EFFECT OF NPK AND COMPOST ON THE GROWTH AND VEGETATIVE YIELD OF RED AMARANTH (*Amaranthus tricolor*)

A THESIS

BY

MOSTAKIMA SHEFA

Student No. 1701131

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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DEDICATED

TO MY

BELOVED FAMILY

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The Author

ABSTRACT

A field experiment was carried out at the Research Field, Department of Soil Science, Hajee Mohammad Danesh Science and Technology University, Dinajpur, during the period from November 2023 to December 2023 in Rabi season to evaluate the efficacy of NPK and compost on the growth and vegetative yield of red amaranth. The experiment was laid out in Randomized Complete Block Design (RCBD) having six treatments with three replications. The treatments were as follows; T_1 = Control, T_2 = 100% NPK, T_3 = 100% compost, T_4 = 25% NPK + 75%compost, T_5 = 50% NPK + 50% compost, T_6 = 75% NPK+ 25% compost. The experimental soil belongs to the Old Himalayan Piedmont Plain (AEZ-1). The soil was sandy loam in texture having pH 5.60, organic matter content 1%, total N 0.080%, available P 3.30 ppm, exchangeable K 0.52 meq 100 g^{-1} soil and available S 7.53 ppm. The application of NPK and compost had a significant effect on the growth and vegetative yield of red amaranth. The tallest plant height (5.90, 21.40, and 26.31 cm at 15, 30, and 45 during final harvest respectively) was found in the treatment T_6 and the shortest plant height (4.50, 9.06, and 13.96 cm at 15, 30, and 45 during final harvest, respectively) was observed in T_1 (control). The maximum number of leaves (4.70, 8.34, 10.40 at 15, 30, and 45 during final harvest, respectively) was recorded in the treatment T_6 whereas the minimum number of leaves (3.79, 5.90, 7.50 at 15, 30, 45 during final harvest, respectively) was found in the T_1 (control). Application of NPK and compost resulted in a considerable influence on the properties of the post-harvest soils such as the highest total N (0.160%), available S (6.53 ppm) inT_3 treatment and soil organic matter content (1.40 %) and EC (0.21 mSm^{-1}) in T_6 treatment. The treatment T_6 produced the highest both fresh and dry shoot weight (3.78 and 1.83 t ha^{-1} respectively) but the lowest fresh and dry shoot weight (1.14 and 0.56 t ha^{-1} respectively) was obtained from the control treatment (T_1). The maximum fresh and dry root weight (1.41 and 0.76 t ha^{-1}, respectively) and tallest root length (7.80 cm) was recorded from the treatment T_6 and the minimum both fresh and dry root weight (0.42 and 0.21 t ha^{-1}, respectively) and smallest root length (6.30 cm) was observed in the T_1 (control). It was obvious that fertility of soil and vegetative growth of red amaranth can be increased substantially with the judicious application of compost with chemical fertilizers. The findings of the study showed that the performance of treatment T_6 was the best among all treatments. This study suggests that amendment of soil with 75% NPK + 25% compost might be an efficient practice for achieving sustainable soil fertility and vegetative growth of red amaranth.

CONTENTS

CONTENTS (Contd.)

CONTENTS (Contd.)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABBREVIATIONS AND ACRONYMS

°C	Degree Celsius
AEZ	Agro Ecological Zone
BADC	Bangladesh Agricultural Development Corporation
BARC	Bangladesh Agricultural Research Council
CD	Cow dung
Cm	Centimeter
DAS	Days After Sowing
EC	Electrical conductivity
et al.	And others
FAO	Food and Agricultural Organization
g	Gram
ha^{-1}	Per hectare
HSTU	Hajee Mohammad Danesh Science and Technology University
K	Potassium
Kg	Kilogram
LSD	Least significant difference
m	Meter
N	Nitrogen
OM	Organic matter
P	Phosphorus
$plant^{-1}$	Per plant
$plot^{-1}$	Per plot
ppm	Parts per million
RCBD	Randomized Complete Block Design
S	Sulphur
VC	Vermicompost
(mS/m)	Mili Siemens per meter

CHAPTER I

INTRODUCTION

Red amaranth (*Amaranthus tricolor*) is one of the most popular leafy vegetable crops, belongs to the family Amaranthaceae, grown throughout the tropics of the world during spring-summer and kharif seasons (Jugulde, 2023; Mondal *et al.*, 2019). Amaranth is a rich foundation of calcium, iron, carotene, protein, and vitamins A and C which are essential to provide nutritional constituents for people which help to decrease malnutrition cases (Oso and Ashafa,2021; Adebayo and James, 2014). Apart from this, vegetables when eaten on daily basis reduces trouble of constipation. Because of its high nutritional value, amaranth has the capacity to assist feeding programmes and is preferred by weaker populations as a component of a diverse diet (Adekiya, 2009). As one of the nutritious and delicious vegetables, red amaranth is a popular vegetable in Bangladesh. It has also quick growing character and higher yield potential. Thus, red amaranth plays a predominant role both in nutrition and food security. The cultivation of red amaranth is increasing day by day in Bangladesh (BBS, 2010) although its production is lower than other amaranth producing countries (Saha *et al.*, 2022).

In this era, frequent crop cultivation using modern/high yielding varieties to meet the demand for increasing population has led to a depletion of soil fertility. Due to continuous exhaustion of plant nutrients from the soil, farming system has become unstable. No crop cultivation system will be sustained if the nutrients input and output in the soil is least balanced. The farmers use chemical fertilizers as a supplemental source of nutrients, but they do not apply in balanced proportion (BARC, 2012). Moreover, organic carbon content in Bangladesh soils is very low (<1.5%) and is being gradually depleted day by day (Ullah *et al.*, 2008, Mondal *et al.*, 2019).

Neither chemical fertilizer nor organic manure alone can help achieve sustainable crop production. Even with balanced use of only chemical fertilizer, high yield level could not be maintained over the years because of deterioration in soil physical and biological environments (Meena *et al.*, 2019). In Bangladesh, most soils have less than 1.5%, and some even less than 1% organic carbon contents (FAO, 2014; Yeasmin *et al.*, 2020). So, integrated nutrient management is the best approach to restore/maintain soil fertility and productivity on sustainable basis. Both manures and fertilizers enhance the growth and yield of red amaranth to a great extent.

Organic fertilizer is one of the most favourable non-chemical plant nutritional sources. It can be produced through composting of organic material by which can consume a wide range of organic residues. It has a positive influence on the physical and chemical structure of soil as well as plant growth (Rehman *et al.*, 2023) by improving the stability of soil aggregates, as well as water retention, bulk density and porosity, and soil thermal dynamics. In addition, it stimulates and increases the absorption of nutrients by plants and favors biological control of bacterial and fungal diseases in plants (Yatoo *et al.*, 2021). Organic fertilizer stimulates growth-promoting hormones such as auxins, gibberellins, and cytokinins that are produced by microorganisms and organic residues (Pathma and Sakthivel, 2012; Vijayabharathi *et al.*, 2015), which improves plant growth and increases plant tolerance to biotic and abiotic stresses (Aremu *et al.*, 2015).

Soil health is improved by the application of organic fertilizer. Generally, the addition of organic fertilizer as an organic source to calcareous soil increases the nutrient cycling; retains soil water, soil structure, and biological processes (Ceritoğlu *et al.*, 2018); and improves rooting by activating the plasma membrane H^+-ATPase, by increasing acidification of the roots external medium. Moreover, the low speed of nutrient degradation and release from vermicompost fertilizer is suitable for perennial plants and trees grown in calcareous soil.

Farmers of Bangladesh are mostly habituated with the use of macro-nutrients, especially nitrogen, phosphorus, sulphur and potassium for crop production as fast-release fertilizer. Nitrogen plays a significant role in photosynthesis, cell division and differentiation, growth and somatic embryogenesis, chlorophyll (Chl) content, photosynthetic rate, anthocyanin production and is an important component of proteins required for the metabolic processes that take place during plant growth (Theunissen *et al.*, 2010; Mu and Chen, 2021). Phosphorus is said to promote root growth, root branching, stem growth, flowering, fruiting, seed formation and maturation. When phosphorus is lacking, stems and foliage often have a red or purplish tinge (Postma *et al.*, 2014). Potassium has a clear role in most biochemical and physiological processes related to plant growth, productivity, and resistance to drought and disease as it is able to regulate osmotic conditions, enhance photosynthesis, and promote carbohydrate metabolism (Johnson *et al.*, 2022). Therefore, plants require quite large amounts of K to produce economic crops and to promote the adaptive plant responses of plants to the environment (Wahba *et al.*, 2019).

In addition, application of compost can increase the efficiency of chemical fertilizers and also improve the soil condition for the production of crop (Mondal *et al.*, 2016). Also, there are some reports on combined effect of NPK (25%) and organic compost (75%) which showed the higher yield of tomato, cabbage, okra compared to recommended dose of full amount NPK (Islam *et al.,* 2017, Farzana *et al.,* 2019, Akhter *et al.,*2019).

However, information on the use of organic fertilizer in combination with inorganic fertilizers for red amaranth is scanty in Bangladesh (AEZ-1). With this view in mind, the present study was conducted with the following objectives:

1. To evaluate the effect of NPK on growth and yield of red amaranth;
2. To evaluate the combined effect of NPK and organic fertilizer for red amaranth production.

CHAPTER II

REVIEW OF LITERATURE

A number of research works have been done on the effect of NPK and compost on soil fertility and the yield of red amaranth in different countries including Bangladesh. A better understanding of the effects of NPK and organic fertilizers on red amaranth in local soils may facilitate the development of suitable soil management practices for better production of this crop. In this episode, an attempt has been made to review some of the available research related to this study. Available information is reviewed and presented here under different suitable sub-heads.

