EFFECT OF DIFFERENT SOIL MIXTURES ON THE GROWTH AND YIELD OF RED AMARANTH FOR ROOFTOP GARDENING

A THESIS

BY

MD. KAMRUJJAMAN

Student No. 1701228

Session: July-December, 2023

MASTER OF SCIENCE (M.S.)

IN

SOIL SCIENCE

DEPARTMENT OF SOIL SCIENCE

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY

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DECEMBER, 2023

DEDICATED

TO MY

BELOVED PARENTS

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ABSTRACT

A pot experiment conducted at the Net House of Hajee Mohammad Danesh Science and Technology University from October to December 2023, the effect of various soil mixtures on red amaranth's growth and yield was investigated. Employing a Completely Randomized Design (CRD) with 7 treatments and 3 replications, the treatments included a control (T_1), as well as T_2 to T_7 contained mixtures involving soil, vermicompost (VC), sand, ash, and bone meal powder in different proportions such as T_2 = 70% soil + 20% VC + 5% sand + 5% Ash + 2.0 g kg^{-1} bone meal powder, T_3 = 65% soil + 25% VC + 5% sand + 5%Ash + 1.5 g kg^{-1} bone meal powder, T_4 =70% soil + 20% VC + 5% sand + 5% Ash + 1.5 g kg^{-1} bone meal powder, T_5 = 60% soil + 20% VC + 15% sand + 5% Ash + 2.0 g kg^{-1} bone meal powder, T_6 = 60% soil + 25% VC + 10% sand + 5% Ash + 1.0 g kg^{-1} bone meal powder and T_7 = 60% soil + 25% VC + 5% sand + 10% Ash + 1.0 g kg^{-1} bone meal powder, respectively. The soil characterized as sandy loam with initial pH (5.25), OM (2.9%), total N(0.14%), available P (262.98 ppm), exchangeable K (1.21 meq.100g^{-1} soil) and available S (224.87 ppm),respectively. The results indicated that the highest growth and yield characters viz., plant height (9.33, 23.7 and 32.44 cm at 10, 20 and 30 DAS, respectively), leaf number (6.27, 9.33 and 14.78 at 10, 15 and 25 DAS, respectively), fresh weight (106.63 g) and root length (12.2 cm) were observed in T_7 treatment where, 60% soil, 25% VC, 5% sand, 10% ash and 1.0 g kg^{-1} bone meal powder were applied and the lowest growth and yield characters were found in T_1 treatment (control). Soil pH, OM, total N, available P, exchangeable K and available S content in post-harvest soil were also influenced by the application of different inorganic and organic fertilizers in a mixture form. The study underscores the positive influence of the specific mixture (T_7) on soil parameters post-harvest. Conclusively, the application of 60% soil, 25% VC, 5% sand, 10% ash, and 1.0 g kg^{-1} bone meal powder as a composite appears to be a promising practice for cost-effective red amaranth cultivation in urban rooftop settings.

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ABBREVIATION AND ACRONYMS

%	=	Percent
@	=	At the rate of
AEZ	=	Agro- ecological zone
C.V.	=	Co-efficient of Variation
Cm	=	Centimeter
CRD	=	Completely Randomized Design
DAS	=	Days after sowing
et al.	=	And authors
g	=	Gram
i.e.	=	That is
K	=	Potassium
kg	=	Kilogram
$Kgha^{-1}$	=	Kilogram $hectare^{-1}$
LSD	=	Least Significance Difference
M.S.	=	Master of Science
meq	=	mill equivalent
mg	=	Milligram
MOP	=	Murate of Potash
N	=	Nitrogen
OM	=	Organic mater
P	=	Phosphorus
ppm	=	Parts Per Million
S	=	Sulphur
SE	=	Stander error
t ha^{-1}	=	Ton $hectare^{-1}$
TSP	=	Triple Super Phosphate
VC	=	Vermicompost
Viz.	=	Namely

CHAPTER I

INTRODUCTION

Bangladesh faces challenges due to its high population density but our land is limited. In particular, experience a reduction in green spaces in urban areas, As a result, the growing greenhouse effect and climate change. To address this, alternative approaches are needed. While expanding cultivable land is limited, rooftop gardening, a form of urban agriculture, offers a systematic solution by cultivating vegetables, fruits, spices, medicinal plants, and flowers on building rooftops. Rooftop gardens not only provide aesthetic benefits but also offer food, temperature control, hydrological advantages, architectural enhancements, wildlife habitats, recreational opportunities, and potential ecological benefits (Shahidullah, 2023). Implementing rooftop gardening as a strategy for urban agriculture can contribute to food security. This approach can lower temperatures around buildings in the summer, insulate them in winter, and extend the lifespan of roofs, contributing to a reduction in carbon emissions. In the context of Bangladesh, rooftop gardening is well-suited for vegetable cultivation. By adopting proper models for vegetable production on rooftop gardens, food production can be increased, meeting the urban population's demand, reducing transportation costs, and promoting the production of safe, fresh, and healthy food. It’s identified in research that 60% space of total Dhaka city occupied with bare roof with no other extensive usage (Nessa *et al.*, 2016). However, these benefits are difficult to understand because the lands which have traditionally been used for agriculture within our urban areas are in high demand and vulnerable to development. Cultivating red amaranth on rooftops is an example, considering its rapid growth, nutritional value, and popularity as a vegetable in Bangladesh(Islam *et al.*, 2020).

It has considerable nutritional value and amaranth (*Amaranthus tricolor*) belonging to the family Amaranthaceae is a delicious vegetable worldwide. Chiefly grown during summer and rainy season, amaranth is an important and Common vegetable in Bangladesh because of its cheapest price, fast growing character and higher yield potential (Hossain, 1996). Amaranth cultivation can contribute to addressing the shortage of vegetables and improving nutritional intake. Thus, amaranth plays an essential role in nutrition as a cheapest source of mineral and vitamin. The leaves and stems of amaranth are rich in protein, fat, calcium, phosphorus, riboflavin, niacin, sodium, iron and ascorbic acid (Jahan *et al.*, 2022). Additionally, it contains food caloric value higher than any other vegetables except potato and tomato (Chaudhury, 1967 and FAO, 1972). A part from this, it is used in table products like soup. Even its seeds are processed into making sweet rolls, crepes cookies crackers etc. (Shanmugavelu, 1989 and Muthukrisna and Irulappan, 1986) However, now amaranth is grown in an area of 8,647.77 ha with total production of 58.095 tones of amaranth and it is increasing gradually due to high yield, easy cultivation process with nutritional value (BBS, 2010). The average yield is 4.79-ton ha^{-1} which is lower than other amaranth producing countries (Talukder, 1999). This author also noted that daily recommended requirement of vegetables is 200 g per head but our consumption is 60 g per head with potato and sweet potato, it was 70 g day^{-1} $person^{-1}$. So, the nation runs with an acute shortage of vegetables and its production should be increased to feed the increasing population of the country. Total vegetable production in our country is about 1.879 thousand tons per year of which 61.9% is produced in Rabi season and 38.09% in Kharif season (BBS, 2010). It is clear that vegetable production in Kharif is very low. However, the highest productions of different vegetables are found during the month of November to April. So, during the month of May to September there is a serious scarcity of vegetables. As a result, the price of vegetables remains high during that period, due to high price rate and shortage of vegetable malnutrition is acute during late summer in Bangladesh. For maximizing red amaranth yield per pot, a balanced use of Urea, TSP, MP, Gypsum, and organic manure such as, vermicompost, Ash, and bone meal is essential. The physical and chemical properties of the soil mixture play a crucial role in achieving higher crop yields. Adding sand improves drainage and vermicompost is recognized for its potential as a soil amendment. In various sources of organic matter, vermicompost have been recognized as having considerable potential as soil amendments (Norman *et al*., 2005). The potting mixture, comprising soil, sand, and compost, is crucial for plant growth. Ash can be added to improve porosity, wet ability, water holding capacity, and cation exchange capacity. Bone meal fertilizer, a slow-release option, increases phosphorus levels and provides calcium for Pot culture emerges as a vital method for year-round vegetable production. Red amaranth, cultivated in pots with an appropriate soil mixture, offers a sustainable solution for rooftop gardens. Commercial and common varieties of red amaranth are Kannara Local, Arun, Raktaranga, Altapeti 20, Lolita, BARI Lal Shak-1 etc. are available in our country. It is easily cultivable in pot culture in Bangladesh with relatively low production costs, growers can cultivate red amaranth on rooftop gardens, meeting family needs, selling surplus in the market, and enjoying economic benefits.

