INVESTIGATION OF ARBUSCULAR MYCORRHIZAL INOCULATION ON GROWTH OF TROPICAL FRUIT SEEDLINGS UNDER SALINE, FLOODING AND NUTRIENT STRESS CONDITIONS

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Investigation of arbuscular mycorrhizal inoculation on growth of tropical fruit seedlings under saline, flooding and nutrient stress conditions

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DECLARATION

This is my original work and has not been presented for a degree in any other University

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DEDICATION

This thesis is dedicated to the most important people in my life: my wife Viola Kiprop, son Brian Ruto, our niece Wanda Abigael and parents Enock and Christine Chebet. You are simply the best, and I thank God for you.

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I wish to first thank God for his goodness, favour and mercy that has made it possible for me to get to this stage in this study. Thank you Lord for your protection and sustenance as I undertook this study. All glory and honour be unto you my God.

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ABSTRACT

Researchers continue to demonstrate the contribution of Arbuscular Mycorrhiza fungi on crop productivity, especially under adverse soil conditions. In sub Saharan Africa, mycorrhizal studies on major fruit crop seedlings have received little attention. Salt stress experiment was undertaken in mycorrhizal and non mycorrhizal passion fruit and mango seedlings subjected to moderate and high salt stress. Data was collected on root colonisation, growth, biomass and nutrient uptake. The study found out that mycorrhizal colonization reduced under salt stress conditions. Plant height, leaf number, chlorophyll content, root, stem and leaf fresh and dry weights was greater in mycorrhiza-inoculated than in un-inoculated seedlings under salt stress conditions. Total leaf accumulation of P and K was higher in mycorrhizal than in non-mycorrhizal plants while Na concentrations were lower under both control and medium salt stress conditions. This study found that a reduction in Na uptake, with a concomitant increase in P and K absorption and high leaf chlorophyll content play a role in alleviating salt stress in plants growing in mycorrhizal passion fruit and mango seedlings growing in saline soils. To investigate the role of mycorrhiza on flooding stress, data was collected on proline, chlorophyll and carotenoid content, total soluble sugars, mycorrhizal root colonization and nutrient uptake in passion fruit subjected to root-zone flooding for 7, 14, 21 and 28 days. The seedlings were grown in sterilized sand under low phosphorus regime for 12 weeks before flooding was initiated. Mycorrhizal inoculation induced greater root, stem and leaf fresh and dry weights, and maintained greater leaf area as opposed to leaf abscission that occurred more rapidly in non-mycorrhizal seedlings under flooding. Chlorophyll a,b and total chlorophyll declined, while carotenoids increased rapid in non-mycorrhizal seedlings under flooding. A rapid increase in leaf proline and a slow decline in total soluble sugars was observed in mycorrhizal seedlings under flooding. Flooding induced a reduction but did not completely inhibit mycorrhizal root colonization. The leaf nitrogen and phosphorus contents declined under flooding, with the decline occurring more rapidly in non-mycorrhizal seedlings. This study found out that increased production of proline, maintenance of optimum nutrient supply in the leaves and delay in degradation of leaf chlorophyll aids mycorrhizal passion fruit seedlings to delay the adverse effects of flooding. The effect of Arbuscular mycorrhiza fungi on growth, nutrient uptake and root infectivity was also determined in passion fruit, rough lemon, papaya, mango and avocado seedlings raised under four phosphorus levels in sand culture and also in low nutrient sterilized and unsterilized media. Arbuscular mycorrhiza increased the leaf area and the root, leaf and stem fresh and dry weights and also induced an increase in the uptake of phosphorus, nitrogen and potassium in the leaf tissues. This study indicated that AM fungi improved the capacity of tropical fruit seedlings to absorb and utilize plant nutrients possibly by increasing the effective root surface area from which available form of nutrients are absorbed and also by increasing access of roots by bridging the depletion zones. Inoculating seedlings with arbuscular mycorrhizal fungi helps to alleviate the adverse effects of global warming and climate change. As a low cost technology, arbuscular mycorrhizal inoculation is recommended as part of the regular practise for incorporating into nursery media used for tropical fruit seedling propagation in Kenya.

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Agriculture is the mainstay of Kenya's economy, contributing over 29.3% of Kenya's GrossDomestic Product (GDP) and another 27% of GDP indirectly through linkages with other sectors (HCD, 2017). Horticulture is the largest subsector in agriculture, contributing 33% of the agricultural GDP and 38% of export earnings (KNBS, 2014).

Large scale horticultural production in Kenya started during World War II to supply food to the Allied Forces stationed in East Africa. The sector has recorded steady growth since 1967 when horticultural crops were declared 'special' for the purpose of Agricultural Act Cap 318 under legal notice no. 229 pf 1967 by the Government of Kenya (HCDA, 2012). In 1968, 1500 metric tons of horticultural produce were exported (Jaffee, 1995). This rose to 163,223 metric tons valued at Ksh. 43.1 billion shillings in 2006 and 261,107 tons valued at Ksh. 101.5 Billion in 2016 (HCD, 2017).

The domestic consumption of horticultural crops has not been accurately quantified but it is estimated that it accounts for 90% of total horticultural production. Over 80% of production is from smallholder farmers, many of whom are not involved in the export business but produce for the domestic markets (Ongeri, 2014). The horticulture sector is seen as a viable solution for Kenya's needs of cash crop diversification, enhancing food nutrition, income generation, employment creation and foreign exchange earnings, in addition to providing raw materials for the agro processing industries (Ministry of Agriculture, 2012).

The fruit sub-sector is an important component of the horticulture sector in Kenya. In 2016, total fruit crops (both domestic and export) earned Ksh. 57 Billion from an area of 172,527 Ha. and volume of 3.2 million tons. Fruits accounted for 26.7% of all horticultural crops while vegetables accounted for 31.7% and cut flowers 32.7%. However, in export terms, 48,667 tons of fruits valued at Ksh. 7.317 Billion were exported in 2016, accounting for 18.63% in volume and 7.2% in value of all

horticultural exports. This made fruit exports lag behind cut flowers (51.19% volume and 69.8% value) and vegetables (30.18% volume and 23% value) exports in 2016 (HCD, 2017).

Fruit crops therefore offer tremendous opportunities for enhancing the income of small-scale farmers in Kenya, and for improving the nutrition of the poor who currently suffer from deficiencies in vitamins, minerals and other micronutrients as a consequence of low consumption of fruits (Mbora *et al.* 2008).

In terms of overall production, the most important fruit crops in Kenya are bananas, mangoes, pineapples, avocados, pawpaws, oranges and passion fruits. However, based on foreign exchange earnings, avocados, mangoes, raspberries and passion fruits are leading (HCD, 2017).The domestic market is the largest source of demand for Kenyan avocados accounting for over 80% of the total production and the rest are exported as fresh fruits or processed and exported as crude oil (Oduol *et al.* 2013).Kenya is ranked 12th in citrus fruit production with a world share of 0.8%. One hundred thousand tons of citrus fruits were harvested from 13,000 Hactares of land (FAO, 2012). The main citrus fruits produced in Kenya are sweet orange, lemons, tangerines and grapefruits (HCD, 2014).

By global standards, Kenyais a minor producer of passion fruits (FAO, 2012). However, Kenya still has significant exports of fresh passion fruits to Europe and strong sales to regional markets (HCDA, 2012). According to HCD (2017), passion fruit export volumes in 2016 were 42,210 tons valued at Ksh. 1.64 billion. Uganda accounted for 76 percent of passion fruit exports in 2012, followed by the EU and Middle East at 17 percent and 5 percent, respectively (HCDA, 2012).

The fruit sub sector in Kenya faces a number of challenges that hamper its growth. These challenges occur at the farm, market centre, export and processing points. At the farm level, there are numerous pest and disease challenges, low soil fertility (Mwangi, 2006) and soil salinity (Mugai, 2004). Unavailability of clean planting materials is also a major cause of low crop production (HCD, 2017). There is also lack of technological packages in terms of training and extension leafletsthat can help farmers increase their production (Pole *et al.* 2012). Consequently, the yields of fruit crops in Kenya are low.

For example, the average yield of passion fruits is 8 tons/ha compared to about 18.9 tons/ha in South Africa (Njuguna *et al*., 2005).

On the marketing stage, challenges include poorly developed transport infrastructure leading to high transport and shipping costs. There is also lack of information on alternative marketing possibilities and alternative product use, such as drying and value addition (KHCP, 2012). Export challenges include inadequate post harvest and husbandry management, inappropriate varieties, inadequate sea freight facilities and high air freight costs are among the major constraints (HCDA, 2012). The smallholder farmers' situation has been exacerbated by the introduction of stringent new rules and market standards following increasing consumer concern about food safety, as well as social and environmental aspects of the food supply chain including poor compliance with EUREPGAP and traceability standards (USAID, 2008). Furthermore, the cost of compliance makes it economically infeasible for the smallholder farmers, particularly to women because of small pieces of land or lack of access to and control over such resources (Mwangi, 2006). Other constraints include price instability in international markets and stiff competition from other countries such as India, Pakistan, Brazil, Mexico and Costa Rica. These competitors offer higher quality varieties at lower prices, mainly due to lower shipping costs (HCDA, 2012).

1.2 Problem Statement

A major problem that faces fruit as well as other agricultural sectors in Kenya is the gradual and adverse change in the soil biological, physical and chemical characteristics. Major soil factors that constraint crop production include high soil salinity (Mugai, 2004), soil moisture stress, low nutrient capital, soil erosion and degradation, low pH with aluminum toxicity, high phosphorus fixation, low levels of organic matter and loss of soil biodiversity. Other adverse changes that have occurred include increased natural resource degradation and a build-up of harmful microbes and pests paralleled by a reduction of beneficial soil organisms.Land degradation and soil fertility depletion are considered the major threats to food security and natural resource conservation in sub-Saharan Africa (Cardoso & Kuyper, 2006).

In Kenya, by 2004, the area covered by saline soils (Solonchaks) of electrical conductivity above 4 dS m^{-1} was estimated to be about 18.0 million ha, accounting for 40% of the arid and semi-arid soils of Kenya (Mugai, 2004).The Exploratory Soil and Agro-Climatic Zone Maps of Kenya showed that most saline soils of Kenya were located in agroecological zones VI-VII, except for some saline soils around the soda lakes of the Southern Rift Valley (aez V) and Coastal area (aez III-IV) (Sombroek *et al.* 1982).

In Southern Rift Valley saline soils, the predominant cation was sodium derived from the weathering of sodium rich minerals (feldspathoids). The predominant anions were chlorides and carbonates/bicarbonates. Salinity in Southern Rift Valley regions was also attributed to lack of drainage of the landscapes and the high solubility of the salts that ensures their presence in the topsoil layers. In Northern Kenya, most of the salinity was due to long-term mineral weathering under conditions of evaporation exceeding precipitation. Sodium chloride was the predominant salt because it is most soluble and rises to the upper soil layers by capillarity under the prevailing arid climatic conditions. In the Coastal area, salinity is mainly derived from in situ salt accumulation and lacustrine influence because the parent materials of these soils are Sub-Miocene and Cretaceous erosion products which were deposited at shallow embayments of the Indian ocean. Salinity in the area was also very high as a result of the high aridity in inland areas and frequent addition of salts from the inundating seawater in swamps(Njue 2004).

The increasing demand in food production is constantly pushing agricultural fields to areas where water and soils have naturally high salt levels.The increase in salinity stress problem in Kenya can also beattributed to man-made factors such as poor irrigation practices, excessive application of chemical fertilizers, use of brackish irrigation water and poor irrigation uniformity (Araus *et al.*, 2007).

High soil salinity increases the osmotic pressure of soil solution causing water to diffuse out of the plant leading to wilting and plant death as extreme salinity occurs. Excessive uptake of Na^+ induces ion competition which diminishes the uptake, transport and internal distribution of nutritional elements such as K, Mg, Ca, P and

N.Salt injury symptoms such as marginal chlorosis and necrosis of leaves, growth reduction, twig and branch dieback, loss of vigour, wilting and death (Evelin *et al.*, 2009).High concentration of Na^+ also causes soil compaction, increases the soil pH, deflocculates humid colloids and disperses clay particles. This destroys the soil structure impairing drainage and root growth (Yuang *et al.*, 2007).

Flooding is one of the weather phenomena that affect many regions of the world. On a world scale, the land area exposed to flooding is > 17 million km^2, equal to twice the size of the USA (Perata *et al.* 2011). Future rainfall projections for Kenya up to the year 2030 broadly indicate that there will be increase in annual rainfall, with the highest amounts expected in Western parts of Kenya around Mount Elgon, Elgeyo Escarpment and Cherangani Hills (GoK, 2010).

Climatic changes, including rising temperatures and increasingly variable rainfall patterns, have resulted in increased frequency of extreme weather events such as floods and droughts. For example, it has been reported that the last two decades have recorded six years with the warmest temperatures and rainfall variability in subSaharan Africa. Decreases in rainfall have been recorded in the Sahel region and increases in the East and Central African region. Consequently climate-related disasters such as floods and droughts have doubled in these regions within the last quarter century and Mozambique, Malawi, Kenya, Madagascar and Ethiopia are examples of Sub Saharan countries likely to experience unexpected extreme climatic events (Opondo, 2013).

Plants develop a variety of responses in order to deal with partial submergence imposed by flooding. The most common anatomical response is the generation of aerenchyma in tissues, which facilitates the transport of oxygen from shoots to roots (Colmer and Voesenek, 2009). At physiological level, flooding modifies water relations and plants carbon fixation, causes the closing of stomata, reduction of transpiration and inhibition of photosynthesis (Mollard *et al.*, 2010). At morphological level, responses to flooding include formation of adventitious roots and increase in plant height (Heydarian *et al.*, 2010). Prolonged flooding inhibits root formation and branching, reduces growth of existing roots, induces root decay and decreases the root/shoot ratio (Ashraf and Harris, 2004).

To overcome these constraints hampering crop production, use of pesticides, synthetic fertilizers and high yielding crop varieties were undertaken in the last century as part of the green revolution package (Dalgaard *et al.,* 2003). Although this technology has been found to increase the global food supply, reduce hunger and improve nutrition, millions of rural communities in the tropics and subtropics are persistently affected by a decline in household food production and have no food security (Stocking, 2003). These raise questions about the sustainability of the current agricultural practices (Dalgaard *et al*., 2003).

Various researchers throughout the world continue to demonstrate the contribution of Arbuscular Mycorrhiza fungi on crop productivity and quality, especially under adverse biotic and abiotic conditions. However, in sub Saharan Africa, many of these studies appear to be focused on field and vegetable crops, while the role of arbuscular mycorrhizae in important tropical fruit crops have so far received little attention (Guissou, 2009).The fruitseedling industry in Kenya is not well developed. There are few institutional fruit seedlings who supply good quality fruit seedlings to farmers in Kenya. These institutions are however located far from the farmers who require these services. Many Kenyan farmers therefore purchase seedlings from roadside nurserymen located in many rural and urban townships in Kenya. Many of these nurserymen are poorly equipped to supply good quality seedlings to farmers.

Tropical soils have low level of native mycorrhizae. Mycorrhizal colonization appears to be especially low in fruit orchards and nurseries. Soil samples collected from 103 orchards in 25 locations in Kenya, representing 13 soil types and 4 regions (high rainfall lowlands, highlands, arid and semi-arid lands and coastal lowlands) show the number of VAM spores in 25-gram soil samples to be 200 or below. Particularly, in more that 60% of these orchards, the number of spores are less than 50 in 25-gram soil sample (Wamocho, 1998). This is in contrast to Japan where the number of VAM spores is over 1000 in spite of use of large amounts of chemical fertilizers and agrochemicals. The root infection by citrus roots in Japan is also reported to be on average 70% (Ishii *et al.,* 1992).

Mycorrhizal colonisation is also low in fruit seedlings. Studies in fruit nurseries in Ethiopia and Somalia indicate that naturally-occurring mycorrhiza formation is sparse,

even in unsterilized soils. This means that poorly performing seedlings are being being transplanted (Michelson, 1992). There is therefore need to undertake studies on the role of arbuscular mycorrhiza fungi on soil chemical properties such as salinity, flooding and nutrient uptake. There is also need to provide guidelines on how to undertake mycorrhiza fungal inoculation into the fruit seedlings planting media. This will enable the benefits of mycorrhization on flooding, salinity and nutrient uptake to be transferred from the seedlings into the fruits growing in the field, thereby improving their productivity.

1.3 Justification for the Study

Among abiotic stresses, soil salinization is probably one of the most important in the world (Zhu 2003). Statistics indicate that 7% of the earth's land surface is affected by soil salinity (Evelin *et al*. 2009). Soil salinity is increasing in a fast rate. By 2050, it is predicted that 50% of all arable lands in the world will be affected by salinity (Porcel *et al.*, 2012). To counteract this salinity problem, many strategies have been proposed. These include searching for new salt-tolerant crops, genetic engineering, removing excessive salt accumulation in groundwater and desalinizing water for irrigation. Although these strategies appear efficient, they are costly and out of reach for developing countries that are the most affected (Ashraf & Harris 2004).

Arbuscular mycorrhiza symbiosis has been reported to counteract the effect of salinity on crop productivity (Huang *et al*. 2013, Younesi and Moradi, 2014). However, no studies have been undertaken to determine the effect of Arbuscular mycorrhiza fungi on passion fruits and mango seedlings under Kenya conditions. One of the research goals was aimed at addressing this knowledge gap.

Kenya was ranked among the 16 worst affected tropical countries by the 1997/98 El Niño event which resulted in severe floods after major rivers in the country attained record peaks causing havoc and destroying livelihoods (Gichere *et al*., 2013). The impact of flooding in Kenya is are often exacerbated by anthropogenic factors like forest degradation and poor land use practices that disrupt watershed areas, drainage basins and flood plains (Opondo, 2013).

To combat flooding menace, it is critical to introduce new improved flood-tolerant crops in arable lands subjected to periodic events of water excess. An additional strategy is to incorporate technologies that can assist the crops to withstand flooding stress. Among the technologies holding much promise in combating flooding stress in crops is use of arbuscular mycorrhizal inoculation.

There have been limited studies on the role of arbuscular mycorrhiza on flooding stress tolerance. Much of these have mainly been confined to flood tolerant crop species such as rice and other plant species such as mangroves (Parlanti *et al.*, 2011). In view of this, this study was undertaken to determine the effect of AM fungi on passion fruit seedlings under flooded conditions compared with non-flooded colonized plants.

One of the major areas that have not been adequately researched is the role of arbuscular mycorrhiza in nutrient uptake of tropical fruit crops. Most tropical soils suffer from low available nutrients, and plant growth under these conditions is largely reliant upon AM symbiosis (Querejeta *et al.*, 2003). The utilization of AM fungi to stimulate and improve fruit seedling growth in nurseries prior to transplanting is not yet well developed in Africa, particularly in Kenya. One of the research goals was to investigate the effects of AM fungi on the growth and nutrient uptake in passion fruit (*Passiflora edulis* var *edulis*), rough lemon (*Citrus limon*), papaya (*Carica papaya* var *Solo*) and mangoes (*Mangifera indica* var peach).

1.4 Objectives

1.4.1 Main Objective

The main objective of the study was to help improve growth and productivity of selected fruit seedlings grown under environmental stress conditions using mycorrhizal inoculation

1.4.2 Specific Objectives

The specific objectives of the study were to:

1. To evaluate the effects of arbuscular Mycorrhizal inoculation on the survival and growth of Passion fruits and mango seedlings under salt stress
2. To determinethe effects of arbuscular Mycorrhizal inoculation on thesurvival and growth of passion fruit seedlings under flooding stress.
3. To assess the effects of arbuscular Mycorrhizal inoculation on the survival and growth selected tropical fruit seedlings under nutrient stress conditions.

CHAPTER TWO

LITERATURE REVIEW

2.1 General introduction to Mycorrhiza Fungi

Mycorrhiza fungi are specialized organisms that live on plant roots in relationship that is mutually beneficial.The host plant supplies the fungus with carbohydrates produced during photosynthesis. In return, the fungi use their extensive network of hyphae in the soil to transfer water and nutrients to the roots (Le Tacon *et al*., 2013).

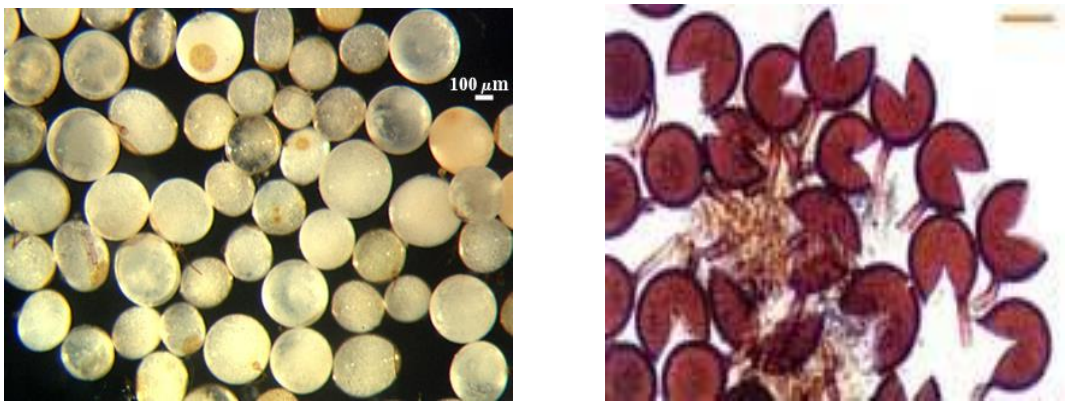
The word *mycorrhiza* was first used by a German researcher A. B. Frank in 1885, and originate from the Greek word *mycos* meaning 'fungus' and *rhiza* meaning 'root. Mycorrhiza fungi are among the most important fungi in the soil and can compose 70% of the mass of the soil fungi. They can also be found in all ecosystems in the world. At least seven different types of mycorrhizal associations have been found, involving different groups of fungi and host plants and distinct morphological patterns. These include ectomycorrhizae, arbutoid mycorrhizae, orchid mycorrhizae and arbuscular mycorrhizae (Smith & Smith, 2011).

Arbuscular mycorrhiza, also called vesicular arbuscular mycorrhiza (VAM) or endomycorrhizae is the most ancient type of mycorrhiza (Smith & Smith, 2011). Paleobotanical and molecular sequence data suggest that the first land plants formed associations with Glomalean fungi from the Glomeromycota about 460 million years ago (Bonfante & Genre, 2008). This is estimated to be about 400 million years before the appearance of root nodule symbioses with nitrogen-fixing bacteria (Redecker *et al*., 2000). It is estimated that arbuscular mycorrhizal (AM) symbioses can be formed with over 250,000 plant species, accounting for probably 90% of terrestrial plant species including gymnosperms and pteridophytes (Feddermann *et al*., 2010). They also occur in some mosses, lycopods and psilotales (Smith & Smith, 2011).

The AM fungi belong to phylum Glomeromycota which includes more than 10 genera namely: *Glomus, Gigaspora, Acaulospora, Sclerocystis, Scutellospora, Enthrophospora, Archaeospora, Diversispora, Paraglomus* and *Pacispora* (Robinson-

Boyer *et al*., 2009). From these genera, 150 - 200 species of AM fungi have so far been distinguished on the basis of morphology (Smith & Read, 2008). However, DNA-based studies havesuggested that the true diversity of these symbionts may be much higher (Santos-Gonzales *et al*., 2007).

A study in north and north-west China found 33 AM fungal species of seven genera, with *Glomus etunicatum*, *G. mosseae* and *G. intraradices* beingthe dominant species (Gai *et al*., 2010). *Glomus* was also the most abundant genus in the rhizosphere of soybean and mung bean (Hindumathi & Reddy, 2011), grapes and apples (Binet *et al*., 2011). When inoculated with *Glomus intraradices*, these crops showed a high percentage of total root length colonization of upto 97%. Plant species with low to moderate percentage of root length colonized by *G. intraradices* included weeds such as *Alopecurus myosuroides, Apera spica-venti, Poa annua* and *Trifolium repens* (Veiga *et al*., 2011).



