THE EFFECT OF POTTING MEDIA AND WATERING REGIME ON THE GROWTH OF AMARANTH (*Amaranthus cruentus*)

BY

EJEMBA AMARACHI PECULIAR

AGR1800193

DEPARTMENT OF CROP SCIENCE

FACULTY OF AGRICULTURE

UNIVERSITY OF BENIN

BENIN CITY

MAY, 2024.

THE EFFECT OF POTTING MEDIA AND WATERING REGIME ON THE GROWTH OF AMARANTH (*Amaranthus cruentus*)

BY

EJEMBA AMARACHI PECULIAR

AGR1800193

A PROJECT REPORT SUBMITTED TO THE

DEPARTMENT OF CROP SCIENCE,

FACULTY OF AGRICULTURE, UNIVERSITYOF BENIN CITY, BENIN CITY

IN PARTIAL FUFILMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF AGRICULTURE DEGREE B. AGRIC (CROP SCIENCE)

MAY, 2024.

CERTIFICATION

This is to certify that this project titled "**The effect of potting media and watering regime on the growth of Amaranth (*Amaranthus cruentus*)**" was carried out by **Amarachi Peculiar EJEMBA (Miss)** with matriculation number **AGR1800193** of the Department of Crop Science, Faculty of Agriculture, University of Benin, Benin City.

____

Mr. Joseph Osagie

Project supervisor

____

Prof. K. E. Law-Ogbomo

Head of Department

Date: ________________

Date: ________________

DEDICATION

I most humbly dedicate this project to God Almighty for his grace, mercies, protection and wisdom and the privilege he gave me to participate in this academic journey

Also to my Parents my source of encouragement and inspiration and a cause for my passionate commitment to excellence in the course of my academic journey I'm most grateful for your sacrifices.

And to my siblings I deeply appreciate you all for your love and support

My friends, course mates and all who have been a source of inspiration to me God bless you all.

ACKNOWLEDGEMENTS

I will forever remain grateful and thankful to God Almighty for his unquantifiable graces upon my life and seeing me throughout my academic journey.

My warm and sincere gratitude goes my supervisor, Mr. Joseph Osagie for his relentless guidance and support, I also appreciate the Head of Department, Prof. K. E. Law Ogbomo, for his guidance and contribution to the success of this work.

I also extend my regards to the lecturers of Crop Science Department, Faculty of Agriculture, University of Benin: Prof. A. T. Adekunle, Prof C. N. C. Nwaoguala, Prof. A. U Osaigbovo, Prof. T. O. Emede, Prof. S. A. Ogedegbe, Prof S. U. Ewansiha, Dr. (Mrs) E. J. Falodun and My Course Adviser Mrs. M. E. Omoregie.

My utmost gratitude goes to my family. My parents Mr. and Mrs. Lawrence Ejemba and my siblings. God bless you all. To all my course mates who partook in this academic journey with me.

TABLE OF CONTENTS

LIST OF TABLES

ABSTRACT

This study was carried out to investigate the effect of watering regime and potting media on the growth of *Amaranthus cruentus*. The experiment was carried out at the Screen house of the Department of Crop Science, Faculty of Agriculture, University of Benin. The treatments includes: Top soil, Top soil amended with *Trichoderma*, Top soil amended with Cow dung, Watering1 (daily watering), Watering2 (watering every two days), Watering3 (watering every three days) and Watering4 (watering every four days) were fitted in a Completely Randomized Design (CRD) replicated three times. Data was analyzed using one way Analysis of Variance (ANOVA). Results of this study showed significant difference ($p < 0.05$) on watering regime and potting media. The different watering regime did not positively affect the growth of *Amaranthus cruentus* as the growth parameters were similar across the different watering regimes. Untreated top soil produced the highest mean values for all growth parameters measured and the lowest was observed with the top soil amended with *Trichoderma*. Further research is recommended to explore the specific mechanisms through which top soil enhances growth of *Amaranthus cruentus*

CHAPTER ONE

1.1 Introduction

Amaranth (*Amaranthus cruentus*) is an important leafy vegetable in Nigeria. It is a genus of annual crops that are recognized by their inflorescence and foliage ranging from purple to green (Kinderson, 2008). Despite the dietary and health benefits of *Amaranthus* spp., its cultivation is still hindered by many biotic and abiotic factors. The abiotic factors are particularly adverse weather conditions and soil characteristics. Growth of *Amaranthus* spp. is affected by low or unreliable rainfall (Tucker 1986; Cunnigham *et al.*, 1992) as well as low level of soil nutrient (Oworu and Dada, 2009), etc. Nevertheless, Amaranth is one of the few dicotyledonous plants that have C4 metabolic pathway, a much more efficient form of photosynthesis than the more common C3 and is linked to proficient production and drought resistance (Lin and Ehleringer, 1983; Ruskin, 1984; Wang and Ebert, 2012.) The C4 metabolic pathway predisposes amaranth to high productivity and thus an essential vegetable candidate to ensure food and nutritional security in developing countries of Africa (Ghannoum, 2009). It can survive with much less water than other food crops in the region such as maize and beans. The current rate of prevalence in climate change globally, predicted uncertainty in future availability of fresh water for agricultural production. Drought stress is one of the most adverse environmental factors limiting plant growth and development (Reddy *et al.*, 2004). The responses of plant to drought stress are highly complex, involving deleterious and/or adaptive changes. Anatomical changes resulting from water limiting conditions in angiosperms are often indicated by modifications of vascular tissues, stomatal conductance (Henzell *et al.*, 1976), cell walls thickness etc. (Shaol *et al.*, 2008). Changes in anatomical features may occur due to water deficit in vascular plants which tends to protect and adapt the species of water stress.