The primary objectives of the study were as follows:

i. To investigate and identify the most suitable soil mixture to enhance the growth and yield of red amaranth;
ii. To streamline and simplify the complex management operations involved in preparing the soil media, making them more accessible for growers.

CHAPTER II

REVIEW OF LITERATURE

Red amaranth is widely grown in Bangladesh; it is a unique amaranth variety with red leaves and deep red stems. A brief and pertinent review of literature has been presented in this chapter. Attention has been made to focus the effect of different pot soil mixtures on the yield contributing characters and yield of amaranths.

Jahan *et al*. (2022) observed that the importance of nutrients, minerals, amino acids, phytochemicals, carotenes, antiradical activity, and antibacterial activity of the entire part of the red amaranth plant. The analysis of the nutritional composition of the whole part of red amaranth was that there was an appreciable quantity of protein, carbohydrate, fat. Potassium was the major trace element. Total 17 amino acids were identified and the most abundant was glutamic acid. The selected vegetable also contained an appreciable amount of carotenes. Plant extract had a modest extent of bacterial growth inhibition activity. Thus, red amaranth is a wonderful source of nutrients, a natural antiradical, and has other bioactive compounds.

Munmun *et al.* (2022) stated that the highest yield of red amaranth was observed from the treatment of VC (7.79 tha^{-1}) followed by lime (5.79 tha^{-1}), compost (5.52 tha^{-1}) and cowdung (4.73 tha^{-1}). The result showed that the effects of VC were more efficient in terms of vigorous production, nutrient contents as well as in the maintenance of soil pH for the potential cultivation of red amaranth compared to the other management. Besides these, the nutrients content of red amaranth was also observed and found that the Ca, Mg, K, P, S and Fe were substantially higher in VC except the Zn and B.

Soliaman *et al.* (2022) reported that the influence of cow dung and poultry manure on the growth of red amaranth grown in the amended soil (mixture of acid and calcareous soil). It was found that 9 ton cow dung ha^{-1} showed the highest uptake of nutrients except for S an Mg. In the post-harvest soil, the maximum nutrient contents increased in the highest doses of cow dung (except for the S, Cu, Mn and Zn) and poultry manure (except for the K, Ca, Mg and Fe) treatments. Results of the study showed that soil amendment (mixture of acid and calcareous soil) can be a suitable reclamation process while the addition of organic manures can also improve soil health.

Shahidullah *et al.* (2021)evaluated that the growth parameters, biomass production and nutrient uptake of red amaranth (*Amaranthus tricolor* L.) as influenced by different types of organic manures. Research is recommended to be undertaken in similar fashion and under varying agro-climatic conditions in Bangladesh to determine and compare the influences of the organic manures on the growth and nutrient uptake of a fast-growing vegetable like red amaranth.

Akamine *et al*. (2021) investigated that growth parameters and yield greatly increased with the NPK fertilizer at 30-40 gm^{-2} for red stem amaranth and 20-30 gm^{-2} for red leaf amaranth. Mineral contents were higher or same in the amaranths cultivated with the fertilizer NPK at 30-40 gm^{-2}, compared to those under control treatments. The results indicate that combined fertilizer NPK at 30-40 gm^{-2} is effective for higher yield and quality of amaranth in the red soil.

Islam *et al*. (2020) identified that biochar application to soil may increase fertility and productivity of soils. It was also observed that the biochar used red amaranth were better appearance than fertilizer used red amaranth. The study concluded that biochar has the potential to improve soil fertility and productivity of red amaranth plant in Bangladesh.

Lestari and Dewi (2020) studied that humic acid of 20 mg L^{-1} applied through the leaves significantly increase plant height, leaf number, the fresh and dry weight of shoot and betacyanin content and humic acid of 20 mg L^{-1} applied through the soil surface also significantly increased leaf number, both fresh and dry weight of shoot and root but reduced oxalate content. Red amaranth (*Amaranthus tricolor* L.) is one of the vegetables that contain betacyanin which is a good source of antioxidants. However, the stem and leaves of red amaranth also contains oxalate which could inhibit calcium absorption in human's body. Moreover, humic acid of 20 mg L^{-1} applied either through foliage spay or soil surface increased plant height, yield and betacyanin content but it reduced oxalate content of red amaranth.

Dehariya *et al.* (2019) laid out an experiment with objectives to find out recommended dose of nitrogen for plant growth and yield of leafy Amaranthus (*Amaranthus tricolor* L.). The application of different level of Nitrogen fertilizer significantly influenced the plant height, Number of leaves, leaf length, leaf width, stem diameter leaf area and yield. Plant height, leaf length, leaf width, leaf area and fresh weight increased with increase in N application. Highest vegetables yield was obtained at 140 kg N ha^{-1} with a mean yield of 187.90 kg ha^{-1}.

Mondal *et al.* (2019) evaluated that the best results in terms of vegetable fresh yield were obtained in the following order: NPK > CD > PM > MOC. Application of MOC is not beneficial due to 30 times higher price than CD and PM. PM added NPK fertilizer combination showed higher vegetable yield (10.87 t ha^{-1}) than CD added NPK fertilizer combination (10.17 t ha^{-1}). The farmers can be recommended to follow NPK + CD fertilizer combination.

Pittelkow *et al.* (2019) reviewed that the phosphorus applied in the sowing furrow increases productivity and phosphorus content in the amaranth foliar tissue in succession to the soybean crop. The highest estimated productivity of amaranth grains was obtained with 98.7 kg ha^{-1} of P_2O_5, with values close to the level of economic response to the application of the input.

Sawatdee *et al.* (2019) identified the effect of cationic nutrient (K, Mg and Ca) concentrations on the biosynthesis of antioxidants while also maintaining the dietary fiber content and mass productivity in *Amaranthus tricolor* L. was chosen as a model vegetable as it was reported to contain high antioxidants in the leaves. It was found that an increase in potassium enhanced the antioxidant activity and total phenolic productivity whereas the mass yield and dietary fiber were not negatively affected. The lowest Mg proportion (2.8 ppm) resulted in no mass productivity. High concentration of Ca (130.2 ppm) could increase the mass yield by up to 34%, compared with the control (70 ppm Ca). The results suggest that producing an antioxidant-rich vegetable, not lowering its original quality, could be achieved by optimization of these nutrient elements.

Peiretti (2018) showed that amaranth (*Amaranthus* spp.) is grown extensively as a leafy vegetable and for grains for human consumption in Central America, Asia and Africa. It has also been used in many countries as a grain, forage or silage crop for many animals, including cattle, chickens, pigs and rabbits. The aim of this review was to highlight the potentialities of amaranth in animal nutrition, in order to increase the knowledge of this plant and to allow its use in animal nutrition as an alternative protein and fibre source and as a bioactive component (essential fatty acids, flavonoids, stanols, tocotrienols and squalene) source.

Yesmin *et al.* (2018) stated that the powdered and composted bones meal hasa significant effect on the growth and yield of *Amaranthus tricolor*. The experiment was laid out by using mutton bone, beefbone, chicken bone both in powdered and compost form and the yield contributing characters like number of leaves, root length, shoot length, fresh weight, dry weight and moisture content were influenced significantly.

Ghosh *et al*. (2017) showed that there were significant differences in growth and yield characters such as plant height, plant diameter, number of leaves per plant, shoot fresh and dry weights, root fresh and dry weights of red amaranth and Indian spinach due to the application of arbuscular mycorrhiza (AM), cowdung (CD) and phosphorus (P) independently and combinedly. When arbuscular mycorrhiza, CD and phosphorus were applied combined, it exhibited a remarkably higher response in growth and yield of these vegetables.