(a) (b)

Plate 2.1: Living spores of Gigaspora (a) Sporocarp of Glomus invermaium(b) typical of the spores often found in field-collected soil (Source: Giovanetti et al., 2006)

The development of mycorrhizal associations begins with spore germination, hyphal growth, host recognition and appressorium formation. Spores form as swellings on one or more subtending hypha in the soil or in roots (Plate 2.1, 2.2). The spores usually develop thick walls and contain lipids, cytoplasm and many nuclei. They may also

aggregate into groups called sporocarps (Smith & Read, 2008) (Plate 2.1b). The spores function as storage structures, resting stages and propagules (Smith & Read, 2008).

Spores can be found in a wide diversity of habitats. For example, studies in Lake Victoria basin showedsignificant differences in richness and relative abundance of indigenous AMF. Lambwe site had the highest total spore count (12.59 per gram root dry weight) while Kibos had the lowest (4.23). In this basin, *Glomus* wasthe dominant AMF in all soils (49.74%) followed by *Scutellospora* (29.60%) and *Gigaspora* (15.80%). Lambwe soils also showed a higher degree of AMF diversity (H = 1.21) while Njoro had the least diversity (H = 1.08) (Othira *et al*. 2014).

In Haryana Agricultural University Hisar, India (longitude of 75° 46’ E), the number of spores per 50 g of soil ranged from 0 to 925 in spring-summer season crops and 25 to 1150 in winterseason crops. Maximum AM fungi spores were found in the rhizospheric soil of sorghum with 925 spores per 50 gram of soil and minimum in cotton with 25 spores per 50 gram of soil, while no spores were found in pigeon pea and urdbean field soils (Bansal *et al.*, 2012).

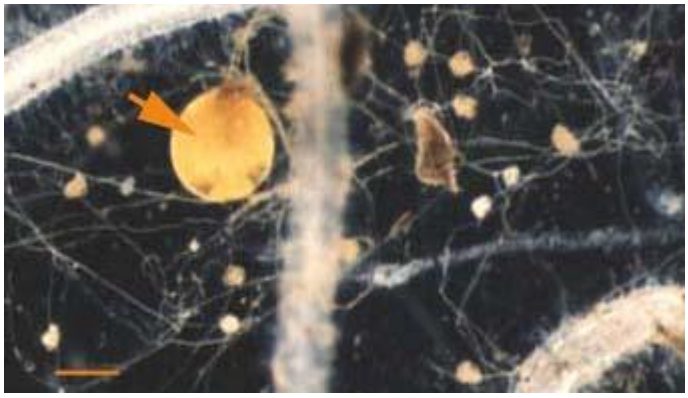
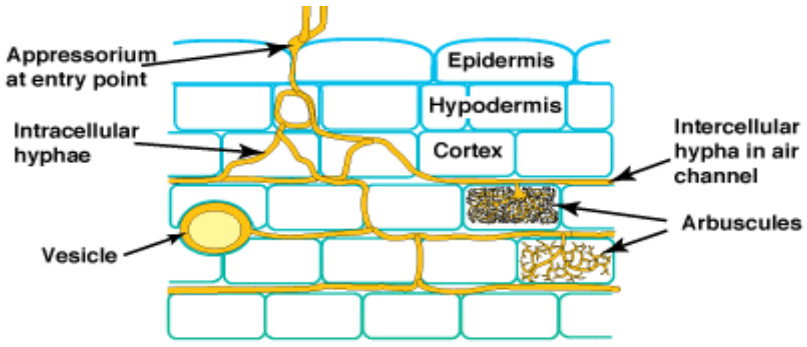


Plate 2.2: Soil hyphae produced by a single germinated spore of *Gigaspora* (arrow) used to start a mycorrhizal association (Source: Giovanetti *et al.*, 2006).

Mycorrhizal associations can be initiated by hyphae that originate from fragments of roots (Plate 2.2, 2.3) (Giovanetti *et al*., 2006). In many cases, there already is a pre-existing network of hyphae resulting from previous root activity. Approximately 10 – 100 meters of mycorrhizal mycelium can be found per cm of root and the hyphae may

extend for up to 8 cm from the root surface. It is also estimated that one gram of soil may contain up to 200 meters of fungal hyphae. The soil hyphae, also known as extraradical or external hyphae, are responsible for nutrient acquisition, propagation and spore formation. There are different types of soil hyphae that are produced, including thick runner or distributive hyphae as well as thin absorptive hyphae (Smith & Read, 2008).

Plate 2.3: Mycorrhizal root system washed carefully from coarse sand to reveal theintact network with external hyphae (arrow) with spores (S) produced by *Glomus* mosseae (Source: Giovanetti et al., 2006)



Figureure 2.1: Hyphae penetration into a host cell, intercellular growth, and mycorrhizalstructure formation (Source: Giovanetti et al., 2006)

Mycorrhizal associations can start when soil hyphae respond to the presence of a root by growing towards it, establishing contact and growing along the surface. One or more hyphae then produce swellings called appresorria between epidermal cells, which aid the hyphae to penetrate the epidermal or cortical cells to enter the root (Figureure 2.1

). After crossing the hypodermis, the hyphae start branching in the outer cortex and spreading along the cortex in both directions from the entry point to form a colony (Figureure 2.1). The hyphae then penetrate the root cortex, where by repeated dichotomous branching and reduction in width, they form arbuscules (Plate 2.4). Arbuscules are considered the major site of exchange between the fungus and host because of the large surface area of the arbuscular interface. Vesicles serve as storage structures, and are generally produced in the older region of infection(Smith & Smith, 2011).

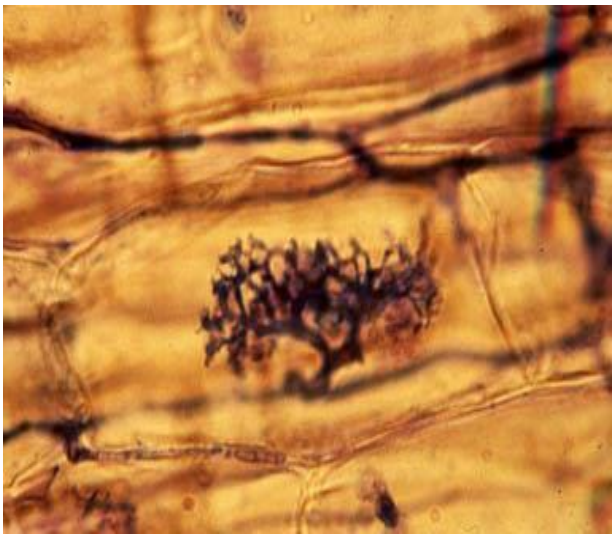


Plate 2.4: Mature arbuscule of *Glomus mosseae* (Source: Giovanetti et al., 2006)

Plant responses to AM colonization vary from highly positive to negative. The beneficial effects of AM inoculation have been found to be greatest under adverse soil and crop conditions (Smith & Smith, 2011). Mineral nutrient acquisition was considered to be the primary function of mycorrhizas, especially uptake of non-mobile nutrients such as phosphorus, copper and zinc (Schnepf *et al*., 2011). Mycorrhiza also played a role in the uptake of potassium, nitrogen, calcium and magnesium, although to a lesser extend (Sundar *et al*., 2010).

Studies have showed thatmycorrhiza fungi enhanced tolerance to drought stress and caused faster recovery after moisture stress in tangerines (Qiang-Sheng *et al*., 2007a) and conferred tolerance to flooding and high soil salinity in *Sclerocaryna birrea* (Muok

and Ishii, 2006). Arbuscular mycorrhiza inoculation antagonized parasitic soil-borne pathogens and pests in bananas (Elsen *et al.*, 2003).

Arbuscular mycorrhiza hyphae networks impacted the soil structure and plant community composition and are therefore important belowground carbon sinks (Le Tacon *et al*., 2013). The high amount of hyphae produced by AMF is correlated with significant increases in the aggregate stability of soils thereby modifying the soil's ability to mobilize nutrients, maintain water content, facilitate root penetration in soil and diminish soil erosion potential (Treseder & Turner, 2007). The AMF mycelium interconnected the root systems of neighbouring plants of the same or different species thereby creating large numbers of fungal linkages connecting together many plants in a community (Giovannetti *et al*., 2006). This suggestedthat AMF formation could be an important element of plant succession in ecosystems (Bellgard & Williams, 2011).

External AM hyphae produced recalcitrant forms of carbon such as chitin and glomalin and therefore are important contributors to the structural stability of the soil and carbon sequestration (Le Tacon *et al*., 2013). It has been found that in no-till and reduced-tillage systems, maintenance of the integrity of the hyphal networks contributed to a rapid AMF infectivity and efficient nutrient uptake (Johnson *et al*., 2010).

Almost all tropical crops are mycorrhizal, and many, if not most are strongly responsive to arbuscular mycorrhizas (Othira *et al*., 2014). Studies however show low impact of mycorrhization in tropical agriculture relative to temperate-zone agriculture. In a report by Wamocho (1998), soil samples collected from 103 orchards in 25 locations, representing 13 soil types and 4 regions (high rainfall lowlands, highlands, arid and semi-arid lands and coastal lowlands) in Kenya, showed the number of VAM spores in 25- gram soil samples to be 200 or below in every orchard. Notably, in more than 60% of these orchards, the number of spores wereless than 50 in 25 gram soil sample (Wamocho, 1998). This is in contrast to Japan where the number of VAM spores were about 1000 or more in spite of use of large amounts of chemical fertilizers and agrochemicals (Ishii *et al*., 1992). The root infections by VAM spores weremuch lower (mostly <30%) in orchards in Kenya (Wamocho, 1998), than in Japanese citrus orchards whose average wereabove 70% (Ishii *et al*., 1992). Studies in fruit/tree

nurseries in Ethiopia and Somalia indicated that naturally-occurring mycorrhiza formation were sparse, even in unsterilized soils, leading to poorly performing seedlings being transplanted (Michelson, 1992).

Various reasons account for the low level of mycorrhization in tropical soils and the subsequent poor infection levels in the roots of tropical crops. Among them is poor soil management. Soils in the tropics are widely degraded.Among the factors responsible for degradation is agricultural tillage. A study carried out in various sites around the Lake Victoria basin indicated that mycorrhizal spore densities werehighest in Lambwe Valley because the soils have experienced less tillage over the years (Othira *et al*., 2014). In Mediterranean cropping systems, greater AM colonization rates wereobserved in maize and soybean plants grown in undisturbed soil relative to plants from soils disturbed by three or four cycles of plant establishment. This is reflected in better growth of the host crop in undisturbed soil (Antunes *et al*., 2006). In wheat, differences in plant dry weight between disturbed and undisturbed soils wereconsistent with a differential AM colonization rate between the two treatments, with greater colonization taking place in the undisturbed soil. No-till system wasan important management technique as it keeps the extraradical mycelium intact and allows the next crop to benefit from the mycelium developed by the previous crop in the rotation. Conversely, tillage reducedthe AM inoculation potential of the soil and the efficacy of mycorrhiza by disrupting the extraradicle hyphal network and reducing the surface area spanned by the hyphae, thus rendering them ineffective (Brito *et al*., 2011).

Related to the issue of bare ground is overgrazing by livestock. Yang *et al* (2013) indicated that grazing of pasture grasses affected the proportion of root length infected by decreasing root length per unit volume of soil. Herbivore grazing altered the leaf photosynthetic rates and the above-ground production and the carbon allocation below ground by altering soil nutrient status through direct inputs of N and P in dung and urine deposition (Van Der Waal, 2011).

2.2 Effect of Arbuscular Mycorrhizal Inoculation on the Survival and Growth of Tropical Fruit Seedlings under Salt Stress

2.2.1 Introduction on Salt Stress

Salt stress has become one of the major limitations on crop productivity and quality in the world. Statistics on salinity (2009) indicated that 7% of the earth's land surface was affected by soil salinity (Elevin *et al*., 2009). It is predicted that by 2050, 50% of all arable lands in the world will be affected by salinity (Porcel *et al.*, 2012).In Kenya, by 2004, the area covered by saline soils (Solonchaks) of electrical conductivity above 4 dS m^{-1} was estimated to be about 18.0 million ha, accounting for 40% of the arid and semi-arid soils of Kenya (Mugai, 2004).

The increase in salinity stress problem is attributed toman-made factors such as poor irrigation practices, excessive application of chemical fertilizers, use of brackish irrigation water and poor irrigation uniformity.The increasing demand in food production is constantly pushing agricultural fields to areas where water and soils have naturally high salt levels (Araus *et al*., 2007).

Historical records indicate that several societies relying on irrigation collapsed due to salinization. For example, in Mesopotamia,increased soil salinity caused a decline in wheat productivity and necessitated a crop change to barley, which was thought to be salt tolerant. However, this strategy failed because the barley yields decreased over time due to salinization and this ultimately led to relocation and decline of population of Mesopotamia (Araus *et al*., 2007).

Salinity is a major soil problem in arid and semi arid climates (Koca *et al*., 2007). Solubility of most salts is temperature-dependent. Solubility is greater in warm dry season when there is a net upward water flux from the groundwater table to the surface soil, than in the cooler wet season when salts are leached from the surface soil by surplus rainfall. Overall, this change between rapid influx of salts in the soil and slow discharge is conducive to net accumulation of salts and development of a saline soil horizon in seasonally dry regions (Singh *et al*., 2011).

2.2.2 Effect of Salt Stress on Crop Productivity

Salt stress entails both osmotic and ionic stresses. High concentration of salt ions (Na^+, Ca^+, Cl^-, SO_4^{2-}) increases the osmotic pressure of soil solution causing water to diffuse out of the plant leading to wilting and plant death as extreme salinity occurs. Excessive uptake of Na^+ and Cl^- affects cell membrane functioning and cell metabolism by reducing enzymatic activities and inhibits protein synthesis. It induces ion competition which diminishes the uptake, transport and internal distribution of nutritional elements such as K, Mg, Ca, P and N.Salinity may cause physiological stresses such as disruption of membranes, lowers photosynthesis and respiration rates.These osmotic and ionic stresses result in salt injury symptoms such as marginal chlorosis and necrosis of leaves, growth reduction, twig and branch dieback, loss of vigour, wilting and death (Evelin *et al*., 2009).

Excessive salinity canadversely affect the physical and chemical properties of soil, microbial processes and plant growth. High concentration of Na^+ causes soil dispersion, increases the soil pH, deflocculates humid colloids and disperses clay particles. This destroys the soil structure impairing drainage and root growth (Njue, 2004; Yuang *et al*., 2007).

2.2.3 Effect of Arbuscular Mycorrhiza Fungi on Growth of Plants under salt stress

The shoot fresh weight, and shoot and root dry weights weresignificantly higher in AMF-treated Tomato variety TCAV10 subjected to salt stress, when compared with control treatment. Inoculation with AMFfurther caused a significant increase (~30%) in the fruit yield of TCAV10 tomato particularly under 2% saline stress (Huang *et al.,* 2013). LikewiseNzanza *et al*., (2012) showed that under saline conditions, *Glomus mosseae* improved growth, fruit yield and quality of tomatoes compared to un-inoculated tomatoes.When irrigated with saline water, tomato plants inoculated with AMF showed greater shoot and root dry matter accumulation than non mycorrhizal plants (Debouba *et al*., 2006).In beans grown in Iran, mycorrhizal inoculation increased the shoot biomass under moderate salinity (Younesi & Moradi, 2014).The AMF

symbiosisimproved the dry weights and alleviated salt stress in lettuce (*Lactuca sativa* L.) and maize (*Zea mays* L.) (Aroca *et al.*, 2013; Estrada *et al*., 2013).

The salt tolerance of banana plantlets as measured by leaf number and plant height also increased considerably in the presence of *Glomus* isolates (Yano-Melo *et al*., 1999). Inoculating *Acacia acuricuformis* with *Glomus fasciculatum* and *G. macrocarpum* also significantly increased the root and shoot weights (Giri *et al*., 2005). The shoot biomass of mycorrhizal zucchini plants was higher than those of non-mycorrhizal plants under saline conditions (Colla *et al*., 2008). Soybean plants inoculated with AM fungus and grown under NaCl concentrations of 0, 50, 100, 150 and 200mM had significantly higher fresh and dry weight compared to the non inoculated plants (Sharifi *et al*., 2007).In wheat, mycorrhizal inoculation increased the shoot and root fresh and dry weights, stem length and leaf area (El-Amri *et al*., 2013).

Soil salinity caused the chlorophyll content in *Sesbania grandiflora to* decreased(Dhanapackiam and Muhammad, 2010). Studies in *Sesbania aegyptiaca* and *S. grandiflora* indicated that the chlorophyll content wasgreater in leaves of seedlings inoculated with *Glomus macrocarpum*than in uninoculated seedlings under saline soil conditions (Giri *et al.*, 2005). Likewise, *Lotus glaber* plants colonized by *G. intraradices*had higher chlorophyll content than non-mycorrhizal plants under salt stress (Sannazzaro*et al*., 2005). Salt stress was also reported to suppress synthesis of chlorophyll in wheat. However, the chlorophyll content increased when mycorrhizaewere inoculated on host plants under both stress and non-stress conditions (El-Amri *et al.*, 2013). The highest chlorophyll content was found in mycorrhizaewheat plants as compared to non-inoculated plants (Borde *et al*., 2010).However, Faycal (2011) reportedthat the concentrations of both chlorophylls *a* and *b* in tomatoesremained constant with time and there was no effect of AM or salt treatment. There was also no significant difference in chlorophyll content between mycorrhizal and non-mycorrhizal citrus plants under saline conditions (Murkute *et al*., 2006).

Increase in salinity stress caused a corresponding rise in proline concentration (Garg and Manchanda, 2009). Mycorrhizal wheat plants exhibited increased proline levels compared to uninoculated controls (El-Amri*et al.*, 2013). It has been reported that

application of mycorrhizae improved tolerance of wheat genotypes to salt stress by maintaining osmotic balance and reducing the free radicals damage induced by osmotic stress (Garg & Manchanda, 2009). Under salinity stress, AMF application increased the accumulation of proline in soybean (Sharifi *et al.*, 2007). However, there was no significant difference in the proline levels between mycorrhizal and non-mycorrhizal bean plants subjected to salt stress (Younesi & Moradi, 2014). Conversely, Rabie and Almadini (2005) and Bhosala and Shinde (2011) reported that non-AMF pigeon peas and Ginger plants accumulated more proline than AMF plants under salinity stress.

There was a significant increase in electrolyte permeability in the root plasma membranes when the tomato plants were treated with salt and AMF (Huang *et al.*, 2013).Arbuscular mycorrhiza fungi was reported to have a regulatory and stimulatory influence on protein, sucrose, glucose and glycine-betaine (GB) synthesis which play a role in osmotic adjustment that helps plant to perform normally under salinity (Evelin *et al.*, 2009).

2.2.4 Effect of Salt Stress on Arbuscular Mycorrhizal Colonization

Conflicting reports have been made on the role of salinity in mycorrhizal hyphal colonization.Soil salinity slowedmycorrhizal root colonization, spore germination and hyphal growth. Salinity was reported to delay early stages of symbiosis of AM fungi rather than inhibiting the symbiosis (Juniper & Abbott, 2006).

Other studies however have not shown a reduction in AM colonization under salinity stress and some even reported an increase in sporulation and colonization. The colonization percentage of tomato was found to be three times higher in salt than non-salt treated plants after eight weeks of growth, and two times higher after ten weeksof growth. There was a significant effect of time on hyphal, vesicular and arbuscular density. The AMF colonization ratios werehigher in tomatoes inoculated with AMF under saline condition compared with non-inoculated treatments (Huang *et al.*, 2013).In non-salinised bean plants, mycorrhizal inoculation produced active colonisation. The level of colonisation in roots of mycorrhizal plants decreased significantly with increasing NaCl concentration (Younesi & Moradi, 2014).

2.2.5 Effect of Salt Stress and Arbuscular Mycorrhizal Inoculation on the Nutrient Uptake of Seedlings

As can be expected, salt stress increases the sodium content in both the roots and shoots of plants. However, mycorrhizal inoculation reduces the accumulation of sodium under saline conditions. In a study in China, both tomato varieties TSS7 and TCAV10 grown under saline stress coupled with AMF-2 inoculation showed diminished Na content in their shoots, fruits and roots when compared with the non-inoculated hybrid cultivars (Huang *et al.,* 2013). In common beanstudy in Egypt, sodium content was higher in non-mycorrhizal than mycorrhizal plants (Younesi & Moradi, 2014).Lower sodium content by mycorrhizal plants under salinity stress was been reported by Sharifi *et al*., (2007),Colla *et al*., (2008), Evelin (2009) and El-Amri *et al*., (2013).

The foliar calcium content in common beans decreased with increasing salinity.However,mycorrhizal plants showed higher calcium than non-mycorrhizal plants (Younesi & Moradi, 2014). The calcium content in the shoots of mycorrhizal tomato plants was higher than in non mycorrhizal plants (Faycal, 2011). Similarly, in wheat, lettuce and onions, the calcium concentration was higher in mycorrhizal plants under salinity stress, and corresponded to increased mycorrhizal colonization and sporulation (El-Amri *et al*., 2013). However, Huang *et al*.,(2013) reported that the shoot calcium concentration was unaffected by either salinity or mycorrhhizal treatments.

The potassium content in common beans declined as salinity increased with mycorrhizal plants having higher potassium content than non-mycorrhizal plants (Younesi & Moradi, 2014). Similarly, mycorrhizal wheat plants had higher potassium than non-mycorrhizal plants under salt stress (El-Amri *et al*., 2013). The potassium content of non mycorrhizal tomato plants declinedafterfour and eight weeks salinity stress while that of mycorrhizal plants remained unchanged (Faycal, 2011). This is in contrast to findings in tomatoes by Huang *et al*., (2013) that the potassium content was not affected by salinity in non-mycorrhizal plantsbut declined in mycorrhizal plants.

The magnesium content of tomato roots was increased by salinity treatment with mycorrhizal plants accumulating more magnesium in the roots compared to non-

mycorrhizal plants (Huang *et al*., 2013). A similar observation was made by Faycal (2011) who found that mycorrhizal plants had higher magnesium content in contrast to non mycorrhizal plants under salinity stress. However, in tomato shoots, Huang *et al*. (2013) found that the Mg concentration was similar among the treatments.

In common beans, the phosphorus content declined under saline conditions.However, the highest concentration of phosphorus was observed in plants inoculated with *G. mosseae* (Younesi & Moradi, 2014).In wheat, the phosphorus content declined with increased salinity in non-mycorrhizal treatments but in mycorrhizal treatments, the levels remained unchanged (El-Amri *et al*., 2013). Similarly, mycorrhizal tomato varieties TSS7 and TCAV10 showedenhanced P content in their shoots (24.0 and 47.6%, respectively), fruits (47.4 and 21.2%, respectively) and roots (<1.0 and 9.1%), respectively, when compared to non-mycorrhizal plants subjected to salinity treatment (Huang *et al,*. 2013). Faycal (2011) showed the P concentrationto be higher in AM than non-AM salt treated roots.These results are consistent with findings by Muok and Ishii (2006); Rabie and Almadini (2005).

In common beans, 22.38% and 47.55% reduction in foliar N concentration was caused by medium and severe salinity levels as compared with the control (non-salt stress). Mycorrhizal inoculation was the most effective treatment for increasing the foliar N concentration (Younesi & Moradi, 2014). In tomato study in China, mycorrhizal plants had higher nitrogen content in relation to non-mycorrhizal plants, irrespective of whether they were raised under saline or non saline conditions (Huang *et al*., 2013).