Tropical soils have been described to be highly weathered, low in nitrogen and organic matter (Obi and Ekperigin, 2001; Ayeni, 2011). This has resulted in nutritionally poor soils leading to reduced productivity and difficulty in both subsistence and commercial agriculture. One of the main processes causing soil degradation is soil organic matter depletion (Kostov, 2016). Decline in organic matter content of soil was reported by Ewulo (2005) to affect not only crop yield, but the physical and chemical properties of the soil. In order to improve the nutritionally poor status of tropical soils, chemical fertilizer application came into the limelight. However, usage of chemical fertilizer was reported to have resulted in poor crop yield, low soil organic matter content and acidity (Milosevic and Milosevic 2009; Ayeni, 2011). In addition to these are non-availability, adulteration, high-cost implication and water pollution (Serpil, 2012; Chude, 2006). The fertility of the soil can be improved by maintenance of its organic matter content, this is said to be possible through the use of organic-based fertilizer (Olowoake and Ojo 2014). Organic-based fertilizers are amendments derived from plant and animal remains such as cow dung.

A good potting medium is fundamental for good nursery management, home gardening and is the foundation of a healthy root system. Potting media have been used for greenhouse production of bedding plants, vegetable transplants and container-grown ornamentals (Aklibasinda *et al.*, 2011). In the last few years, farmers and nursery workers have shown their interest on potting media, since they play an important role in plant production (Kashihara *et al.*, 2011). Soilless mixtures should be formulated with special attention on optimal physical, chemical and biological properties that promote germination and healthy seedling growth. Topsoil is relatively heavy and dense, so it can contribute to poor aeration and drainage in a potting medium. In soilless medium, replaces the soil because the field soil is often poorly suited to cultivation due to unfavorable chemical (reaction, nutrient availability), physical (density, structure, water retention) and biological (presence of pathogens, exhaustion) limitations (Onoh *et al.,* 2015). The increase in utilization of available land for physical and infrastructural development, rapidly declines the supply of quality top soil. Therefore promoting the utilization of soilless materials in the production of horticultural crops is useful (Awang *et al.*, 2009). An ideal media must be free of pests heavy enough to prevent the pot from tipping over, but light enough to allow ease of transport. The mix should retain sufficient water to reduce the need for frequent watering, but have enough porosity to allow for good drainage and to provide air for plant roots (Tsakaldimi and Ganatsas, 2016). The ideal amount of potting media would be the amount that adds the desired plant nutrients. A good potting medium will contain a mixture of ingredients with different particle sizes and characteristics which will balance out the aeration and water retention (Kuslu *et al.*, 2010).

Soil-borne diseases are the major limitation to crop production, particularly for ornamentals and vegetables. These diseases are caused by wide range of plant pathogens including bacteria, fungi and parasitic nematodes. Different soil-borne bacteria and fungi are able to colonize plant roots and have beneficial effects on plant growth. *Trichoderma* spp. is a well-known bio control agent which can be used to enhance the growth response of plants. *Trichoderma* sp. can reduce the severity of plant diseases by inhibiting plant pathogens in the soil through their potential antagonistic activities. Moreover, as revealed by research in recent decades, some *Trichoderma* strains can interact directly with roots increasing plant growth pretension, making them resistant to diseases and tolerant to abiotic stresses (Hermosa *et al.*, 2012). *Trichoderma* spp. control deleterious root microorganisms which are causing obvious diseases and they involve in direct production of growth stimulating factors such as plant hormones and growth factors. They increase the nutrient uptake through enhanced root growth or by promoting the availability of necessary nutrients. They help to reduce the concentrations of inhibitory substances of plant growth in soil. According to Altomare *et al.* (1999). T. *harzianum* strain 1295-22 increased the plant vigor part from the growth enhancement. Therefore, it shows that it not only enhances the growth of plants but they increase the vigor of the plants.

1.2 Justification of study

The effects of climate change on water use in agriculture in the form of changes in net irrigation requirement, demand and crop water use cannot be overemphasized. Therefore, knowledge of water requirements of *Amaranthus* spp. is important for proper and efficient use of water in its production.

Most of the multifaceted environmental and health issues associated with the heavy use of synthetic fertilizers and agrochemicals could be resolved by the adoption of organic agricultural practices with the objective of promoting and expansion of organic agriculture industry. Hence this research aims to formulate low-cost organic potting media using cow dung, soils amended with *Trichoderma*.

1.3 Main Objective

The aim of the study was to investigate the effect of potting media and watering regime on the growth of *Amaranthus* cruentus.

1.4 Specific Objectives

The specific objectives of the study were to determine the:

i. physical and chemical properties of the experimental soil and cow dung

ii. effect of potting media on the growth of *Amaranthus cruentus*.

iii. effect of watering regime on the growth of *Amaranthus cruentus.*

CHAPTER TWO

LITERATURE REVIEW

2.1 Amaranthus cruentus

Amaranth (*Amaranthus* cruentus. L.) is a cosmopolitan genus of annual plants that are recognized by their inflorescence and foliage ranging from purple to red and green or gold (Kinderson, 2008). It is a leafy vegetable which contains important mineral nutrients such as calcium, iron, phosphorus, magnesium, zinc, copper, manganese, etc. (USDA Nutrient Database, 2010). Amaranthus is a vegetable of high dietary value grown and consumed in most parts of the Tropics (Tindall, 1983). It is an excellent source of protein as it supplies the essential amino acids that cannot be produced by human body (Marcone *et al.*, 2003). The health advantages of Amaranthus also include its therapeutic value on cardiovascular diseases (Anonymous, 2006). Oils of amaranth have shown the capability to lower total cholesterol level while the leaves are good astringent (Larkcom, 1991). Apart from its uses as a vegetable, it has also been used as an effective alternative to drug therapy in people with hypertension and cardiovascular disease (CVD) (Martiorosyan and Miroshnichen, 2007). The demand for this crop as vegetable has increased, especially in the urban centres where people are not involved in primary production (Schippers, 2002). This has made the vegetable to become an important commodity in our market and production an important economic activity for the rural women. The yield per hectare of this crop is low (7.60 t ha-1) when compared to that of United States (77.27 t ha-1) and world average (14.27 t ha-1) (FAO, 2007).