2.1 Effect of NPK fertilizer on crop production

Jugulde (2023) conducted four experiments on the Research Farm of the Department of Agricultural Technology, Federal Polytechnic. The first experiment was to see the effect of nitrogen fertilizer on the growth of Amaranthus. The second was on the effect of nitrogen fertilizer on the yield of Amaranthus. The third was to compare the effect of different concentrations of nitrogen fertilizer on the growth of Amaranthus. The fourth was to compare the effect of different concentrations of nitrogen fertilizer on the yield of Amaranthus. The results show that nitrogen fertilizer had statistically significant effect on the growth of Amaranthus ($p < 0.01$).

Akamine *et al.*(2021) evaluated the effects of fertilizers 0 (Control), N, P, K, N+P (NP), N+K (NK), P+K (PK) and N+P+K (NPK) on red leaf amaranth in two experiments in Okinawa. Each of the N, P and K fertilizers was applied at 50 g. In addition, the effects of NPK (N:P: K=1:1:1) fertilizer at 0, 10, 20, 30 and 40 g were evaluated on red stem amaranth and red leaf amaranth. Growth and yield of amaranth cultivated under N, P, K, NK and PK treatments were very poor, but significantly higher with the NPK followed by NP. Growth parameters and yield greatly increased with the NPK fertilizer at 30-40 g for red stem amaranth and 20-30 g for red leaf amaranth. Mineral contents in the amaranths did not clearly differ with the different fertilizers. Mineral contents were higher or same in the amaranths cultivated with the fertilizer NPK at 30-40 g, compared to those under control treatments. The results indicate that combined fertilizer NPK at 30-40 g is effective for higher yield and quality of amaranth in the red soil.

Hariyadi *et al.* (2019) conducted a study at the Experimental Garden of the Faculty of Agriculture, Merdeka University Surabaya, East Java to examine the effect of the dose and time of NPK fertilizer application on the growth and yield of tomato plants (*Lycopersicum esculentum* Mill). The study used Factorial Randomized Block Design (RBD) consisting of two factors with three replications and two sample plants. The first factor was NPK fertilizer doses (N_1 = NPK 2 g plant^{-1}; N_2 = NPK 4 g plant^{-1}; N_3 = NPK 6 g plant^{-1}) and the second factor was the time of NPK application (W_1 = day 0; W_2 = day 0-14; W_3 = day 0-14-28). The results show that the combination treatment of dose and application time of NPK has a very significant effect on plant height, number of leaves, total fruit number and total fruit weight of tomato plants. The combination treatment of N_3W_3 (NPK 6 g plant^{-1} and day 0-14-28) appears to produce the highest growth and yield of tomato plants though, statistically (BNT 5%), this was not significantly different from the combination treatment of N_2W_3 (NPK 4 g plant^{-1}and 0-14-28 days).

Akinbile *et al.* (2016) examined the behavioral effect of different types of organic and inorganic fertilizer application on *Amanthus curentus.* Standard rates of cow dung (16 t ha^{-1}); NPK (0.25 t ha^{-1}) and control (no fertilizer) were administered to a 5 X 5m^2 plot using randomized complete block design (RCBD) with three treatments and three replicates. Final biomass yield of the vegetable for cow dung, N.P.K and control were 30,667±5.22 kg ha^{-1}, 60,408± 2.45 kg ha^{-1} and 46,825± 10.22kg ha^{-1} respectively while edible yield was 11,125 ±5.54 kg ha^{-1}, 20, 925±6.43 kg ha^{-1} and 11,092±3.33 kg ha^{-1}. Agronomic responses to the three treatments 7 weeks after planting (WAP), 18.83±2.30 cm for cow dung, 23±2.75 cm for the NPK and 17.75±2.40 cm for the control respectively. Plant height responses to the treatment were 70.08±5.45 cm for cow dung, 108.42±5.89 cm for NPK and 89±1.32 cm for control respectively in the same WAP. NPK was outstanding in all treatments during the experiment going by the responses.

Skwaryło-Bednarzand Krzepiłko (2009) conducted a field experiment to investigate the effect of various doses of NPK fertilizers on chlorophyll content in the leaves of two varieties of amaranth, ‘Rawa’ and Aztek in South-Eastern Poland. The following combinations of macro-element doses were applied: I - 50 kg N, 40 kg P and 40 kg K ha^{-1}, II - 70 kg N, 50 kg P and 50 kg K ha^{-1}, III - 90 kg N,60 kg P and 60 kg K ha^{-1} and IV - 130 kg N, 70 kg P and 70 kg K ha^{-1}. The highest chlorophyll-*a* content in the ‘Rawa’ variety was found with combination III of NPK fertilizer, while for ‘Aztek’ it was highest with combination II. The highest chlorophyll *b* content per unit fresh mass of ‘Rawa’ leaves was found with combination II of macro-element fertilizers, while for ‘Aztek’ this value was highest with combination III. Statistically significant dependencies were found between the NPK fertilizer doses used and the amount of chlorophyll in the fresh leaf tissue of both amaranth varieties.

2.2 Effect of organic fertilizers on crop production

The use of organic fertilizer is not without its challenges. The nutrient content of organic fertilizers can vary widely depending on the source material, making it difficult for farmers to accurately gauge nutrient application rates (Diacono & Montemurro, 2010). Moreover, the nutrients in organic fertilizers are often released slowly over time, which may not meet the immediate nutrient needs of fast-growing crops (Ge et al., 2016).

In contrast, organic fertilizer , which are synthetically produced, provide nutrients in a readily available form that can be quickly absorbed by plants. Numerous studies have shown that inorganic fertilizers can significantly increase crop yield in the short term (Zhang et al., 2018). Furthermore, the nutrient content of inorganic fertilizers is consistent and predictable, allowing for precise nutrient management (Roberts et al., 2013).

However, the extensive use of organic fertilizer has been linked to several environmental issues. Nitrate leaching from excessive fertilizer application can contaminate groundwater, posing a risk to human health (Sutton et al., 2011). Additionally, the production of inorganic fertilizers is energy-intensive and contributes to greenhouse gas emissions (Ladha et al., 2015).

The impact of both organic and inorganic fertilizers on soil health is another area of concern. While organic fertilizers can improve soil structure and promote soil biodiversity, some studies suggest that continuous use of organic fertilizer can lead to nutrient imbalances and soil acidification (Guo et al., 2015). On the other hand, long-term use of inorganic fertilizers can degrade soil structure and reduce soil biodiversity (Liu et al., 2010).

In terms of sustainable agriculture, the choice between organic and inorganic fertilizers is not straightforward. A study by Seufert *et al.* (2012) suggests that organic farming systems can produce comparable yields to conventional systems when best management practices are used. However, they also note that organic farming requires more land to produce the same yield as conventional farming due to its lower nutrient density.

Several studies have suggested that integrating organic and inorganic fertilizers may offer a solution to these challenges. For instance, Chivenge *et al.* (2015) found that combining organic and inorganic fertilizers could improve soil fertility while maintaining high crop yields. Similarly, a study by Drinkwater *et al.* (1998) found that integrating organic and inorganic nutrient sources could reduce nitrate leaching and improve nitrogen use efficiency.

In conclusion, both organic and inorganic fertilizers have their benefits and drawbacks. Organic fertilizers can improve soil health but may not provide sufficient nutrients for high-yielding crops. In contrast, inorganic fertilizers can boost crop yields but may have negative environmental impacts and degrade soil health over time. Therefore, an integrated approach that combines the benefits of both types of fertilizers may be the most sustainable solution for future agriculture.

2.3 The combined effect of NPK and organic fertilizer on crop production

The experiment was conducted by Baran *et al.* (2022) to evaluate the performance of dhap residue and nutrient sources on the growth and yield of red amaranth, radish and garlic at Gopalganj district in Bangladesh. The single factor experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. There were eight treatments viz. control (without organic and inorganic fertilizer), cow dung, recommended dose of NPK, 50% cow dung + 50% recommended dose of NPK, dhap residue, dhap residue + cow dung, dhap residue + recommended dose of NPK, dhap residue +50% cow dung+50% recommended dose of NPK. Dhap residue significantly influences the growth and yield of all three crops i.e., red amaranth, radish and garlic. In respect of red amaranth, the tallest plant (43.70 cm and 42.37 cm, respectively) and maximum number of leaves (33.00 and 33.33, respectively) per plant as well as yield (20.88 and 21.32 t ha^{-1}, respectively) were observed from dhap residue + 50% cow dung + 50% recommended dose of NPK which was significantly similar to dhap residue + recommended dose of NPK in both the years. Similar results were also observed in radish for root growth and in bulb production of garlic. From economic consideration, the application of dhap residue + 50% cow dung + 50% recommended dose of NPK fertilizers were suitable for growth and yield as well as cost effective for red amaranth, radish and garlic production under the climatic conditions in Gopalganj district of Bangladesh.

Sheik *et al.* (2022) conducted a study to measure the release of the major nutrients viz. available nitrogen (N), phosphorus (P), and potassium (K) in alkaline soil amended by recycled organic soil conditioners. The soil was amended by compost (Cm) and vermicompost (VC) @ 5 t ha^{-1} and a mixture of compost and vermicompost (Cm + VC) @ 2.5 t ha^{-1}. Chemical fertilizers (Cf) were added @ 98.842 kg ha^{-1} of urea and 64.99 kg ha^{-1} of triple superphosphate (TSP), with amended soils being incubated for 120 days maintaining 50% field moisture holding capacity. Due to the sufficient content of potassium in experimental soil for plant growth, extra potassium was not added. Available soil N, P, and K were determined at every 0, 15, 30, 45, 60, 90, and 120 days of incubation. The highest available N and K release was found in VC treated soils at the incubation period of 45 days. On the other hand, the highest P release was recorded in Cm treated soils at the incubation period of 45 days. In this experiment, the addition of Cm, VC and Cm + VC showed better release of cumulative plant available N, P and K than either control (C) or Cf and were arranged as VC > Cm > Cm + VC > Cf > C, Cm > Cm + VC > VC > Cf > C and Cm + VC > VC > Cm > C > Cf for N, P and K, respectively. The results of this experiment revealed that the addition of compost and/or vermicompost is predominant over chemical fertilizer in supplying major nutrients for crops in alkaline soil.