Sokoto and Victor (2017) observed that seed rate at 3kg ha^{-1} produced significantly highest fresh and dry weight. Seed rate at 3 kg ha^{-1} and drilling method of planting would be beneficial for the farmers in Sokoto State and areas with similar environmental conditions for optimum yield of amaranths.

Nessa (2016) stated that addition of textile sludge did not increase the content of copper (Cu), cobalt (Co), cadmium (Cd), nickel (Ni) and manganese (Mn), but lead (Pb), chromium (Cr), zinc (Zn) and iron (Fe) content crossed the maximum permissible limit set by FAO/WHO. Textile sludge can improve the nutrient contents of pot soil and growth of red amaranth and it can be used as soil improver if Pb, Cr, Zn and Fe content can be controlled in the textile sludge.

Ohshiro *et al*. (2016) laid out that the growth and yield of all amaranth lines were higher in gray soil (pH 8.4) than in dark red soil (pH 6.6) and red soil (pH 5.4). The combined NPK fertilizer resulted in highest growth parameters and yield of amaranths in all soils. Amaranth lines had higher Na in dark red and red soils, while K and Mg in gray soil, Ca in gray and red soils, and Fe in dark red soil. It was found that gray soil is best for amaranth cultivation and the combined NPK fertilizer is effective in gray soil in Okinawa for higher yield and minerals of amaranth.

Sanni (2016) evaluated the effects of compost, cow dung and NPK 15-15-15 fertilizer amendments on the growth andyield performances of *Amaranthushybridus*. The obtained results indicated that all treatments significantly achieved an increment in morphological parameters (numbers of leaves stem girth, leaf area and plant height) and fresh weight yield comparing with the control. The best results in terms of these characters were obtained in the following order Cow dung > compost > NPK 15-15-15 and control.

Abayomi and Adebayo (2014) conducted an experiment to evaluate the effect of compost, organomineral, and inorganic fertilizers on the growth and yield of *Amaranthuscaudatus* as well as its residual effects. *Amaranthus* was grown with compost Grade B (unamended compost), organ mineral fertilizer Grade A (compost amended with mineral fertilizer), and NPK 15-15-15 and no fertilizer (control). All the treatments except control were applied at the rate of 100kg Nha^{-1}. The results indicated that the *Amaranthus* yield of 18.9 tha^{-1} produced from Grade A was significantly higher than 17.6tha^{-1} obtained from NPK fertilizer. Residual effect of *Amaranthus* growth parameters such as plant height, number of leaves, and yield values obtained from Grade A was also significantly higher than that of NPK, compost, and control values.

Bednarz and Krzepilo (2013) reported that catalase activity exhibited a downward trend during the vegetation period of amaranth. The highest catalase activity was noted in the leaves during the first stage i.e., the seedling stage. Increasing levels of NPK led to an increase in catalase activity. The level of catalase activity in the amaranth seeds was also significantly affected by fertilization and the variety of amaranth. Higher levels of the fertilizers caused an increase in catalase activity in the seeds.

Miah *et al.* (2013) conduct an experiment to enhance the production of red amaranth (*Amaranthus tricolor* cv: BARI lalshak 1) through the improvement of growth and yield of red amaranth by optimizing the appropriate levels of nitrogen fertilizer. The treatment combinations were T_0 (0 kg N ha-1), T_1 (50 kg N ha^{-1}), T_2 (75 kg N ha^{-1}), T_3 (100 kg N ha^{-1}), T_4 (125 kg N ha^{-1}) and T_5 (150 kg N ha^{-1}), respectively. Data on plant height, leaf number, root-shoot growth and dry weight along with yield and BCR (benefit cost ratio) indicated that urea applied at the rate of 150 kg N ha^{-1} had a significant effect on the short-term growth and yield of red amaranth.

Miah *et al*. (2013) reviewed that among different levels of N such as 0, 50, 75, 100, 125, 150 kg ha^{-1} the highest nutrient content in most of the cases were observed when N was applied @ 150 which was applied to boost up the production of red amaranth cv: BARI lal shak-1 under certain agro-climatic conditions.

Malik *et al.* (2011) observed a significant impact of zinc on growth and yield of red amaranth and rice. The concentration of zinc increased with increasing zinc treatment in red amaranth and rice roots, shoots and grain. The length of roots and shoots, the fresh and dry matter production decreased with increasing zinc levels for red amaranth. In case of Rice the length of roots, shoots and spikelets increased with increasing zinc levels. The results showed that zinc influenced the growth and yield of red amaranth and rice.

Yunus *et al.* (2007) suggested that cow dung and poultry manure appeared to be compatible to urea for stem amaranth cultivationin terms of plant height, fresh weight, stem length, diameter and fresh weight, leaf length, breadth and number production accompanied with the gross yield.

Alam *et al.* (2007) found that the application of VC and NPKS significantly influenced the growth and yield of red amaranth. The 10 t ha^{-1} VC showed better growth and yield than 100% NPKS in red amaranth. Application of various amounts of VC (2.5, 5, 10 tha^{-1}) with NPKS fertilizers (50% and 100%) increased the vegetative growth and yield of red amaranth. The yield of red amaranth was strongly correlated with total dry matter, plant height, leaf length and also stem length. The results showed that effects of VC are more efficient for the vigorous production of red amaranth. It is also suggested that VC (10 tha^{-1}) + NPKS (50%) is more favorable for vigorous production of red amaranth and maintenance of soil environment but VC (5 t ha^{-1}) + NPKS (100%) can be economically and environmentally suitable.

Materechera and Mukwevho (2007) reported that leaf amaranth is a common indigenous food plant with a high potential to improve the nutritional security, especially of rural households in South Africa. Increasing the rate of manure N application significantly improved growth and dry matter yields of edible leaves over the control. Differences among the manure rates were small at the beginning of the harvesting period but became more apparent towards the end, suggesting higher N release due to mineralization of the manure. The cumulative leaf dry matter yields of amaranth that were defoliated weekly were significantly lower than those defoliated fortnightly. The study confirms that chicken manure is an important resource that can be used by resource poor farmers to supply nutrients and improve productivity of this less conventional crop.

Freeze *et al.* (1993) stated that the value of manure as an amendment for restoring the productivity of slightly unfertile land is sufficient to allow manure to be hauled further than would be the case in unfertile land the application of cow-dung and poultry manure significantly decreased the toxic metal Cr, Co, Cd and Pb in red amaranth. Application of above manures reduced the uptake of heavy metals appreciably followed by the better growth of the crop.

The application of cow dung was found satisfactory to reduce the toxic effects of heavy metals. The application of cow dung and poultry manure significantly decreased the toxic metal Cr, Co, Cd and Pb in red amaranth stated by Nuruzznman *et al.* (1993).

Makus (1992) told that biomass production of amaranth was most responsive to increasing levels of supplemental P (to 90 kg ha^{-1}) and less responsive to increasing levels of supplemental K (to 180 kg ha^{-1}). Average yield increases from N, K and P were 1.15, 1.27 and 14.5-fold, respectively. Supplemental P increased leaf number per plant and the percentage of non-edible stem tissue. Plant water content was increased by K and P. In a mineral soil testing 59 kg N, 14 kg P and 84 kg K ha^{-1}, P was the most critical nutrient needed by the vegetable amaranth.

Singh and Whitehead (1992) studied the effect of soil pH and moisture on the vegetative growth of amaranth in the greenhouse during 1990–91. Soil pH levels of 4.5, 5.3 and 6.4 and soil water levels of 3, 6, 12 and 18% comprised the treatments for the two studies. The plants grown in pH 6.4 soil were significantly taller with more branches, leaves and greater leaf area than plants grown in pH 5.3 or 4.7 soil. The study indicated that a soil with pH of 6.4 could produce high yielding vegetable amaranth. Irrigation at 6% soil water in Dothan sandy loam soil produced optimal vegetative growth in amaranth.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted in the Net House of Hajee Mohammad Danesh Science and Technology University, Dinajpur-5200, from September to November, 2023. A brief description of the experimental site, characteristics of soil, climate, planting material, soil collection, soil and pot preparation and sowing, experimental design, treatments, fertilizer doses at different treatments, intercultural operations, harvesting, data collection, soil sample preparation, soil analysis and statistical analysis have been explained in this chapter.