2.2 Effect of potting media on plant growth

N. Hewavitharana and S.D.P. Kannangara (2019) carried out an investigation to formulate a low-cost organic potting medium enriched with *Trichoderma* spp. which can effectively control soil borne diseases and enhance the growth of selected vegetables i.e, *Abelmoschus esculentus* and *Amaranthus viridis*. T. *virens*, T. harzianum and T. *asperullum* were selected and mass produced separately, using sawdust as the carrier material. Three different potting media (coir dust+ invasive plants (2:3); T-1, rice husk + invasive plants (2:3); T-2 and coir dust + rice husk + invasive plants (1:1:3); T-3) were prepared. All the potting media were divided into two parts and one set was treated with *Trichoderma* spp. while the other set was used as controls, without adding *Trichoderma*. Physical and chemical properties of the four potting media were analyzed following standard methods. Effect of *Trichoderma* amended potting media on plant growth was evaluated using A. *esculentus* and A. *viridis* by measuring several growth parameters and disease incidence under greenhouse conditions. Of the four-potting media, T-1 exhibited optimum physical and chemical properties. The highest growth performance of A. *esculentus* and A. *viridis* observed in plants treated T-1 medium with *Trichoderma* amendments with lower ($p<0.05$) disease incidence (5 %). A. *esculentus* and A. viridis planted without *Trichoderma* treatment in T-2 showed significantly lower ($p<0.05$) growth than T-1 and T-3 media.

Bell *et al.* (2000) inoculated cucumber seeds at sowing with a mixture of seven isolates of *Trichoderma harzianum*, previously observed to confer plant growth promotion in commercial horticulture. The *Trichoderma* mixture was applied by three different methods: spore-coated organic pellets, a dried biomass powder, or seed coating. These were added to three different growing media: sterile potting mix, field soil (naturally containing a *Pythium* sp.) or field soil drenched with captan. There was no effect of inoculation in potting mix. The number of healthy seedlings was lower in the untreated field soil than in the soil treated with captan. The numbers of healthy seedlings were lower in the pellet and dried biomass treatments than in untreated field soil, but with seed coating, the numbers of healthy seedlings were not significantly affected. The effect of seed coating was tested again, with the isolates of T *havzianum* applied individually and as a inixture to field soil. There was no significant effect on the number of healthy seedlings compared with controls in any *Trichoderma* treatment.

Yahya *et al.* (2021) carried out a field experiment to investigate the effect of *Trichoderma harzianum* T-22 application and three growing media (soil, 1:3 soil: peatmoss, 1:1 soil: peatmoss) and three pruning training method (1, 4, 6 branches) and their interaction on the vegetative and flowering growth of *Lantana camara*. Results showed that T. *harzianum* application, the growing medium, pruning training method and their interaction had significant effects on the vegetative and flowering growth of plant. The highest average of plant height, stem diameter, leaves number, chlorophyll content and flowering date given in T. *harzianum* increased plant height which was 52.31 cm, stem diameter 8.06 cm, leaves number 164.65, chlorophyll content 25.98 SPAD.

According to Younis *et al.*, (2007), growing media plays a vital in the growth of plants by providing them nutrients, anchoring the plant and providing minerals.

2.3 Effect of potting media in controlling plant disease

According to Hewavitharana *et al.* (2018) Compost amendments with *Trichoderma* spp. can be very effective in controlling diseases caused by root rot pathogens of identified *Fusarium oxysporum* and *Rhizoctonia solani*. In addition to that, *Trichoderma* treated *Solanum melongena* enhance the growth performance compare to the untreated controls.

The Growth response of rooted cuttings from six promising strains of jojoba to eight different potting media was studied by Bashir *et al.*, (2007). The potting media were field soil (control) and its combinations with either each of FYM, leaf mold and sewage sludge (1:1 by weight) or with the combination of two of these three except the last that consisted of the combination of these three only excluding field soil (1:1:1 by weight). The pooled analysis revealed that the growth of rooted cuttings was affected significantly by potting media and the strains, but the interaction between potting media and the strains for all the parameters studied was found statistically non-significant. The combination of field soil + FYM + leaf mold gave the maximum survival percentage (76.80), maximum number of shoots (3.72), the highest shoot length (7.70 cm) and the maximum number of leaves per shoot (12.60). The minimum values of these parameters were recorded when the cuttings were planted in field soil (control). The combinations consisting of field soil and the material having organic matter in form of leaf mold or FYM were found to be better for good survival and growth of rooted cuttings than the media consisting of field soil alone or the media containing only organic matter.

Eed, (2016) study aimed to find out the effect of different potting media on percent survival and growth of rooted cuttings of jojoba plant under greenhouse and shade house conditions. The results revealed that the highest value of survival percentage, height of plant (cm) and number of shoots and leaves per plant were obtained by the use of medium containing peat moss+ vermiculite+ perlite (1:1:1) compared to the other media used either individually or in combinations. However, the medium comprising of local available media (sand and soil) additional to imported medium (peat moss) had a comparative value of studied parameters opposite the previous mentioned medium.

2.4 Effect of potting media on seed germinaton, seedling growth and vigor.

Dayeswari *et al.*, (2017) conducted an experiment to study the influence of potting media on seed germination, seedling growth and vigor in TNAU Papaya CO. 8 with different treatments viz., control (M1), cocopeat+ vermicompost+ azospirillum+ phosphobacteria (M2), cocopeat+ vermicompost+ pseudomonasfluorescens (M3), cocopeat+ azospirillum+ phosphobacteria (M4), cocopeat+ azospirillum+ phosphobacteria+ pseudomonasfluorescens (M5) and cocopeat+ vermicompost+ azospirillum+ phosphobacteria+ pseudomonasfluorescens (M6) were evaluated and compared. The best results were obtained by cocopeat+ vermicompost+ azospirillum+ phosphobacteria+ pseudomonasfluorescens (M6) followed by cocopeat+ vermicompost+ pseudomonasfluorescens (M3) which showed highest seed germination percentage, seedling height, seedling girth, leaf nutrient contents, chlorophyll content and leaf soluble protein content.