2.3 Effect of Arbuscular Mycorrhizal Inoculation on the Survival and Growth of Tropical Fruit Seedlings under Flooding Stress

2.3.1 Introduction on Flooding Stress

Flooding sets in motion a variety of physical, chemical and biological processes that alter the capacity of soils to support plant growth. Shortly after the soil is flooded, the remnant oxygen is depleted by the respiration of roots and micro-organisms and the environment becomes hypoxic (*i.e.* oxygen levels limiting respiration) and later anoxic (*i.e.* respiration is completely inhibited) (Wegner, 2010). As flooding time increases,

progressive decrease in the soil reduction-oxidation potential (redox potential) occurs. This allows potentially toxic compounds such as sulfides, CO_2, soluble Fe and Mn, ethanol, lactic acid, acetaldehyde, acetic and formic acid to accumulate in the soil and rhizosphere (Fiedler *et al*., 2007).

Plants develop a variety of anatomical, morphological and physiological responses in order to deal with partial submergence imposed by flooding. The most common anatomical response is the generation of aerenchyma in tissues, which facilitates the transport of oxygen from shoots to roots (Colmer & Voesenek, 2009). The mechanisms responsible for aerenchyma have not yet been fully elucidated although it is known to involve ethylene, which accumulates in submerged organs. In hypoxic roots of maize, exogenous ethylene induced aerenchyma formation while ethylene inhibitors repressed its development. In addition, both 1-aminocyclopropane-1-carboxylate (ACC) synthase activity and ACC concentrations have been found to be high in hypoxic maize roots (Geisler-Lee *et al*., 2010). In rice stems, Parlanti *et al*., (2011) demonstrated that aerenchyma formed in response to ethylene and H_2O_2.

At physiological level, flooding modifies water relations and plants carbon fixation. Closing of stomata, with or without leaf dehydration, reduction of transpiration and inhibition of photosynthesis are responses that can occur within hours or days, depending on the tolerance to flooding of each plant species (Mollard *et al*., 2010). Flooding causes a reduction in water uptake by plant roots. In flood sensitive species like *Solanum lycopersicum*, *Pisum sativum*, *Helianthus annuus* and *Nicotiana tabacum*, a few hours after the soil becomes flooded, the water uptake by roots declined due to a reduction of the root hydraulic conductivity (Islam & McDonald, 2004).

At morphological level, responses to flooding include formation of adventitious roots. These adventitious roots, which have high porosity, help plants to continue with water and nutrient uptake under flooding conditions (Colmer & Voesenek, 2009). In soya beans subjected to flooding, adventitious roots comprised about 90% of the total root length (Hattori *et al*., 2013). As a morphological adaptation to flooding, the rapid emergence of adventitious roots has been reported in Sesbania and*Pterocarpus officinalis* Jacq. (Shiba and Daimon, 2003) and azuki beans (Komori *et al*., 2010).

Another morphological change is the increase in plant height. *Rumex palustris* was reported to be taller than its non-flooded counterparts as a result of increase in the insertion angles and length of their aerial organs (Heydarian *et al*., 2010). In *Paspalum dilatatum*, the first morphological response to flooding was the increase in the tiller insertion angle followed by the elongation of the leaf sheaths, and lastly elongation of leaf blades (Mollard *et al*., 2010).

Prolonged flooding reduced the rate of stem thickening in most flood-intolerant species but increased thickening in flood-tolerant plants. The promotion of shoot elongation by submergence occurred in wetland and amphibious species over a wide taxonomic range in China e.g. *Rumex palustris, Ranunculus sceleratus, Nymphoides peltata, Potamogeton pectinatus* and *P. distinctus* (Mommer & Visser, 2005). Elongation has been reported in the internodes of rice under submergence. Soya bean study in Japan indicated that flooding reduced stem growth, inhibited leaf elongation, led to leaf yellowing, lowered photosynthesis, reduced root growth and ultimately, lowered nutrient uptake (Hattori *et al*., 2013).

Soil inundation inhibited root formation and branching, reduced growth of existing roots, induced root decay and decreased the root/shoot ratio. In maize, short term reduction in root and leaf growth rates began within 1.12 hours of flooding. Almost immediately, leaf elongation ceased and N, P, and K concentration in leaves decreased, but in roots N, P and K concentrations increased. Flooding resulted in loss of nitrogen through denitrification and leaching. Oxygen deficiency decreased the rate at which ammonium and nitrate are supplied to plants resulting in nitrogen deficiency in waterlogged soils (Ashraf & Harris, 2004).

2.3.2 Effect of Flooding Stress on Arbuscular Mycorrhizal Colonization

Arbuscular mycorrhiza fungi were historically thought to be rare in wetland ecosystems because the soils of wetlands are often saturated and subsequently lack available oxygen for aerobic soil microorganisms (Dolinar & Gaberˇsˇcik, 2010). As a result, little attention was given to research on mycorrhiza fungi in aquatic and wetland habitats (Stevens *et al*., 2011). However, an increasing number of studies have revealed

that AM fungi exist in wetland habitats (Stevens *et al*., 2010). Many of these studies indicate that flooded conditions reduce, but do not completely inhibit mycorrhizal colonization. For example, a rice study in Iran showed that root colonization by AMF is decreased by flooding conditions from 43% to 27% (Hajiboland *et al*., 2009). Similarly, in six aerobic rice genotypes, relatively high colonization of roots (28-57%) were observed (Gao *et al*., 2007). Several wetland plant species that were thought to be nonmycorrhizal have been found to have high levels of AM fungi colonization. For example, 23 AMF phylotypes were detected in samples of 27 roots from three mangrove speciesin China (Wang *et al*., 2011).

Flooding has been shown to inhibit AM fungal root colonization in purple nutsedge (Muthukumar *et al*., 1997). In snap beans, percent root colonization was not affected by flooding (Sah *et al*., 2006). This observation is consistent with wetland studies by Miller and Sharitz (2000) who reported that flooding inhibited initial root colonization in semiaquatic grass but once mycorrhizae were established, flooding had no effect.

In Ullapara, Bangladesh, abundant AM spores were observed in flooded farmers' fields. Heavy colonization was subsequently observed in onion roots grown after the flood water subsided. The spore population subsequently increased in the rhizosphere soils of onion (Khanam, 2008).In soya beans, the AM colonization ratio reduced from 12.5% (in the primary and lateral roots) and 14.5% (in the adventitious roots) in unflooded treatments to 0.8% and 7.5 % in flooded treatments, respectively (Hattori *et al*., 2013).

2.3.3 Effect of Arbuscular Mycorrhizal on Growth and Nutrient Uptake of Seedlings under Flooding Stress

The leaf chlorophyll content of both mycorrhizal and non-mycorrhizal rice plants was significantly reduced when roots were subjected to flooding stress. Despite this, mycorrhizal plants had higher chlorophyll content in relation to non-mycorrhizal plants under flooding stress. In snap beans, two periodic short-term flooding events significantly reduced root length below that of non flooded plants. Mycorrhizae-treated plants had the greatest height, biomass and leaf area in relation to nonflooded plants

(Sah, *et al*., 2006).In rice, mycorrhizal colonization significantly contributedto uptake of P and K in flooded but not in non-flooded plants (Hajiboland *et al*., 2009). Under flooded conditions, Gao *et al*., (2007) reportedthat mycorrhizal inoculation increased Zn uptake.

2.4 Effect of Arbuscular Mycorrhizal Inoculation on Growth and Nutrient Uptake of Tropical Fruit Seedlings

2.4.1 Role of Arbuscular Mycorrhiza on Physical Growth of Plants

Mycorrhiza inoculation increased the plant height, stem diameter, leaf number, flag leafwidth, number of grains per plant, 100-seed weight and protein percent values of sweet corn in USA (Tas, 2014). Similar observations in corn were made by Qiao *et al*., (2011) in pigeon peas, Al-Karaki (2013) in sour oranges and Suri and Choudhary (2013) in soybeans.

In sweet basil (*Ocimum basilicum*) research in Iran, AMF inoculation significantly increased plant height, fresh and dry matter, oil content and oil yield as compared to non-inoculated plants. The shoot fresh weight was significantly increased by all three mycorrhiza fungi species, but only inoculation with G. *intraradices* and *G. fasciculatum* increased root dry weight. Additionally, oil composition, linalool and methyl chavicol content was improved by AMF inoculation (Zolfaghari *et al*., 2013). Likewise, Rasouli-Sadaghiani *et al*., (2010) showed that mycorrhizal basil plants had significantly higher shoot and root dry weight and plant height.

In linseed (*L. usitatissimum*) study in India, the fresh and dry weights of shoots and roots, the chlorophyll content and the root lengths were significantly increased after 120 days of *Glomus mosseae* and *Acaulospora laevis* inoculation (Neetu *et al*., 2012). Studies showed that cotton plant biomass increased significantly when the plants were inoculated with AM fungi (Sridevi & Ramakrishnan, 2010).

In a study in tea in India, Tomanr *et al*. (2012) reported that plants inoculated with AM fungi had increased caffeine and catechin content. Similarly, AM fungi-treated tea plants showed increased total polyphenols than non-inoculated plants. 31% and 100%

increase in amino acids and total protein content were observed in mycorrhizal plants over non-mycorrhizal control. Maximum increase in total polyphenols (15%) and caffeine content (34%) were found in mycorrhizal plants over non-mycorrhizal controls (Singh *et al*., 2010). Several fold increase in caffeine content in plants inoculated by AM fungal spores have been reported (Gogoi & Singh, 2011).

Plum trees inoculated by mycorrhizal fungi had greater trunk cross-sectional-area than the control (Świerczyński & Stachowiak, 2010). In *Schefflera* cuttings, using mycorrhizal fungi in the rooting substrate increased root initiation, number of rooted cuttings, total root length and number of roots per cutting compared to non-mycorrhizal controls (Fatemeh & Zaynab, 2014). Endomycorrhiza enhanced adventitious root formation and facilitated root initiation and root development of cuttings. Combination of mycorrhiza and auxins are reported to stimulate better root formation in difficult to root plant species. AMF increased the length and fresh weight of geranium roots (Nowak & Nowak, 2013).

Arbuscular mycorrhizal inoculation has been reported to improve the yield and quality of soybeans (Suri & Choudhary, 2013), chick peas (Yaseen *et al*., 2012), pigeon peas (Qiao *et al*., 2011), sour oranges (Al-Karaki, 2013), Jew's mallow (Nwangburuka *et al*., 2012), sunflower (Vaseghmanesh *et al*., 2014) and temulawak (Samanhudi *et al*, 2014).

2.4.2 Role of Arbuscular Mycorrhiza on Nutrient Uptake of seedlings

2.4.2.1 Role of arbuscular mycorrhiza in the Uptake of Phosphorus

Phosphorus is one of the most critical elements required for plant growth, making up about 0.2% of dry weight of plant tissues. Although in soil it may be present in relatively large quantities, it is one of the most difficult nutrients for plants to acquire (Smith & Smith, 2011). This is because a huge proportion of soil phosphorus is unavailable or poorly available because of the very low solubility of phosphates of iron, aluminum and calcium, leading to soil solution concentrations of 10 μm or less. Phosphorus has very low mobility (Schachtman *et al.*, 2008). Frequently, direct uptake of orthophosphate (Pi) by root epidermal cells through the direct pathway is not

matched by its replacement leading to the development of phosphorus depletion zones in the rhizosphere. The concentration of orthophosphate (Pi) ions is about 1,000-fold higher in root cells than in the soil solution, further compounding the challenge and making uptake more difficult (Bucher, 2007).

Plants have evolved strategies to increase either phosphorus uptake or availability in the soil. One of these strategies is the mycorrhizal uptake pathway. In this pathway, orthophosphate Pi is taken up into AM fungal hyphae by fungal transporters located several centimeters from the root. It is then translocated to intracellular fungal structures (arbuscules and hyphal coils) in root cortical cells containing specialized AM fungus-plant interfaces. Release of Pi and uptake by the host plant takes place in these interfaces. AM-inducible plant PiT genes, which are different from those in the direct pathway, are expressed, sometimes exclusively, in the colonized cortical cells. These PiT genes are involved in the uptake of Pi released by the fungi and have been shown to occur in all potentially AM plants investigated, regardless of their responsiveness to AM fungal colonization (Bucher, 2007).

The major advantage of the AM symbiosis for plants in acquiring P is that AM fungi provide a very effective pathway by which P is scavenged from large volumes of soil and rapidly delivered to cortical cells within the root (Smith & Smith, 2011). This is because individual fungal hyphae have much smaller diameters than roots, therefore allowing access to narrower soil pores and increasing the soil volume explored (Smith & Read, 2008; Schnepf *et al*., 2011). However, the extent to which an AM plant grows better than a nonmycorrhizal counterpart depends in part on the size of its root system, including numbers and extent of root hairs (Smith & Smith, 2011). Plants with low root-shoot biomass ratios, slow root growth rates, and/or poor development of root hairs show relatively larger growth increases with mycorrhizal inoculation (Smith & Read, 2008).

Inoculating soil with AM fungi and different levels of superphosphate improved P content in Linseed (*Linum usitatissimum*) roots and shoots (Neetu *et al*., 2012). A significant increase in shoot P concentration was observed when *L. usitatissimum* was inoculated with *G. mosseae* or *G. intraradices* and their combination (Rydlová *et al*.,

2011). Symbiosis between mycorrhizal fungi and *Zea mays* roots caused better phosphorous absorption by extending hyphae into the soils (Ghorbanian *et al.,* 2011).

In addition to increasing absorption surface in mycorrhizal root systems, mycorrhizal plants increased uptake of P from poorly soluble P sources, such as iron and aluminum phosphates and rock phosphate. Solubilization of soil P is achieved by rhizospheric modifications through the release of organic acids, phosphatase enzymes and some specialized metabolites like siderophores (Shenoy & Kalagudi, 2005).

Despite the advantages of AM on phosphorus acquisition, growth differences between mycorrhizal and nonmycorrhizal plants tend to disappear as available soil P in the soil increases (Smith & Read, 2008). Research in sunflower in Iran indicated that the highest seed yield, biological yield, seed hollowness and 1000-seed weight occured with application of 0 kg P/ha and mycorrhiza treatment. Treatment combinations of mycorrhiza and 200 kg P/ha and nonmycorrhizal 200 kg P/ha combination did not show significant difference in terms of seed yield of sunflower(Vaseghmanesh*et al*., 2014).

Very high P application alters root colonization (particularly reducing arbuscule development) and decrease AM fungal biomass per plant, including both biomass in roots and in soil (Smith & Read, 2008). Reduction in appressorium formation was reported in pea (*Pisum sativum*) roots at high P (Balzergue *et al*., 2011). High P levels in the soil can reduce spore germination and hyphal growth from the germinated spores and inhibit early colonization of the roots and growth of the extraradical mycelium (Smith & Smith, 2011). Similarly, Graham and Eissenstat (1998) reported that in high P fertility regime, mycorrhizae act as a carbon drain on citrus and therefore becoming parasitic to the host plant. The expression of genes encoding high-affinity Pi transporters (PiTs) in cells were reduced by high P supply (Smith & Smith, 2011).

2.4.2.2 Role of arbuscular mycorrhiza in the uptake of nitrogen

Like in the case of phosphorus, the major benefit of mycorrhiza in increasing uptake of N to plants is by availing greater soil exploration and supply to host roots (Sundar *et al*., 2010). Nitrogen uptake was significantly increased in mycorrhizal chickpea plants in Pakistan (Yaseen *et al*., 2012). However, there is information on the negative effects

of nitrogen fertilization on mycorrhizal formation. High level of nitrogen fertilization in wheat decreased spore numbers and colonization by mycorrhizal fungi (Smith & Read, 2008). Similarly, a study across North American grasslands showed that nitrogen fertilization reduces AM hyphal densities in phosphorus rich soil, but increases AM hyphal densities when phosphorus is in limited supply (Johnson *et al.*, 2010).

2.4.2.3 Role of arbuscular mycorrhiza in the uptake of Ca, K and Mg

Calcium and magnesium uptake were significantly increased in mycorrhizal chickpea plants (Yaseen *et al.*, 2012). This was attributed to greater soil exploration and increased uptake of K, Mg and Ca and supply to the host roots (Sundar *et al.*, 2010). Uptake of K was increased by AMF inoculation in cowpea and sorghum (Bagayoko *et al.*, 2000), decreased in millet (Bagayoko *et al.*, 2000) and was unchanged in barley (Mohammad *et al.*, 2003).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Sites

The study sites were in Jomo Kenyatta University of Agriculture and Technology (JKUAT), Juja in Kiambu County (1255 m asl, 1.03°S, 37.01°E) and University of Eldoret (UoE), Uasin Gishu County (2073 m asl, 0.5°N, 35.3E°).

3.2 Seed Germination

Passion fruit (*Passiflora edulis* var edulis (purple)), mango (*Mangifera indica* var kent), rough lemon (*Citrus jambhiri*) and papaya (*Carica papaya* var Mountain) seeds were germinated in sterile sand.Uniform seedlings were then selected and transferred to the holding media in 5 liter polythene pots (20 cm in diameter and 25 cm depth) and raised inside a polyethylene-covered greenhouse.

3.3 Mycorrhizal Inoculum Content

Plate 3.1: Inoculum substrate containing approximately 200 spores of arbuscular mycorrhiza fungi

At transplanting, seedlings were inoculated with 50g of AM inoculum containingapproximately 200 spores of a mixture of *Glomus caledonium, G. etunicatum, Gigaspora magarita* and *Scutellospora* sp(supplied by Dudutech, Naivasha, Kenya) (Plate 3.1).

3.4 Treatments and Experimental Design for Salinity Stress Experiment

The experiment was set up in sterilized low nutrient sand and red soil media (1:1 vol/vol) using passion fruit and mango seedlings. The passion fruit experiment was laid out in Completely Randomized Design consisting of treatment combinations of AM inoculation and un-inoculated, no salinity and salinity at two levels 4.9 and 9 dS/m respectively, (corresponding to 3 and 9 grams NaCl per litre of irrigation water, respectively) with four replications per treatment. In mangoes, the treatment combinations were AM inoculation and un-inoculated, no salinity and salinity at two levels 4.9 and 9 dS/m and two seed conditions (with endosperm and endosperm removed) with four replicates per treatment. The salinity effect was achieved by adding NaCl solution to the potting media starting 4 weeks after mycorrhizal inoculation. Three hundred mls of NaCl dissolved in water and made to the respective concentrations was applied weekly.The experiment was terminated and biomass harvested when severe symptoms of salt stress (> 50% burned leaf surface and/or leaf abscission) was observed.

3.5 Treatment and Experimental Design for Flooding Stress Experiment

The experiment was set up in sterile sand using passion fruit seedlings. The seedlings were raised in unflooded conditions for twelve weeks before flooding was initiated. The flooding experiment was set up as a Completely Randomized Design for flooding periods of 7, 14, 21 and 28 days, for both mycorrhizal and non mycorrhizal treatments using ten replicates per treatment. Mycorrhizal and non-mycorrhizal seedlings were also held in unflooded conditions for similar experiment period to act as the controls. The flooding experiment was set up by placing the potted seedlings in wide, non-perforated wooden structures supported by polythene to hold the water (Plate 3.2). Water was regularly piped into the structure so that the pots were covered by water to

about 2 cm above the surface. This water level was maintained throughout the flooding period.

3.6 Treatments and Experimental Design for Nutrient Stress Experiment

The experiment was set up in sterile sand using passion fruits, mangoes, avocado, lemons and papaya seedlings. The experiments were laid out as a Completely Randomized Design consisting of two kinds of AM inoculation (AM inoculated and un-inoculated) and four phosphorus concentrations (0, 0.44, 0.88 and 1.68 mg/ml) with six replicates per treatment. The plants were watered once a week with 300 mls of half strength Hoagland's nutrient solution (Millner and Kitt, 1992) modified to the respective P concentrations (Table 3-1).

Plate 3.2: Flooding initiated by placing the pots in wooden beds lined with polythene to hold water

An experiment was also laid out in low nutrient soil and sand media (1:1 vol/vol) consisting of two kinds of AM inoculation (AM inoculated and un-inoculated) and two media conditions (sterile and non-sterile) with six replicates per treatment (Table 3-2).

3.7 Plant Growth Measurements

Weekly measurements were taken on plant height and leaf number, starting two weeks after inoculation till termination of experiments (16 weeks for flooding and salinity and 20 weeks and 18-32 weeks for nutrient stress experiments). At seedling harvest, measurements were taken on leaf area, chlorophyll content and leaf, stem and root fresh and dry weights. The chlorophyll estimation was done by using only tender leaves using a leaf chlorophyll meter.

3.8 Nutrient Analysis Determinations

Table 3.1: Composition of the liquid fertilizer (Hoagland's nutrient solution) used in the experiments to study the effect of root-zone flooding and nutrient stress onmycorrhizal and non-mycorrhizal seedlings

Mineral element concentration (µM)	g/500 ml deionised water	Final
$Ca(NO_3)_2.4H_2O$	118.10	5000
KNO_3	50.55	5000
$MgSO_4$	124.24	2000
KH_2PO_4	6.81	20
NaFeEDTA	1.84	100
$Na_2MoO_4.2H_2O$	0.24	0.4
H_2BO_3	3.09	20
$NiSO_4.6H_2O$	0.26	0.4
$ZnSO_4.7H_2O$	1.44	1
$MnCl_2.4H_2O$	1.98	2
$CuSO_4.5H_2O$	0.62	1
$CoCl_2.6H_2O$	0.24	0.4

Oven-dried shoots were ground with a mortar and pestle and 1 gram from each seedling weighed and dry-ashed by heating for 5 hours at 550ºC in a muffle furnace. The ash was taken up in 20% HCl and the solution made up to 20 mls with distilled deionised water. Two hundred microliter aliquots from these solutions were further diluted to 10 mls before analyzing for Ca, Mg, Na and K by atomic absorption spectrophotometry. Phosphorus, as molybdate-reactive P was measured by blue colorimetry at 730 nm using a spectrophotometer. The nitrogen estimation was done by micro Kjeldahl method.

Table 3.2: Nutrient analysis results for soil: sand mixture

PARAMETER	METHOD	RESULT	UNITS
pH	pH meter	6.18	
Conductivity	EC meter	0.17	mmhos/cm
Organic Matter	ICARDA	2.21	%
Total N	Macro Kjeldahl	0.64	%
Phosphorus as P	UV-VIS Spectrometry	9.48	mg/kg
Sodium	Flame emission spectrometry	272.67	mg/kg
Potassium	Flame emission spectrometry	263.81	mg/kg
Calcium	Flame emission spectrometry	1179.48	mg/kg
Magnesium	UV-VIS Spectrometry	240.71	mg/kg
Aluminium	Flame emission spectrometry	943.54	mg/kg
Iron	Atomic Absorption Spectrometry	97.48	mg/kg
Manganese	UV-VIS Spectrometry	193.33	mg/kg
Copper	Atomic Absorption Spectrometry	5.13	mg/kg
Boron	Atomic Absorption Spectrometry	0.56	mg/kg
Zinc	Atomic Absorption Spectrometry	4.73	mg/kg
CEC	Calculated	9.81	me/100g
Ca:Mg	Calculated	4.9	

3.9 Evaluation of Mycorrhizal Root Infection Levels

At seedling harvest, root tips (1 ± 0.2 cm) were excised and cleared by autoclaving in 10% KOH followed by staining in 0.05% tryphan blue, glycerol and lactic acid (1:1:1)

solution. The frequency of mycorrhizal infection was noted per field (10 grids) for 10 fields, using the grid intersect method (Giovannetti and Mosse, 1980). To convert the data into percent infection, the frequency of infection as a fraction of the total number of grids observed was multiplied by 100.

3.10 Determination of the Soil Mycorrhizal Colonization

The isolation of AM fungal spores was carried out by the wet-sieving and decanting method of Gerdemann and Nicolson (1963). 25 g of soil were mixed with 500 ml of water in a beaker and stirred with a glass rod to make a uniform suspension. The suspension was left for five minutes to allow the mycorrhizal debris to float to the top. The suspension was then passed through different sieves (500, 300, 250, 125, 105 and 45 µ mesh sizes). This process was repeated 8-9 times to trap all spores of AM fungi. The population of AM fungi was then determined by the grid intersect method. A piece of paper was cut according to the diameter of the Petri dish and 1 cm^2 grids were made on it. The spores present per cm^2 were counted under compound microscope (100-1000X).