Atteya *et al.* (2021) carried out this study to assess the use of fertilizers, compost and NPK (as traditional minerals and as nanoparticles), in order to improve pods, seeds, and fixed oil contents, as indicators of the quality of the production of the *Moringa oleifera* trees in calcareous soil conditions. In this experiment, it was observed that all parameters and the yield of pods, seeds, and fixed oil of the *Moringa oleifera* tree were significantly improved by increasing the level of compost and using NPK fertilization and combination treatments in both seasons of the study. The combination treatments of 10- and 20-ton ha^{-1} compost plus NPK control produced the highest percentage of oleic acid with insignificant differences between them.

Ali *et al.* (2018) conducted a field experiment at South Surma upazilla of Sylhet district to evaluate the effect of organic compost, cow dung and inorganic fertilizers on the growth and yield of cauliflower (*Brassica oleracea* var. botrytis L.) in acid soil. The experiment comprised of four treatments viz. T_1 = 135-60-135- 21-3-1.5 kg ha^{-1} of N-P-K-S-Zn-B, T_2 = T_1 + Cow dung (5 t ha^{-1}), T_3 = T_1 + Vermicompost (5 t ha^{-1}) and T_4 = Vermicompost (10 t ha^{-1}). The experiment was laid out in a randomized complete block design with three replications. The results on growth parameters recorded at 15, 30 and 45 DAT showed significant variation in different growth and yield contributing characters. The tallest plant (24.47 cm) was recorded at 45 DAT in T_3 treatment. The same treatment at 30 DAT produced the highest number of leaves plant^{-1} (8.33) while T_4 had the lowest number of leaves plant^{-1} (5.93). The longest length and breadth of the largest leaf and spreading of plants were recorded 19.60, 10.03 and 16.53 cm at 45 DAT in T_3, respectively. The highest curd yield (29.72 t ha^{-1}) was recorded in T_3 treatment. Post-harvest soil analysis showed a higher amount of organic matter, total N, available P, exchangeable K and available S contents than in initial soil. This might be due to residual effect of compost. The results revealed that organic compost addition with recommended dose of chemical fertilizers T_3 performed better compared to only inorganic fertilizers.

Kiran *et al.* (2016) carried out a pot experiment to check the response of different organic manures and inorganic fertilizers on the growth and yield of radish, at Horticulture Departmental experimental area, Faculty of Agriculture, Gomal University, D.I. Khan. The experiment was laid out in RCD with seven treatments replicated thrice. The treatments included control, farmyard manure (FYM) @ 25 t ha, poultry manure (PM) @ 10 t ha, goat manure (GM) @ 15 t ha^{-1}, press mud (PrM) @ 20 t ha^{-1}, sewage sludge (SS) @ 20 t ha and nitrogen, phosphorus, potassium (NPK) @ 120-65-100 kg ha^{-1}. Data on leaf plant, leaf length (cm), fresh leaf weight plant (g), dry leaf weight plant (g), root length (cm), root diameter (cm), fresh root weight plant (g), dry root weight plant (g), total biomass plant (g), root yield pot (g) and root yield (t/ha) were recorded and analyzed statistically. The results revealed that all growth attributes and yield were significantly enhanced by the application of organic manures and NPK. The highest values were found in NPK treated plants followed by PM, GM, SS, PrM and FYM, respectively.

The experiment was carried out by Mondal *et al.* (2016) at the research farm of Bangladesh Institute of Nuclear Agriculture, Mymensingh, Bangladesh to evaluate the effects of cow dung (CD), poultry manure (PM) and mustard oil cake (MOC) along with NPK fertilizer amendments on the growth and yield performances of red amaranth in silty loam soil. The treatments were (i) NPK (control), (ii) NPK + CD, (iii) NPK + PM and (iv) NPK + MOC. All three types of manures significantly increased the plant height and numbers of leaves plant^{-1}, thereby fresh weight, yield compared with the control (NPK). 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}). PM added fertilizer combination also had almost equal investment and cost-benefit ratio in comparison with CD. The lowest marginal benefit-cost ratio (1.09) was observed in MOC added NPK fertilizer combination though it showed higher vegetable yield (11.08 t ha^{-1}). The farmer can be recommended to follow NPK + CD fertilizer combination. Manures applied post soil analysis showed improves the soil physiochemical properties.

Farjana *et al.* (2016) conducted the experiment to evaluate the growth and yield of cabbage (*Brassica oleracea*L.var. capitata cv. Atlas-70) as influenced by organic and inorganic fertilizers, and mulching. Research methods: The experiment comprised of two different factors such as, factor-A; four different types of fertilizers viz. F_0 (control, no fertilizer), F_1 (vermicompost), F_2 (inorganic fertilizer), and F_3 (mixed of organic and inorganic fertilizer) and factor-B; types of mulches viz. M_0 (control, no mulch), M_1 (water hyacinth), M_2 (rice straw), M_3 (black polythene). This two factors experiment was conducted in Randomized Complete Block Design (RCBD) with three replications. Findings: Significant variation was found among the treatments. Result showed F_3M_3 (combination organic and inorganic fertilizer with black polythene) had the highest growth (plant height, stem length, root length, number of roots etc.) and yield (105.93 t ha^{-1}) in cabbage. The yield was 63.92% higher from the combined effect of fertilizer and mulch as black polythene (F_3M_3) compared to control (F_0M_0). So, mineral fertilizer and vermicompost with black polythene had the best performance considering the growth and yield of cabbage.

An experiment was conducted by Kansotia *et al.* (2015) at Agronomy Farm, College of Agriculture, Bikaner. Application of organic compost up to 6 t/ha and 80 kg N+ 40 kg P_2O_5/ha significantly increased the number of branches/plant, number of siliqua/plant, number of seed/siliqua seed yield, straw yield, better nitrogen and phosphorus content, uptake in seed and stover, higher protein and oil contents.

Jahan *et al.* (2014) conducted an experiment at experimental field of the Soil Science Division, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh to study the effect of organic compost and conventional compost on the growth and yield of cauliflower. The experiment comprised of twelve treatments viz. T_1: 100% Recommended Dose of Chemical Fertilizer (RDCF; RDCF= $N_{250}P_{35}K_{65}S_{40}Zn_5B_1$ $kgha^{-1}$); T_2: 80% RDCF; T_3: 60% RDCF; T_4: 100% RDCF+ compost @ 1.5 tha^{-1}; T_5: 80% RDCF+ compost @ 3 tha^{-1}; T_6: 60% RDCF+ compost @ 6 tha^{-1}; T_7: compost @ 6 tha^{-1}; T_8: 100%RDCF+ Conventional compost @ 1.5 tha^{-1}; T_9: 80% RDCF+ Conventional compost @ 3 tha^{-1}; T_{10}: 60% RDCF+ Conventional compost @ 6 tha^{-1}; T_{11}: Conventional compost @ 6 tha^{-1} and T_{12}: Control (No fertilization) following Randomized Complete Block Design with three replications. Maximum plant height (49.4 cm), number of leaves plant^{-1} (16.3), circumference of curd (46.5 cm), curd height (20.7 cm), total weight (1.60 kg plant^{-1}), marketable weight (13.0 kg plant^{-1}), curd yield (37.6 tha^{-1}) and stover yield (29.7 tha^{-1}) were found from T_4which was statistically identical with or followed by T_8 and T_5. From the experiment it was found that vermicompost was better than conventional compost in combination with chemical fertilizers.

Mal *et al.* (2014) conducted a study to find out the response of compost and inorganic fertilizers on growth, yield and quality of sprouting broccoli at UBKV, Pundibari, West Bengal, India. The treatments comprised of five levels of vermicompost (0, 2.5, 5, 7.5 and 10 t ha^{-1}) and four levels of inorganic fertilizers (0, 50, 75 and 100% of recommended dose) were evaluated in two factor factorial RBD with three replications. The result revealed that successive increase in compost level significantly increased the growth and yield attributes and application of highest level of compost (10 t ha^{-1}) registered 38% and 43% improvement of central head weight and total head yield respectively over control, whereas application of100% recommended fertilizers enhanced the head weight and total head yield by 32% and 35% respectively over control. The nutrient schedule comprising of higher level of compost (10 t ha^{-1}) and 100% of recommended inorganic fertilizers emerged as potential nutrient source and resulted in many fold improvement in the form of vigorous growth, early head initiation, advanced head maturity and higher yield as well as superior quality of head as compared other nutrient combination.

Singh *et al.* (2010) conducted a field experiment to investigate the effects of organic compost and NPK fertilizer application on morpho-physiological traits, yield and quality attributes of tomato (*Solanum lycopersicum* L.). The application of compost together with NPK fertilizer increased plant height, leaf area, leaf weight, fruit weight, fruit yield, fruit density, post-harvest life and TSS of tomato. Application of compost alone too increased the shelf-life by 250% and TSS beyond 4.5%, both of which are traits highly desirable for summer production of tomato and the related processing industry. Present study reveals that application of compost in the amount of 7.5 t ha^{-1} in combination with 50% dose of NPK fertilizer (60:30:30 kg ha^{-1}) was optimum for obtaining better quality and productivity of field grown tomatoes in mild-tropical agro-climate, eventually integrated nutrient supply will sustain the soil fertility and plant productivity eco-friendly.