According to Hewavitharana and Kannangara (2019) *Trichoderma* amendments improved the physical, chemical and biological properties of the selected potting media. Their study demonstrated the growth enhancing potentials of *Trichoderma* amendments with coir dust organic potting medium on the growth of *Amaranthus* spp.

Increasingly, commercial seed treatments are being viewed as a means to increase the value of the seed and to improve plant growth and productivity. Among many types of seed treatments for various purposes, seed treatment with beneficial microorganisms is becoming increasingly important. The results from Zheng and Shetty (1999) study suggest that the selected *Trichoderma* inoculants produced from apple pomace are beneficial for seed treatment and improve the seedling vigor of peas and that it is also possible to extend the seed treatment approach to other plant species.

As a result of enhanced seedling vigor, plant productivity may be significantly improved.

2.5 Effect of watering regime on plant growth

Ribeiroa *et al.*, (2017) study was conducted aiming to (1) assess the vegetative growth and leaf nutritional content of Amaranthus hybridus and A. tricolor when subjected to different watering regimes (80%, 50% and 20% of total available water) during the rainy and dry seasons. Vegetative growth was sensitive to soil water at 50% and 20% of available water. However, the leaf and side-shoot number, leaf area and yield were less sensitive to short-interval water deficits during the rainy season. Leaf calcium and crude protein contents were higher at low water levels. Leaf yield was significantly affected by temperature, where total leaf yield increased during the rainy season, and decreased during the dry season. Both species have the potential for sustainable leaf production during rainy and dry seasons.

Dada and Ohu (2013) carried out a study to examine the effect of varying watering regimes and soil amendments on two Amaranthus species (A. hypochondriacus L. and A. hybridus L.) grown on marginal soil. Data were collected on number of leaves produced, plant height (cm), fresh shoot yield (g) and dry matter yield (g). The 0.05 effect of NPK and compost on growth, fresh shoot and dry matter yield of the two varieties of *Amaranthus* was statistically comparable in pots watered once a week. The performance with respect to the height, number of leaves, shoot and dry matter yield of *Amaranthus* sp. were in the order NPK= compost>control. A. hypochondriacus grown on NPK amended pots and watered twice a week had the highest fresh shoot and dry matter yield. Augmenting poor soil with compost and applying 250 ml of water once a week was proved to enhance growth and fresh shoot yield of A. hybridus. Highest stomata density was observed in adaxial surface of A.

hybridus in control pot watered once a week which was comparable to the stomata density of A. hybridus in NPK augmented pot watered twice a week.

According to Masariramb *et al.* (2012) Application of 1.0 FC resulted in significantly the highest number of leaves, plant height, stem girth, fresh mass of plants. Leaf area and LAI when compared to the other treatment applications except for 0.85 FC application. This suggests that water application to or close to field capacity promoted leaf emergence of *Amaranthus* plant. Watering the *Amaranthus* excessively should be avoided, always leaving the soil dry for a few days between one watering and the other.

With moderate irrigation water supply, the action of organic fertilizers is more important, since irrigating the organically fertilized lettuce by 80% of crop evapotranspiration enhanced the lettuce yield with saving 20% of irrigation water (Elrahman etc al., 2022). It has been demonstrated that increased application of organic fertilizer (manure) could decrease the amount of leachate (Girotto *et al.* 2013), due to the enhanced water-holding capacity by organic fertilizer, while inorganic fertilizer may not influence soil water-holding capacity (Li *et al.,* 2018).

2.6 Effect of watering regime on weed reduction

El–Metwally *et al.*, (2022) conducted two–year field trials to seek the best compatible practice between irrigation regime and weed control method in onion. Three irrigation water regimes (60%, 80% and 100% of the crop water requirements, CWR) and seven weed control practices (rice, wheat and peanut straws as soil mulches as well as oxadiargyl, oxyfluorfen, weeding, and unweeded) were applied. Findings revealed that the application of 60% of CWR either with peanut straw mulch or weeding recorded the maximum reduction in weed biomass.

2.7 Effect of watering regime on yield

Fellah *et al.*, (2018) carried out a field experiment to evaluate the beneficial effects of supplemental irrigation, at different phenological phases, on theoretical yield components of two varieties (GTA-Dur and Vitron) of durum wheat under field conditions. Field experiments included six water regime treatments: crop evapotranspiration 'ETc' throughout the wheat-growing season (i.e. adequately irrigated); rainfed conditions (no irrigation); and four supplemental irrigation treatments (T1–T4) applied respectively at the beginning of four phenological phases of wheat growth (tillering, heading, flowering and grain filling). Yield components were significantly influenced at the beginning of the cropping season, while the components expressed in weights were influenced at late cropping. Theoretical grain yield of the variety Vitron increased by 33% at T1, 84.3% at T2, 424% at T3, 902% at T4 and 1100% at Etc. Water productivity (WP) increased by 45–70% in irrigation treatments compared to rainfed conditions. The findings stress that the consistency between appropriate water regime and adequate varietal choice increases WP and crop productivity, and improves irrigation water conservation.

Si *et al.*, (2020) carried out a field experiment with five nitrogen application rates (0, 120, 180, 240, and 300 kg ha−1, referred as N0, N1, N2, N3, and N4) and three irrigation levels (40, 30, and 20 mm per irrigation, referred as I1, I2, and I3). Results showed that increasing irrigation and nitrogen application rates notably improved actual evapotranspiration, leaf area index, aboveground biomass, grain yield, and water use efficiency (WUE) of winter wheat.