3.11 Determination of Chlorophyll and Carotenoids Content

The chlorophyll a and b were determined according to the methods of Arnon (1949) and carotenoids according to Davies (1976). The fresh leaves were cut to 0.5cm segments and extracted overnight in 80% acetone at -10°C. The extract was centrifuged at 14000 x *g* for 5 minutes and the absorbance of the supernatant was read at 480, 645 and 663 nm using a spectrophotometer. The chlorophyll a, b and the total chlorophyll and carotenoids were calculated using the formula below:

Chl a = [12.7 (OD 63 – 2.69 (od 645)] x V/1000 x W

Chl b = [22.9 (OD 645 – 4.68 (od 663)] x V/1000 x W

V = volume of the extract (mls)

W = weight of the fresh leaf tissue (grams)

Carotenoids $gml^{-1} = A^{car}/Em \times 100$

Where A^{car} = OD 480 + 0.14 (od 663) – 0.638 (OD 645)

$E^{100\%}cm = 2500$

3.12 Determination of Proline and Total Soluble Sugars:

Free proline and total solublesugars were extracted from 1 g of fresh roots and leaves (Blighand Dyer, 1959). Proline was estimated by spectrophotometricanalysis at 515 nm of the ninhydrin reaction, according to Bates*et al*. (1973). Soluble sugars were analyzed by 0.1 ml of thealcoholic extract reacting with 3 ml freshly prepared anthrone(200 mg anthrone + 100 ml 72% (w:w) H_2SO_4) and placed in a boilingwater bath for 10 min according to Irigoyen et al. (1992). Aftercooling, the absorbance at 620 nm was determined in a spectrophotometer. The calibration curve was made usingglucose in the range of 20–400 µg ml^{-1}.

3.13 Statistical analysis

The data obtained was subjected to Analysis of Variance using Genstat software. All treatment means were tested for Least Significant Difference (LSD) and the means separated by Duncan's Multiple Range (Little and Hills, 1978) at 95% and 99% level of significance.

CHAPTER FOUR

RESULTS

4.1 Effect of Arbuscular Mycorrhizal Fungi on Salt Stress of Passion Fruits and Mango Seedlings

The following are results of studies on the influence of AM fungi on salinity stress of passion fruits and mango seedlings. Results are presented on mycorrhizal root colonisation, plant height, leaf area, leaf number, chlorophyll content, fresh and dry weights and leaf macronutrient contents.

Table 4.1: Effect of arbuscular mycorrhizal fungi and salinity stress on mycorrhizal root colonisation, plant height, leaf number and chlorophyll content of passion fruit seedlings

TREATMENTS	Root colonisation %	Plant Height (cm)	Leaf No.	Leaf Area (cm^2)	Chlorophyll (%)
Mycorrhizal, 0 dS/m EC	52.6 ± 5.4	59.0a[z]	16.0a	642a	41.3a
Non-mycorrhizal, 0 dS/m EC	0.0	50.4b	15.5ab	534.7b	43.3a
Mycorrhizal, 4.9 dS/m EC	23± 3.1	47.8b	12.6c	464.3c	33.4b
Non-mycorrhizal, 4.9 dS/m EC	0.0	34.3c	14.2bc	323.2d	29.6b
Mycorrhizal, 9 dS/m EC	16 ± 1.6	23.5d	12.4c	235.7e	15.0c
Non-Mycorrhizal, 9 dS/m EC	0.0	24.2d	4.0d	90.5f	17.3c
GRAND MEAN		39.9	12.4	381.7	30.0
LSD ($p \leq 0.05$)		7.4	2.3	52.1	5.2
CV (%)		12.5	12.3	9.2	11.6

[z]Column values followed by different letters are significantly different at $p<0.05$ n=6)
KEY: dS/M = deciSiemens/metre, EC = Electrical Conductivity

4.1.1 Mycorrhizal Root Colonisation Levels

Mycorrhizal root colonisation occurred in only the inoculated treatments (Table 4.1, 4.3). The unstressed mycorrhizal seedlings recorded higher colonisation compared to salt stressed seedlings (Table 4.1, 4.3).

4.1.2 Plant Height (cm), Leaf Number, Leaf Area (cm^2) and Chlorophyll Content (%)

4.1.2.1 Passion Fruit Seedlings

In passion fruits, unstressed mycorrhizal plants (0 dS/M EC) had significantly higher plant height and leaf area compared to unstressed non-mycorrhizal plants (0 dS/M EC) (Table 4.1, Plate 4.1). However, there was no significant difference between the unstressed treatments in leaf number and chlorophyll content (Table 4.1). Unstressed mycorrhizal plants also had higher plant heights, leaf number, leaf area and chlorophyll content compared to non-mycorrhizal plants subjected to both 4.9 and 9.0 dS/M EC salt stress (Table 4.1,Plate 4.1). Unstressed mycorrhizal plants had significantly higher plant height, leaf area and chlorophyll content compared to mycorrhizal plants subjected to 4.9dS/M salt-stressed (Table 4.1, Plate 4.1). However, there was no significant difference between the two treatments in leaf number (Table 4.1). Unstressed mycorrhizal plants had significantly higher plant height, leaf number, leaf area and chlorophyll content compared to mycorrhizal plants subjected to 9.0 dS/M EC salt stress (Table 4.1). Mycorrhizal plants subjected to 4.9 dS/M EC salt stress had significantly higher plant height, leaf area and chlorophyll content compared to mycorrhizal plants subjected to 9 dS/M EC (Table 4.1). However, there was no significant difference between the two treatments in leaf number (Table 4.1) Mycorrhizal plants subjected to 4.9 dS/M EC salt stress had significantly higher plant height and leaf area compared to non-mycorrhizal plants subjected to the same salt stress treatment (Table 4.1). However, there was no significant difference in leaf number and chlorophyll content between both mycorrhizal and non-mycorrhizal plants subjected to 4.9 dS/M EC salt stress (Table 4.1). Mycorrhizal plants subjected to 4.9 dS/M EC salt stress had significantly higher plant height, leaf number, leaf area and

chlorophyll content than non-mycorrhizal plants subjected to 9 dS/M salt stress (Table 4.1). Mycorrhizal plants subjected to 9 dS/M EC salt stress had significantly higher leaf number and leaf area than non-mycorrhizal plants subjected to 9 dS/M salt stress (Table 4.1). However, there was no significant difference between the two treatments in plant height and chlorophyll content (Table 4.1). Unstressed, non- mycorrhizal plants had significantly higher leaf area and chlorophyll content than mycorrhizal plants subjected to 4.9 dS/M salt stress (Table 4.1). However, there was no significant difference between the two treatments in plant height and leaf number (Table 4.1). Unstressed, non-mycorrhizal plants also had significantly higher plant height, leaf number, leaf area and chlorophyll content than to mycorrhizal plants subjected to 9 dS/M salt stress, and also compared to non-mycorrhizal plants subjected to both 4.9 and 9 dS/M salt stress (Table 4.1).

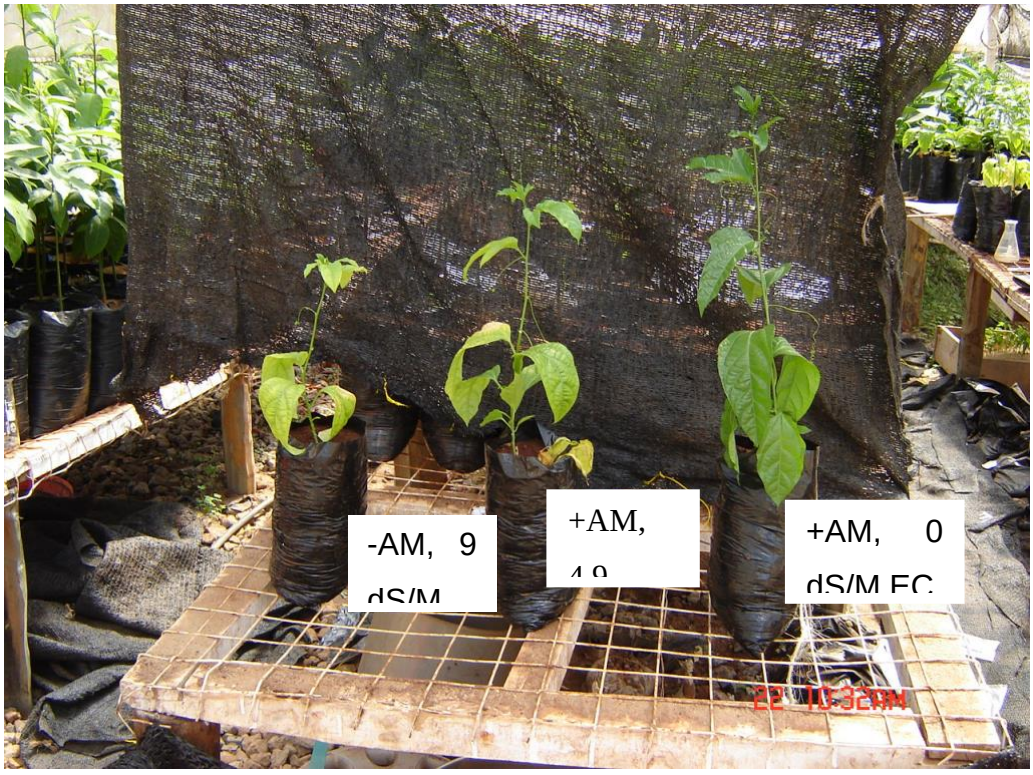


Plate 4.1: Effect of arbuscular mycorrhiza fungi and salt stress in passion fruit seedlings

KEY: dS/M = deciSiemens/metre, EC = Electrical Conductivity

4.1.2.2 Mango Seedlings

In mangoes, unstressed mycorrhizal seedlings containing an intact endosperm had significantly higher plant height, leaf number, leaf area and chlorophyll compared to both non-mycorrhizal seedlings that were not subjected to salt stress and those subjected to 4.9dS/M salt stress with and without the endosperm (Table 4.2, Plate 4.2). Similarly, unstressed mycorrhizal seedlings which had the endosperm removed had significantly higher plant height, leaf number, leaf area and chlorophyll compared to both non-mycorrhizal seedlings that were not subjected to salt stress and those subjected to 4.9 dS/M salt stress with or without the endosperm (Table 4.2).

Table 4.2: Effect of arbuscular mycorrhizal fungi, endosperm and salt stress on the plant height, leaf number, leaf chlorophyll and root colonisation of mango seedlings

	Plant Ht (cm)	Leaf No.	Leaf Area (cm^2)	Chloro phyll (%)	Root Colonisation %
Endosperm attached, mycorrhizal, 0 dS/M	36.4a[z]	14.7a	395a	51.5a	48.2 ± 3.4
Endosperm attached, mycorrhizal, 4.9 dS/M	23.7bc	10.0cd	252.8c	28.9d	31.2 ± 3.2
Endosperm attached, non-mycorrhizal, 0 dS/M	27.0b	11.8bc	304.8 b	43.1b	0.0
Endosperm attached, non-mycorrhizal 4.9	18.2d	6.3e	141e	26.4de	0.0
Endosperm removed, mycorrhizal, 0 dS/M	34.5a	12.8ab	407.4a	49.3ab	51.5 ± 2.3
Endosperm removed, mycorrhizal 4.9 dS/M	20.8cd	9.0d	230.5c d	30.5d	27.2 ± 4.7
Endosperm removed, non-mycorrhizal 0 dS/M	20.1cd	10.0cd	195.1 d	39.0c	0.0
Endosperm removed, non-mycorrhizal, 4.9	16.5d	5.7e	81.3f	20.3e	0.0
GRAND MEAN	24.9	10.0	249.0	36.1	
LSD($p \leq 0.05$)	5.4	2.0	51.1	6.9	
CV (%)	14.9	13.5	14.1	13.1	

[z]Column values followed by different letters are significantly different at $p<0.05$ n=6)

KEY: * = dS/M = deciSiemens/metre, EC = Electrical Conductivity

Under 4.9 dS/M salt stress, mycorrhizal mango seedlings containing an endosperm had significantly higher plant height, leaf number and leaf area compared to non-mycorrhizal seedlings subjected to 4.9dS/M salt stress with or without the endosperm, but there was no significant difference in leaf chlorophyll content between the two treatments (Table 4.2, Plate 4.2). Similarly, under 4.9dS/M salt stress, mycorrhizal seedlings without the endosperm had significantly higher leaf number, leaf area and chlorophyll compared to non-mycorrhizal seedlings without the endosperm subjected to 4.9dS/M salt stress, but there was no significant difference in plant height between the treatments (Table 4.2).Under both non salt-stress and 4.9dS/M salt stress, there was no significant difference in plant height, leaf number, leaf area and chlorophyll content between mycorrhizal plants with and without an endosperm attachment (Table 4.2, Plate 4.2).

Plate 4.2: Effect of arbuscular mycorrhizal fungi and salt stress on mango seedlings

KEY: * dS/M = deciSiemens/metre, EC = Electrical Conductivity

Under non salt-stress conditions, mycorrhizal seedlings that contained an endosperm and those without the endosperm had significantly higher plant height, leaf number, leaf area and chlorophyll than mycorrhizal seedlings with and without the endosperm subjected to 4.9 dS/M salt stress (Table 4.2). With endosperm attached, there was no significant difference in plant height and leaf number between mycorrhizal plants subjected to 4.9dS/M salt stress and unstressed, non-mycorrhizal plants (Table 4.2). However, the unstressed non-mycorrhizal plants had significantly higher leaf area and chlorophyll content than mycorrhizal plants subjected to 4.9dS/M salt stress when both had endosperms (Table 4.2).

4.1.3 Fresh and Dry Weights

Under salt stress, non-mycorrhizal seedlings with endosperm had significantly higher leaf number and leaf area than non-mycorrhizal seedlings without endosperm, although there was no significant differences in plant height and chlorophyll content between the two treatments (Table 4.2).

4.1.3.1 Fresh and dry weight of passion fruit seedlings

In passion fruits, AM inoculation increased the fresh and dry weights of the leaves, stems and roots compared to non-mycorrhizal seedlings under both non-salt stress and salt stress conditions (Table 4.3). Arbuscular Mycorrhizal inoculation increased the fresh and dry weights of the leaves, stems and roots under non-stress soil conditions compared to mycorrhizal seedlings subjected to 4.9dS/M and 9dS/M salt stress conditions (Table 4.3). Similarly, mycorrhizal seedlings subjected to 4.9dS/M salt stress had significantly higher fresh and dry weights compared to mycorrhizal seedlings subjected to 9dS/M salt stress (Table 4.3).

Table 4.3: Effect of arbuscular mycorrhizal fungi and saltstress on the fresh and dry weights (g) of passion fruit seedlings

TREATMENTS	Fresh weight (g)			Dry weight (g)		
	Leaves	Stem	Roots	Leaves	Stem	Roots
Mycorrhizal, 0 dS/m EC	13.6a[z]	5.4a	20.2a	3.4a	1.7a	6.4a
Non-mycorrhizal, 0 dS/m EC	10.9b	3.7b	16.8b	2.8b	1.1bc	2.2b
Mycorrhizal, 4.9 dS/m EC	10.5b	3.1bc	14.5b	2.3c	0.9cd	1.6c
Non-mycorrhizal, 4.9 dS/m	7.9c	2.5c	11.3d	1.4d	0.8d	1.0d
Mycorrhizal, 9 dS/m EC	3.7d	1.7d	5.7e	1.1d	0.5e	0.7d
Non-Mycorrhizal, 9 dS/m EC	2.2d	1.6d	5.2e	0.5f	0.3e	0.5d
GRAND MEAN	8.1	3.0	12.3	1.9	0.9	2.1
LSD($p \leq 0.05$)	2.0	0.6	2.7	0.4	0.2	0.5
CV (%)	16.4	14.5	14.5	13.7	18	15.9

[z]Column values followed by different letters are significantly different at $p<0.05$ n=6)

KEY: * = dS/M = deciSiemens/metre, EC = Electrical Conductivity

There was no significant difference in leaf, stem and root fresh weights, and stem dry weights between unstressed non-mycorrhizal seedlings, and mycorrhizal seedlings subjected to 4.9dS/M salt stress (Table 4.3). However, unstressed mycorrhizal seedlings had significantly greater leaf and root dry weights, compared to mycorrhizal seedlings subjected to 4.9dS/M salt stress (Table 4.3). Unstressed mycorrhizal seedlings had significantly greater fresh and dry weights compared to mycorrhizal seedlings subjected to 9 dS/M salt stress (Table 4.3). Mycorrhizal seedlings subjected to 4.9dS/M salt stress had greater fresh and dry weights compared to non-mycorrhizal seedlings subjected to 4.9dS/M and 9dS/M salt stress (Table 4.3). However, there was no significant difference between seedlings subjected to 9dS/M salt stress, whether mycorrhizal or non-mycorrhizal (Table 4.3).

4.1.3.2 Fresh and dry weight of mango seedlings

In mangoes, arbuscular mycorrhizal inoculation of seedlings containing or without an endosperm increased the leaf, stem and roots fresh and dry weights compared to non-mycorrhizal seedlings with or without an endosperm under both non-stress and salt-stress conditions (Table 4.4). Unstressed mycorrhizal seedlings containing and without the endosperm had significantly higher fresh and dry weights in relation to mycorrhizal seedlings subjected to 4.9dS/M salt stress (Table 4.4).There was no significant difference between unstressed mycorrhizal plants, whether they contained an endosperm or without the endosperm (Table 4.4). There was no significant difference between 4.9dS/M-salt-stressed mycorrhizal plants, whether they contained an endosperm or without the endosperm (Table 4.4).

Table 4.4: Effect of arbuscular mycorrhizal fungi, endosperm and salt stress on the fresh and dry weights (g) of mango seedlings

	Fresh weight (g)			Dry weight (g)	
	Leaves	Stems	Roots	Roots	Leaves
Endosperm attached, mycorrhizal, 0 dS/M EC	9.1a	4.4a	10.7a	3.8a	3.2a
Endosperm attached, mycorrhizal, 4.9 dS/M EC	5.7b	2.0b	6.6b	2.2b	1.7b
Endosperm attached, non- mycorrhizal, 0 dS/M	6.1b	2.3b	6.6b	2.5b	1.9b
Endosperm attached, non-mycorrhizal, 4.9 dS/M	2.7d	1.0c	5.2c	1.4d	0.6d
Endosperm removed, mycorrhizal, 0 dS/M EC	8.8a	4.1a	10.2a	3.6a	2.9a
Endosperm removed, mycorrhizal, 4.9 dS/M EC	5.5b	1.8b	6.2b	2.0bc	1.5bc
Endosperm removed, non-mycorrhizal, 0 dS/M	4.1c	1.1c	3.8d	1.5cd	0.9cd
Endosperm removed, non-mycorrhizal, 4.9 dS/M	1.3e	0.4d	2.8d	1.0d	0.6d
GRAND MEAN	5.2	2.0	6.1	2.1	1.6
LSD($p \leq 0.05$)	0.6	0.5	1.1	0.5	0.6
CV (%)	16.1	16.5	11.8	14.6	24.6

[z]Column values followed by different letters are significantly different at $p<0.05$ n=6)

KEY: * = dS/M = deciSiemens/metre, EC = Electrical Conductivity

There was no significant difference in fresh and dry weights between unstressed non-mycorrhizal plants and mycorrhizal plants containing or lacking an endosperm, but

subjected to 4.9dS/M salt stress (Table 4.4). However, under 4.9dS/M salt stress, mycorrhizal plants had significantly higher fresh and dry weights compared to unstressed non-mycorrhizal that lacked the endosperm (Table 4.4). Under salt stress, mycorrhizal seedlings had significantly higher fresh and dry weights compared to non-mycorrhizal seedlings, where both either contained or lacked the endosperm (Table 4.4).

Under unstressed conditions, non-mycorrhizal seedlings containing an endosperm had significantly higher fresh and dry weights compared to unstressed non-mycorrhizal seedlings lacking an endosperm (Table 4.4).Under salt-stress, non-mycorrhizal seedlings with an endosperm had significantly higher stem and root fresh weights and root dry weights compared to non-mycorrhizal seedlings without an endosperm, but there was no significant difference in leaf fresh and dry weights between the two treatments (Table 4.4).

4.1.4 Leaf Nutrient Results

4.1.4.1 Leaf Nutrient of Passion FruitSeedlings

In mycorrhizal passion fruit seedlings, increase in salinity caused an increase in the levels of Na and K, caused a reduction in the levels of Mg but did not affect the levels of N, P and Ca (Table 4.5). There was no significant difference in the levels of N, P, Ca and Mg between unstressed mycorrhizal plants and mycorrhizal plants subjected to 4.9dS/M salt stress (Table 4.5). There was no significant difference in the N, P and Ca content between unstressed mycorrhizal seedlings and seedlings subjected to 9dS/M salt stress ((Table 4.5). However, 9dS/M salt stressed mycorrhizal seedlings had significantly higher K and Na content than unstressed mycorrhizal seedlings although it had lower Mg content (Table 4.5). There was no significant difference in the N, P, K and Ca content between mycorrhizal plants subjected to 4.9dS/M salt stress than those subjected to 9dS/M salt stress (Table 4.5). However, mycorrhizal plants subjected to 4.9dS/M salt stress had increased Magnesium content while those subjected to 9dS/M had significantly higher sodium content (Table 4.5). In non-mycorrhizal seedlings, there was no significant difference in N, P, Ca and Mg between unstressed seedlings

than seedlings subjected to 4.9dS/M salt stress (Table 4.5). However, unstressed seedlings had higher K content, while seedlings subjected to 4.9dS/M had higher Na content (Table 4.5). There was no significant difference in N and Ca content between unstressed non-mycorrhizal seedlings and those subjected to 9 dS/M salt stress (Table 4.5). However, unstressed seedlings had significantly higher P, K and Mg content, while seedlings subjected to 9dS/M salt stress had significantly higher Na content (Table 4.5). There was no significant difference in N, P, K, Ca and Na content between non-mycorrhizal plants subjected to 4.9dS/M salt stress than non-mycorrhizal plants subjected to 9dS/M salt stress (Table 4.5). However, non-mycorrhizal seedlings subjected to 4.9dS/M salt stress had significantly higher Mg content than non-mycorrhizal plants subjected to 9dS/M salt stress (Table 4.5).

Table 4.5: Effect of arbuscular mycorrhizal fungi and salt stress on the leaf nutrient content of passion fruit seedlings

	N	P	K	Ca	Mg	Na
Non-mycorrhizal, 0 dS/m EC	5.7a[z]	0.5b	8.4b	2.3a	4.8ab	2d
Non-mycorrhizal, 4.9 dS/m EC	5.0a	0.3bc	4.8c	2.5a	4.3b	8.7ab
Non-Mycorrhizal, 9 dS/m EC	5.2a	0.2c	3.7c	2.3a	3.1c	9.9a
Mycorrhizal, 0 dS/m EC	5.5a	0.9a	8.5b	2.2a	5.1a	2.2d
Mycorrhizal, 4.9 dS/m EC	5.1a	1.1a	12.8a	2.6a	4.4ab	5.2c
Mycorrhizal, 9 dS/m EC	5.2a	1.1a	14.7a	2.7a	3.4c	8.4b
GRAND MEAN	5.3	0.7	8.8	2.4	4.2	6.1
LSD($p \leq 0.05$)	0.8	0.2	2.4	0.7	0.7	1.4
CV (%)	10.3	23.4	18.7	19.9	11.7	15.4

[z]Column values followed by different letters are significantly different at $p<0.05$ n=6)

Under non-stress conditions, mycorrhizal seedlings had significantly higher P content than non-mycorrhizal seedlings, while there was no significant difference between the two treatments in N, K, Ca, Mg and Na levels (Table 4.5). There was no significant difference in N and Ca content between unstressed, mycorrhizal seedlings and non-mycorrhizal seedlings subjected to 4.9dS/M and 9dS/M salt stress (Table 4.5). Unstressed, mycorrhizal seedlings had significantly higher P, K and Mg content, while non-mycorrhizal seedlings subjected to 4.9dS/M and 9 dS/M salt stress had

significantly higher Na content (Table 4.5). Mycorrhizal seedlings subjected to 4.9dS/M salt stress had significantly higher P, K and Na content than unstressed, non-mycorrhizal seedlings (Table 4.5). However, there was no significant difference in N, Ca and Mg between the two treatments (Table 4.5). Mycorrhizal seedlings subjected to 9dS/M had significantly higher P, K and Na, lower Mg content but no significant difference in N and Ca content than unstressed, non-mycorrhizal treatment (Table 4.5). Mycorrhizal seedlings subjected to 9dS/M salt stress had significantly higher P and K content, and lower Mg content than non-mycorrhizal seedlings subjected to 4.9dS/M salt stress (Table 4.5). However, there were no significant differences between the two treatments in N, Ca and Na content (Table 4.5). Similarly, Mycorrhizal seedlings subjected to 9dS/M salt stress had significantly higher P and K content than non-mycorrhizal seedlings subjected to 9dS/M salt stress (Table 4.5). However, there were no significant differences between the two treatments in N, Ca, Mg and Na content (Table 4.5).