Wang *et al.* (2010) investigated a pot experiment to evaluate the effects of cow manure compost on plant growth, metabolite contents, and antioxidant activities of Chinese cabbage were. Five treatments were designed by mixing vermicompost and soil at ratio of 0:7, 1:7, 2:7, 4:7, 7:0 (w/w). Marketable weight of Chinese cabbage was significantly ($p < 0.05$) higher in the 2:1 treatment than in the other treatments, while plants grown in the full soil treatment (0:7) showed the lowest marketable weight. Organic fertilizer application significantly increased the nutrient content of Chinese cabbage leaves ($p < 0.05$), especially in the 4:7 treatment, with increases in the contents of soluble sugar, soluble protein, vitamin C, total phenols, and total flavonoids by 62%, 18%, 200%, 25%, and 17% compared to the full soil treatment, respectively. The antioxidant activities expressed by 2, 2-Dipenyl-1-picrylhydrazyl-scavenging activity, hydroxyl (OH^-) scavenging activity, and iron (Fe^{2+}) chelating activity were higher by 92%, 40%, and 36% in the 4:7 than 0:7 the treatment, respectively. Organic fertilizer application significantly increased ($p < 0.05$) the plant contents of 16 essential amino acids; the total amino acid content showed the greatest increase in the 4:7 treatment, 90% compared to the full soil treatment.

Zhenyu and Yongliang (2005) conducted an experiment in the field to test efficiency of organic fertilizer, and two crops were produced. The results showed that: when the second crop was finished, compared with that of soil before test, contents of soil organic matter, total N, P increased respectively by 78.7%, 47.9%, 40.8% in the treatment of only applying compost, which also increased respectively by 38.4%, 21.9%, 28.2% in the treatment of applying vermicompost with inorganic fertilizer; total number of the three sorts of microorganisms increased respectively by 108.2%, 51.8% in two treatments of only applying vermicompost and applying compost with inorganic fertilizer. Employing organic fertilizer could increase available nutrients, promote the growth of leaf area, accelerate accumulation of dry matter, when the first and second crops were finished, compared to the treatment of no fertilizer, only applying organic compost increased yield by 45.5% and 77.5%, applyingcompost with inorganic fertilizer increased yield by 76.1% and 103.9%, the difference was great significant. So, employing organic fertilizer could improve the quality of cabbage.

CHAPTER III

MATERIALS AND METHODS

A study was conducted to find out the effect of different NPK and compost on the growth and yield of red amaranth. This chapter presents a short description about experimental period, site description, soil and climatic condition of the experimental area, experimental details, treatments, experimental design and layout, intercultural operations, data collection and statistical analysis. The details of experiments and methods are described below-

3.1 Experimental period

The experiment was conducted in Rabi season during the period from November 2023 to December 2023

3.2 Description of the experimental site

The field experiment was conducted at the north side of the Central Mosque of Hajee Mohammad Danesh Science and Technology University, Dinajpur-5200. The geographically the experimental field is located at 25.69º N latitude ; 88.65º E longitude and 40 m above sea level. The Agro Ecological Zone (AEZ) of the area is the Old Himalayan Piedmont Plain (AEZ-1) (Appendix-I).

3.3 Soil characteristics

The soil of the experimental plot was sandy loam with pH 5.60. The initial soil (0-15 cm depth) test revealed that the soil contained 0.080% total nitrogen, 3.30 ppm available phosphorus, 0.52 meq/100g soil exchangeable potassium, 7.53 ppm available sulphur. General soil type was Non calcareous flood plain and the parent material of this soil was alluvial deposit. The details of the plot soil have been presented in table 3.1.

Table 3.1. Morphological, physical and chemical characteristics of the initial soil of the experimental field

A. Morphological characteristics of the initial soil sample

Characteristics	Value
General Soil type	Non – calcareous Brown Floodplain Soil
Parent Material	Piedmont alluvium
Drainage	Moderately well drained
Topography	High land
Flood level	Above flood level

B. Physical characteristics of the initial soil sample

Characteristics	Value
Sand	56.00 %
Silt	34.00 %
Clay	10.00 %
Textural class	Sandy loam

C. Chemical characteristics of the initial soil sample

Characteristics	Value
pH	5.60
Organic matter (%)	0.82
Electrical conductivity (mSm^{-1})	0.14
Total N(%)	0.080
Available P(ppm)	3.30
Exchangeable K(meq/100g soil)	0.52
Available S (ppm)	7.53

3.4 Climatic condition

The climate of the experimental site was under the subtropical climate, characterized by three distinct seasons, the winter season from November to December. There was no rainfall during the months of December. The average maximum temperature of experimental site during the period of study was 21°C and the average minimum temperature was 13.33°C. Details of the meteorological data of air temperature, relative humidity and rainfall during the period of the experiment was collected from the weather station of Bangladesh Wheat and Maize Research Institute, Dinajpur and has been presented in Appendix II.

3.5Planting materials

A local variety of Amaranth was used as a test crop in the experiment. It was red amaranth (*Amaranthus* spp.) and leafy type quick growing short duration summer vegetable. Seeds are collected from the sell center of Bangladesh Agricultural Development Corporation (BADC), Noshipur, Dinajpur.

3.6 Treatments of the experiment

There are 6 treatments with 3 replications for conducting the whole experiment which were as follows:

T_1 = Control

T_2 = 100% NPK

T_3 = 100% Compost

T_4 = 75% Compost + 25% NPK

T_5 = 50% Compost + 50% NPK

T_6 = 25% Compost + 75% NPK

3.7 Experimental design and layout

The experiment was laid out following Randomized Complete Block Design (RCBD) with three replications. There were three blocks and each block containing 6 plots. Thus, the total number of plots was 18. The size of unit plot was $1m^2$ (1 m × 1 m). The distance between the plot to plot and the row to row were maintained 0.5 m and 0.25 m, respectively.

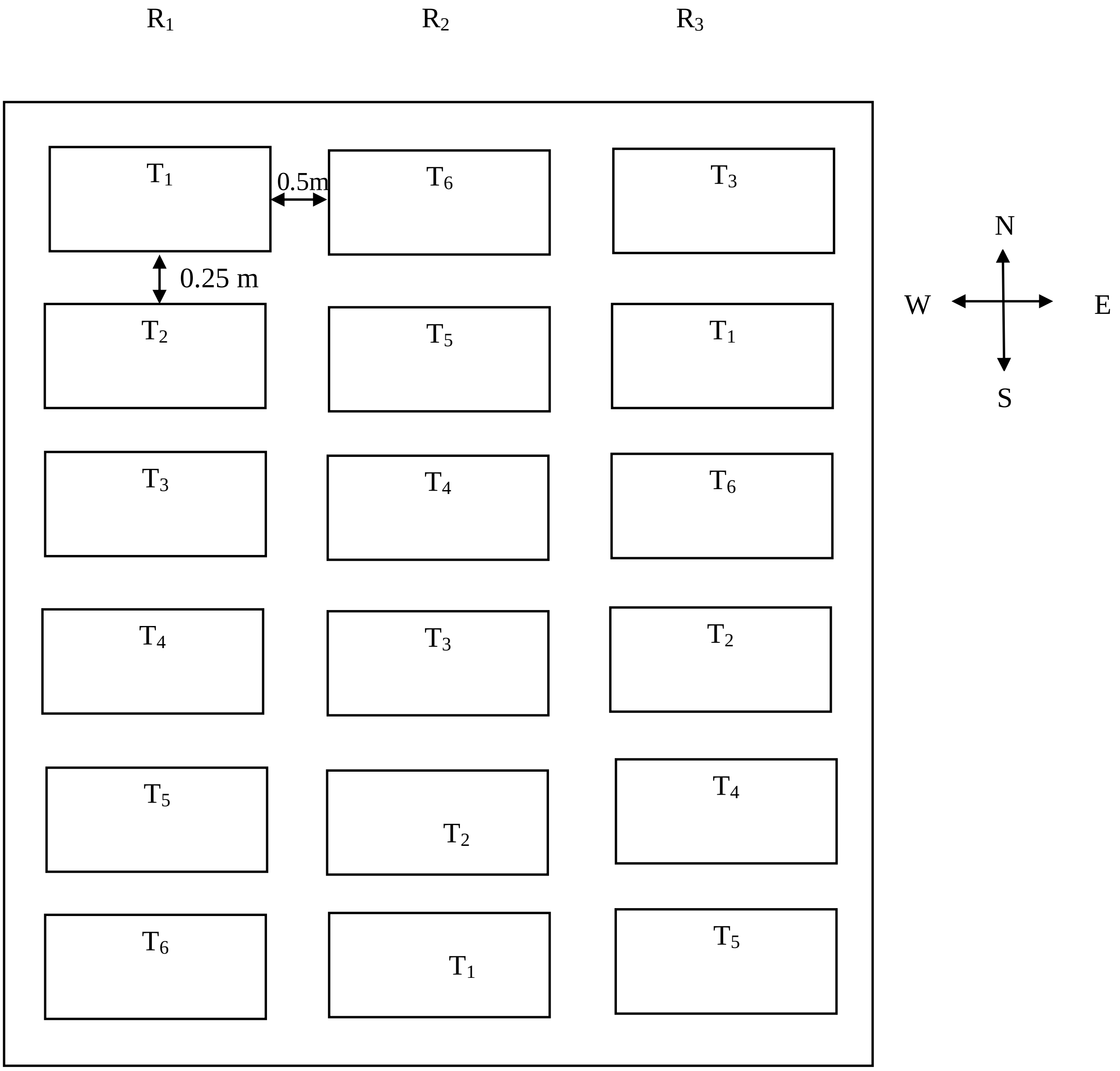

Figure 3.1: Layout of the experimental plot

3.8 Land preparation

The experimental land was prepared with the help of power tiller by three successive ploughing and cross-ploughing followed by laddering. Weeds and crop residues of previous crops were removed from the field. The experimental plot was divided into unit plots in accordance with the experimental design.