3.1 Experimental site

The experiment was carried out at the Net House of Hajee Mohammad Danesh Science and Technology University, Dinajpur-5200, from September to November, 2023. Geographically the experimental site was at 25°13' N latitude and 88°23' E longitude with an elevation of 37.5 m above the mean of sea level. It situated under the Agro Ecological Zone (AEZ-1) named Old Himalayan Piedmont Plain.

3.2 Characteristics of Soil

The land was medium high belonging to the Old Himalayan Piedmont (AEZ -1), which falls into non-calcareous brown floodplain soils (UNDP and FAO, 1988). The general characteristics of the soil are shown in Table 3.1-3.3.

3.3 Climate

The experimental area belongs to a subtropical climatic zone which has heavy rainfall, high humidity, high temperature, and a relatively long day period during Kharif-II season (16 July to 15 October) and scanty rainfall and low humidity, low temperature, and short-day period during Rabi season (October-March). The experiment was conducted during both kharif -II and Rabi season from September to November, 2023.

Table 3.1 Morphological characteristics of the soil of Soil Science Research Field of HSTU

Morphology	**Characteristics**
Location	Soil Science Research Field, Department of Soil Science, HSTU
AEZ	Old Himalayan Piedmont Plain (AEZ-1)
General soil type	Non-calcareous brown floodplain soil
Parent material	Piedmont alluvium
Drainage	Well drained
Flood level	Above flood level

Table 3.2 Physical characteristics of the soil of Soil Science Research Field of HSTU

Characteristics	**Value**
Sand (%)	53.20
Silt (%)	29.60
Clay (%)	17.20
Textural class	Sandy loam

Table 3.3 Chemical characteristics of the initial soil sample

Characteristics	**Content**
pH	5.25
OM (%)	2.9
Total Nitrogen (%)	0.14
Available P (ppm)	162.98
Exchangeable K (meq 100 g^{-1}soil)	1.21
Available S (ppm)	224.87
EC (mS/cm)	3.42

3.4 Planting material

The plant material of the experiment was BARI Lal Shak-I (*Amaranthustricolor*). It is a quick growing annual plant having a height of 1.2 metres and width of 0.8 meters within 4 to 5 months. It is self-pollinating and monoecious (both male and female flowers are present in the same plant). It likes well drained soil with full sun. Seeds are sown directly in the soil and the seedlings become mature plant within 2-3 months. The plant usually dies off after 4-5 months.

3.5 Soil collection, soil and pot preparation and seed sowing

Soil was collected from Soil Science Research Field, HSTU, Dinajpur from a depth of 0-15 cm. The collected soil was sun dried. Weeds and stubbles in the soil were removed. Then the all the ingredients such as soil, sand, vermicompost, Ash, bone meal along with other chemical fertilizers i.e., Urea, TSP, MP and Gypsum were well mixed in individual amount per pot. The total amount of the soil mixture for one pot was 6 kg. Then fresh water also added into the soil mixture. The pots were kept in 10 to 15 days for incubation. Then the seeds were collected from BRAC Nursery Basher Hat, Sadar, Dinajpur and sown on the pots at 1st October, 2023.

3.6 Experimental design

The experiment was conducted in Completely Randomized Design (CRD) with 7 treatments and 3 replications. A total of 21 experimental pots were needed.

3.7 Treatments

There were seven (7) treatments as follows:

T_1 = Control (only soil)

T_2 = 70% soil + 20% VC + 5% sand + 5% Ash + 2.0 g kg^{-1} bone meal powder

T_3 = 65% soil + 25% VC + 5% sand + 5% Ash + 1.5 g kg^{-1} bone meal powder

T_4 = 70% soil + 20% VC + 5% sand + 5% Ash + 1.5 g kg^{-1} bone meal powder

T_5 = 60% soil + 20% VC + 15% sand + 5% Ash + 2.0 g kg^{-1} bone meal powder

T_6 = 60% soil + 25% VC + 10% sand + 5% Ash + 1.0 g kg^{-1} bone meal powder

T_7 = 60% soil + 25% VC + 5% sand + 10% Ash + 1.0 g kg^{-1} bone meal powder

Where, VC = vermicompost, respectively.

3.8 Fertilizer doses at different treatment

In case of chemical fertilizers, Urea, TSP, MP and Gypsum were also mixed with each treatment mixtures during soil preparation as per 2.45 g kg^{-1}, 0.85 g kg^{-1}, 1.25 g kg^{-1} and 490 mg kg^{-1} material, respectively.

3.9 Intercultural operations

Intercultural operations were held to ensure normal growth of the crop. The following intercultural operations were followed:

3.9.1 Weeding

The experimental pots were monitored and weeds were removed regularly from the pots.

3.9.2 Irrigation

The experimental pots were monitored regularly and water supplied whenever necessary.

3.9.3 Thinning

The plants were thinned out properly for better yield from the rest of the plants which were selected for final result of the experiment.

3.9.4 Insect and pest control

The crop was mainly protected from ant's attack by applying Dursban-20 EC. The leaves and shoots were attacked by some sap-sucking insects i.e., aphid, thrips during the vegetative stage. For pest control, Limit of 20SL (Imidachloropid) was applied at appropriate doses whenever necessary.

3.10 Harvesting

Harvesting was completed on 12th November, 2023 when the plant growth was maximum for use as vegetable.

3.11 Data collection

Data collection was done on 15th October to after harvest. As per objectives of the study the following data were collected from randomly selected 3 plants

i. Plant height
ii. Leaf number per plant
iii. Fresh plant weight
iv. Root length
v. Yield
vi. Soil pH
vii. EC

3.11.1 Plant height (cm)

The plant height was measured from randomly selected 3 sample plants in centimeter from the ground level to the leaf at the top.

3.11.2 Leaf number per plant

The number of leaves plant per were counted from the selected 3 plants and mean value was calculated.

3.11.3 Fresh plant weight (g)

Fresh weight of 3 plants from each pot was measured in gram (g) after harvest and averaged as well.

3.11.4 Fresh Root length (cm)

Length of the root of 1 plant per pot was measured in centimeter (cm) after harvest.

3.11.5 Yield

The fresh weight of plants was measured with an electrical balance from each treatment and their average was calculated at gram (g).

3.11.6 Soil pH

Soil pH was measured by using Soil pH meter in 3 times Between 10 days gap from 1st data collection to 2nd data and again 10 days gap due to next data collection.

3.11.7 EC

Pot mixture soil EC was measured by EC meter in 3 times Between 10 day's gap from 1st data collection to 2nd data and again 10 days gap due to next data collection.

3.11.8 Soil sample preparation

After harvesting, soil samples were collected from all the pots around 200 gm and sun-dried. Then the dried samples were crashed and sieved through a 2 mm (10 mesh) sieve. Then the sieved soil sample was stored in a clean plastic container for analysis.

3.12 Analysis of soil sample

Chemical properties of all soil samples were analyzed at the Soil Science Laboratory-1, Department of Soil Science, HSTU, Dinajpur. The following analysis of soil sample were done-

i. Soil pH
ii. EC
iii. Total Nitrogen content (N)
iv. Available phosphorus (P)
v. Exchangeable potassium (K)
vi. Available sulphur (S)
vii. OM content
viii. Organic Carbon

3.12.1 Soil pH

Soil pH was determined using a glass electrode pH meter at 1:2.5, soil-water ratio. The suspension was allowed to stand for one hour with occasional shaking before determination (Jackson, 1967).

