.70 mg/kg) them (Table: VI). The overall effect of poultry manure and cow dung treatment on Cu content of red amaranth shoot is significant ($p\leq 0.05$) over the control (T_{0M}) except for T_1, T_5 and T_6 (Table: VII). Cow dung treated plants had the highest Cu content (7 mg/kg) with the highest dose T_3 (9 t/ha) of it. But poultry manure treated plants showed a decreasing trend with increasing doses of it and T_6 produced the lowest value (5.20 mg/kg) as far the treatment of poultry manure is concerned (Fig. 4).

Iron

The Fe content of red amaranth shoot was maximum (380.17 mg/kg) in acidic soil (T_A) while the minimum (200.14 mg/kg) was in T_C (calcareous soil). In manipulated (control) soil, the Fe level was in between (290.20 mg/kg)

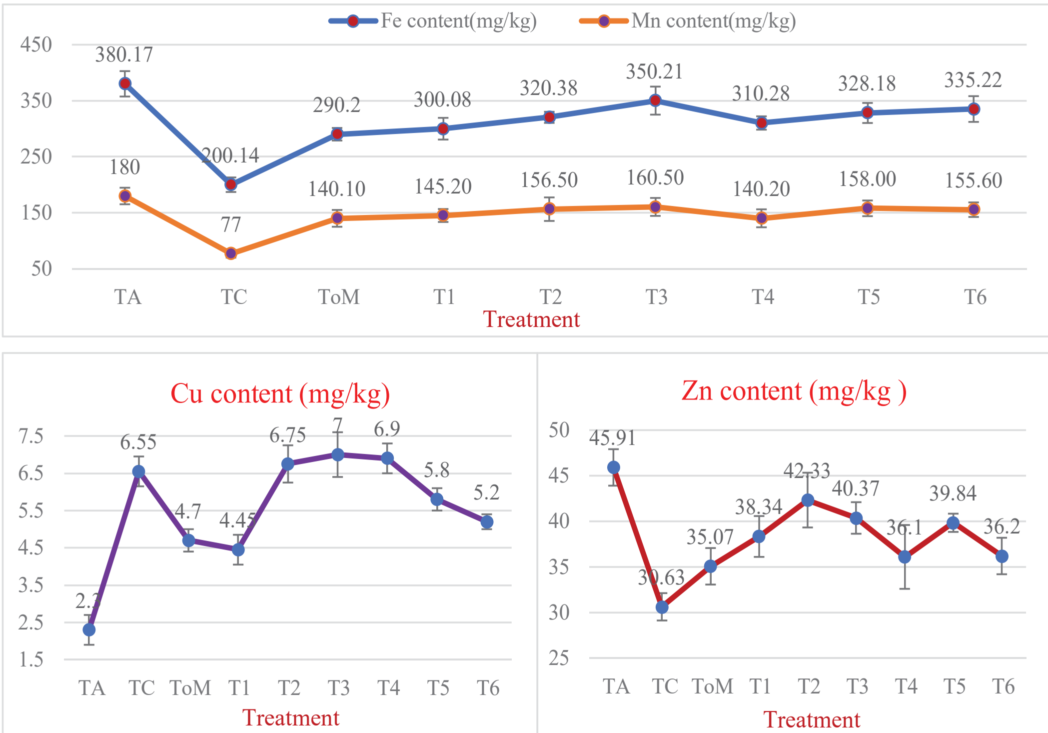

Fig. 4. Fe, Mn, Cu and Zn content of red amaranth as affected by manipulation of soils, poultry manure and cow dung

them (Table: VI). Application of two type of manure treatments increased the Fe content of amaranth shoots significantly ($p \leq 0.05$) comparing to the control (T_{0M}) except the T_1 (Table: VII). The maximum Fe content in the amaranth shoot (350.21 mg/kg) was noticed in T_3 (9 t/ha cow dung). Both poultry manure and cow dung exhibited increasing Fe content with increasing doses of both poultry manure and cow dung (Fig. 4).