3.9 Manure and fertilizer application

The recommended dose was N 75 kg ha^{-1}, P 18 kg ha^{-1}, K 30 kg ha^{-1} and compost 3 t ha^{-1}, (Fertilizer Recommendation Guide, 2018. Page-100). The full dose of K from muriate of potash (MP), and P from triple super phosphate (TSP) were applied to all experimental plots as per treatments. One half of N from urea was applied as basal dose during the final land preparation and the rest of urea was applied 20 days after sowing. NPK and Compost per plot requirements were calculated as per the treatments respectively. From full amounts of TSP, MOP. As organic fertilizer was applied before four days of final land preparation. Rate of fertilizer have been given below:

Table 3.2: Rate of fertilizers

Name of the fertilizers	Rate	Amount per plot (100%)
Urea	N_{75}	16.30 g m-^{2}
P_20_5	P_{18}	22.9 g m-^{2}
K_2O	K_{30}	11 g m-^{2}
Compost	3 t ha^{-1}	0.3 kg m^{-2}

Table 3.3. Chemical compositions of organic manure

Name of organic fertilizer	Nutrient content (%)			
	N	P	K	S
Compost	1.48	0.28	1.27	0.32

3.10 Seed sowing

Seeds were sown in well-prepared land on 1st November 2023. The seeds were sown at about 1.3 cm depth by broadcasting method and covered uniformly with light soil for proper germination at 1.5-2.0 kg ha^{-1}.

3.11 Intercultural operation

After the establishment of crops, various intercultural operations were accomplished for better growth and development of the red amaranth crops.

3.11.1 Thinning

Thinning was done 10 days after sowing (DAS) and 20 DAS. Thinning was done in the entire unit plots with special care to maintain constant plant population per plot.

3.11.2 Weed control

Weddings were done to keep the plots free from weeds, which ultimately ensured better growth and development. It keeps the soil aerated by breaking the soil crust. It also conserves the soil moisture. The newly emerged weeds were uprooted carefully by mechanical means.

3.11.3 Irrigation and drainage

Irrigation was done as and when the field seemed dry to each plot to ensure sufficient moisture for normal crop growth. Proper drainage facilities were developed to avoid stagnation of water.

3.12 Harvesting

Red amaranths were harvested at 45-50 days after sowing, on 1st December 2023, when the plant growth was maximum for use as vegetable. Harvesting was done plot wise by uprooting the plants by hand carefully and calculated yield $plot^{-1}$ in kg and then it was converted in ton ha^{-1}.

3.13 Data collection

The data on the following parameters were collected from each treatment.

Physical properties of plants

- Plant height

- Number of leaves plant^{-1}
- Shoot weight plot^{-1}
- Root weight plot^{-1}
- Root length

Chemical Properties of Soil

- Soil pH
- Electrical conductivity (EC)
- Organic matter (OM)
- Particle density
- Total N content
- Available P
- Exchangeable K
- Available S

3.14 Detailed Procedures for Recording Data

A brief outline of the data collecting procedure followed during the experiment is given below:

3.14.1 Plant height

Plant height was measured from the soil level to the terminal leaf using a meter scale in centimeter (cm). From each unit plot 5 sample plants were measured, and mean value was recorded. Plant height was recorded periodically to observe the growth parameters of plants at 15, 30, 45 DAS and final harvest.

3.14.2 Number of leaves plant^{-1}

To estimate the number of leaves per plant, leaves were counted at 15, 30, 45 DAS and final harvest from 5 selected plants. All the leaves of selected plants were counted separately, and mean value was calculated.

3.14.3 Shoot weight plot^{-1}

The fresh shoot weight of individual plot was measured with the electrical balance in gram (g), and then dried in the sun to remove the extra moisture and later dry weight was recorded in gram (g) and converted into ton ha^{-1}.

3.14.4 Root weight plot^{-1}

After the final harvest, the fresh root of individual plot was weighed with electrical balance in gram (g). Then the roots were oven dried for 72 hours at 70^{o}C. Dry weight (g) plot^{-1} was taken with the help of an electronic balance and converted into t ha^{-1}.

3.14.5 Root length

The length of the root of the selected 10 plant per plot was measured in centimeter (cm) after harvest.

3.14.6 Soil analysis for chemical properties and essential nutrients

Soil samples were collected from each pot at three different points and then mixed to form one composite sample for each replication. The samples were sealed in plastic bags and transported to the lab, and then plant detritus and other fragments were removed. After air-dried, the soil samples were ground and passed through a 2 mm sieve for analysis of total N content, available P, exchangeable K, available S, soil pH, electrical conductivity (EC), organic matter (OM).

3.14.6.1 Soil pH

The soil pH was determined in 1:2.5 soil: water suspension by potentiometric method using glass electrode pH meter (Jackson, 1973).

3.14.6.2 Electrical conductivity (EC)

Electrical conductivity was determined with the help of a conductivity meter following Jackson (1973).

$$\text{Electrical conductivity of soil} = \text{observed EC of soil} \times K$$

3.14.6.3 Soil organic matter content (OM)

Organic carbon in soil was determined by Walkley and Black's (1934) wet oxidation method. The underlying principle is to oxidize the organic carbon with an excess of 1 N $K_2Cr_2O_7$ in presence of conc. H_2SO_4 and to titrate the residual $K_2Cr_2O_7$ solution with 1 N $FeSO_4$ solution. The OM content was calculated by multiplying the percent OC with the van Bemmelen factor of 1.724 (Piper, 1950).

$$\%\ \text{Organic matter} = \%\ \text{Organic carbon} \times 1.724$$

3.14.6.4 Particle density

The particle density of a soil = dry mass (g) of soil / volume of soil particles. Where D_p is particle density; ODwt is oven-dry weight of soil; V_s is volume of solids. Particle density takes into account the mass and volume occupied by the solid particles only. It excludes the volume occupied by air and water. Jun 24, 2021

The **particle density** of a soil = dry mass (g) of soil / volume of soil particles.

$$Dp=ODwt/Vs$$

Where D_p is particle density; ODwt is oven-dry weight of soil; V_s is volume of solids. Particle density takes into account the mass and volume occupied by the solid particles only

3.14.6.4 Available Sulphur (S)

Available S was determined by 0.15% CaCl2 extraction method (Page *et al.*, 1982).

3.14.6.5 Total Nitrogen content (N)

Total nitrogen was determined by Micro-Kjeldahl method (Jackson, 1973). Total N content of soil was determined following the micro-Kjeldahl method. The soil was digested with H_2O_2 and conc. H_2SO_4 in presence of a catalyst mixture (K_2SO_4: $CuSO_4.5H_2O$: Se in the ratio of 10: 1: 0.1) and the nitrogen in the digest was determined by distillation with 40% NaOH followed by titration of distillate trapped in H_3BO_3 with0.01N H_2SO_4 (Page *et al.*, 1982).

3.14.6.6 Available phosphorus (P)

Phosphorus was extracted from soil samples by the sodium bicarbonate (0.5 OM, Ph 8.5) method according to Olsen *et al.* (1954) and determined by the ascorbic acid–molybdenum blue method at wavelength of 660 nm in Spectro-photometer as described by Jackson (1973).

3.14.6.7 Exchangeable potassium (K)

The exchangeable cations like potassium (K) extracted with 1 N ammonium acetate and determined using the Flame photometer (Jackson, 1973).

fero3.15 Statistical analysis

The collected data on various parameters were statistically analyzed with the help of the computer package programme Statistix 10. The significance of differences between treatments was estimated by Tukey HSD at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

This experiment was performed to know the effect of NPK and compost on the growth and vegetative yield of red amaranth. Data on different levels of growth parameters and post-harvest soil test were recorded to find out the suitable fertilizer mixtures for red amaranth production. The results have been presented by graphs and tables, discussed and possible interpretations are given under the following heading:

4.1 Physical properties of plant

4.1.1 Plant height

The plant height of red amaranth varied significantly for different treatments at different days after sowing (DAS) (Table 4.1). Among the treatments, at 15 DAS, T_4 exhibited the tallest plant height (6.00 cm) which was statistically similar to T_6 (5.90 cm), while T_1 had the lowest height (4.50 cm), indicating that T_4 promoted the most rapid early growth. Moving to 30 DAS, T_6 lead with the highest plant height (21.40 cm), while T_1 remained the lowest value (9.06 cm). This trend persisted at 45 DAS, with T_6 boasting the highest value (26.31 cm), and T_1 maintaining the lowest value (13.96 cm). Similarly, Oroka (2016) reported that vermicompost alone and in mixture with NPK significantly increased the plant morphological parameters and yield and yield components. Ali *et al.* (2018) also found similar trends.

4.1.2 Number of leaves plant^{-1}

The number of leaves of red amaranth plant statistically significant at different days after sowing (DAS) for six different treatments (Table 4.2). At 15 DAS, T_2 had the highest number of leaves (4.70), while T_1 had the lowest (3.79). As the days progressed to 30 DAS, T_6 exhibited statistically superior and the highest leaf count (8.34), while T_1 remained at the lowest (5.90). This trend continued at 45 DAS, with T_6 having the highest number of leaves (10.40) and T_1 having the lowest (7.50). Overall, the data indicates that T_6 consistently outperformed other treatments in terms of leaf production at 30 and 45 DAS stages, while T_1 consistently had the fewest leaves. Kashem *et al.* (2015) stated that number of leaves was influenced significantly by the application of vermicompost and NPK fertilizer in the growth media. In addition, Saha *et al.* (2022) found that vermicompost has a positive effect on red amaranth production.