3.12.2 Total nitrogen content (N)

Soil N was determined by Micro-Kjeldahl method (Bremner and Mulvancey, 1982). The Soil sample (1.0g) was digested with 3 ml concentrated H_2SO_4 and 1.1 g catalyst mixture (K_2SO_4:$CuSO_4.5H_2O$: Se powder in a ratio 100:10:1). N was estimated by distillation with 40% NaOH followed titration distillate trapped in H_2B0_3 indicator solution with 0.01 N (Page *et al*., 1989).

3.12.3 Available phosphorus (P)

Available P was extracted from the soil with 0.5 M sodium bicarbonate solution pH 8.5 (Olsen *et al*., 1954). P in the extract was then determined by developing blue color with $SnCl_2$ reduction of phosphomolybdate complex and color intensity was measured colorimetrically at 660 nm wavelength (Page *et al*., 1989).

3.12.4 Exchangeable potassium (K)

Exchangeable K was determined by the ammonium acetate extraction method using a flame photometer as described by Page *et al*. (1989).

3.12.5 Available sulphur (S)

Available S was determined by extraction the soil sample with 0.01 M Ca $(H_2PO_4)_2$. The S content in the extract was estimated and the intensity of turbid was measured by spectrophotometer at 420 nm wavelength.

3.12.6 Organic Matter (OM) content

Soil organic carbon content was determined volumetrically by wet oxidation method using $K_2Cr_2O_7$ and H_2SO_4 mixture and $FeSO_4$ solution was used for titration as outlined by Jackson (1967). The OM content was calculated by multiplying the percent organic carbon with Benmmelen factor of 1.724 (Piper, 1950).

3.12.7. Organic carbon content (%)

This was estimated following the method developed by Walkley and Black (1935). The principle underlying the method is to oxidize the OM with the excess of 1 N K_2Cr_2O solution in presence of concentrated H_2SO_4, and to titrate the remaining unreacted Cr_2O solution with N $FeSO_4$. Finally, the organic carbon contents were then calculated by multiplying the percent organic carbon with the Van-Bemmelen factor 1.724 (Peper, 1950).

3.13 Statistical analysis

The collected data were statistically analyzed to find out the level of significance using a Completely Randomized Design (CRD) with the help of the statistical program Statistix version 10.0. The mean differences were compared by the Least Significant Difference test (LSD test) at a 5% level of significance (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The results of the performance of red amaranth under different soil mixture are presented in table 4.1 to 4.5. In this chapter, moreover, the findings of the study and interpretation of the results under different sections comprising growth, yield contributing characteristics, yield and quality parameters analysis are presented and discussed in this chapter under the following sub-headings to achieve the objectives of the study.

4.1. Effect of different soil mixtures on growth, yield contributing characters and yield of red amaranth

4.1.1 Plant height (cm)

One of the most important parameters is plant height which is positively correlated with the yield of red amaranth. Combined effects of different soil mixtures showed statistically significant influence on plant height (Table 4.1). The average highest plant height of three selected plants per pot at 10 DAS was recorded 9.33 cm at T_7 treatment which was identical with T_6 (8.67 cm) and the lowest one was recorded in T_1 treatment (4.66 cm). Statistically similar result was found in treatment T_3, T_4, T_5. On the other hand, the highest plant height at 20 DAS was recorded as 23.7cm in T_7 treatment which was identical with T_6 (19.43 cm), T_3 (16.26 cm) and T_4 (15.6cm), respectively and the lowest one was recorded as 8.67 cm in T_1 treatment. Statistically similar result was found in T_4 and T_5. Furthermore, the highest plant height of 30 DAS was recorded as 32.44 cm in T_7 treatment which was identical with T_6 (28.5 cm), T_3 (25.55cm), T_4 (24.23 cm), T_5 (22.93 cm) and T_2 (22.14 cm) respectively and the lowest one was obtained 13.55 cm in T_1 treatment. Here, the results were more or less same in case of 30 DAS.

The increase in height of red amaranth plants amended with organic is probably due to release of nutrients which promoted vigorous plant growth through efficient photosynthesis (Sanni, 2016). Nitrogen fertilization tended to increase plant height as nitrogen involves in cell division and cell elongation of plants (Mazumder *et al.,* 2019). Also, there are some reports on combine effect of NPKS (25%) and Vermicompost (75%) have given higher yield of tomato, cabbage, okra compared to recommended doses of full amount NPKS and control (Akther *et al.,* 2019; Farzana *et al.,* 2019; Islam *et al.,* 2007).

Table 4.1 Effect of different soil mixtures on plant height of red amaranth at different DAS

Treatments	Plant height (cm)		
	At 10 DAS (Mean±SE)	At 20DAS (Mean±SE)	At 30 DAS (Mean±SE)
T_1	4.66 ± 0.33c	8.67±0.23 d	13.55±1.64 e
T_2	7.99±0.18 b	14.6±0.51 c	22.14±1.22 d
T_3	8.87±1.00ab	16.26±1.6bc	25.55±0.38c
T_4	8.45±0.39ab	15.6± 1.07 c	24.23±0.55 cd
T_5	8.0 b±0.39 b	15.42±0.46 c	22.93±0.31 d
T_6	8.67±0.19 ab	19.43±1.73 b	28.5±0.49 b
T_7	9.33±1.09 a	23.7±0.94 a	32.44±1.28 a
CV %	6.95	11.54	5.53

In the column, figures having similar letter(s) do not differ significantly at 5% level of probability.

Where,

T_1 = Control (only soil)

T_2 = 70% soil + 20% VC + 5% sand + 5% Ash + 2.0 g kg^{-1} bone meal powder

T_3 = 65% soil + 25% VC + 5% sand + 5% Ash + 1.5 g kg^{-1} bone meal powder

T_4 = 70% soil + 20% VC + 5% sand + 5% Ash + 1.5 g kg^{-1} bone meal powder

T_5 = 60% soil + 20% VC + 15% sand + 5% Ash + 2.0 g kg^{-1} bone meal powder

T_6 = 60% soil + 25% VC + 10% sand + 5% Ash + 1.0 g kg^{-1} bone meal powder

T_7 = 60% soil + 25% VC + 5% sand + 10% Ash + 1.0 g kg^{-1} bone meal powder

Where, VC = vermicompost and SE= Standard error, respectively.

4.1.2 Number of leaves

As shown in Table 4.2 the average number of leaves per plant (three selected plants) were varied insignificantly by various combination of soil mixtures. Highest number of leaves per plant at 10 DAS was obtained 6.27 from treatment T_7 which was identical with T_6, T_3, T_4, T_5 and T_2 and the lowest one was recorded 3.34 from control treatment T_1. Here, the results varied insignificantly. On the other hand, the highest number of leaves at 20 DAS was obtained 9.33 from T_7 treatment which was identical with T_6, T_3 and T_4 treatment respectively and the lowest one was recorded 6.22 from control treatment T_1 treatment. Furthermore, the highest number of leaves at 30 DAS was found 14.78 from treatment T_7 which was identical with T_6, T_3 and T_4 and the lowest one was recorded 9.33 in control treatment T_1 where statistically identical with T_5, T_4 and T_2 treatment.

Changes in the number of leaves are bound to affect the overall performance of amaranth as the leaves serve as photosynthetic organ of the plant (Miah *et al*., 2013). Increased in leaf number in soil amended with organic fertilizer could probably be attributed to N availability which promoted leaf area during vegetative development and also helped to maintain functional leaf area during the growth period (Cox *et al*., 1995). Many researchers reported that application of CD or CM or MOC along with chemical fertilizers increased plant height and leaf number in leafy vegetable crops that supported the present results (Sanni, 2016; Noor *et al*., 2007; Islam *et al*., 2006).