Manganese

The Mn content in acidic soil (T_A) containing amaranth shoot was the highest (180 mg/kg) whereas the lowest (77 mg/kg) was observed in T_C (calcareous soil). In manipulated (control) soil (T_{0M}), the Mn level was in between (140.1 mg/kg) them (Table: VI). Mixing of the acid and calcareous soil reduced Mn toxicity. The Mn content of amaranth shoots increased with different treatments of both two types of manure but not significantly (Table: VII). The maximum Mn content in the red amaranth shoot (160.50 mg/kg) was resulted in T_3 (9 t/ha cow dung). Mn content in plant increased as per increasing doses of both poultry manure and cow dung except the highest dose of poultry manure which increased than the control but decrease than its medium dose, T_5 (Fig. 4).

Zinc

Zn concentration was found as the highest (45.91 mg/kg) in plants grown in T_A (acid soil), while T_C (calcareous soil) caused the lowest (30.63 mg/kg) and plants grown in manipulated soil (T_{0M}) remained in between (35.07 mg/kg) them (Table: VI). The overall effect of the poultry manure and cow dung on Zn content of red amaranth shoot is not significant (Table: VII). Cow dung treated plants had higher Zn content with the medium dose (6 t/ha) of it. Higher dose of cow dung caused a decrease in Zn content than the medium dose but higher than the control. Poultry manure treated plants showed the same trend (Fig. 4). Magkos *et al.* (2003) mentioned that higher contents of minerals such as Fe, Cu, Mn, Zn have been obtained in organic vegetables. Similar findings

Table VI. Influence of soil manipulation on the micronutrient contents of red amaranth

Treatment (t/ha)	Cu (mg/kg)	Fe (mg/kg)	Mn (mg/kg)	Zn (mg/kg)
T_A	2.30±0.11	380.17±12.6	180.00±9.38	45.91±4.40
T_C	6.55±0.15	200.14±9.82	77.00±3.91	30.63±2.99
T_{0M}	4.70±0.14	290.20±8.27	140.10±8.07	35.07±3.17

Table VII. Micronutrients content of red amaranth grown in manipulated soil as affected by poultry manure and cow dung

Treatment (t/ha)	Cu (mg/kg)	Fe (mg/kg)	Mn (mg/kg)	Zn (mg/kg)
T_{0M}	4.70	290.20	140.10	35.07
T_1	4.45	300.08	145.20	38.34
T_2	6.75	320.38	156.50	42.33
T_3	7.00	350.21	160.50	40.37
T_4	6.90	310.28	140.20	36.10
T_5	5.80	328.18	158.00	39.84
T_6	5.20	335.22	155.60	36.20
LSD at 5%	0.92	11.92	NS	NS

were documented by Saha *et al.* (2022) and Adekiya *et al.* (2019).

Conclusion

Acid and calcareous soils confront severe nutrient deficiency, low organic matter content associated with low agricultural productivity. Findings from this study suggest that, mixing of these two problematic soils positively affects the OC, pH, CEC, macronutrient elements (N, K, P, S, Mg and Ca) and micronutrients (Fe, Mn, Zn and Cu) of soil. Status of nutrients in the red amaranth plant was also better in manipulated soil than individual calcareous and acid soils. For better improvement of the manipulated soil, cow dung and poultry manures were added. The highest plant height, fresh weight and dry matter production were obtained with the highest dose of cow dung (9 t/ha) and medium dose of poultry manure (4 t/ha) in the manipulated soil. Application of cow dung in the manipulated soil was found to increase N, K, P, Ca, Cu, Mn and Fe contents with the increasing rates of cow dung but S, Mg and Zn contents increased up to the medium dose (6 t/ha). On the other hand, poultry manure resulted highest nutrient content with the medium dose of it (4 t/ha), except for the N, S, Mg and Fe, where the highest value obtained with the highest dose (6 t/ha). Thus, acid soils can be amended by calcareous soils and for the improvement of its fertility, productivity, animal manure can be added. However, this requires a detailed study to come to a more precise conclusion.