4.1.4.2 Leaf Nutrient Content of Mango Seedlings

In mangoes, there was no significant difference in N, P, K, Ca, Mg and Na levels between unstressed mycorrhizal plants with an endosperm than unstressed mycorrhizal plants without the endosperm attachment (Table 4.6). There was no significant difference in all the nutrients between mycorrhizal plants subjected to 4.9dS/M salt stress and containing the endosperm, and mycorrhizal plants subjected to 4.9 dS/M salt stress, but without the endosperm (Table 4.6).Unstressed mycorrhizal plants containing an endosperm had significantly higher P content compared to unstressed non-mycorrhizal plants that contained an endosperm (Table 4.6). However, there were no significant differences in the levels of N, K, Ca, Mg and Na between the two treatments (Table 4.6).

Table 4.6: Effect of arbuscular mycorrhizal fungi, endosperm and salt stress on the leaf nutrient content of mango seedlings

	N	P	K	Ca	Mg	Na
Endosperm attached, mycorrhizal, 0 dS/M EC	4.2a[z]	0.6a	4.7b	1.5a	3.4ab	1.2c

Endosperm attached, mycorrhizal, 4.9 dS/M EC	3.9a	0.8a	9.2a	1.6a	2.8bc	3.4b
Endosperm attached non-mycorrhizal 0 dS/M EC	3.9a	0.4 b	4.9b	1.5a	2.9bc	1.2c
Endosperm attached, non-mycorrhizal, 4.9 dS/M EC	3.5a	0.2 b	2.8c	1.5a	2.3cd	5.4a
Endosperm removed, mycorrhizal, 0 dS/M EC	4.1a	0.6a	4.6b	1.6a	3.5a	1.2b
Endosperm removed, mycorrhizal, 4.9 dS/M EC	4.0a	0.7a	8.9a	1.7a	2.9bc	3.3b
Endosperm removed, non-mycorrhizal, 0 dS/M EC	3.3a	0.3 b	4.8b	1.5a	2.7cd	1.2c
Endosperm removed, non-mycorrhizal, 4.9 dS/M EC	3.0a	0.3 b	2.5c	1.4a	2.1d	5.8a
GRAND MEAN	2.7	0.5	5.3	1.5	2.8	2.8
LSD($p \leq 0.05$)	0.6	0.2	1.3	0.4	0.6	0.6
CV (%)	9.7	23.9	17.0	15.6	14.8	15.4

[z]Column values followed by different letters are significantly different at $p<0.05$ n=6)

KEY: * = dS/M = deciSiemens/metre, EC = Electrical Conductivity

Compared to unstressed non mycorrhizal seedlings that did not have an endosperm, unstressed mycorrhizal plants had significantly higher N, P and Mg, while there was no significant difference between the two treatments in K, Ca and Na (Table 4.6). Mycorrhizal plants subjected to 4.9dS/M salt stress with or without endosperm had significantly higher K and Na levels than unstressed mycorrhizal plants (Table 4.6). However, there was no significant difference between the two treatments in N, P, Ca and Mg content (Table 4.6). Unstressed mycorrhizal plants had significantly higher N, P, K, Ca and Mg than non-mycorrhizal plants subjected to 4.9dS/M salt stress, whether with or without endosperm (Table 4.6). Mycorrhizal plants subjected to 4.9dS/M salt stress with and without endosperm had significantly higher P, K and Na than unstressed non-mycorrhizal plants containing an endosperm (Table 4.6). However, there were no significant differences between the treatments in N, Ca and Mg content (Table 4.6).Mycorrhizal plants subjected to 4.9dS/M salt stress with and without endosperm had significantly higher N, P, K and Na than unstressed non-mycorrhizal plants containing an endosperm (Table 4.6). However, there were no significant differences between the treatments in Ca and Mg content (Table 4.6).Mycorrhizal plants subjected to 4.9dS/M salt stress with and without endosperm had significantly higher N, P and K compared to non-mycorrhizal plants subjected to similar salt stress, with or without an

endosperm but had significantly lower Na content (Table 4.6). However, there were no significant differences between the treatments in Ca and Mg content (Table 4.6).

4.2 Results of Effects of Arbuscular Mycorrhizal Fungi on Flooding Stress of Passion Fruit Seedlings

The following are results of studies on the influence of AM fungi on flooding stress of passion fruits seedlings. Results are presented on mycorrhizal root colonisation, plant height, leaf area, leaf number, fresh and dry weights, proline, soluble sugars, chlorophyll and carotenoid content and leaf macronutrient contents.

4.2.1 Effect on Plant Height

There was a significant increase in plant height in mycorrhizal treatments starting from the 8th week (Figureure 4.1, Plate 4.3, 4.4, 4.5). During the flooding period, plant growth (as measured by increase in height) ceased in both mycorrhizal and non-mycorrhizal seedlings, but growth continued in the unflooded controls (Figureure. 4.1, Plate 4.3, 4.4, 4.5).

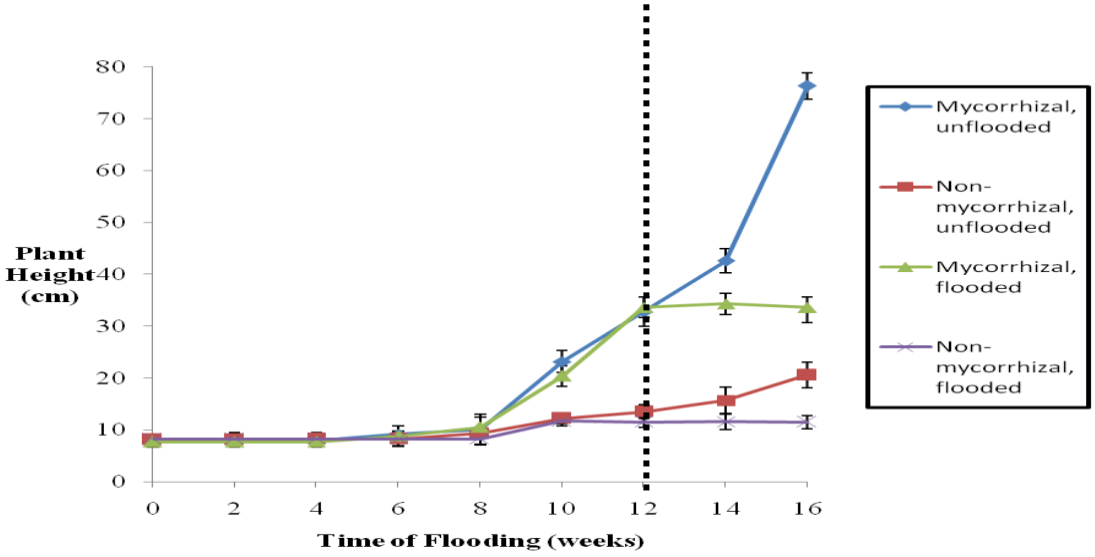


Figure 4.1: Effect of arbuscular mycorrhiza fungi and flooding stress on plant height (cm) of passion fruit seedlings

*** Dotted line shows time when flooding was initiated**

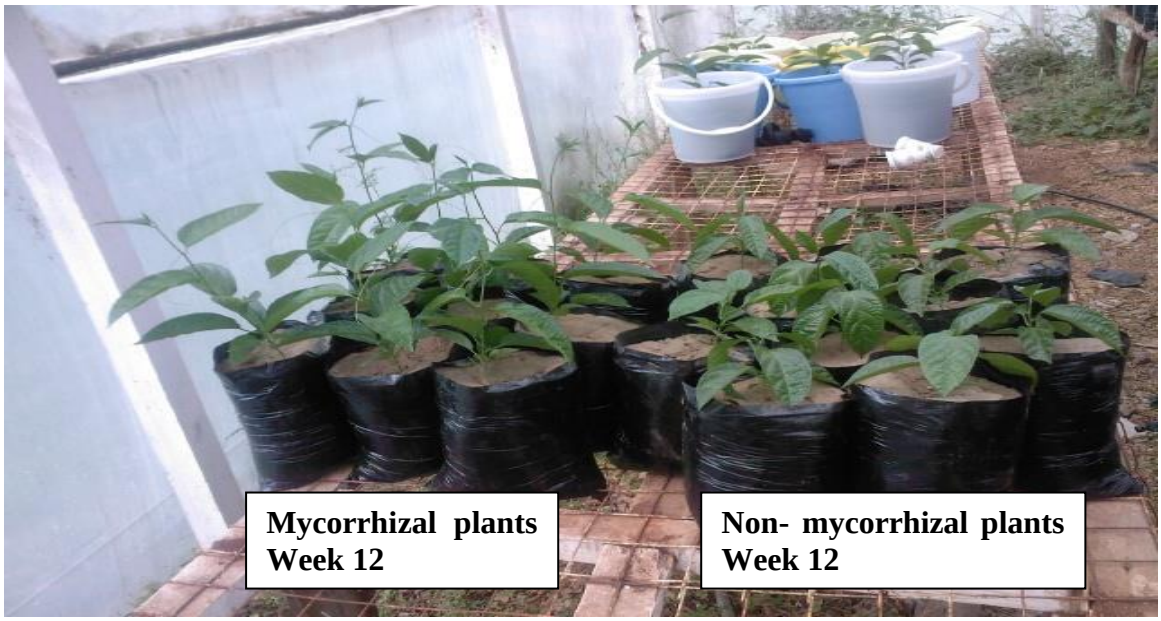


Plate 4.3: Passion fruit seedlings at the start of the flooding period (12th week). Mycorrhizal seedlings were significantly taller than non-mycorrhizal plants

4.2.2 Leaf Number

Passion fruit treatments that were not subjected to flooding continued to increase in leaf number while the flooded seedlings experienced a decrease over the flooding period (Table 4.7, 4.8, Figure 4.2).The leaf numbers of flooded mycorrhizal and non mycorrhizal seedlings were significantly reduced after day 14 of flooding compared to the leaf number of unflooded mycorrhizal seedlings (Table 4.7, Figure 4.2). Under flooding, there was a reduction in the leaf number, starting from the 14th day in non-mycorrhizal seedlings, while mycorrhizal treatments showed a reduction in the leaf number from the 21st day of flooding (Table 4.7, Figure 4.2). Mycorrhizal seedlings

had significantly higher leaf number compared to non-mycorrhizal seedlings from the 14th day of flooding (Table 4.7, Figure 4.2).

Table 4.7: Effect of arbuscular mycorrhiza fungi and flooding stress on the leaf number ofpassion fruit seedlings

	Days of flooding				
Treatments	Day 0	Day 7	Day 14	Day 21	Day 28
Mycorrhizal, unflooded	14.8a[z]	14.8a	15.2a	15.8a	16.3a
Non-Mycorrhiza unflooded	12.8a	12.8a	13.4a	13.3a	13.7b
Mycorrhizal, flooded	14.6a	14.6a	13.8a	8.5b	5.7c
Non-Mycorrhizal, flooded	13.2a	13.2a	8.2b	2.7c	1.2d
GRAND MEAN	13.9	13.8	12.2	10.1	9.2
LSD($p \leq 0.05$)	5.2	2.9	2.9	2.2	2.4
CV (%)	24.3	13.5	15.3	14.3	20.5

[z]Column values followed by different letters are significantly different at $p<0.05$ n=6)

4.2.3 Leaf Area

At the start of the flooding experiment, mycorrhizal plants had higher leaf area than non-mycorrhizal plants (Table 4.8, Plate 4.6). Unflooded mycorrhizal plants had significantly higher leaf area throughout the experiment period than non-mycorrhizal plants that were either subjected to flooding or not subjected to flooding (Table 4.8, Plate 4.6). Comparison of mycorrhizal plants subjected to flooding and those held unflooded show that those subjected to flooding had reduced leaf area from the 21st day of flooding (Table 4.8). When non-mycorrhizal plants are compared, the unflooded seedlings had significantly higher leaf area from the 14th day, compared to the seedlings subjected to flooding (Table 4.8).

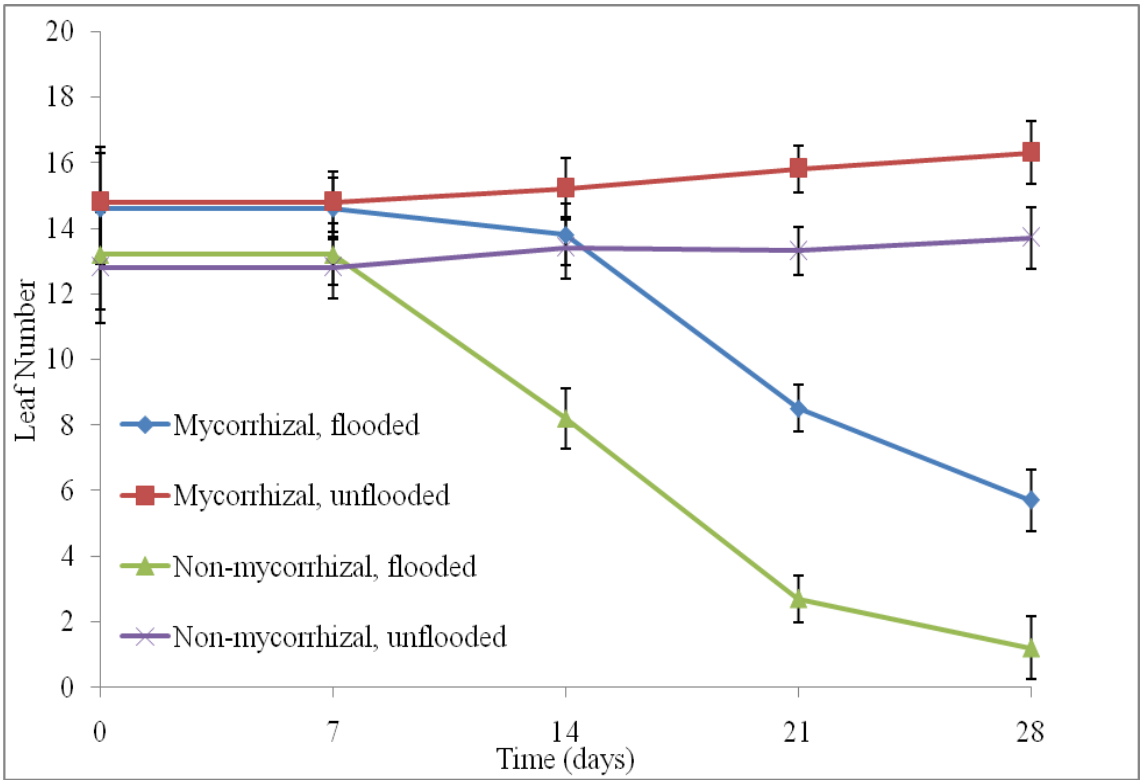


Figure 4.2: Effect of arbuscular mycorrhizafungi and flooding stress on the leaf number of passion fruit seedlings

Table 4.8: Effect of arbuscular mycorrhiza fungi and flooding stress on the leaf area (cm^2) of passion fruit seedlings

	Days of flooding				
Treatments	Day 0	Day 7	Day 14	Day 21	Day 28
Mycorrhizal, flooded	468.5a[z]	456.1a	413.5a	237.1c	178.6c
Mycorrhizal, unflooded	447.4a	453.5a	473.7a	498.8a	508.3a
Non-Mycorrhizal, flooded	232.1b	227.1b	172.9c	57.9d	39.6d
Non-Mycorrhiza unflooded	221.7b	237.5b	263.6b	318.6b	335.4b
GRAND MEAN	342.4	343.6	330.9	278.1	265.5
LSD($p \leq 0.05$) (%)	62.2	59.3	61.6	59.9	66.5
CV	11.8	11.2	12.1	14.0	16.3

[z]Column values followed by different letters are significantly different at $p<0.05$ n=6)

Plate 4.4: Mycorrhiza Plant Growth under Flooding and Non Flooding Stress Controls

Plate 4.5: Non-mycorrhizal plant growth under flooding and non flooding stress

4.2.4 Fresh weight

The leaf and root fresh weights increased in unflooded treatments but decreased in flooded treatments (Figure. 4.3, 4.4). Unflooded mycorrhizal seedlings had significantly higher leaf and root fresh weights than both unflooded and flooded non-mycorrhizal seedlings (Figure. 4.3, 4.4). The root and leaf fresh weights were significantly higher in unflooded mycorrhizal treatment than mycorrhizal seedlings subjected to flooding from the 21st day of flooding (Figure. 4.3, 4.4, Plate 4.7).From the start of flooding till the 14th day, flooded mycorrhizal seedlings had significantly higher leaf and root fresh weights than unflooded non-mycorrhizal seedlings (Figure. 4.3, 4.4). However, there was no significant difference in leaf and root fresh weight between the two treatments on the 21st (Figure. 4.3, 4.4). On the 28th day of flooding, flooded mycorrhizal seedlings had significantly higher leaf and root fresh weights than unflooded non-mycorrhizal seedlings (Figure. 4.3, 4.4). Flooded non-mycorrhizal seedlings had the lowest leaf and root fresh weights (Figure. 4.3, 4.4).

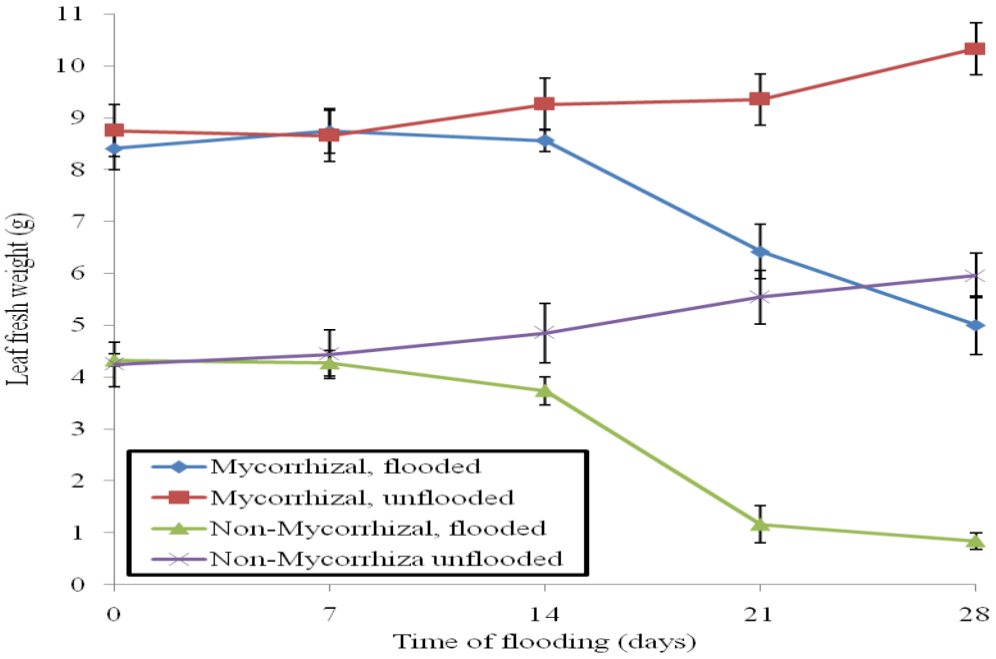


Figure 4.3: Effect of arbuscular mycorrhiza fungi and flooding stress on the leaf fresh weight of passion fruit seedlings

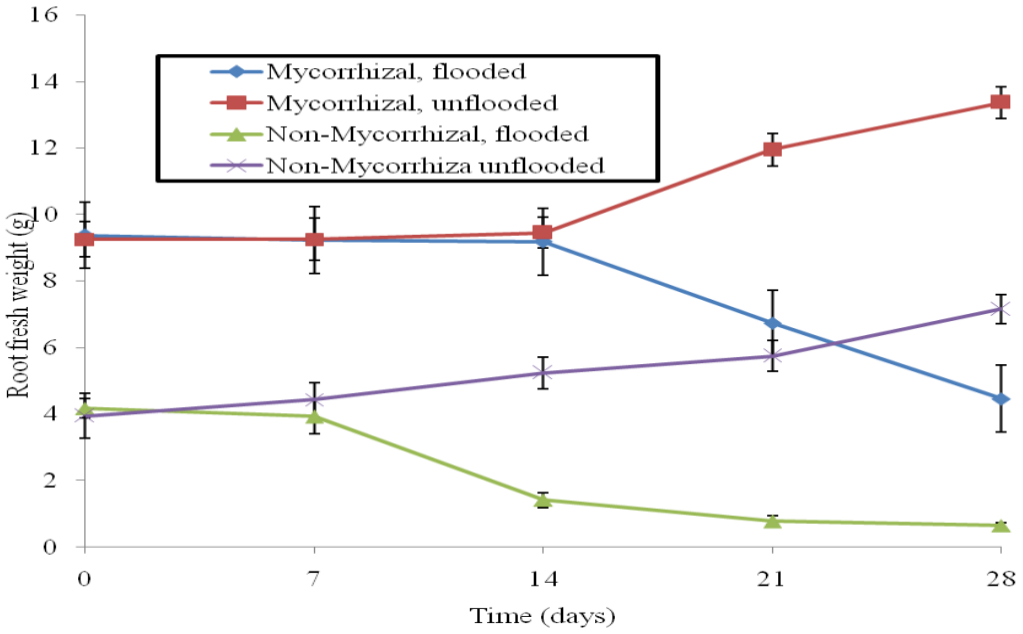


Figure 4.4: Effect of arbuscular mycorrhiza fungi and flooding stress on the root fresh weight (g) of passion fruit seedlings

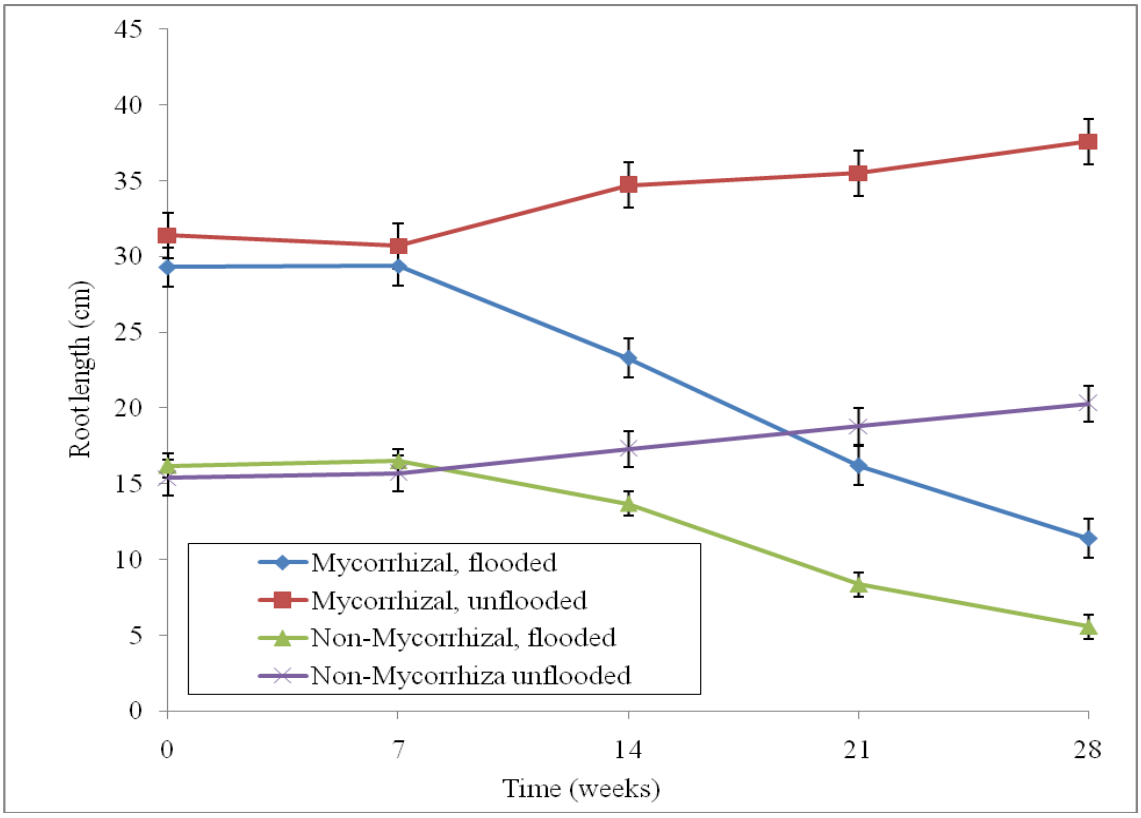


Figure 4.5: Effect of arbuscular mycorrhiza fungi and flooding stress on the root length (cm) of passion fruit seedlings

4.2.5 Root Length

Root length increased under unflooded conditions but decreased from the 7th day in flooded treatments (Figure. 4.5). Mycorrhizal plants had significantly longer roots than non-mycorrhizal plants under both flooded and unflooded conditions (Figure. 4.5).