Table 4.2 Effect of different soil mixtures on number of leaves per plant at different DAS

Treatments	Number of leaves		
	At 10 DAS (Mean±SE)	**At 20 DAS (Mean±SE)**	**At 30 DAS (Mean±SE)**
T_1	3.34±0.13 e	6.22±0.29 e	9.33 ±0.19 d
T_2	4.63 ±0.06 d	7.22 ±0.29 d	10.56 ±0.11 c
T_3	5.67 ±0.12 b	8.22 ±0.11bc	11.56 ±0.48bc
T_4	5.2 ±0.06 c	7.89 ±0.11 c	10.77 ±0.29 c
T_5	5.23 ±0.06 c	8.22 ±0.11bc	11±0.50 c
T_6	6 ±0.11 a	8.67 ±0.19 b	12.55 ±0.39 b
T_7	6.27±0.14 a	9.33 ±0.19 a	14.78 ±0.48 a
CV %	3.57	4.37	5.76

In the column, figures having similar letter(s) do not differ significantly at 5% level of probability.

Where,

T_1 = Control (only soil)

T_2 = 70% soil + 20% VC + 5% sand + 5% Ash + 2.0 g kg^{-1} bone meal powder

T_3 = 65% soil + 25% VC + 5% sand + 5% Ash + 1.5 g kg^{-1} bone meal powder

T_4 = 70% soil + 20% VC + 5% sand + 5% Ash + 1.5 g kg^{-1} bone meal powder

T_5 = 60% soil + 20% VC + 15% sand + 5% Ash + 2.0 g kg^{-1} bone meal powder

T_6 = 60% soil + 25% VC + 10% sand + 5% Ash + 1.0 g kg^{-1} bone meal powder

T_7 = 60% soil + 25% VC + 5% sand + 10% Ash + 1.0 g kg^{-1} bone meal powder

Where, VC = vermicompost and SE = Standard error, respectively.

4.1.3 Fresh weight of plant (g) per pot

Different combination of soil mixtures showed insignificant variation on fresh weight of red amaranth plant (Table 4.3). The maximum fresh weight of three selected plant of red amaranth was obtained in treatment T_7 (106.63g) and T_6, T_3, T_4 gradually decreased and lowest value found T_1(28.57g) where T_4 and T_5 statistically similar.

Application of organic fertilizers probably increased nitrogen in the soil which positively affected leaf fresh weight and quality of the leaves because nitrogen stimulates plant vegetative growth and increases leaf area. This is in line with the findings of different studies elsewhere (Sanni, 2016; Noor *et al.*, 2007; Islam *et al*., 2006). The poor performance of red amaranth grown in control treatment revealed that when nutrients are available in adequate amount, plants tend to grow at their optimum potential. These nutrients deficient were probably the limiting factor of plant growth and productivity in control treatment (T_1) statistically similar result was found in $T_5$and T_4 treatments.

4.1.4 Root length (cm)

The root length of one selected plant per pot had significantly varied at different soil mixtures (Table 4.3). The root length ranged between 12.2 cm and 2.05 cm. The highest root length (12.2cm) was recorded in treatment T_7. On the other hand, the lowest one (2.05cm) was recorded in control treatment in treatment T_1. Statistically similar result was found in treatment T_5, T_4 and T_2.

Table 4.3 Effect of different soil mixtures on the growth contributing characteristics of red amaranth

Treatments	Fresh Weight (g) per pot (Mean±SE)	Root length (cm) (Mean±SE)
T_1	28.57±0.04 d	2.05±4.37 c
T_2	46.23 ±0.48 cd	4.81±3.09bc
T_3	61.09 ±0.45bc	6.32±2.39 b
T_4	55.15 ±0.68 c	4.75 ±1.20bc
T_5	53.82 ±0.45 c	4.53 ±1.46bc
T_6	78.48 ±0.12 b	6.89 ±1.29 b
T_7	106.63 ±0.26 a	12.2±1.37 a
CV %	18.26	32.44

In the column, figures having similar letter(s) do not differ significantly at 5% level of probability.

Where,

T_1 = Control (only soil)

T_2 = 70% soil + 20% VC + 5% sand + 5% Ash + 2.0 g kg^{-1} bone meal powder

T_3 = 65% soil + 25% VC + 5% sand + 5% Ash + 1.5 g kg^{-1} bone meal powder

T_4 = 70% soil + 20% VC + 5% sand + 5% Ash + 1.5 g kg^{-1} bone meal powder

T_5 = 60% soil + 20% VC + 15% sand + 5% Ash + 2.0 g kg^{-1} bone meal powder

T_6 = 60% soil + 25% VC + 10% sand + 5% Ash + 1.0 g kg^{-1} bone meal powder

T_7 = 60% soil + 25% VC + 5% sand + 10% Ash + 1.0 g kg^{-1} bone meal powder

Where, VC = vermicompost and SE= Standard error, respectively.

4.2 Impact of different soil mixtures on the chemical properties during different growth level

4.2.1 Soil pH

The pH shown in Table 4.3 the average per pot was varied insignificantly by various combinations of soil mixtures. Highest pH at 10 DAS was obtained 5.73 from treatment T_3 which was identical with T_7, T_6, T_5 and T_4 and the lowest one was recorded 5.3 from control treatment T_2.Here, the results varied insignificantly. On the other hand, the highest pH at 20 DAS was obtained 5.67 from T_7 treatment which was identical with $T_5$and the lowest one was recorded 5.13 from control treatmentT_2treatment. Furthermore, the highest pH at 30 DAS was found 5.87 from treatment T_4 which was identical with T_5,T_6 and $T_7$and the lowest one was recorded 5.2in treatment$T_2$where statistically identical with T_1 treatment.

Table 4.4 Effect of different soil mixtures on soil pH of during production of red amarnth.

Treatments	Soil pH		
	At 10 DAS (Mean±SE)	**At 20 DAS (Mean±SE)**	**At 30 DAS (Mean±SE)**
T_1	5.53±0.13 ab	5.33±0.10 bc	5.23±0.11 b
T_2	5.3±0.03 b	5.13±0.06 c	5.2±0.03 b
T_3	5.73±0.06 a	5.33±0.14bc	5.6±0.13 ab
T_4	5.7±0.10 a	5.6±0.04 ab	5.87±0.67 a
T_5	5.73±0.67 a	5.67±0.03 a	5.77±0.15 a
T_6	5.7±0.10 a	5.47±0.13 ab	5.73±0.02 a
T_7	5.67±0.13 a	5.67±0.67 a	5.8 ±0.55 a
CV %	3.46	3.39	4.23

In the column, figures having similar letter(s) do not differ significantly at 5% level of probability.

Where,

T_1 = Control (only soil)

T_2 = 70% soil + 20% VC + 5% sand + 5% Ash + 2.0 g kg^{-1} bone meal powder

T_3 = 65% soil + 25% VC + 5% sand + 5% Ash + 1.5 g kg^{-1} bone meal powder

T_4 = 70% soil + 20% VC + 5% sand + 5% Ash + 1.5 g kg^{-1} bone meal powder

T_5 = 60% soil + 20% VC + 15% sand + 5% Ash + 2.0 g kg^{-1} bone meal powder

T_6 = 60% soil + 25% VC + 10% sand + 5% Ash + 1.0 g kg^{-1} bone meal powder

T_7 = 60% soil + 25% VC + 5% sand + 10% Ash + 1.0 g kg^{-1} bone meal powder

Where, VC = vermicompost and SE= Standard error, respectively.

4.2.2 EC

The EC shown in Table 4.5 the average per pot were varied insignificantly by various combination of soil mixtures. Highest EC at 10 DAS was obtained 2.67mS/cm from treatment T_3 which was identical with $T_6$and the lowest one was recorded 1.24mS/cm from control treatment T_1. On the other hand, the highest EC at 20 DAS was obtained 2.29mS/cm from T_6 treatment which was identical with T_5, T_2 and T_3 and the lowest one was recorded 1.11mS/cm from control treatment T1 which was identical with T_4 treatment. Furthermore, the highest EC at 30 DAS was found 1.89mS/cm from treatment T_5 which was identical with T_6 and T_3 and T_2 identical with T_4, T_7 and the lowest one was recorded 0.79mS/cm in treatment T_1 treatment.