A greenhouse pot experiment was conducted by Mlakar *et al.*, (2012) to study the effect of drought induced at different phenological stages on growth, biomass production and yield performance of grain amaranth *Amaranthus* cruentus G6. After emergence seedlings were exposed to different soil water regimes: constant adequate moisture (W1) and drought (W2) throughout the growing period, drought initiated at crop inflorescence formation (W3), drought condition during pre-inflorescence formation (W4) and treatment W5 where drought condition occurred in the period from the beginning of inflorescence formation to the beginning of flowering. The growth and yield performance of amaranth were assessed by measuring root length, stem height and inflorescence length, and by evaluating fresh and dry weight of plant parts, grain yield and harvest index. Drought stress initiated at different phenological stages affected the evaluated morphological parameters, assimilate allocation and grain yield. Drought throughout the growing period resulted in grain and biomass yield reduction for 51% and 50%, respectively. Water deficit during inflorescence formation appears to be critical growing stage influencing grain yield, while soil drying in the vegetative growth stages improve the assimilate allocation to the above-ground biomass and particularly to the grain.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Description of the study

The study was carried out at the Department of Crop Science University of Benin, Benin city, Edo state Nigeria. The screen house experiment was carried out from January to March 2024 at the Experimental Farm of the Department of Crop Science, University of Benin, Benin City.

3.2 Collection of seeds and soil

Treated seeds were obtained from Greenery Seeds, Benin City. Top soil rich in humus were obtained from Santua garden.

Seeds of *Amaranths* were planted four per bag and thinned to two per stand. During thinning, plants with higher vigor were left to establish.

3.3 Preparation of substrate

Corn cobs (*Zea mays*) were gotten from Uselu market, Benin city, Edo state. The corn cobs were chopped and milled rough at Uselu market with a milling machine. The corn cobs were soaked in water for 24 hours and water was drained with the use of a sieve.

3.4 Apparatus and equipment used

The equipment used are: conical flask, stirring rod, Petri dishes, inoculating needle, pressure pot, gas cylinder, aluminum foil paper.

3.5 Preparation of culture media

39g of PDA (Potato Dextrose Agar) was weighed into conical flask and dissolved in 1000ml of water. The dissolved PDA was sterilized in an autoclave at a temperature of 121°C for 20 minutes

3.6 *Trichoderma harzianum* Isolation and preparation of inoculum

Isolation and identification of *Trichoderma*

The *Trichoderma* used in this study was subcultured from a soil obtained from Sapele Road, Benin City. Pure cultures of the *Trichoderma* isolates were maintained on PDA at 25°C and the isolates were identified using morphological and reproductive characters as well as microscopic analysis (Watanabe, 2002)

3.7 Preparation of *Trichoderma* soil inoculum.

Corn cobs (Zea mays) were obtained from Uselu market in Benin city. The substrate was soaked in water for 24 hours before sieving. The moistened substrate was weighed 200g in polytene bags. Sterilization of substrate was carried out at 121°C for 15mins.

The substrates were inoculated using 2cm PDA plug cut from a 7-day old *Trichoderma* culture, incubated and observed daily for growth until full colonization of the substrate was observed.

3.8 Treatments

Treatment code	**Treatment Type**
Ts	Top soil
Ts+Tri	Top soil amended with *Trichoderma*
Ts+CD	Top soil amended with Cow dung
W1	Watering daily
W2	Watering every two days
W3	Watering every three days
W4	Watering every four days

3.9 Plant data collected

The following data were collected every three weeks for the period of twelve weeks:

- Number of leaves: This was determined by counting the leaves on the plant
- Plant height (cm): This was determined by using a meter rule from the ground level of the seedling to the main shoot apex
- Leaf length (cm): This was determined using a meter rule from the leaf tip to the point of attachment of the petiole.

- Leaf breadth (cm): This was determined by using a meter rule from the left side of the leaf blade to the right.
- Collar girth (cm): This was determined using a meter rule and thin thread to measure the circumference.

3.10 Experimental Design

This study was laid out as a complete randomized design (CRD) involving 3 treatments (Top soil, Top soil + *Trichoderma* and Top soil + Cow dung). Following 4 watering regimes; watering daily, watering every two days, watering every three days and watering every four days were replicated three times.

CHAPTER FOUR

4.0 RESULTS

The physiochemical test results of the soil used for this study is presented in table 4.1. It shows that the soil was slightly acidic with a pH of 5.62 and with a percentage sand (88.7%), silt (6%) and clay (5.3%) that proves the textural class of the soil to be Sandy.

The growth evaluation of *Amaranthus* cruentus due to the different soil treatments and watering regime is presented in tables 4.3. It was observed that top soil produced the highest all growth parameters measured: Plant height (20.9cm), number of leaves (16), collar girth (2.6cm), leaf breadth (1.99cm), leaf length (4.33cm), root length (6.70cm), fresh weight (4.27g) and dry weight (0.43g).

On the effect of watering regimes on the growth of *Amaranthus* cruentus, there was no significant difference among the treatments in all growth parameters measured except for root length where watering daily had the highest (5.44cm) but statistically similar to watering every two and three days respectively.

The interaction between soil treatment with cow dung, *Trichoderma* and watering regimes is presented in table 4.4. It was observed that there was no significant difference in all parameters measured.

Table 4.1: Soil Physiochemical test results

Parameters	**Values**
PH	5.62
Total Nitrogen (g/kg)	0.62
Total organic Carbon (g/kg)	9.44
Available Phosphorus (mg/kg)	5.68
K (cmol/kg)	0.16
Ca (cmol/kg)	0.65
Mg (cmol/kg)	0.18
Na (cmol/kg)	0.11
H^+ (cmol/kg)	0.23
Al^{3+} (cmol/kg)	0.15
Sand (g/kg)	887
Silt (g/kg)	60
Clay (g/kg)	53
Textural Class	Sandy

Table 4.2: Chemical analysis of cow dung manure treatment

Parameters	Values
pH	6.20
Total nitrogen (g/kg)	1.22
Total organic carbon (g/kg)	28.5
Availabe phosphorus (mg/kg)	16.2
K (%)	0.014
Ca (%)	4.21
Mg (%)	0.46
Na (%)	0.0048
H^+ (%)	0.0001
Al^{3+} (%)	0.018

Table 4.3: Growth evaluation of *Amaranthus* cruentus due to the different soil treatments and watering regimes.