Table 4.1: Effect of different treatments on plant height of red amaranth at different DAS

Treatments	Plant height (cm)		
	At 15 DAS	At 30 DAS	At 45 DAS
T_1	4.50 d	9.06 f	13.96 f
T_2	4.80 c	15.32 d	24.24 d
T_3	5.10 b	11.60 e	18.55 e
T_4	6.00 a	19.80 b	24.53 c
T_5	4.40 d	18.60 c	24.62 b
T_6	5.90 a	21.40 a	26.31 a
CV (%)	1.66	0.97	0.10
LSD	0.069	0.126	0.017

Values in a column with different letters are significantly different at $p \leq 0.05$ applying LSD.

CV% = Coefficient of variation

LSD=Least Significant Difference

Here,

T_1 = Control

T_2 = 100% NPK

T_3 = 100% Compost

T_4 = 75% Compost + 25% NPK

T_5 = 50% Compost + 50% NPK

T_6 = 25% Compost + 75% NPK

Table 4.2: Effect of treatments on number of leaves plant^{-1} of red amaranth at different DAS

Treatments	Number of leaves plant^{-1}		
	At 15 DAS	At 30 DAS	At 45 DAS
T_1	3.79 c	5.90 f	7.50 f
T_2	4.70 a	6.30 e	9.00 d
T_3	4.40 b	6.70 d	8.20 e
T_4	4.60 a	7.90 b	10.10 c
T_5	4.60 a	7.56 c	10.20 b
T_6	4.30 b	8.34 a	10.40 a
CV (%)	2.45	1.59	0.50
LSD	0.088	0.126	0.038

Values in a column with different letters are significantly different at $p \leq 0.05$ applying LSD.

CV% = Coefficient of variation

LSD=Least Significant Difference

Here,

T_1 = Control

T_2 = 100% NPK

T_3 = 100% Compost

T_4 = 75% Compost + 25% NPK

T_5 = 50% Compost + 50% NPK

T_6 = 25% Compost + 75% NPK

Both fresh and dry weight of shoot of red amaranth were significantly different among the different treatments (Table 4.3). In terms of fresh shoot weight, T_1 had the lowest (1.14 t ha^{-1}), while T_6 had the highest fresh shoot weight (3.78 t ha^{-1}) which was similar to T. This indicates T_6 being the most productive in terms of fresh shoot weight.

When considering dry shoot weight of red amaranth, a similar pattern emerges. T_1 again had the lowest dry shoot weight (0.56 t ha^{-1}), while T_6 had the highest dry shoot weight (1.83 t ha^{-1}) which was identical with all other treatments except T_1. This consistent pattern demonstrates that T_6 consistently outperformed the other treatments in terms of both fresh and dry shoot weight. Similar results were reported also by Kashem *et al.* (2015) and Alam *et al.* (2007).

4.1.4 Root weight

There was a significant variation for both fresh and dry root weight of red amaranth across the treatments (Table 4.4). In terms of fresh root weight, T_1 had the lowest weight (0.42 t ha^{-1}), while T_6 had the highest fresh root weight (1.41t ha^{-1}). This indicates T_6 being the most productive in terms of fresh root weight.

Similarly, when considering red amaranth dry root weight, T_1 had the lowest dry root weight (0.21 tha^{-1}), while T_6 had the highest dry root weight (0.76 t ha^{-1}). Again, this consistent pattern demonstrates that T_6 consistently outperformed the other treatments in terms of both fresh and dry root weight. Alam *et al.* (2007) also suggested that vermicompost (5 t ha^{-1}) + NPKS (100%) can be economically and environmentally suitable. The results are in consonance with the findings of Kashem *et al.* (2015).

4.1.5 Root length

The red amaranth root length was statistically different due to different treatments (Table 4.4). The highest and statistically superior root length (7.80 cm) was observed in treatment T_6. On the other hand, the lowest root length (6.30 cm) was found in treatment T_1. This data clearly demonstrates a progressive increased in root length from T_1 to T_6, with treatment T_6 exhibiting the most extensive root growth, while treatment T_1 has the shortest root length among the treatments. Similar result was reported also by Ali *et al.* (2018) that vermicompost addition with recommended dose of chemical fertilizers performed better compared to only inorganic fertilizers.

Table 4.3: Effect of treatments on shoot fresh and dry weight of red amaranth

Treatments	Shoot weight (t ha^{-1})	
	Fresh	Dry
T_1	1.14 c	0.56 b
T_2	3.19 ab	1.82 a
T_3	3.02 b	1.23 ab
T_4	2.81 b	1.63 a
T_5	3.20 b	1.82 a
T_6	3.78 a	1.83 a
CV(%)	12.52	24.84
LSD	0.292	0.299

Values in a column with different letters are significantly different at $p \leq 0.05$ applying LSD.

CV% = Coefficient of variation

LSD=Least Significant Difference

Here,
T_1 = Control
T_2 = 100% NPK
T_3 = 100% Compost
T_4 = 75% Compost + 25% NPK
T_5 = 50% Compost + 50% NPK
T_6 = 25% Compost + 75% NPK

Table 4.4: Effect of treatments on root fresh and dry weight, root length of red amaranth

Treatments	Root weight (t ha^{-1})		Root length (cm)
	Fresh	Dry	
T_1	0.42 c	0.21 d	6.30 f
T_2	1.17 ab	0.67 ab	6.80 d
T_3	1.12 b	0.40 c	6.50 f
T_4	0.98 b	0.52 bc	7.10 c
T_5	1.17 ab	0.58 b	7.30 b
T_6	1.41 a	0.76 a	7.80 a
CV(%)	14.83	15.79	0.94
LSD	0.126	0.067	0.053

Values in a column with different letters are significantly different at $p \leq 0.05$ applying LSD.

CV% = Coefficient of variation

LSD=Least Significant Difference

Here,
T_1 = Control
T_2 = 100% NPK
T_3 = 100% Compost
T_4 = 75% Compost + 25% NPK
T_5 = 50% Compost + 50% NPK
T_6 = 25% Compost + 75% NPK

4.2 Chemical properties of soil

4.2.1 Soil pH

The different treatments for red amaranth had a significant effect on post-harvest soil pH (Table 4.5). In the initial, soil pH was 5.60. After applying treatments, treatment T_4 exhibited the highest pH level (6.98), representing the treatment with the most neutral soil. In contrast, treatment T_1 had the lowest pH level (5.60), indicating the treatment with the most acidic soil. This data illustrates a clear range of pH values across the treatments, with treatment T_4 showing the soil neutrality, while treatment T_1 displayed the lowest soil pH, indicating acidity.

4.2.2 Electrical conductivity (EC)

There were no significant variations in EC levels of post-harvest soil across the treatments for red amaranth crop (Table 4.5). Before applying the treatments, the EC was 0.14 mS/m. However, applying treatments, among these treatments, the highest EC value (0.21 mS/m) was observed in treatment T_6, while the lowest EC value (0.05 mS/m) was found in treatments T_1.

4.2.3 Organic matter (OM) content in soil

Organic matter content of post-harvest soil differed significantly for six different treatments (Table 4.5). In the initial soil, organic matter (OM) content was 0.82. After treatment application, treatment T_6 experienced the highest organic matter content (1.40 %), followed by the treatments T_5, T_4, T_2 and T_1 which also had high organic matter content (0.94%, 1.17%, 0.94% and 0.88% respectively) over initial soil. In contrast, treatment T_1 had the lowest organic matter content (0.88%), indicating the treatment with the least organic matter. This data illustrates a clear difference in organic matter content across the treatments; with treatments T_6 had the highest levels of organic matter, while treatment T_1 displayed the lowest organic matter content among the treatments. Likewise, vermicompost with inorganic fertilizer had a positive effect in case of organic matter of post-harvest soil reported by Kashem *et al.* (2015).

Table 4.5: Effects of NPK and compost on soil pH, electrical conductivity and organic matter content of the post-harvest soils for red amaranth production

Treatments	Soil pH	Electrical conductivity (mS/m)	Organic matter content (%)
T_1	5.60 b	0.05 d	0.88 c
T_2	6.46 d	0.19 a	0.94 c
T_3	6.00 a	0.02 f	0.98 a
T_4	6.98 a	0.10 e	1.17 b
T_5	6.63 c	0.14 c	0.94 c
T_6	6.65 c	0.21 a	0.14 bc
CV(%)	0.29	6.10	9.57
LSD	0.158	0.006	0.082
Initial soil	5.60	0.14	0.82

Values in a column with different letters are significantly different at $p \leq 0.05$ applying LSD.

CV% = Coefficient of variation

LSD=Least Significant Difference

Here,
T_1 = Control
T_2 = 100% NPK
T_3 = 100% Compost
T_4 = 75% Compost + 25% NPK
T_5 = 50% Compost + 50% NPK
T_6 = 25% Compost + 75% NPK

4.2.4 Particle density

There were no significant variations in particle density of post-harvest soil across the treatments for red amaranth crop (Table 4.6). Before applying the treatments, the particle density was 2.24 g/cm. However, applying treatments, among these treatments, the highest particle density value (2.26 g/cm) was observed in treatment T_6, while the lowest particle density value (2.13 g/cm) was found in treatments T_3.

Table 4.6: Effect of treatments on particle density of the post harvest soil of red amaranth

Treatments	Particle density (g cm^{-3})
T_1	2.24 a
T_2	2.25 a
T_3	2.13 b
T_4	2.17 ab
T_5	2.19 ab
T_6	2.26 a
CV(%)	2.25
LSD	0.041

Values in a column with different letters are significantly different at $p \leq 0.05$ applying LSD.