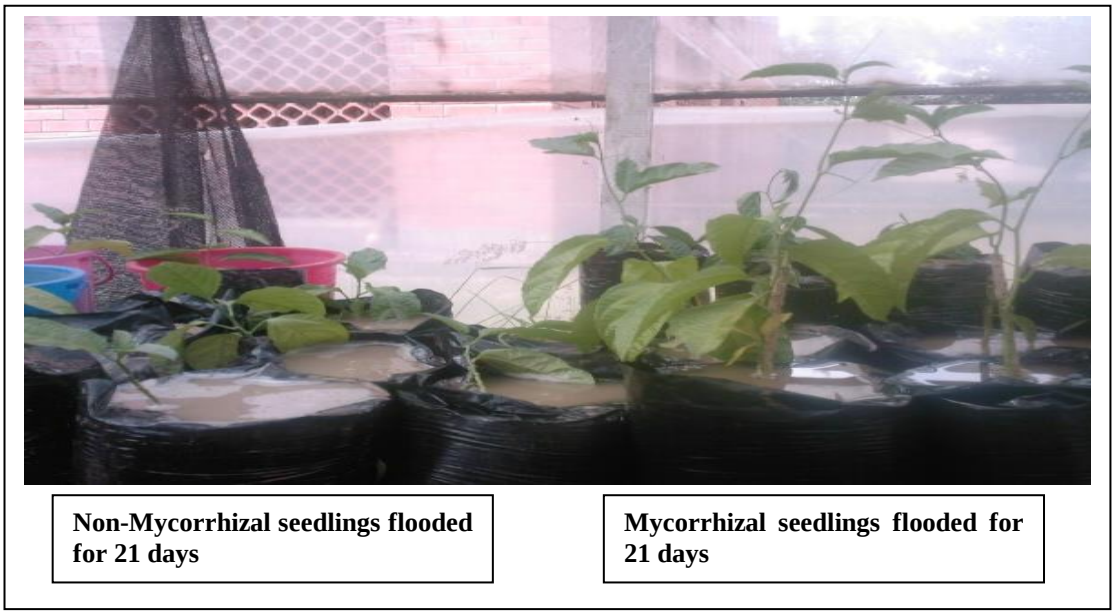


Plate 4.6: Mycorrhizal and non-mycorrhizal treatments after 21 days offlooding

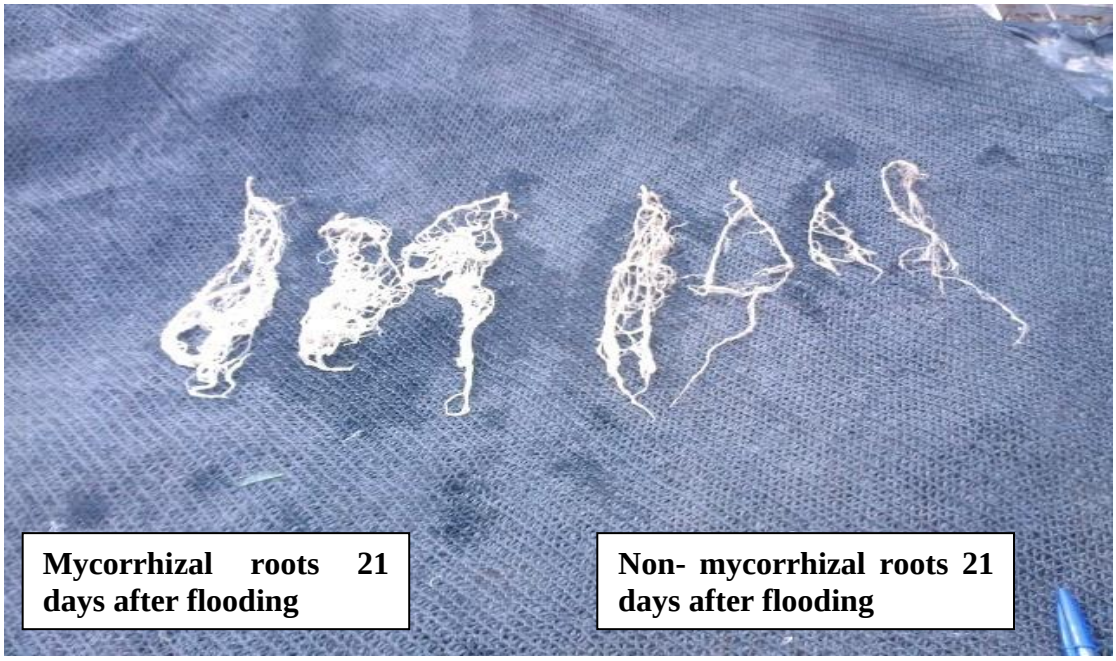


Plate 4.7: Lateral root loss in non-mycorrhizal seedlings after 21 days of flooding

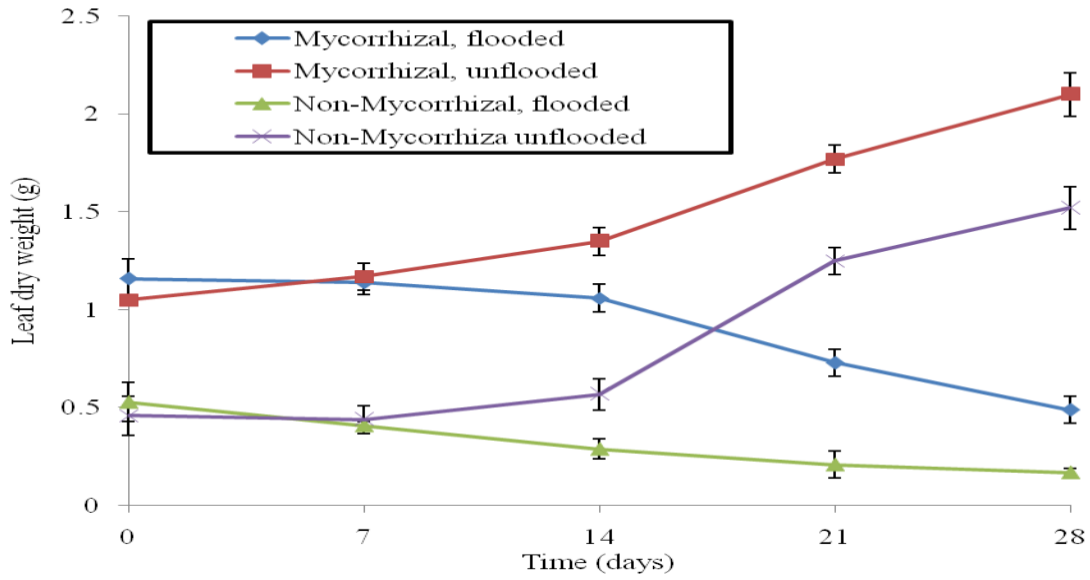


Figure 4.6: Effect of arbuscular mycorrhiza fungi and flooding stress on the leaf dry weight (g) of passion fruit seedlings

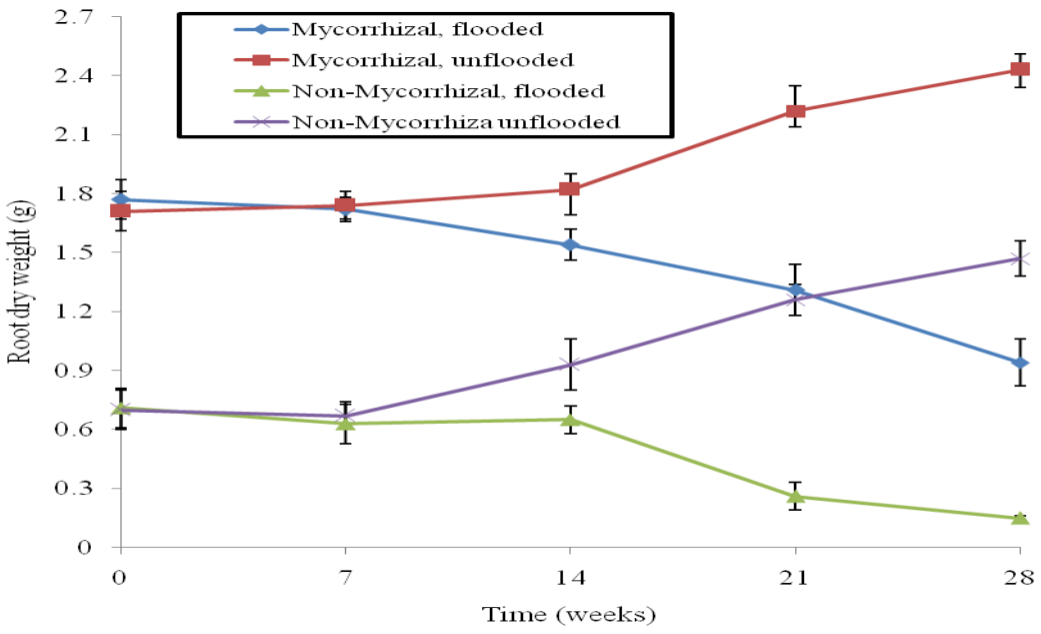


Figure 4.7: Effect of arbuscular mycorrhiza fungi and flooding stress on the root dry weight (g) of passion fruit seedlings

4.2.6 Dry Weight

At the start of the flooding experiment, mycorrhizal seedlings had higher root and leaf dry weights (Figure. 4.6, 4.7). The dry weights were unchanged for 14 days but increased in unflooded treatments while reducing in flooded treatments (Figure. 4.6, 4.7). Mycorrhizal treatments had significantly higher dry weights under flooding, than non-mycorrhizal seedlings under flooding (Figure. 4.6, 4.7).

4.2.7 Proline Concentration

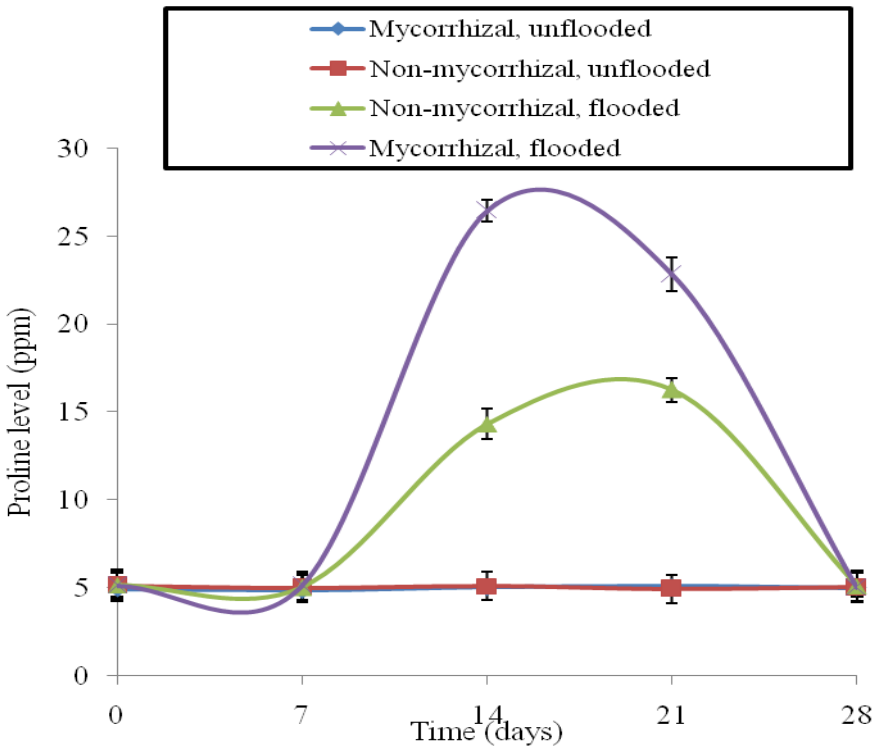


Figure 4.8: Effect of arbuscular mycorrhiza fungi and flooding stress on the proline level (ppm) of passion fruit seedlings

The proline concentration was low at the start of flooding and remained constantly low in unflooded treatments (Figure. 4.8). It increased in flooded treatments from the 7th day, but decreased to the unflooded levels by the 28th day (Figure. 4.8). The highest proline concentration was achieved by flooded, mycorrhizal seedlings (Figure. 4.8). The proline concentration peaked in flooded mycorrhizal seedlings just after the 14th

day, while in flooded non-mycorrhizal seedlings, the peak occurred just before the 21st day (Figure. 4.8).

4.2.8 Chlorophyll and Carotenoids content

The total chlorophyll and the chlorophyll a and b content were similar at the start of flooding for all treatments (Figure. 4.9, 4.10). The chlorophyll content remained unchanged in unflooded treatments but declined under flooding (Figure. 4.9, 4.10). The total chlorophyll, Chlorophyll a and b levels were significantly lower under 7, 14 and 21 days of flooding in non-mycorrhizal treatments compared to flooded mycorrhizal treatments but by the 28th day, there was no significant difference in the levels between the two treatments (Figure. 4.9, 4.10).

Fig. 4-8 Effect of AM fungi and flooding on the Chlorophyll a,b of passion fruit seedlings

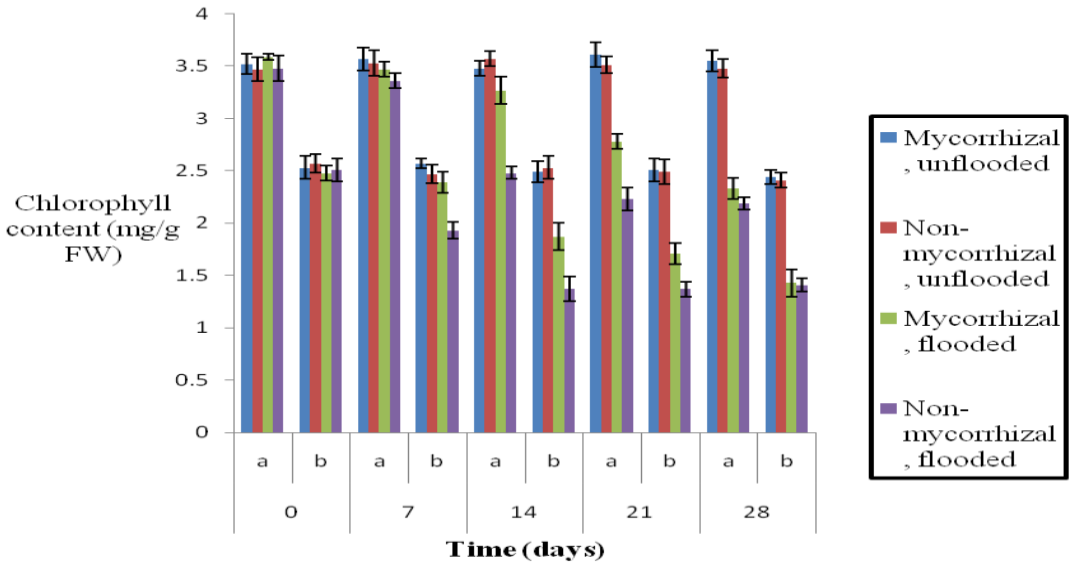


Figure 4.9: Effect of arbuscular mycorrhiza fungi and flooding on the chlorophyll a, b of passion fruit seedlings

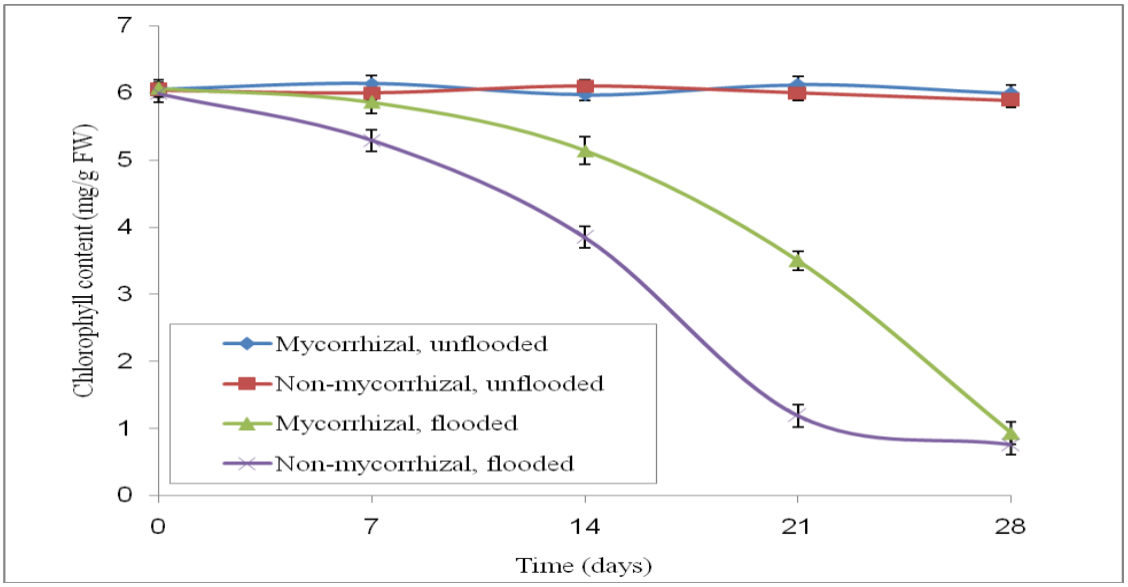


Figure 4.10: Effect of arbuscular mycorrhiza fungi and flooding on the total chlorophyll of passion fruit seedlings

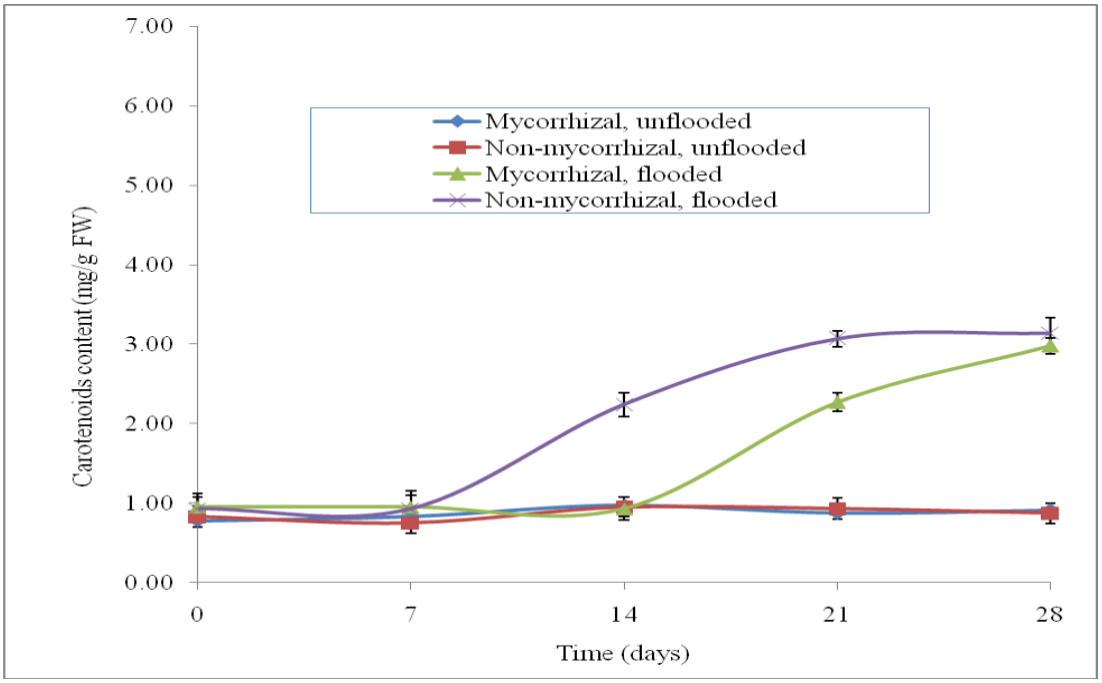


Figure 4.11: Effect of arbuscular mycorrhiza fungi and flooding on the carotenoids content of passion fruit seedlings

The unflooded treatments maintained low carotenoids content while the levels increased under flooding (Figure. 4.11). Under 14 and 21 day of flooding, the carotenoid level was significantly higher in non-mycorrhizal seedlings compared to mycorrhizal seedlings but the levels were similar after 28 days of flooding (Figure. 4.11).

4.2.9 Mycorrhizal Root Colonization

Mycorrhizal root colonization remained constant under unflooded conditions (Table 4.17). Under flooding, the colonization declined after the 14th day, but was not completely inhibited (Table 4.9).

Table 4.9: Effect of arbuscular mycorrhiza fungi and flooding on the mycorrhizal colonization of the roots of passionfruit seedlings

Treatments	Mycorrhizal colonization/ Days of Flooding				
	0	**7**	**14**	**21**	**28**
Mycorrhizal, unflooded	32.7±2.2	31.2±3.3	34.2±4.1	33.8±5.4	35.1±3.9
Non-mycorrhizal, unflooded	0	0	0	0	0
Mycorrhizal, flooded	34.1±4.3	32±4.4	32.5±4.4	13.7±4.4	14.6±5.3
Non-mycorrhizal, flooded	0	0	0	0	0

4.2.10 Soluble Sugar Content

The leaf and root soluble sugar content remained constant in unflooded treatments (Figure. 4.12 and 4.13). Under flooding, the total soluble sugars increased sharply and then dropped to the control levels (Figure. 4.12 and 4.13).

4.2.11 Leaf Nitrogen Content

Unflooded treatments constantly retained high leaf N content in the course of the flooding period while flooded treatments had reduced N rate starting after the 7th day in both non-mycorrhizal and 14th day in mycorrhizal treatments (Figure.4.14). Flooded mycorrhizal treatments had significantly higher N on the 7th, 14th and 21st day of flooding than flooded non-mycorrhizal seedlings (Figure.4.14).