Source: Treatments	Plant height (cm)	Number of leaves	Collar girth (cm)	Leaf breadth (cm)	Leaf length (cm)	Root length (cm)	Fresh weight (g)	Dry weight (g)
TS	20.9^{a}	16.00^{a}	2.600^{a}	1.996^{a}	4.329^{a}	6.708^{a}	4.273^{a}	0.4283^{a}
TS + CD	12.39^{b}	13.96^{a}	1.442^{b}	1.675^{a}	2.496^{b}	5.248^{b}	1.703^{b}	0.3692^{a}
TS + Tri	4.00^{c}	2.00^{b}	0.925^{c}	0.558^{b}	0.567^{c}	1.525^{c}	1.000^{b}	0.1083^{b}
SED	1.435	1.455	0.1159	0.2062	0.329	0.677	0.604	0.1199
Watering regimes								
Daily	13.33a	12.39a	1.711a	1.500a	2.744a	5.444a	2.748a	0.3989a
Two days	13.31a	11.78a	1.678a	1.450a	2.650a	4.919ab	2.565a	0.3283a
Three days	12.09a	9.56a	1.656a	1.383a	2.383a	4.222ab	2.110a	0.2544a
Four days	11.04a	8.89a	1.578a	1.306a	2.078a	3.398b	1.879a	0.2261a
SED	1.657	1.680	0.1338	0.2380	0.380	0.781	0.697	0.1385
CV%	28.2	33.5	17.1	35.8	32.8	36.9	63.6	97.3

Table 4.4: Growth evaluation of *Amaranthus* cruentus seedlings due to soil treatments and watering regime.

Source	**Df**	**Plant height**	**Number of leaves**	**Collar girth**	**Leaf breadth**	**Leaf length**	**Root length**	**Fresh weight**
ST	2	860.66***	686.34***	8.82861***	6.8326***	42.4784***	85.719***	35.635***
WR	3	10.85^{ns}	25.78^{ns}	0.02889^{ns}	0.0640^{ns}	0.8068^{ns}	7.138^{ns}	1.447^{ns}
ST×WR	6	4.41^{ns}	11.17^{ns}	0.01194^{ns}	0.1195^{ns}	0.4374^{ns}	3.147^{ns}	2.101^{ns}
RESIDUAL	24	12.35	12.70	0.08056	0.2550	0.6513	2.747	2.187

LSD: Least significant difference

*** : Means are significant at $p < 0.001$

* : Means are significant at $p < 0.005$

ns: Not significant at $p > 0.05$

CHAPTER FIVE

5.1 DISCUSSION

This study was carried out to evaluate the effect of potting media and watering regime on the growth of *Amaranthus* cruentus.

Results from this study showed that the best growth parameters were obtained from top soil and the least was obtained from the top soil amended with *Trichoderma*. On the effect of watering regime on the growth of *Amaranthus* cruentus, the result agreed with Khan *et al.* (2021) who reported that the growth of *Amaranthus* spp. were reduced with reduction in watering regimes.

Results on the effect of potting media on the growth of *Amaranthus* cruentus was contrary to the findings of Anozie *et al.* (2022) who reported that topsoil amended with cow dung had the highest growth as opposed to top soil which had the lowest.

5.2 CONCLUSION

This study was carried out to investigate the effect of potting media and watering regime on the growth of *Amaranthus* cruentus. From the findings of this study, the different watering regime did not positively affect the growth of *Amaranthus* cruentus as the growth parameters were similar across the different watering regimes. The best growth parameters were gotten from the top soil and the least was gotten from the top soil amended with *Trichoderma*.

REFERENCES

Abd–Elrahman, S. H., Saudy, H. S. and El–Fattah, D. A. A. (2022). Effect of Irrigation Water and Organic Fertilizer on Reducing Nitrate Accumulation and Boosting Lettuce Productivity. *J Soil Sci Plant Nutr* 22: 2144–2155

Afnan B. Yahya, Mohammed D. Al-Sawaf and Nidal Y. Al-Morad. (2021). Effect of biofertilizer *Trichoderma harzianum* t-22 application, growing medium and training methods on some characteristics for *Lantana camara* plants. *Mesopotamia J. of Agric*, 49(1).

Ahmed M. Eed. (2016). Effect of various potting media on percent survival and growth of jojoba (*Simmondsia chinensis*) Rooted Cuttings. I*nt.J.Curr.Microbiol.App.Sci*. 5(9): 454-461.

Aklibasinda, M. T., Tunc, Y., Bulut and Sahin, U. (2011). Effect of different growing media on Scotch pine (Pinussylvestris) production. *The Journal of Animal and Plant Science,* 21(3): 535-541

Altomare, C., Norvell, W. A., Bjorkman, T. and Harman, G. E. (1999). Solubilization of phosphates and micronutrients by the plant-growth promoting and bio-control fungus *Trichoderma harzianum* rifai 1295-22. *Application of Environment Microbiology*, 65: 2926-2933.

Anonymous, (2006). Health-benefits-of-amaranthkiwicha. Larkcom, J. (1991). Oriental Vegetables. The complete Guide for Garden and Kitchen. John Murray publishers Ltd., London. 34: 201-205.

Asad, Muhammad, Khan., Ahmadreza, Mobli., Jeff, Werth., Bhagirath, S., Chauhan. (2021). Effect of Soil Moisture Regimes on the Growth and Fecundity of Slender Amaranth (Amaranthus viridis) and Redroot Pigweed (*Amaranthus retroflexus*). Weed Science, 69(1):82-87.

Awang, Y., Shaharom, A.S., Mohamad, R. B. and Selamat, A. (2009). Chemical and physical characteristics of cocopeat-based media mixtures and their effects on the growth and development of *celosia cristata*. *American Journal of Agricultural and Biological Sciences,* 4(1): 63-71.