CV% = Coefficient of variation

LSD=Least Significant Difference

Here,

T_1 = Control
T_2 = 100% NPK
T_3 = 100% Compost
T_4 = 75% Compost + 25% NPK
T_5 = 50% Compost + 50% NPK
T_6 = 25% Compost + 75% NPK

4.2.5 Total N

There were significant differences in the total N content of post-harvest soil of red amaranth for different treatments (Table 4.7). Before applying treatments, total N percentage was 0.080. After post-harvest soil analysis, among these treatments, the highest nitrogen content of 0.160% was observed in treatment T_3 which was statistically similar with T_2 and T_6. In contrast, the lowest nitrogen percentage (0.084%) noticed in treatment T_1. These measurements provide valuable insights into the variations in nitrogen levels under different treatment conditions, with treatment T_6 displaying the highest nitrogen content among the treatments. Ali *et al.* (2018) conducted an experiment and found that post-harvest soil analysis showed a higher amount of total N contents than in initial soil. This might be due to residual effect of vermicompost.

4.2.6 Available P

Available P concentrations of post-harvest soil were significantly influenced by different treatments for red amaranth cultivation (Table 4.7). In the initial soil, available P was 3.30 ppm. After post-harvest soil analysis, among these treatments, treatment T_2 exhibited the highest P concentration (4.90 ppm). In contrast, treatment T_1 had the lowest phosphorus concentration at (2.06 ppm), representing the treatment with the lowest phosphorus levels. This data illustrates a notable contrast in phosphorus content across the treatments, with treatment T_2 showing the highest phosphorus concentration, while treatment T_1 displays the lowest. Zhenyu and Yongliang (2005) found that employing vermicompost could increase available nutrients for crops.

4.2.7 Exchangeable K

The exchangeable K concentrations in post-harvest soil varied significantly for different treatments (Table 4.7). Before applying treatment, the exchangeable K in initial soil was 0.52 meq/100 g soil. After post-harvest soil analysis, among these treatments, treatment T_6 showed the highest potassium concentration (0.12 meq/100 g soil) which is similar to treatment T_2 (0.11 meq/100 g soil). Conversely, treatment T_1 had the lowest potassium concentration (0.05 meq/100 g soil), representing the treatment with the lowest potassium levels. This data highlights a clear gradient in potassium indicating that treatment T_6 possesses the highest potassium concentration, while treatment T_1 exhibits the lowest. This statement was also supported by Ali *et al.* (2018).

4.2.8 Available S

Statistically significant differences were found in post-harvest soil available sulfur (S) concentrations for different treatments (Table 4.7). In the initial soil, available S was 7.53 ppm. After post-harvest soil analysis, among these treatments, treatment T_3 had the highest sulfur concentration (6.53 ppm). In contrast, treatment T_1 showed the lowest sulfur concentration (3.76 ppm). Similar results were also found by Kashem *et al.* (2015) and Zhenyu and Yongliang (2005)

Table 4.7: Effects of NPK and compost on total N, available P, exchangeable K and available S of the post-harvest soils for red amaranth production

Treatments	Nutrients content			
	Total N (%)	**Available P (ppm)**	**Exchangeable K (meq/100 g soil)**	**Available S (ppm)**
T_1	0.084 d	2.06 e	0.05 a	3.76 d
T_2	0.140 b	4.90 a	0.11 a	5.02 b
T_3	0.160 a	2.68 d	0.06 c	6.53 a
T_4	0.110 c	2.65 d	0.09 b	5.53 a
T_5	0.110 c	2.89 c	0.09 b	4.76 d
T_6	0.140 b	3.68 b	0.12 a	6.51 c
CV(%)	8.44	1.49	5.75	1.28
LSD	0.009	0.038	0.005	0.053
Initial soil	0.080	3.30	0.52	7.53

Values in a column with different letters are significantly different at $p \leq 0.05$ applying LSD.

CV% = Coefficient of variation

LSD=Least Significant Difference

Here,
T_1 = Control
T_2 = 100% NPK
T_3 = 100% Compost
T_4 = 75% Compost + 25% NPK
T_5 = 50% Compost + 50% NPK
T_6 = 25% Compost + 75% NPK

4.3 Correlation and regression studies

4.3.1 Correlation between plant height and yield

The relationship between plant height and yield showed positive and significant correlation (Figure 4.1). At 45 DAS the relationship between plant height and fruit yield has been found out. The correlation co-efficient value of R_2 was 0.741 at 5% level of probability. The line of regression X (Plant height) on Y (yield) having y = 3.338x + 9.104 revealed that the number of fruits or yield depends on the character of plant height, which was represented in the figure 4.1.

4.3.2 Correlation between Leaf number and yield

The relationship between leaf number and yield of chili at 45 DAS showed positive and significant correlation. The correlation co-efficient value was R^2 = 0.580 at 5% level of probability. The line of regression X (Leaf number) on Y (yield) having y = 0.743x + 6.354 was shown in the figure 4.2.

4.3.3 Correlation between Root length and yield

At 45 DAS the relationship between root length and yield of chili has been found out. The correlation co-efficient value was R^2 = 0.598 at 5% level of probability. The line of regression X (Root length) on Y (yield) having y = 0.346x + 5.624 was shown in the figure 4.3. The line of regression revealed that the yield depends on the character of plant height, leaf number and root length because the positive slope indicates that the yield was directly correlated as well as increasing in the plant height, leaf number and root length increased the yield of red amaranth.

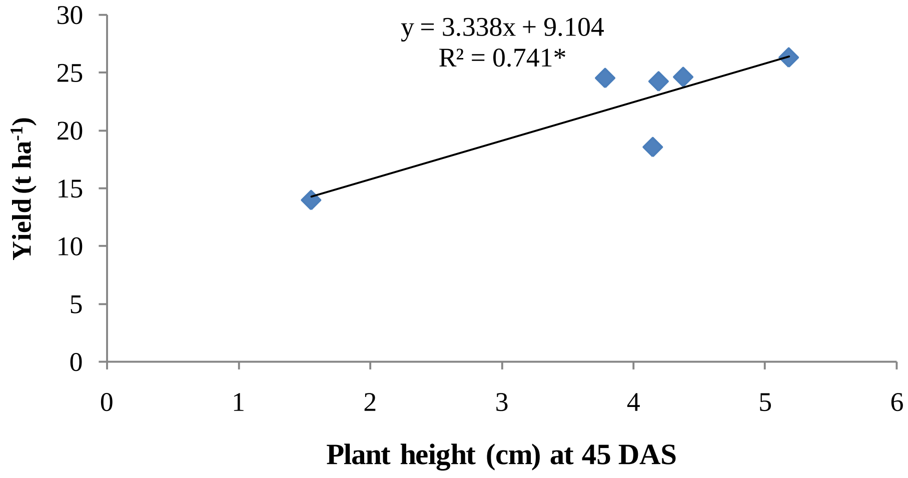

Figure 4.1: Showing the different treatments on plant height of red amaranth at 45 DAS

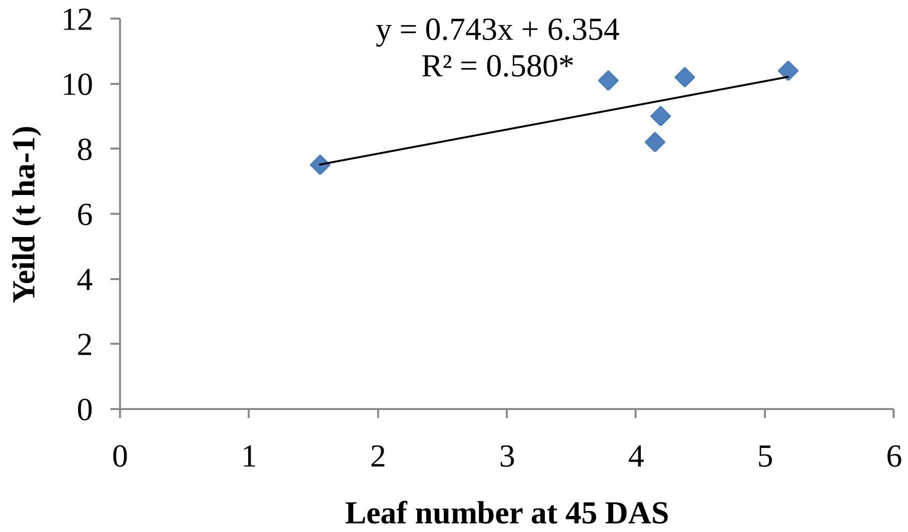

Figure 4.2: Showing the treatments on number of leaves plant^{-1} of red amaranth at 45 DAS