Table 4.5 Effect of different soil mixtures on EC of during red amaranth cultivation

Treatments	**EC(mS/cm)**		
	At 10 DAS (Mean±SE)	**At 20 DAS (Mean±SE)**	**At 30 DAS (Mean±SE)**
T_1	1.24±0.01 c	1.11±0.02 b	0.79±0.03 b
T_2	2.3±0.01 ab	2.05±0.03 a	1.57±0.67 ab
T_3	2.67±0.02 a	2.3±0.02 a	1.85±0.05 a
T_4	1.77±0.01bc	1.33±0.01 b	1.16±0.01 ab
T_5	2.29±0.1 ab	2.05±0.10 a	1.89±0.33 a
T_6	2.6±0.03a	2.29±0.11 a	1.79±0.06 a
T_7	1.89±0.02 b	1.71±0.03 ab	1.69 ±0.3 ab
CV %	15.15	21	34.41

In the column, figures having similar letter(s) do not differ significantly at 5% level of probability.

Where,

T_1 = Control (only soil)

T_2 = 70% soil + 20% VC + 5% sand + 5% Ash + 2.0 g kg^{-1} bone meal powder

T_3 = 65% soil + 25% VC + 5% sand + 5% Ash + 1.5 g kg^{-1} bone meal powder

T_4 = 70% soil + 20% VC + 5% sand + 5% Ash + 1.5 g kg^{-1} bone meal powder

T_5 = 60% soil + 20% VC + 15% sand + 5% Ash + 2.0 g kg^{-1} bone meal powder

T_6 = 60% soil + 25% VC + 10% sand + 5% Ash + 1.0 g kg^{-1} bone meal powder

T_7 = 60% soil + 25% VC + 5% sand + 10% Ash + 1.0 g kg^{-1} bone meal powder

Where, VC = vermicompost and SE= Standard error, respectively.

4.2.3 OM (%)

The OM value of the post harvest soil showed significant difference (Table 4.6). The highest OM percentage 4.11 (%) was observed in T_3 treatment and gradually decreased significantly T_2 (3.67%), T_4, T_7, T_6,T_5 and the lowest OM percentage value 1.59 % was observed in T_1 treatment. Where, the OM percent of initial soil was 2.9%. The study proved that the OM percentage was increased in post harvest soil compared to the initial soil due to the use of organic manure i.e., ash and organic fertilizers i.e., vermicompost, bone meal powder in a combination.

Table 4.6 Effect of different soil mixtures on OM of the post harvest soil

Treatments	**Organic Matter (%)** **(Mean±SE)**
T_1	1.59±0.02 g
T_2	3.67±0.02 b
T_3	4.11±0.02 a
T_4	3.39±0.01 c
T_5	2.78±0.01 f
T_6	2.96±0.01 e
T_7	3.05±0.02 d
CV %	0.97

In the column, figures having similar letter(s) do not differ significantly at 5% level of probability.

Where,

T_1 = Control (only soil)

T_2 = 70% soil + 20% VC + 5% sand + 5% Ash + 2.0 g kg^{-1} bone meal powder

T_3 = 65% soil + 25% VC + 5% sand + 5% Ash + 1.5 g kg^{-1} bone meal powder

T_4 = 70% soil + 20% VC + 5% sand + 5% Ash + 1.5 g kg^{-1} bone meal powder

T_5 = 60% soil + 20% VC + 15% sand + 5% Ash + 2.0 g kg^{-1} bone meal powder

T_6 = 60% soil + 25% VC + 10% sand + 5% Ash + 1.0 g kg^{-1} bone meal powder

T_7 = 60% soil + 25% VC + 5% sand + 10% Ash + 1.0 g kg^{-1} bone meal powder

Where, VC = vermicompost and SE= Standard error, respectively.

4.2.4 Total nitrogen (N) in soil

The total N content in the post harvest soil varied insignificantly. Soil N content of the post harvest soil was lower than the initial soil. The total N content of the post harvest soil ranged between 0.056% and 0.11%. The highest N content 0.11% of post harvest soil was found in T_1treatment and the lowest 0.056% one was recorded in treatmentT_4 andT_6 treatment. Sreelatha *et al.,* (2006) also showed that organic manures had a positive influence on total and available N content of soil.

4.2.5 Available phosphorus (P) in soil

The available P content of the post harvest soil varied significantly by different treatments (Table 4.5). Available P content in soil varied from 114.92 ppm to 162.93 ppm. The maximum P content (162.93 ppm) was observed in treatment T_3 and gradually decreased in T_6 (149.32ppm), T_7 (145 ppm), T_2 (144.67), T_4 (136.5 ppm) and T_1 (122.49 ppm). The lowest P content 114.92 ppm) was observed in treatment T_5 whereas the available P content of initial soil was 162.98 ppm.

4.2.6 Exchangeable potassium (K) in soil

The exchangeable potassium content (K) of the post harvest soil influenced considerably due to the environmental fact (Table 4.5). The exchangeable K content of initial soil was 1.21 meq100g^{-1} soil and the values of post harvest soil ranged from 0.19 to 0.64 meq100g^{-1}. The highest exchangeable K 0.64 meq100 g^{-1} soil was found in treatment T_4 and the lowest 0.19 meq100g^{-1} soil was recorded in treatment T_2.

4.2.7 Available sulphur (S) in soil

The available S content in the studied soil varied significantly and ranged from 23.1 ppm to 123.24 ppm (Table 4.5). The maximum S content (123.24ppm) was found in treatment T_4 and the lowest (23.1 ppm) one was found in treatment T_1 whereas, the available S content of the initial soil was 224.87 ppm.

Table 4.5 Effect of different soil mixtures on the total N, available P, exchangeable K and available S of the post harvest soil

Treatments	Total N (%)	Available P (ppm)	Exchangeable K (meq/100 g soil)	Available S (ppm)
T_1	0.11±0.01 a	122.49±0.52 e	0.32±0.32d	23.1 g±0.03 g
T_2	0.08±0.01 b	144.66±0.83c	0.19±0.05f	120.24±0.12 c
T_3	0.8±0.01 b	162.93±0.90a	0.44±0.008b	121.39 ±0.15b
T_4	0.05±0.01 c	136.5±0.46d	0.64±0.01a	123.24±0.45a
T_5	0.08±0.01 b	114.92±0.64 f	0.37±0.01c	69.82±0.27d
T_6	0.05±0.01 c	149.32±0.66b	0.32±0.005 d	36.55±0.34f
T_7	0.08±0.01 b	145.0±0.76c	0.25±0.028 e	31.57±0.05f
CV %	4.9	1.49	4.24	0.58

In the column, figures having similar letter(s) do not differ significantly at 5% level of probability.

Where,

T_1 = Control (only soil)

T_2 = 70% soil + 20% VC + 5% sand + 5% Ash + 2.0 g kg^{-1} bone meal powder

T_3 = 65% soil + 25% VC + 5% sand + 5% Ash + 1.5 g kg^{-1} bone meal powder

T_4 = 70% soil + 20% VC + 5% sand + 5% Ash + 1.5 g kg^{-1} bone meal powder

T_5 = 60% soil + 20% VC + 15% sand + 5% Ash + 2.0 g kg^{-1} bone meal powder

T_6 = 60% soil + 25% VC + 10% sand + 5% Ash + 1.0 g kg^{-1} bone meal powder

T_7 = 60% soil + 25% VC + 5% sand + 10% Ash + 1.0 g kg^{-1} bone meal powder

Where, VC = vermicompost and SE= Standard error, respectively.

CHAPTER V
SUMMARY AND CONCLUSION

5.1 Summary

The experiment was conducted at the Net House of HSTU during the period of September to November 2023 to evaluate the performance of red amaranth under different treatments of soil mixtures. The experiment soil belonged to the Agro- Ecological Zone (AEZ-1) named Old Himalayan Piedmont Plain. Initially, the soil was sandy loam in texture having pH, OM, total N, available P, exchangeable K and available S were 5.25, 2.9%, 0.14%, 162.98 ppm,1.21meq100g^{-1} soil and 224.87 ppm respectively.