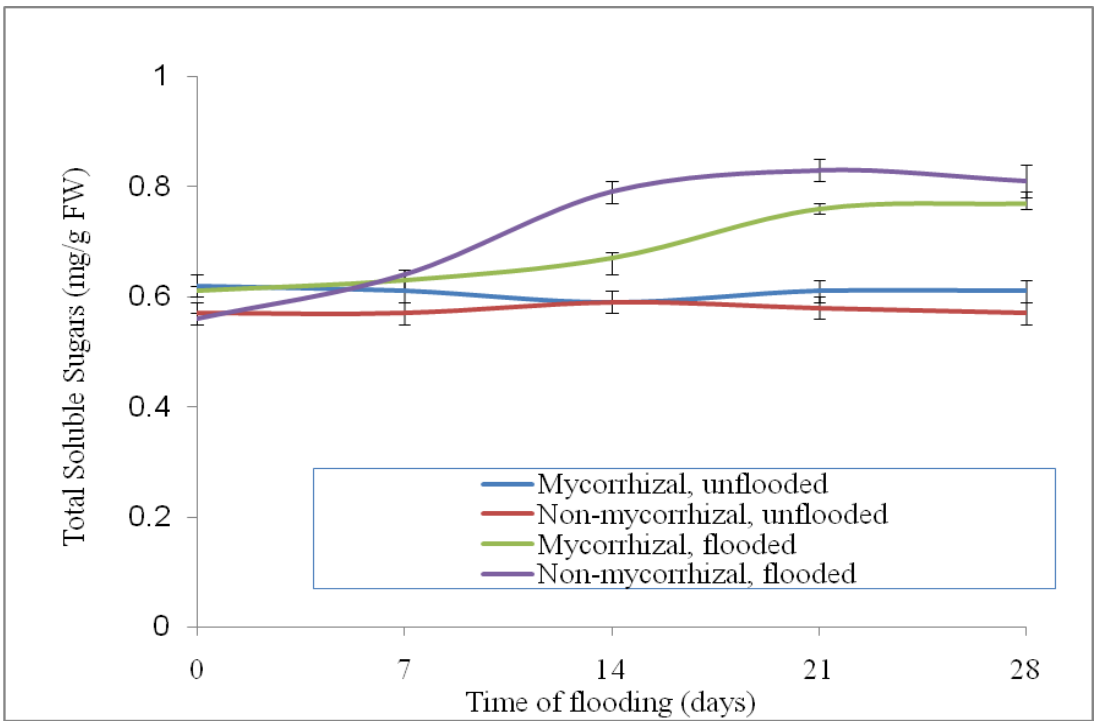


Figure 4.12: Effect of arbuscular mycorrhiza fungi and flooding stress on total soluble sugars of passion fruit leaves

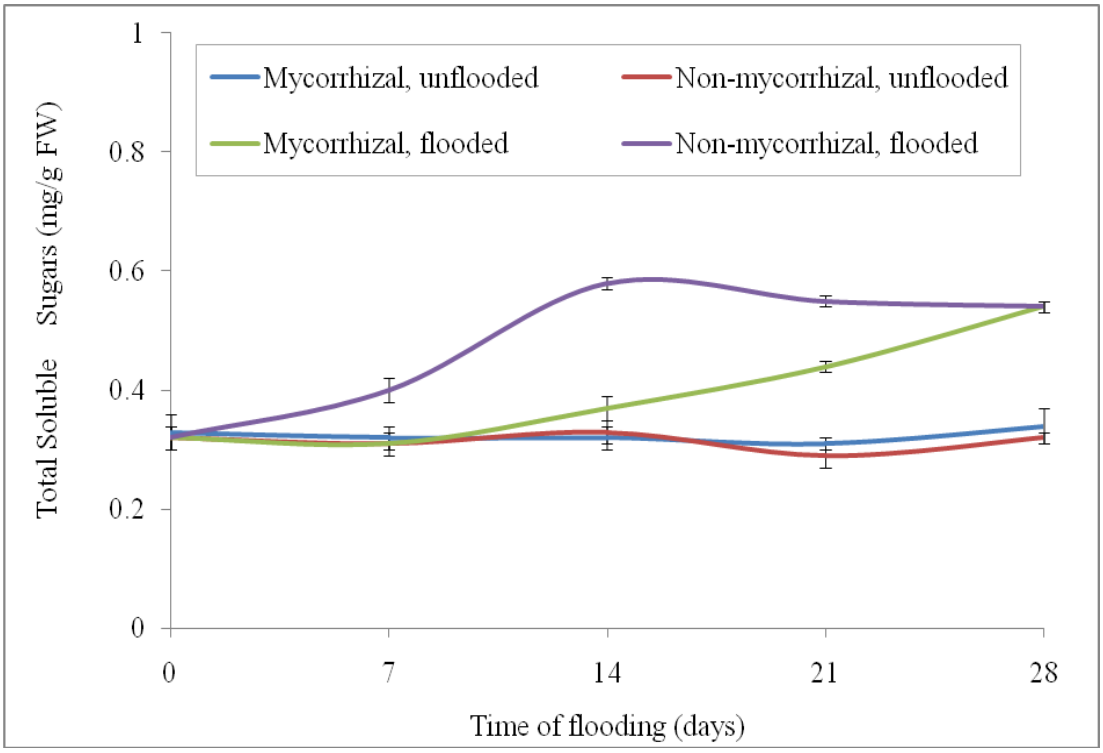


Figure 4.13: Effect of arbuscular mycorrhiza fungi and flooding stress on total soluble sugars of passion fruit roots

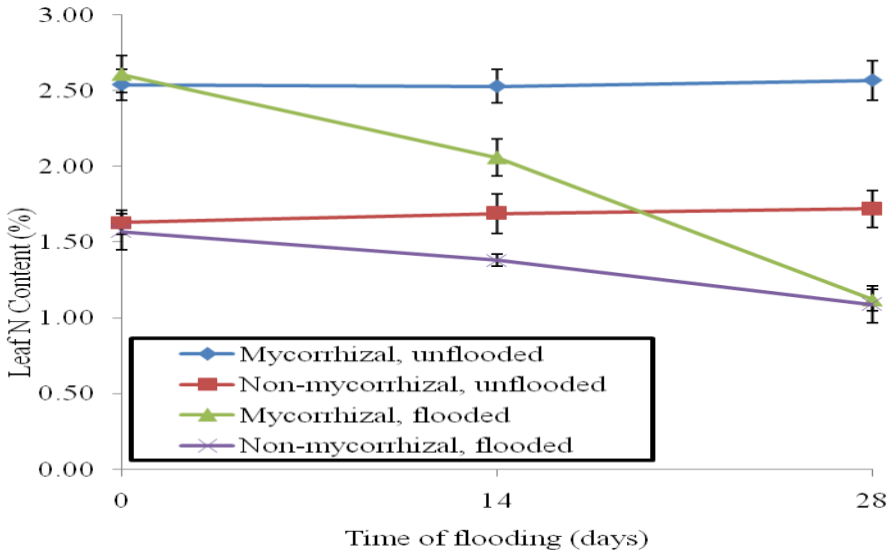


Figure 4.14: Effect of arbuscular mycorrhiza fungi and flooding stress on leaf nitrogen content (%) of passion fruit seedlings

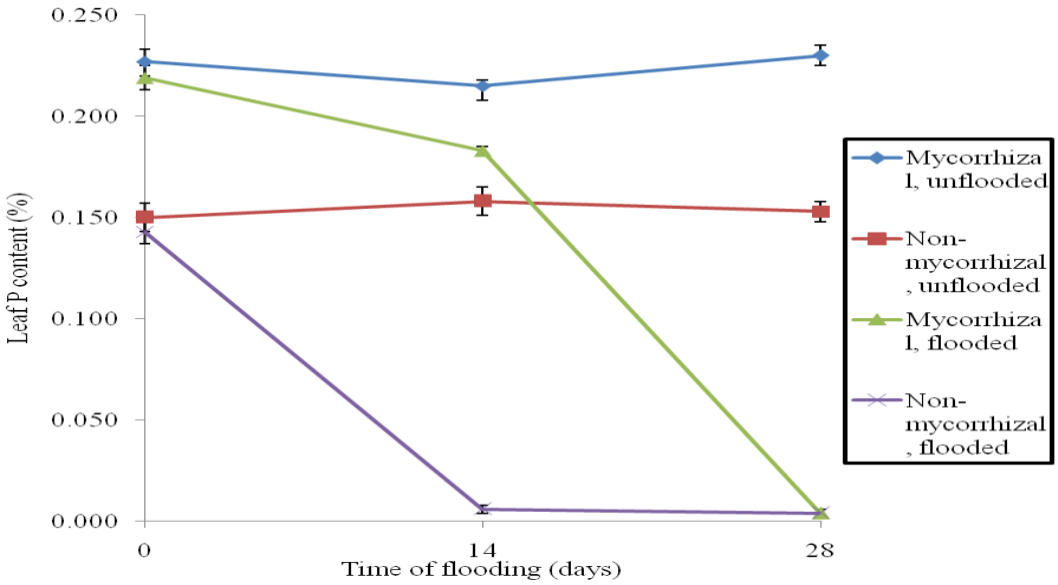


Figure 4.15: Effect of arbuscular mycorrhiza fungi and flooding on leaf phosphorus content (%) of passion fruit seedlings

4.2.12 Leaf phosphorus content

Mycorrhizal treatments had higher phosphorus content at the start of flooding (Figure. 4.15). The leaf phosphorus content remained relatively constant over the next 28 days in unflooded treatments (Figure. 4.15). Flooding caused a reduction in the phosphorus content with significant differences observed on the 14th day. Mycorrhizal treatments maintained significantly higher phosphorus for the first 14 days under flooding stress compared to non-mycorrhizal seedlings under similar flooded conditions (Figure. 4.15). However, there was no significant difference between the flooded treatments on the 28th day of flooding (Figure. 4.15).

4.3 Effect of Arbuscular Mycorrhiza Fungi on Growth and Nutrient Uptake of Seedlings under Modified PhosphorousMedia and Low Nutrient Sand: Soil Media

4.3.1 Plant Height

4.3.1.1 Effect of arbuscular mycorrhiza fungi on plant height of passion fruits and rough lemon seedlings raised under half strength hoagland solution with modified phosphorous rates

There was no significant difference in plant height in passion fruits seedlings subjected to varied phosphorus concentrations in the first 9weeks from transplanting (Figure. 4.16). On the 12th and 15th week, mycorrhizal passion fruit seedlings subjected to 1.68ppm P had the highest plant height (Figure. 4.16). On the 18th week, mycorrhizal seedlings subjected to 0.44, 0.88 and 1.68 ppm P had the highest plant height while on the 21st week, mycorrhizal seedlings subjected to 0.44 and 0.88 ppm P had the highest plant height (Figure. 4.16).

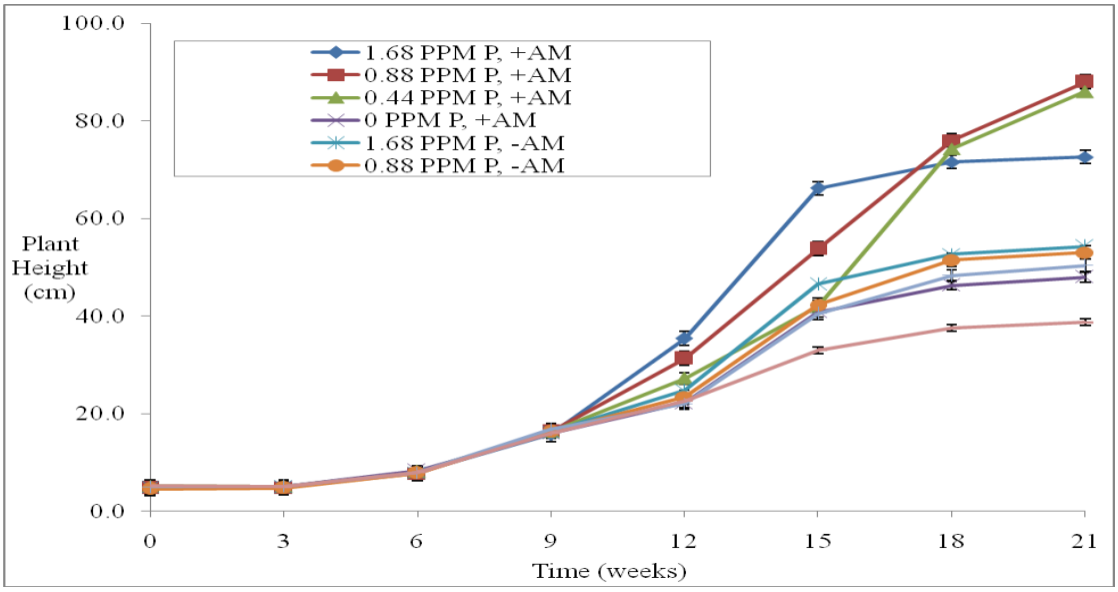


Figure 4.16: Effect of arbuscular mycorrhiza fungi and p on the plant height (cm) of passion fruits (passiflora edulis var edulis) seedlings

In rough lemons, there was no significant difference in plant height in seedlings subjected to varied phosphorus concentrations in the first 12 weeks from transplanting (Figure. 4.17). On 16th, 20th and 24th week after transplanting, mycorrhizal lemon seedlings subjected to 0.44, 0.88ppm and 1.68 ppm P had the highest plant height but plant height increase waned in mycorrhizal, 1.68 ppm P such that from 28th to 32nd week, mycorrhizal seedlings subjected to 0.44 and 0.88 ppm P had the highest plant height (Figure. 4.17). There was no significant difference in plant height between mycorrhizal plants that were not supplied with P (0 ppm P) and non mycorrhizal plants

subjected to 0.44, 0.88 and 1.68 ppm P in both lemons and passion fruits (Figure. 4.16, 4.17). Non-mycorrhizal plants that were not supplied with P (0 ppm P) had the lowest plant height in both passion fruits and lemons (Figure. 4.16, 4.17).

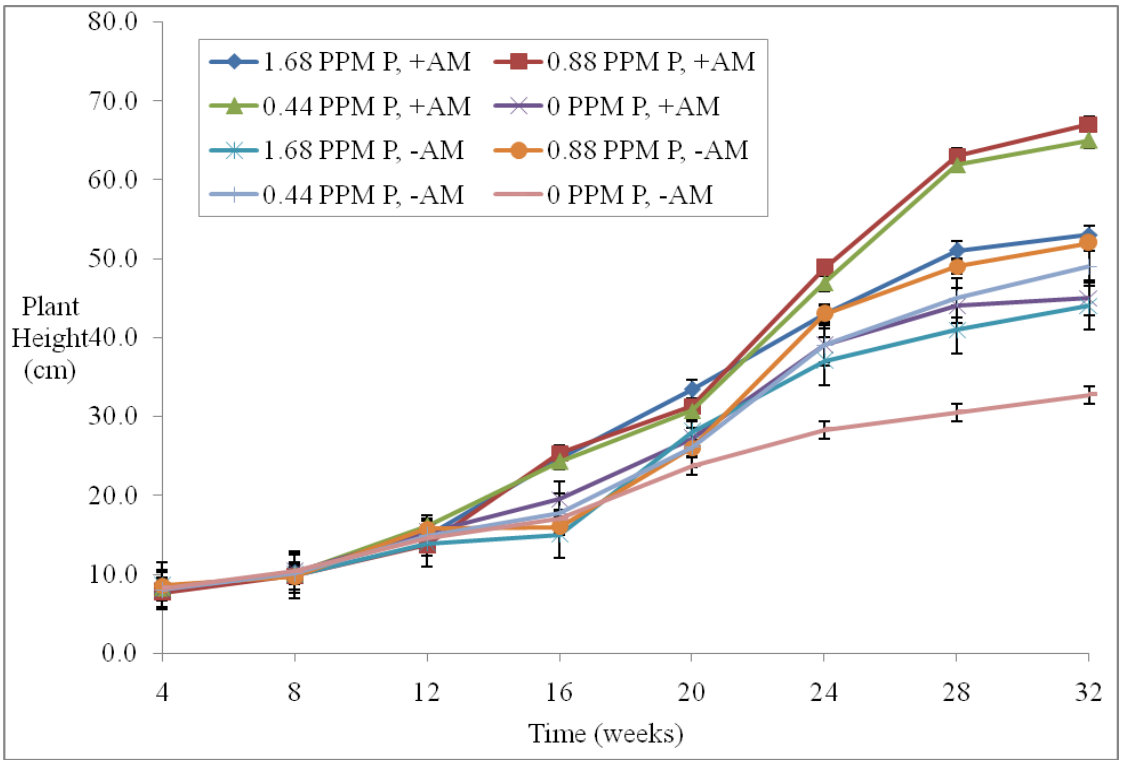


Figure 4.17: Effect of arbuscular mycorrhiza fungi and P on the plant height (cm) of rough lemon (*Citrus jambhiri*) seedlings

4.3.1.2 Plant Height Results of Papaya and Lemon Seedlings raised under Low nutrient Sand: soil Sterilized and Non-sterilized Media

In low nutrient sand: soil media, arbuscular mycorrhizal lemon and papaya seedlings had higher plant height than to non-mycorrhizal seedlings in both sterilized and unsterilized media (Figure 4.18, 4.19). There was no significant difference in plant height between the mycorrhizal treatments, whether in sterilized or un-sterilized media (Figure 4.18, 4.19). Non-mycorrhizal seedlings raised in sterilized media had significantly higher plant height than non-mycorrhizal seedlings raised in unsterilized media in papaya and lemon seedlings (Figure 4.18, 4.19).

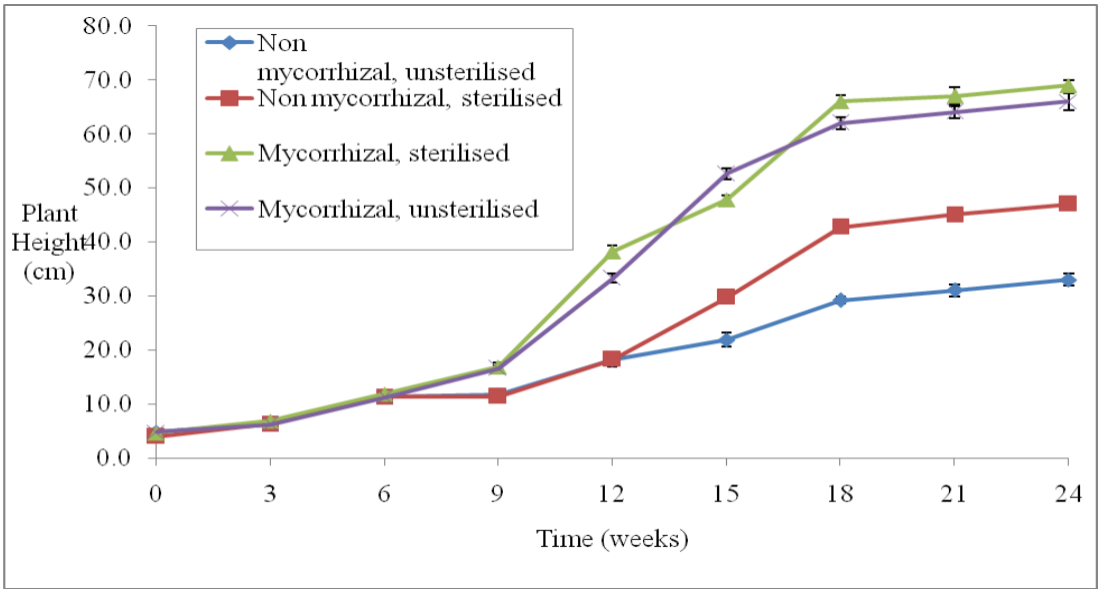


Figure 4.18: Effect of arbuscular mycorrhizafungi and media condition on plant height (cm) of papaya (Carica papaya var mountain) seedlings

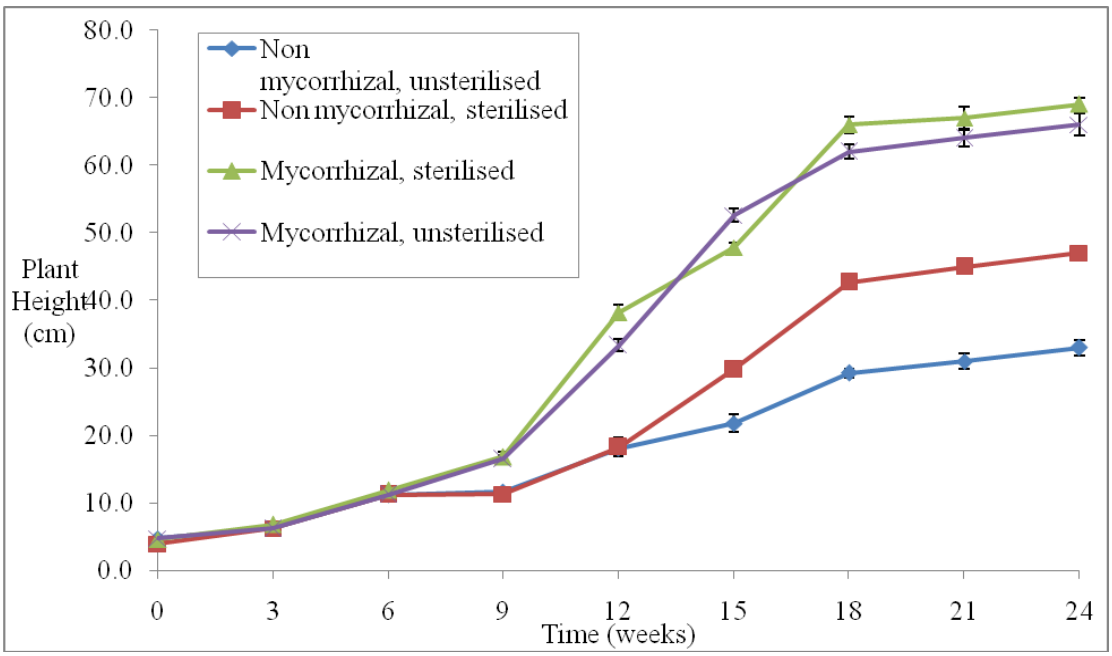


Figure 4.19: Effect of arbuscular mycorrhiza fungi and media condition on plant height (cm) of roughlemon (*Citrus jambhiri*) seedlings

In mangoes, mycorrhizal plants with both intact endosperms and those with endosperm removed had significantly higher plant height compared to non mycorrhizal plants with and without intact endosperm (Figure. 4.20). There was no significant difference in plant height between mycorrhizal plants with intact endosperm and those with the endosperm removed (Figure 4.20). There was also no significant difference in plant height between non-mycorrhizal plants with intact endosperm and those with the endosperm removed (Figure 4.20).

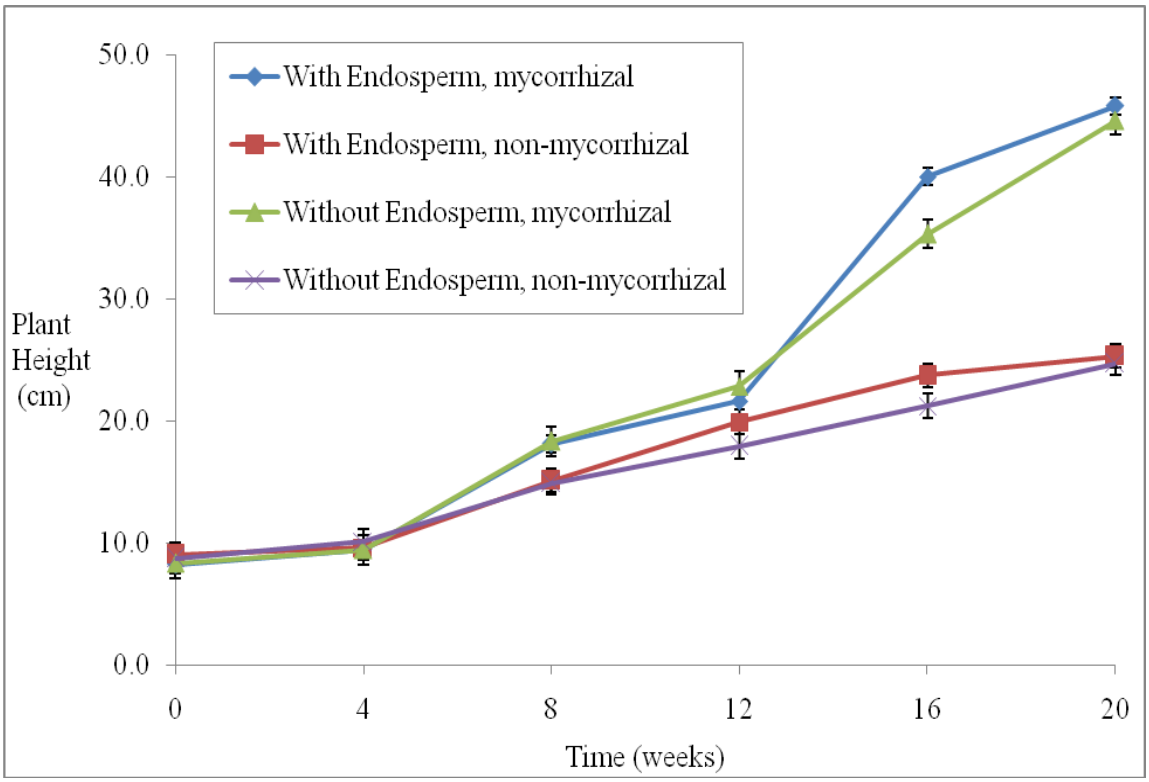


Figure 4.20: Effect of arbuscular mycorrhiza fungi and endosperm condition on the plant height of mango (*Mangifera indica* var peach) seedlings

4.3.1.4 Effect of Arbuscular mycorrhiza fungi on plant height of avocado seedlings with endosperm attached or removed at transplanting time

Mycorrhizal and non mycorrhizal avocado seedlings both containing an endosperm attached had significantly higher plant height compared to both mycorrhizal and non-mycorrhizal plants which had the endosperm removed at the beginning of the experiment (Figure 4.21). Mycorrhizal seedlings without an endosperm had significantly higher plant height compared to non mycorrhizal seedlings without the endosperm (Figure. 4.21).