References

Adekiya AO, Aboyeji CM, Dunsin O, Asamu F, Owolabi AO, Aremu CO and Owolabi IO (2019), Poultry manure addition affects production, plant nutritional status and heavy metals accumulation in green Amaranth (*Amaranthus hybridus*), *Intl J Agric & Bio*. **22**(5): 993-1000. https://www.researchgate.net/publication/337276549

Adeleye EO, Ayeni LS and Ojeniyi SO (2010), Effect of poultry manure on soil physicochemical properties, leaf nutrient contents and yield of yam (*Dioscorea rotundata*) on alfisol in southwestern Nigeria, *J Am*

Sci. **6**(10): 871-878. https://www.researchgate.net/-publication/259999743

Akinrinade EA, Iroh L, Obigbesan GO, Hilger T, Romheld V and Neumann G (2006), Response of cowpea varieties to phosphorus supply on an acidic alumi-haplic-Acrisol from Brazil, *Nig J Soil Sci.* **16**: 115-120. https://www.researchgate.net/publication/325854063

Akanni DI and Ojeniyi SO (2008), Residual effect of goat and poultry manures on soil properties, nutrient content and yield of amaranthus in southwest Nigeria, *Res J Agron*. **2**(2): 44-47. https://docsdrive.com/?pdf=medwelljournals/rjagr/2008/44-47

Asghar HN, Ishaq M, Zahir ZA, Khalid M and Arshad M (2009), Response of radish to integrated use of nitrogen fertilizer and recycled organic waste. (Available at http://www.pakbs.org/ pjbot/ PDFs/ 38(3)/ PJB **38**(3): 691. Pdf. Accessed 23 December 2010).

Black CA (1965), Methods of Soil Analysis. Part 2. Agron series 9. American society of agronomy. Madison. Wisconsin. pp 891-899. https://www.scirp.org

Brady NC and Weil RR (2002), Soil acidity. In: The Nature and Properties of Soils. 13th Ed. Pearson Education Private Ltd, Patparganj, Delhi 110 092, India. pp 363-364.

Ewulo BS (2005), Effect of poultry and cattle manure on sandy clay loam soil, *J Animal & Veterinary Sci.* **4**: 839-841. https:// www. researchgate. net/ publication/ 26591139

Ewulo BS, Ojeniyi SO and Akanni DA (2008), Effect of poultry manure on selected soil physical and chemical properties, growth, yield and nutrient status of tomato, *Afr J Agric Res*. **3**(9): 612-616. https://academicjournals.org/article/article1380813223

FRG (Fertilizer Recommendation Guide) (2012), Bangladesh Agricultural Research Council, Government of Bangladesh. pp 274. https://www.researchgate.net/publication/282939933

Ghosh A, Tahjib-Ul-Arif M, Chamely SG, Haque MR, Rahman MM and Bhuiyan MAH (2017), Comparative effect of arbuscular mycorrhiza, cowdung and phosphorus on growth and yield contributing characters of red amaranth (*Amaranthus tricolor* L.) and Indian spinach (*Basella alba* L.), *Tropical Plant Research* **4**(2): 254-263. DOI: 10.22271/tpr.2017.v4.i2.035

Hossain MB, Khan HR, Khanom S and Hossain SA (2021), Amelioration of soil acidity by the application of maize straw ash in mixed soil, *Dhaka Univ J Biol Sci.* **30**(2): 207-219. https:// www. researchgate. net/ publication/ 353130176

Islam MM, Karim AJ, Jahiruddin M, Majid NM, Miah MG, Ahmed MM and Hakim MA (2011), Effects of organic manure and chemical fertilizers on crops in the radish-stem amaranth-Indian spinach cropping pattern in homestead area, *Australian journal of crop science*, **5**(11): 1370-1378. https://www.researchgate.net/publication/267917015

Huq SMI and Alam MD (2005), A Handbook on Analyses of Soil, Plant and Water. BACER-DU, University of Dhaka, Bangladesh. pp 32-123. https://www.scirp.org

Jackson ML (1973), Soil Chemical Analysis, 1st ed. Prentice-Hall Inc., Englewood Cliffs. NJ, pp 498

Kahu JC, Umeh CC and Achadu AE (2019), Effects of Different Types of Organic Fertilizers on Growth Performance of *Amaranthus caudatus* (Samaru Local Variety) and *Amaranthus cruentus* (NH84/452), *Asian Journal of Advances in Agricultural Research* **9**(2): 1-12. http://dx.doi.org/10.9734/ajaar/2019/v9i229994

Kumwat PD and Jat NL (2005), Effect of organic manure and nitrogen fertilization on productivity of barely (*Hordeum vulgare*), *Indian J Agron.* **50**: 200-202. http://dx.doi.org/10.59797/ija.v50i3.5105

Lucas RE and Knezek BD (1972), Climatic and soil conditions promoting micronutrient deficiencies in plants. *In:* J J Mortvedt *et al.* Ed. Micronutrients in Agriculture, Soil Science Society of America, Inc., Madison, WI. pp 265-288.