Ayeni, L. S. (2011.) Integrated Plant Nutrition Management. A Panacea for Sustainable crop Production in Nigeria. *International Journal of Soil Science* 6, 19 – 24.

Bell, J. V., Stewart, A. and Rowarth, J, S. (2000). Application method and growing medium affects the response of cucumber seedlings to inoculation with *Trichoderma harzianum*. *Australasian Plant Pathology* 29, 15-18.

Chude, V. (2006). Fertilizer situation in Nigeria. Paper presented by Alhaji Bello Sule, Director Fertilizer Department to the Program Advisory Committee on Agriculture and Food Security on 6 September, 2006. Abuja, Nigeria.

Dada, O. A. and Ohu, O. B. Growth and Stomatal Response of *Amaranthus* spp. to Different Watering Regimes, Organic and Inorganic Soil Amendments. *Nigerian Journal of Science,* 47: 15-26.

Dayeswari, D., Rayaprolu, S. and Jone, A. (2017). Effect of Potting Media on Seed Germination, Seedling Growth and Vigour in TNAU Papaya Co.8 (*Carica papaya* L.), *Int. J. Pure App. Biosci.* 5(3): 505-512.

Ewulo, B. (2005). Effect of Poultry Dung and cattle Manure on Chemical Properties of Clay and Sandy Clay loam Soil. *Journal of Animal and Veterinary Advances* 4 (10): 839 – 841.

FAO. (2007). Food and Agriculture Organisation. 2007 FAOSTAT. FAO Statistic Division. Rome.

Ghannoum, O. (2009). C4 photosynthesis and water stress. *Annals of Botany* 103: 635 – 644.

Girotto E, Ceretta CA, Lourenzi CR, Lorensini F, Tiecher TL, Vieira RCB, Trentin G, Basso CJ, Miotto A, Brunetto G (2013). Nutrient transfers by leaching in a no–tillage system through soil treated with repeated pig slurry applications. *Nutr Cycl Agroecosyst* 95:115–131.

Halifu, S., X. Deng, X. Song and R. Song. (2019). Effects of two *Trichoderma* strains on plant growth, rhizosphere soil nutrients, and fungal community of Pinus sylvestris var. mongolica annual seedlings. Forests, 10(9):1–17.

Halifu, S., X. Deng, X. Song and R. Song. (2019). Effects of two *Trichoderma* strains on plant growth, rhizosphere soil nutrients, and fungal community of Pinus sylvestris var. mongolica annual seedlings. Forests, 10(9):1–17.

Harman, G.E. (2006). Overview of mechanisms and uses of *Trichoderma* spp. *Phytopathology,* 96(2):190-194.

Henzell, R.G., McCree, K.J., van Bavel, C.H.M., Sachertz, K.F. (1976). Sorghum genotype variation in stomatal sensitivity of leaf water deficit. *Crop Sci*., 16: 660-662.

Hermosa, R., Viterbo, A. Chet, I. and Monte, E. 2012. Plant beneficial effects of *Trichodoma* and of its genes. *Microbiology,* 158: 17-25.

Hewavitharana, N. and Kannangara, S. D. P. (2019). Evaluation of organic potting media enriched with *Trichoderma* spp. and their effect on growth performance of selected vegetables. *International Journal of Sciences and Applied Research* 6(1): 13-25

Sadiku, I. B. S., Yusuf, K. O., Ayodele, Olanrewaju, Ogunlela. (2023). Response of *Amaranthus cruenthus* to Different Aeration Methods and Varying Irrigation Levels. Indonesian Journal of Agricultural Research, 5(2):132-148.

Anozie, E. C., Egwunatum, A. E., Ezenwenyi, J. U. and Okonkwo, C. I. (2022). Effects of Different Potting Media on the Germination and Early Growth of *Newbouldia laevis*. (P. Beauv.) Seem.. *Asian Journal of Research in Agriculture and Forestry*, 220-234.

Jerónimo EMM Ribeiro, Petrus J ieterse, Sebastião I Famba. Vegetative growth of *Amaranthus hybridus* and *Amaranthus tricolor* under different watering regimes in different seasons in southern Mozambique. *South African Journal of Plant and Soil* 34 (3), 201-210, 2017

Kashihara, Y., Shinoda. K., Murata. N., Araki, H. and Hoshino, Y. (2011). Evolution of the horticultural traits of genus Alstroemeria and genus Bomarea. *Turkish Journal of Botany,* 3: 239-245.

Kinderson, D. (2008). The Rodale Institute Farming System Trial.: The first fifteen years, Kurztown. 27-54.

Kostov, O. S. (2016) Tropical Soils: Importance, Research and Management. *Uttar Agriculture Science Journal* 2 (3): 22 – 29.

Li Y, Li J, Gao L, Tian Y (2018). Irrigation has more influence than fertilization on leaching water quality and the potential environmental risk in excessively fertilized vegetable soils. PLoS ONE 13: e0204570.

Lin, Z. F., Ehleringer, J. (1983). Photosynthetic characteristics of *Amaranthus tricolor,* a C4 tropical leafy vegetable. Photosynthesis Research 4: 171 -178.

Lorito, M., Woo, S. L., Harman, G. E. and Monte, E. (2010). Translational research on *Trichoderma*: From ‘omics to the field. Annal Review *Phytopathology*, 48:395-417.

Marcone, M. F., Kakuda, Y., Yada, R. Y. (2003). Amaranth as a rich dietary source of beta-sitosterol and other phytosterols. *Plant Foods Hum Nutr*. 58 (3): 207-11.

Martirosyan, D. and L. A. Miroshnichenko (2007). Amaranth oil for cardiovascular disease. Functional food centre. Dallas.

Masariramb, M. T., Dlamini, Z., Manyatsi, A. M., Wahome, P. K., Oseni, T. O. and Shongwe, V. D. (2012). Soil Water Requirements of Amaranth (Amaranthus hybridus) Grown in a Greenhouse in a Semi-Arid, Sub-Tropical Environment. *American-Eurasian J. Agric. and Environ. Sci*., 12 (7): 932-936.