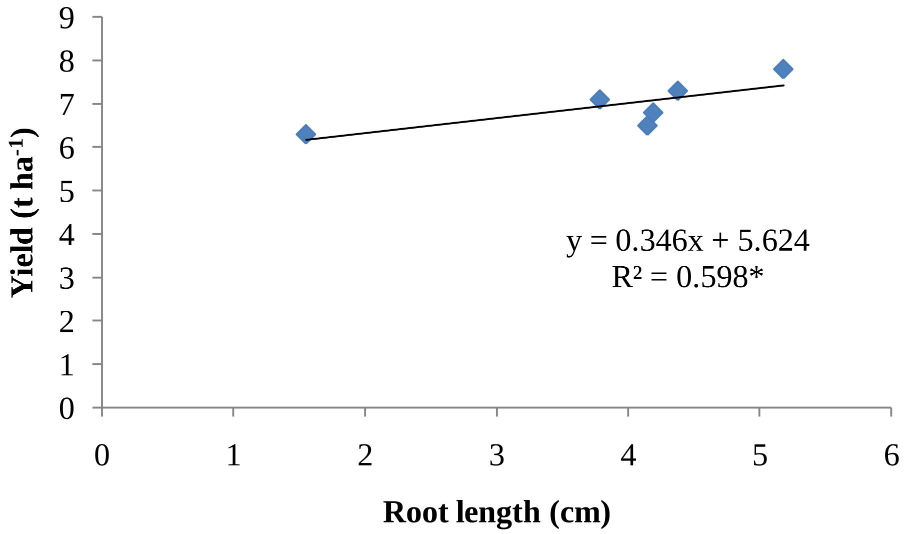

Figure 4.3: Showing the treatments on root length of red amaranth

CHAPTER V

SUMMARY AND CONCLUSIONS

5.1 Summary

The experiment was conducted at Soil Science Research Field, Hajee Mohammad Danesh Science and Technology University, Dinajpur, during the period of November 2023 to February 2024 with a view to evaluate the effects of NPK and compost on the vegetative growth and yield of red amaranth. The experimental soil belongs to the Old Himalayan Piedmont Plain (AEZ-1) The soil was sandy loam in texture having pH 5.60, organic matter content 0.82%, total N 0.080%, available P 3.30 ppm, exchangeable K 0.52 meq 100 g^{-1} soil and available S 7.53 ppm The experiment was laid out in a Randomized Complete Block Design (RCBD). There were six treatments with three replications in the experiment. So, the total number of plots was 18. The unit plot size was (1 m × 1 m) = 1 m^2. Different levels of NPK and compost were used as treatment viz T_1 = Control, T_2 = 100% NPK, T_3 = 100% Compost, T_4 = 75% Compost + 25% NPK, T_5 = 50% Compost +50% NPK, T_6 = 25% Compost + 75% NPK. Compost was applied before four days of final land preparation. Per plot requirements NPK were calculated as per the treatments andfull amounts of TSP, MOP were applied as basal dose. Urea was applied in 2 equal splits: one half was applied at basal dose during final land preparation and the rest was applied at 15 DAS (Day after Sowing). Seeds were sown on 1st November 2023. The crop was allowed to grow until maturity and intercultural operations such as weeding, and irrigation were done whenever required in order to support normal growth of the plant. The crop was harvested on 20th December 2023. Plot wise yield and yield components were recorded. Soil samples were collected before fertilizers application and after harvest. Initial and post-harvest soil samples were analyzed for physical and chemical properties of soil using the standard methods. All the data were statistically analyzed by F test and the mean differences were judged by Tukey HSD by means of Statistix 10 software.

The results revealed that the vegetative growth of red amaranth as well as plant height, number of leaves $plant^{-1}$, shoot weight $plot^{-1}$, root weight $plot^{-1}$, root length and nutrients content in post-harvest soil i.e., total N content, available P, exchangeable K, available S, soil pH, electrical conductivity (EC), organic matter (OM) responded significantly due to application of NPK and organic fertilizers. The tallest plant height (5.90, 21.40, and 26.31 cm at 15, 30, and 45 during final harvest respectively) was found in the treatment T_6 and the shortest plant height (4.50, 9.06, and 13.96 cm at 15, 30, and 45 during final harvest, respectively) was observed in T_1 (control). The maximum number of leaves (4.70, 8.34, 10.40 at 15, 30, and 45 during final harvest, respectively) was recorded in the treatment T_6 whereas the minimum number of leaves (3.79, 5.90, 7.50 at 15, 30, 45 during final harvest, respectively) was found in the T_1 (control). The treatment T_6 produced the highest both fresh and dry shoot weight (3.78 and 1.83 t ha^{-1} respectively) but the lowest fresh and dry shoot weight (1.14 and 0.56 t ha^{-1} respectively) was obtained from the control treatment (T_1).

The maximum fresh and dry root weight (1.41 and 0.76 t ha^{-1}, respectively) and tallest root length (7.80 cm) was recorded from the treatment T_6 and the minimum both fresh and dry root weight (0.42 and 0.21 t ha^{-1}, respectively) and smallest root length (6.30 cm) was observed in the T_1 (control).

Application of NPK and compost resulted in a considerable influence on the properties of the post-harvest soils such as pH, organic matter content, total N, available P, exchangeable K and available S. In post-harvest soil, the combined application of NPK and compost gave positive results. It also increased soil fertility status. The highest percentage of total N of and available S (0.160 % and 6.53 ppm, respectively) were found in T_3 treatment and lowest percentage of N and available S (0.084 % and 3.76 ppm, respectively) were in T_1 treatment. The highest available P (3.68 ppm) and exchangeable K (0.12 meq/100 g soil) were found in both cases at T_6 and the lowest available P and K (2.06 ppm and 0.05 meq/100 g soil, respectively) was in T_1 (control) treatment. The highest pH (6.98) was observed for T_4 treatment while T_1 showed the lowest value (5.60). In post-harvest soil electrical conductivity was statistically different for different treatments. The soil electrical conductivity percentage was highest (0.21ms/m) in T_6 which was statistically similar with T_2 and the soil electrical conductivity percentage was lowest (0.05ms/m) in T_1. The soil organic matter percentage was highest (0.17 %) in T_4 treatment which was statistically identical to T_6. The lowest organic matter content (0.88 %) was found in T_1 treatment. Finally, it can be concluded from the present study that the application of NPK and compost with the recommended doses showed better performance in respect of vegetative growth of red amaranth and also increased the fertility status in soil. Moreover, 75% NPK + 25% compost (T_6) gave better performance than other combinations in all aspects. So, NPK with compost will be profitable for red amaranth cultivation.

5.2 Conclusions

From the results of the study, it may be concluded that:

i. Integrated use of NPK and compost can significantly increase the vegetative growth of red amaranth and also produced the maximum yield.

ii. Application of 75% NPK + 25% compost satisfactorily increased the amount of organic matter, total N, available P, exchangeable K and available S in soil to some extent.

5.3 Recommendation

a. Application of 75% NPK with 25% compost may be suggested for the production of red amaranth in the soil of Old Himalayan Piedmont Plain.
b. Considering the above observation further study may be needed to enhance the soil fertility status by combined application of NPK and compost to ensure the better growth and yield performance of red amaranth in different agro ecological zones (AEZ) of Bangladesh for regional adaptability.

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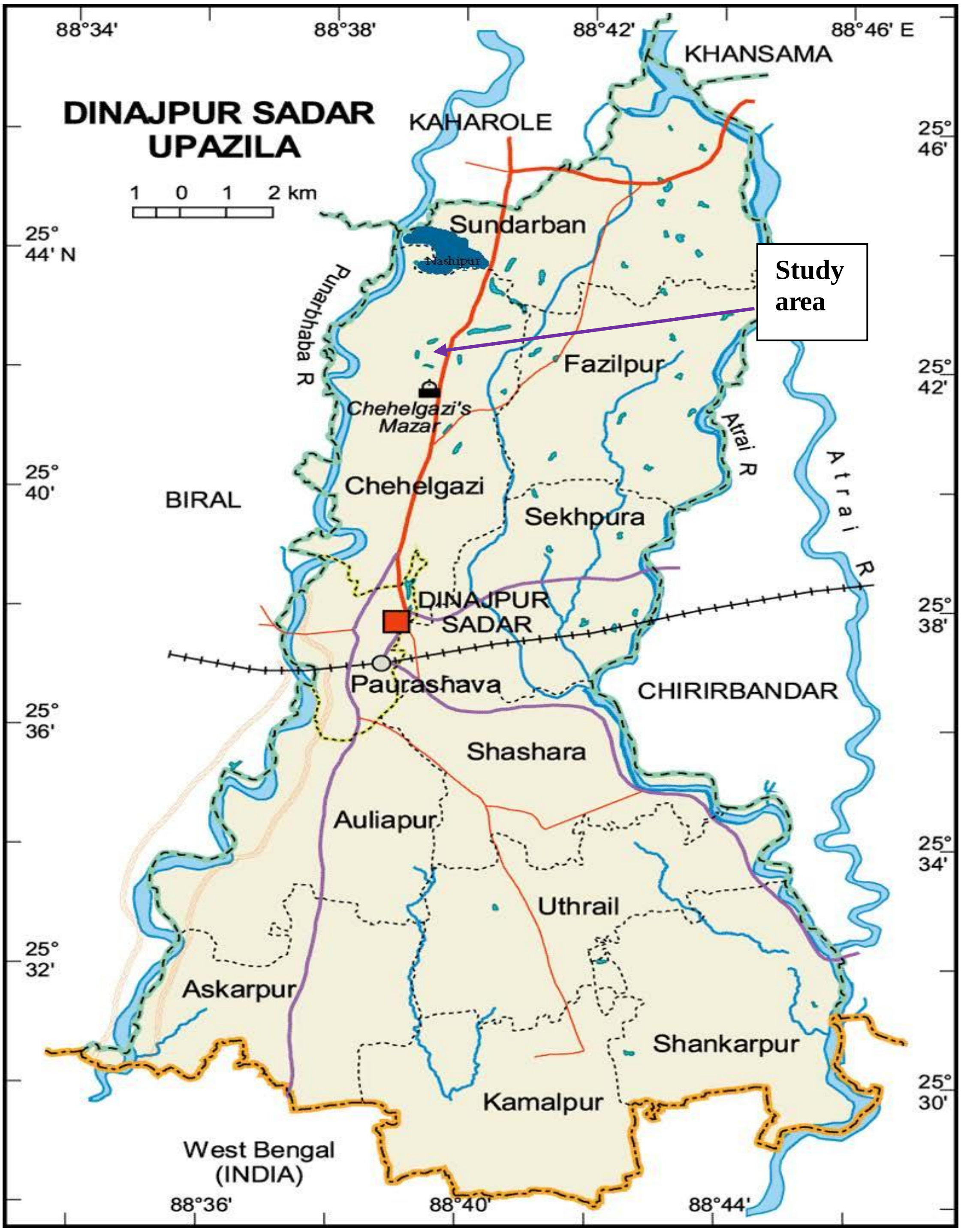
APPENDICES

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



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

Year	Month	**Temperature (^{0}C)			** Humidity (%)	**Rainfall (mm)
		Maximum	Minimum	Average (^{0}C)		
2023	November	29.88	13.38	21.11	82	0
	December	22.22	10.55	17.78	87	0

**Monthly average

Source: Bangladesh Wheat and Maize Research Institute, Nashipur, Dinajpur.

Appendix III. Some photographs of experimental site