Miah MY, Roy PK, Islam MS and Fazal KI (2013), Stem amaranth yield in response to organic Manuring, *J Environ Sci & Natural Resources* **6**(2): 19-23.

Magkos F, Arvaniti F and Zampelas A (2003), Organic food: Nutritious food or food for thought? A review of evidence, *Int J Food Sci Nutri.* **54**: 357-371.

Mondal MMA, Ahmed F, Nabi KME, Noor MMA and Mondal MTA (2019), Performance of organic manures on the growth and yield of red amaranth (*Amaranthus* *tricolor*) and soil properties, *Res Agric Livest Fish.* **6**(2): 263-269. http:// dx.doi.org/ 10.3329/ ralf. v6i2. 43049

Monira US, Miah MY, Mia MAB and Rahman GKM (2007), Tomato fruit yield in response to organic manuring, *J Agril Edu Technol.* **10**: 93-98. https://www.researchgate.net/publication/263037602

Nevens F and Reheul D (2003), The application of vegetable, fruit and garden waste (VFG) compost in addition to cattle slurry in a silage maize monoculture: nitrogen availability and use, *European J Agron.* **19**: 189-203. http://dx.doi.org/10. 1016/S1161-0301(02)00036-9

Noor S, Mahiuddin M, Shil NC and Talukdar MR (2007), Integrated nutrient management for brinjal+ red amaranthus know cropping pattern. Annual Research Report (2007-2008), Soil Sci Div Bangladesh Agril Res Inst Gazipur. p 115-120.

Okokoh SJ and Bisong BW (2011), Effect of Poultry Manure and Urea- N on Flowering Occurrence and Leaf Productivity of *Amranthus cruentus* in Calabar, *J Apl Sic Environ Management*, **15**(1): 13-15. http://dx.doi.org/10.4314/jasem.v15i1.65667

Olowoake AA and Adeoye GO (2013), Influence of differently composted organic residues on the yield of maize and its residual effects on the fertility of an Alfisol in Ibadan, Nigeria, *Intl J Agric Env Biotech* **6**(1): 79-84. https://orgprints.org/id/eprint/32885/7/32

Rahman MM and Azam GM (2005), Fertility evaluation of Old Meghna River Floodplain soils in Bangladesh for sustainable agriculture, *Chiang Mai J Sci.* **32**(2): 127-137.

Saha M, Mousomi KN, Maukeeb ARM, & Mondal S (2022), Vermicompost Enhances the Yield and Quality of Red Amaranth Subjected to Acidic Soil, *American Journal of Agricultural Science, Engineering, and Technology*, **6**(2): 74-81. https://doi.org/10.54536/ajaset.v6i2.509

Sanni KO (2016), Effect of compost, cow dung and NPK 15-15-15 fertilizer on growth and yield performance of Amaranth (*Amaranthus hybridus*). *International Journal of Advances in Scientific Research* **2**(3): 76-82. https://www.researchgate.net/publication/301204298

Sattar MA, Ali MS, Siddik AB and Hashem MA (2007), Effect of different organic fertilizers on growth and yield of mukhi kachu cv. Sali kachu, *Bangladesh J Environ Sci*. **13**(2): 439-442. https://www.researchgate.net/publication/353702939

Soliaman SB, Hossain MB, Saha MK, Mandal R and Khan MHR (2022), Impacts of Cow Dung and Poultry Manure on the Mineral Nutrient Uptake of Red Amaranth Grown in a Mixture of Acid and Calcareous Soils, *Dhaka University Journal of Biological Sciences* **31**(2): 329-342. https:// doi.org/ 10.3329/ dujbs.v31i2. 60891

Zhang M, Li Y, Stoffella P and McLaughlin M (2002), Replacing calcareous soils with acid soils to grow rainforest species at Fairchild tropical garden, Miami, *Proceedings of the Florida State Horticultural Society* **115**: 146-149. https:// journals. flvc.org/ fshs/ article/ download/86441/83357/0