According to treatments, the total number of pots was 21. All fertilizers and manures were applied at the time of soil preparation. Seeds were sown on 11th September 2023. The crop was allowed to grow until maturity and intercultural operations (weeding, thinning, irrigation and pesticide application) were done whenever required to support the normal growth of the plant.

Yield components were recorded from each pot. Soil samples were collected before fertilizer application and also after harvesting. The collected data were analyzed and the mean differences were compared by the Least Significance Difference test (LSD test) at a 5% level of significance. The results revealed that the highest growth and yield characteristics such as plant height, leaf number per plant, fresh Weight of the plant, root length of the plant responded significantly due to the application of vermicompost, ash, sand, bone meal powder along with other chemical fertilizers at different doses in a form of pot soil mixtures. The application of different inorganic fertilizers and organic manures had significant effect in different parameters of red amaranth. The highest plant height was obtained 9.30 cm, 23.7 cm and 32.44 cm at 10, 20 and 30 DAS respectively from T_7 treatment and the lowest plant height was obtained 4.66 cm, 8.67 cm and 13.55 cm at 10, 15 and 30 DAS from T_1 treatment. The maximum averaged number of leaves of three plants per pot was obtained 6.27, 9.33 and 14.78 at 10, 15 and 30 DAS respectively from T_7 treatment and the lowest number of leaves per pot was obtained 3.33, 6.22and 9.33 at 10,15 and 30 DAS, respectively from T_1 treatment. Again, the maximum fresh weight was obtained 106.63g from T_7 treatment and the lowest one was 28.57g from T_1 treatment. The maximum root length was obtained 12.2cm from T_7 treatment. On the other hand, the lowest root length was obtained 2.05 cm from T_1 treatment. There was considerable variation observed in pH of post harvest soil. The highest pH (6.2) was recorded in T_7 and the lowest pH (5.0) was recorded in T_1 treatment. There was significant variation recorded in OM status of post harvest soil. The highest OM (4.11%) was estimated in T_3 treatment. The lowest OM (1.59%) was observed in T_1 (Control). There was considerable variation observed in total N content of post harvest soil. The highest N content (0.11 %) was recorded in T_1 and the lowest N content (0.05%) was recorded in T_4 treatment. The highest available P (162.93 ppm) content was observed in $T_3$and lowest available P content (144.92 ppm) was observed in T_5. The highest exchangeable K (0.64meq $100g^{-1}$) was recorded in $T_4$and lowest exchangeable K (0.19meq $100g^{-1}$) was recorded in T_1. There was significant variation recorded in available Sof post harvest soil. The maximum available S (123.24 ppm) was found in T_4 and minimum available S (23.1 ppm) was recorded in T_1 (control). There was considerable variation recorded in EC of post harvest soil. The highest EC (2.73) was recorded in T_6 and lowest EC (1.42) was recorded in T_1 (control) treatment.

5.2 Conclusion

From the result of this study, it may be concluded that, the combined effect of the pot soil mixture influenced both growth and yield of red amaranth. All the treatments showed better performance in red amaranth growth and yield but one treatment showed superior results than the others. The overall result showed that the soil mixtures of 60% soil, 25% VC, 5% sand, 10% ash, 1.0 g kg^{-1} bone meal powder in T_7 treatment, produced the maximum growth and yield of red amaranth in pot culture for rooftop cultivation.

5.3 Recommendations

i. The application of the soil mixtures of 60% soil, 25% VC, 5% sand, 10% Ash and 1.0 g kg^{-1} bone meal powder was found optimum which should be tested to a narrower extent of mixture.

ii. This finding should be replicated with other vegetables of Amaranthaceous family for rooftop cultivation in urban areas.

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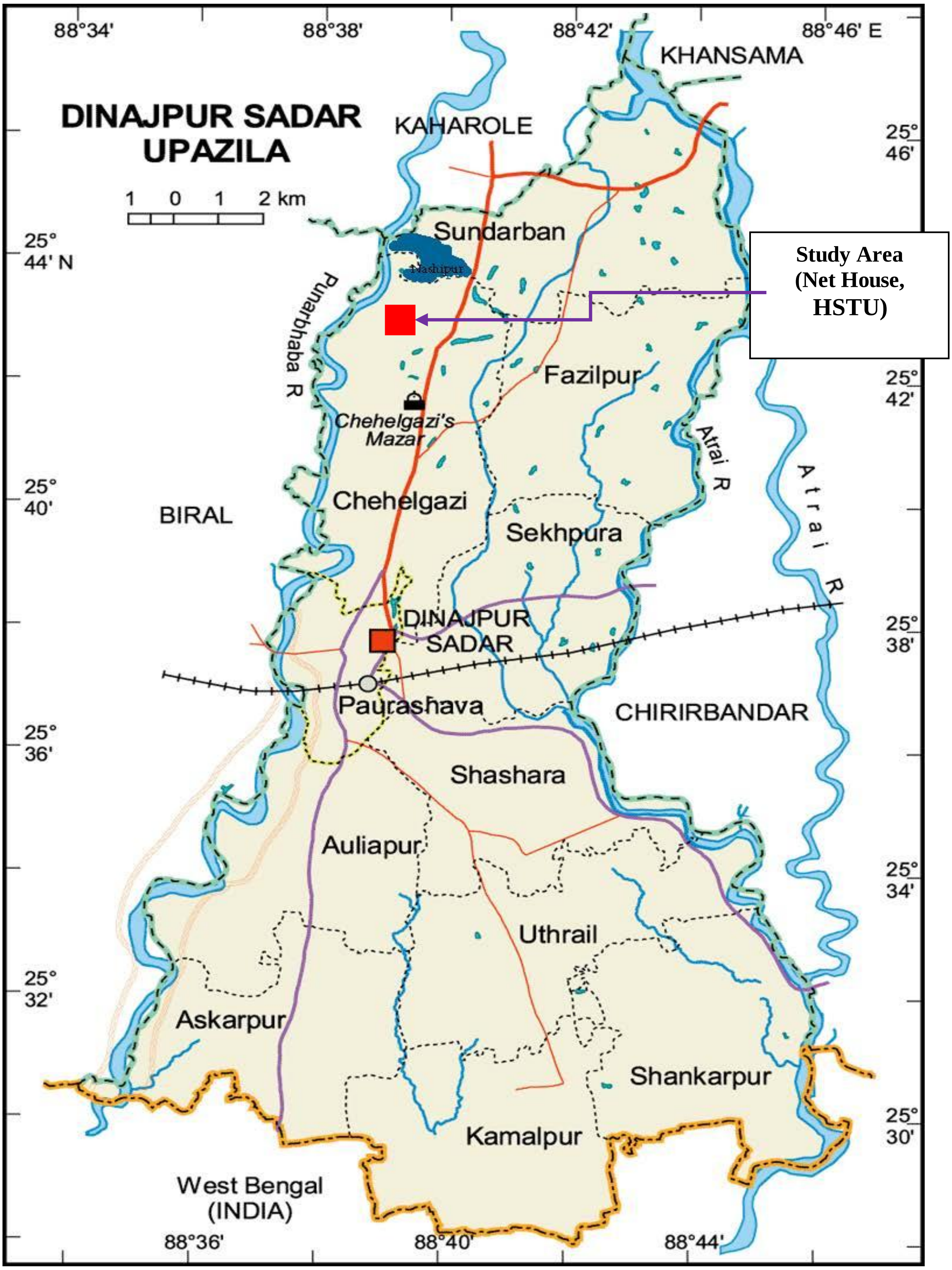
APPENDICES

Appendix I. Location of the experimental site (map of Dinajpur Sadar Upazila showing the research area)



Appendix II. Monthly recorded air temperature, relative humidity, and rainfall during the research period (From September 2023 to December 2023)

Year	Month	**Temperature (^{0}F)			**Relative Humidity (%)	**Rainfall (in)
		Maximum	Minimum	Average		
2023	September	74.8	54.0	64.9	56	30.29
	October	86.4	63 9	74. 0	61	30.02
	November	86.2	70.0	77.7	64	0

**Monthly average

Source: Personal Weather Station Dashboard.

Appendix-III: Experimental photo