Mehmood, T., Ahmad,W., Ahmad,K.S., Shafi,J., Shehzad,M.A., and Sarwar,M.A. (2013). Comparative effect of different potting media on vegetative and reproductive growth of floral shower (*Antirrhinum majus* L.). Universal Journal of Plant Science, 1(3):104–111.

Millosevic, T. and Millosevic, N. (2009) Effect of zeolite, organic and inorganic fertilizers on soil chemical properties, growth and biomass yield of apple trees. Plant and soil Environment 55 (12), 528 – 535.

Muhammad Azhar Bashir, Mushtaq Ahmad and Muhammad Akbar Anjum. Effect of Various Potting Media on Growth of Rooted Jojoba (Simmondsia chinensis) Cuttings. International journal of agriculture and biology 1560–8530/2007/09–1–147–151.

Obi, O. and Ekperigin, J. (2001). Effect of wastes and soil pH on growth and grain yield of crops. *African Soils* 32, 3 – 15.

Olle, M., Ngouajio,M., and Siomos,A. (2012). Vegetable quality and productivity as influenced by growing medium: A review. Zemdirbyste, 99(4):399–408.

Olowoake, A. A. and Ojo, J. A. (2014) Effect of Fertilizer Types on the Growth and Yield of Amaranthus caudatus in Ilorin, Southern Guinea Savanna Zone of Nigeria. Advances in Agriculture 2014, Article ID 947062.

Oworu, O. O and Dada, O. A. (2009). Influence of compost on growth, nutrient uptake and dry matter accumulation of grain amaranths (*Amaranthus hypochondriacus*. L.) on *Oxic Paleulstalf. Nig. J. Sci.* 43:7-18.

Peter-Onoh, C. A., Ngwuta1, A. A., Obiefuna, J. C., Ogoke, I. J., Orji, J. O., Nwokeji, E. M., Iheanacho, L. U., Nwagbaraocha, N. and Abana, P. C. (2015). Influence of growth media on the rate of emergence, growth parameters and development of garcinia cola seedlings in southeastern Nigeria. *International journal of agriculture and rural development*, 18(2): 2316-2321.

Reddy, A.R., Chiatanya, K.V and Vivekanandan, M. (2004). Drought induced responses of photosynthesis and antioxidant metabolism in higher plants. *J. Plant Physiol.* 161: 11891202.

Rubio, M.B., Domínguez,S., Monte, E., and Hermosa,R. (2012). Comparative study of *Trichoderma* gene expression in interactions with tomato plants using high density oligonucleotide microarrays. *Microbiology*, 158(1):119–128.

Ruskin, F. R. (1984). Amaranth: modern prospects for an ancient crop. Board on Science and Technology for International Development. Report of an Ad Hoc Panel of the

Schippers, R. R. (2002). African indigenous vegetables: An overview of the cultivated species. Natural Resources Institute/ACP-EU Technical Centre for Agricultural and Rural Cooperation. Chaltham. UK. p. 214.

Serpil, S. (2012) Investigation of Effect of Chemical Fertilizers on Environment. 1, 287 – 292.

Shaol, H. B., Chu, L. Y., Jaleel, C. A and Zaho, C. X. (2008). Water deficit stress-induced anatomical changes in higher plants. CR. *Biol*. 331: 215-225.

Shoresh, M., Harman,G. E., and Mastouri,F. (2010). Induced systemic resistance to fungal biocontrol agents. *Annual review of phytopathology*, 48:21-43.

Sihem Fellah, Abdelkader Khiari, Mohammed Kribaa, Abdelkrim Arar, Haroun Chenchouni. Effect of Water Regime on Growth Performance of Durum Wheat (*Triticum Durum* Desf.) During Different Vegetative Phases. *Irrigation and Drainage*, 67(5): 762-778.

Silva Grobelnik Mlakar, Martina Bavec, Manfred Jakop, Franc Bavec. (2012). The effect of drought occurring at different growth stages on productivity of grain Amaranth *Amaranthus* cruentus. *Journal of Life Sciences* 6 (3): 283-286, 2012

Tindall, H. D. (1983). Vegetables in the Tropics. AVI Publishing Company, Incorporated 553pp.

Tsakaldimi, M. and Ganatsas, P. A. 2016. Synthesis of results on wastes as potting media substitutes for the production of native plant species. Reforesta Journal, 1: 147-163.

Tucker, J. (1986). Amaranth: The once and future crop. *Bioscience* 36 (1): 9-13.

USDA Nutrient Database, 2010; Composting part 637, Nationanl Engineering handbook, NRCS, US. Department of Agriculture, Washington, D.C.

Vinale, F., Nigro, M., Sivasithamparam, K., Flematti, G., Ghisalberti, E. L., Ruocco, M., ... and Lorito, M. (2013). Harzianic acid: a novel siderophore from *Trichoderma harzianum.* FEMS microbiology letters, 347(2), 123-129.

Wang, S.T and Ebert, A.W. (2012). Breeding of leafy amaranth for adaptation to climate change. High value vegetables in Southeast Asia: Production, supply and demand, SEAVEG Regional Symposium, 24-26 January 2012. 36 - 46.

Younis, A., Ahmad, M., Riaz, A. and Khan, M. A. (2008). Effect of different potting media on growth and flowering of dahlia coccinia cv. Mignon. *Horticulturae* 10(17): 660-804.

Zhuanyun Si, Muhammad Zain, Faisal Mehmood, Guangshuai Wang, Yang Gao, Aiwang Duan. Effects of nitrogen application rate and irrigation regime on growth, yield, and water-nitrogen use efficiency of drip-irrigated winter wheat in the North China Plain. Agricultural Water Management Volume 231, 31 March 2020, 106002

Zuoxing Zheng and Kalidas Shetty. Effect of apple pomace-based *Trichoderma* inoculants on seedling vigour in pea (*Pisum sativum*) germinated in potting soil. Process Biochemistry Volume 34, Issues 6–7