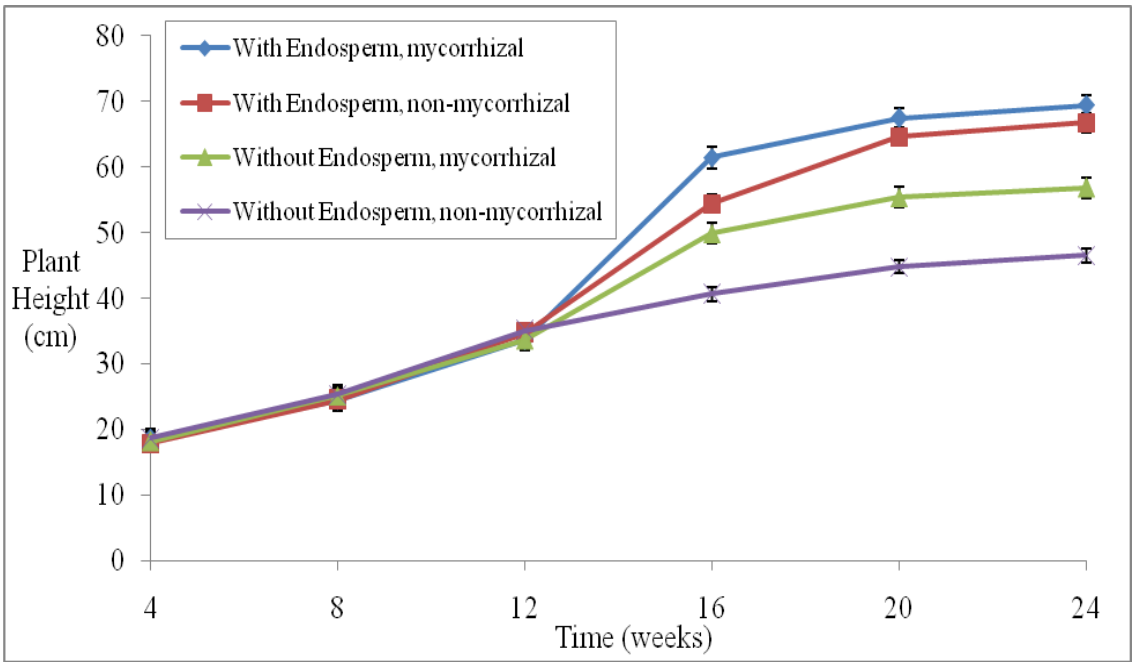


Figure 4.21: Effect of arbuscular mycorrhiza fungi and endosperm condition on the plant height of avocado (*Persea americana*) seedlings

4.3.2 Results on Leaf Number, Leaf Area, Stem Girth and Fresh and Dry Weights

4.3.2.1 Passion fruits and lemon seedlings raised under half strength Hoagland Solution with modified P rates

Table 4.10: Effect of arbuscular mycorrhiza fungi and phosphorus rates on the leaf number, stem girth leaf, stem and root fresh and dry weights and leaf area of passion fruits (*Passiflora edulis* var edulis) seedlings

Treatment	Leaf no.	Fresh weight (g)			Dry weight (g)			Leaf area
		Leaf	Stem	Root	Leaf	Stem	Root	(cm2)
0 PPM P, -AM	11.2c[z]	6.0c	1.8c	13.5d	2.1d	0.3a	3.5d	292.1d
0.44 PPM P, -AM	12.7b	7.9b	2.2ab	19.0c	2.3cd	0.4a	4.8c	360.0bc
0.88 PPM P, -AM	12.6bc	8.7b	2.2ab	21.5bc	2.5bcd	0.5a	4.6c	348.6bcd
1.68 PPM P, -AM	13.2ab	8.7b	2.1bc	17.7cd	2.5bcd	0.3a	4.5c	346.7bcd
0 PPM P, +AM	13.3ab	8.3b	2.3ab	18.8c	2.3cd	0.4a	4.3cd	338.0cd
0.44 PPM P, +AM	14.2a	10.7a	2.5a	29.3a	3.1a	0.5a	8.9a	402.8ab
0.88 PPM P, +AM	14.6a	10.6a	2.4ab	30.5a	2.9ab	0.4a	9.2a	418.8a
1.68 PPM P, +AM	13.6ab	8.7b	2.3ab	26.2ab	2.6bc	0.6a	6.8b	377.7abc
LSD ($p \leq 0.05$)	1.4	1.6	0.3	4.9	0.4	0.3	0.8	57.1
CV (%)	16.3	17.4	14.3	12.6	14.3	9.8	10.7	12.7

Column values followed by different letters are significantly different at $p<0.05$ (n=6).

There was no significant difference in stem dry weight between all treatments in passion fruits (Table 4.10). In lemons, there was no significant difference in stem girth and stem fresh and dry weights between all treatments (Table 4.11). Mycorrhizal passion fruits and lemons seedlings supplied with 0.44, 0.88 and 1.68ppm P had the highest leaf and root fresh and dry weights, leaf number and leaf area (Table 4.10, 4.11) compared with non mycorrhizal plants supplied with 0.44, 0.88 and 1.68 ppm P in both passion fruits and lemons (Table 4.10, 4.11). Mycorrhizal plants supplied with 1.68 ppm P had significantly higher leaf and root fresh and dry weights compared to mycorrhizal plants that did not receive P (0 ppm P) but there were no significantly differences between the two treatments in leaf number, stem girth, stem fresh and dry weights and leaf area. Non-mycorrhizal plants which did not have P supply (0 ppm P)

had the lowest leaf number, leaf and root fresh and dry weights and leaf area in both lemons and passion fruits (Table 4.10, 4.11).

Table 4.11: Effect of arbuscular mycorrhiza fungi and p on the leaf number, stem girth, leaf, stem and root fresh and dry weights and leaf area of rough lemon (*Citrus jambhiri*) seedlings

Treatment	Leaf no.	Stem	Fresh weight (g)			Dry weight (g)			Leaf area (cm^2)
		Girth	Leaf	Stem	Root	Leaf	Stem	Root	
0 PPM P, -AM	38.2d[z]	1.0a	4.5d	5.8a	10.5e	0.6d	1.3a	2.4d	230.2d
0.44 PPM P, -AM	42.7cd	1.0a	5.3c	5.9a	13.0cd	0.8cd	1.5a	3.9bc	281.4bcd
0.88 PPM P, -AM	42.6cd	1.0a	5.7c	5.9a	13.5bcd	1.1b	1.5a	3.5c	290.7bcd
1.68 PPM P, -AM	45.2bc	1.1a	5.6c	5.9a	12.7d	1.0bc	1.2a	3.6bc	258.6cd
0 PPM P, +AM	43.3bcd	1.0a	5.5c	5.8a	12.8d	0.8cd	1.4a	3.3c	275.1bcd
0.44 PPM P +AM	54.2a	1.1a	6.7ab	6.3a	15.3a	1.6a	1.6a	4.8a	320.8ab
0.88 PPM P +AM	58.6a	1.1a	7.0a	6.2a	15.2ab	1.4a	1.5a	4.7a	362.7a
1.6 PPM P +AM	48.6b	1.0a	6.5b	5.9a	14.5bc	1.1b	1.4a	4.3ab	300.0bc
LSD ($p \leq 0.05$)	5.4	0.2	0.4	0.49	1.7	0.2	0.4	0.7	62.1
CV (%)	16.3	8.9	7.4	7.8	12.6	14.3	9.8	10.7	12.7

[z]Column values followed by different letters are significantly different at $p<0.05$ n=6)

Mycorrhizal rough lemon seedlings raised in both sterilized and unsterilized media had significantly higher leaf number, leaf and root fresh and dry weights and leaf area than non-mycorrhizal plants under both sterilized and unsterilized media (Table 4.12). There was no significant difference between all lemon treatments in stem girth and stem fresh weights (Table 4.12). There was no significant difference in all parameters between mycorrhizal plants raised in either sterilized or unsterilized media (Table 4.12). Non mycorrhizal plants raised in sterilized media had significantly higher leaf and root fresh weight compared to non-mycorrhizal plants raised in unsterilized media (Table 4.12).

4.3.2.2 Results on Rough Lemon Seedlings raised under low Nutrient Sand: Soil Sterilized and Non-Sterilized Media

Table 4.12: Effect of arbuscular mycorrhiza fungi and media condition on the leaf number, stem girth, biomass and leaf area of rough lemon (Citrus jambhiri) seedlings

Treatment	Leaf	Stem	Fresh weight (g)			Dry weight (g)			Leaf area (cm^2)
	no.	Girth (cm)	Leaf	Stem	Root	Leaf	Stem	Root	
-AM, -ST	26.5^{bz}	0.9^{a}	4.5^{c}	6.7^{a}	11.8^{c}	1.1^{b}	1.3^{b}	1.7^{b}	217.4^{b}
-AM,+ ST	29.6^{b}	1.0^{a}	4.8^{b}	7.1^{a}	12.4^{b}	1.3^{b}	1.4^{ab}	2.3^{b}	260.3^{b}
+AM, -ST	35.3^{a}	1.0^{a}	5.1^{a}	7.2^{a}	15.2^{a}	1.8^{a}	1.5^{a}	3.1^{a}	326.0^{a}
+AM,+ST	39.0^{a}	0.9^{a}	5.2^{a}	7.2^{a}	15.5^{a}	1.8^{a}	1.4^{ab}	3.4^{a}	344.4^{a}
LSD ($p \leq 0.05$)	5.3	0.2	0.2	0.6	0.4	0.3	0.1	0.5	44.8
CV%	10.0	7.5	14.4	9.7	11.5	10.8	7.4	7.8	9.1

[z]Column values followed by different letters are significantly different at $p<0.05n=6$)

4.3.2.3 Results on Papaya Seedlings raised under Low Nutrient Sand: SoilSterilized and Non-sterilized Media

Mycorrhizal papaya seedlings raised in both sterilized and unsterilized media had significantly higher stem and root fresh weight, root dry weight and leaf area than non-mycorrhizal plants under both sterilized and unsterilized media (Table 4.13). There was no significant difference between all papaya treatments in leaf number, leaf fresh and dry weight and stem dry weight (Table 4.13). There was no significant difference in all parameters between mycorrhizal plants raised in either sterilized or unsterilized media (Table 4.13). Non mycorrhizal plants raised in sterilized media had significantly higher root fresh and dry weight and leaf area compared to non-mycorrhizal plants raised in unsterilized media (Table 4.13).

Table 4.13: Effect of arbuscular mycorrhiza fungi and media condition on the leaf number, fresh and dry weight and leaf area of papaya (*Carica papaya* varmountain) seedlings

Treatments	Leaf dry weight (g)			Dry Weight (g)				Leaf
	No.	Leaf	Stem	Root	Leaf	Stem	Root	Area (cm2)
Non mycorrhizal, unsterilised	7.8a	5.5a	7.3b	13.6c	1.2a	0.8a	4.2c	117.4c
Non mycorrhizal, sterilized	8a	5.6a	7.3b	15.4b	1.3a	0.8a	4.7b	160.3b
Mycorrhizal, unsterilised	7.6a	5.8a	7.9a	19.9a	1.2a	0.8a	6.2a	226.1a
Mycorrhizal, sterilised	7.8a	5.7a	8.2a	20.5a	1.3a	0.8a	6.0a	244.3a
LSD ($p \leq 0.05$)	0.5	0.4	0.5	1.4	0.2	0.2	0.4	34.8
CV (%)	10	14.4	9.7	11.5	10.8	14.4	7.8	9.1

[z]Column values followed by different letters are significantly different at $p<0.05$ (n=6)

4.3.2.4 Results on Mango Seedlings with Endosperm Attached or Removed at Transplanting time

Mycorrhizal mango plants with and without endosperm had significantly higher leaf number, leaf area and leaf, stem and roots fresh weight, leaf and root dry weights than non mycorrhizal plants with and without endosperm attached (Table 4.14, Plate 4.8). There was no significant difference between mycorrhizal and non mycorrhizal plants in stem girth and in stem dry weights (Table 4.14). There was no significant difference in all parameters between mycorrhizal plants with and without endosperm attachment (Table 4.14). There was also no significant difference in all parameters between non-mycorrhizal plants with and without endosperm attachment (Table 4.14).

Table 4.14: Effect of arbuscular mycorrhiza fungi and endosperm condition on the leaf number, stem girth, fresh and dry weights and leaf area of mango (*Mangiferaindica* var Peach) seedlings

Treatment	Leaf no.	Stem Girth	Fresh weight (g)			Dry weight (g)			Leaf area (cm^2)
			Leaf	Stem	Root	Leaf	Stem	Root	
+ED, +AM	16.8a	1.3a	18.5a	16.1a	23.2a	4.4a	5.2a	4.2a	377.3a
-ED, +AM	16.6a	1.2a	18.8a	15.8a	22.4a	4.6a	5.0a	3.8a	385.8a
+ED, -AM	14.0b	1.2a	17.9b	15.4b	20.5b	3.8b	4.7a	3.3b	341.7b
-ED, -AM	13.4b	1.1a	17.4b	15.1b	19.8b	3.6b	4.7a	2.9b	329.7b
LSD($p \leq 0.05$)	0.8	0.3	0.7	0.3	1.0	0.4	0.7	0.4	27.4
CV	12.7	10.6	9.5	8.4	12.5	14.9	8.9	12.8	17.8

[z]Column values followed by different letters are significantly different at $p<0.05$ (

n=6)

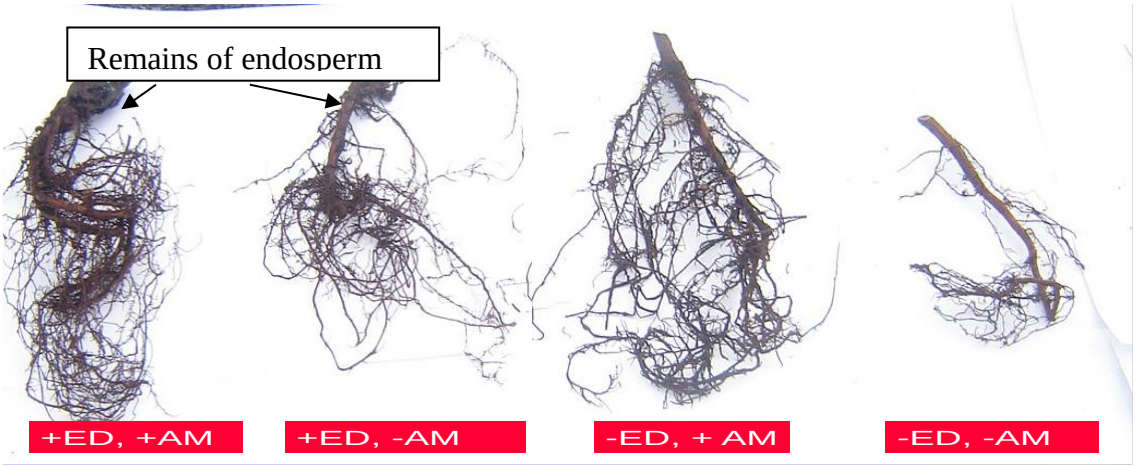


Plate 4.8: Root appearance of mycorrhizal (+AM) and non mycorrhizal (-AM) mango seedlings with (+ED) and without endosperm (-ED) **attachment**

4.3.2.5 Results on Avocado Seedlings with Endosperm Attached or Removed at Transplanting Time

Mycorrhizal and non-mycorrhizal avocado seedlings with endosperm attached had significantly higher leaf number, leaf area and leaf and roots fresh and dry weights than both mycorrhizal and non mycorrhizal plants without endosperm attached (Table

4.15). There was no significant difference between all treatments in stem girth and in stem fresh and dry weights (Table 4.15). There was also no significant difference in all parameters between mycorrhizal and non mycorrhizal plants with endosperm attachment (Table 4.15). Mycorrhizal plants without endosperm attachment had significantly higher leaf numbers, leaf and root fresh and dry weights and leaf area (Table 4.15).

Table 4.15: Effect of arbuscular mycorrhiza fungi and endosperm detachment on the leaf number, stem girth, fresh and dry weight and leaf area of avocado (Persea americana) seedlings

Treatment	Leaf	Stem	Fresh weight (g)			Dry weight (g)		Leaf area
	no.	Girth	Leaf	Stem	Root	Leaf	Stem	(cm^2)
+ED, +AM	58.6a	1.4a	30.6a	15.7a	105.8a	7.4a	3.4a	856.6a
+ED, -AM	56.9a	1.5a	29.7a	15.7a	112.4a	7.6a	3.7a	873.5a
-ED, + AM	52.2b	1.5a	27.7b	14.8a	39.9b	6.8b	3.7a	747.8b
-ED, -AM	47.7c	1.3a	25.1c	15.0a	27.8c	5.6b	3.5a	643.4c
LSD($p \leq 0.05$)	3.8	0.2	2.4	1.2	9.4	0.5	0.3	97.5
CV	11.5	8.4	15.4	10.3	12.7	9.2	7.8	13.5

[z]Column values followed by different letters are significantly different at $p<0.05$ (n=6)

4.3.3 MycorrhizalRoot Colonisation

Mycorrhizal seedlings had significantly higher root colonisation than non-mycorrhizalseedlings (Table 4.16). There was no significant difference in % root colonisation between mycorrhizal seedlings held in both sterilized and non-sterilized media (Table 4.16). Non-mycorrhizal plants held in unsterilized media had low mycorrhizal colonisation % while that held in sterilized media did not have any root colonisation (Table 4.16).

Table 4.16: Effect of arbuscular mycorrhizafungi and planting media on the mycorrhizal root colonisation (%) of rough lemon (*Citrus jambhiri*) and papaya (*Carica papaya* var *mountain*) seedlings raised in sterilized and unsterilized media

Treatment	Rough lemons	Papaya
-AM, -ST	7.1 ± 4.5	8.7 ± 3.2
-AM, + ST	0	0
+AM, -ST	51.1 ± 2.9	43.2 ± 3.9
+AM, +ST	55.3 ± 2.4	45.3 ± 1.5

[z]Means ±SE (N=6)

4.3.4 MycorrhizaSpore Numbers in Sterilized and Unsterilized Media

At the start of the experiment, sterilized media did not have any mycorrhizal spores while unsterilized media had a low spore count (Table 4.17). At the end of the experiment period, mycorrhizal inoculation caused a significantly higher spore count in both sterilized and unsterilized media (Table 4.17).

Table 4.17: Effect of media sterilization on mycorrhiza spore number at the beginning and at the end of the experiment period

	Spores per 25 gram soil sample		
	Beginning	End	
		Papaya	Lemons
+AM, +ST	0	676 ± 29	898 ± 48
+AM, -ST	68 ± 8[z]	777 ± 36	856 ± 39
-AM, +ST	0	0	0
-AM, -ST	57 ± 17	158 ± 16	183 ± 31

[z]Means ±SE (N=6)

4.3.5 Leaf Nutrient content in Sterilized and Unsterilized Media

4.3.5.1 Results on Rough Lemon Seedlings

Mycorrhizal seedlings had significantly higher N, P and K% compared to non mycorrhizal seedlings (Table 4.18). There was no significant difference in Ca and Mg content between all treatments (Table 4.18).

Table 4.18: Effect ofarbuscular mycorrhiza fungi and planting media on the % leaf nutrient content of rough lemon (Citrus jambhiri) seedlings

	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
-AM-ST	2.0 ± 0.1[z]	0.2 ± 0.05	2.1 ± 0.2	2.8 ± 0.1	1.6 ± 0.1
-AM+ST	2.0 ± 0.1	0.3 ± 0.07	1.9 ± 0.2	3.1 ± 0.2	1.7 ± 0.2
+AM-ST	2.3 ± 0.1	0.4 ± 0.05	2.6 ± 0.1	3.0 ± 0.1	1.6 ± 0.1
+AM+ST	2.3 ± 0.2	0.4 ± 0.04	2.6 ± 0.1	3.1 ± 0.1	1.6 ± 0.2

[z]Means ±SE (N=6)

4.3.5.2 Results on Papaya Seedlings

Table 4.19: Effect of arbuscular mycorrhiza fungi and planting media on the % leaf nutrient content of papaya seedlings

	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
-AM-ST	1.9±0.1[z]	0.2 ± 0.1	2.3 ± 0.1	1.9 ± 0.2	0.8 ± 0.1
-AM+ST	1.9±0.1	0.2 ± 0.1	2.2 ± 0.2	2.1 ± 0.1	0.9 ± 0.1
+AM-ST	2.0±0.1	0.4 ± 0.1	2.9 ± 0.1	2.0 ± 0.2	0.9 ± 0.1
+AM+ST	2.0±0.1	0.4 ± 0.1	2.9 ± 0.2	2.1 ± 0.1	0.8 ± 0.1

[z]Means ±SE (N=6)

Mycorrhizal seedlings had significantly higher P and K% compared to non mycorrhizal seedlings (Table 4.19). There was no significant difference in N, Ca and Mg% between all treatments (Table 4.19).

4.3.6 Leaf Nutrient % in Mango and Avocado Seedlings with and without Endosperm Attachment

4.3.6.1 Results on Mango Seedlings

Mycorrhizal seedlings with and without endosperm attached had significantly higher P and K% compared to non mycorrhizal seedlings (Table 4.20). There was no significant difference in N, Ca and Mg content between all treatments (Table 4.20).

Table 4.20: Effect of arbuscular mycorrhiza fungi and endosperm condition on the % leaf nutrient content of mango (Mangifera indica) seedlings

	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
+ED, +AM	2.3 ± 0.2 [z]	0.5 ± 0.1	2.4 ± 0.2	2.7 ± 0.2	1.7 ± 0.1
-ED, +AM	2.3 ± 0.1	0.5 ± 0.1	2.4 ± 0.1	2.9 ± 0.2	1.6 ± 0.1
+ED, -AM	2.3 ± 0.1[z]	0.2 ± 0.1	2.0 ± 0.2	2.8 ± 0.1	1.5 ± 0.1
-ED, -AM	2.3 ± 0.3	0.2 ± 0.1	1.9 ± 0.1	2.8 ± 0.2	1.6 ± 0.1

[z]Means ±SE (N=6)

4.3.6.2 Results on Avocado Seedlings

Mycorrhizal seedlings with and without endosperm attached had significantly higher P% compared to non mycorrhizal seedlings (Table 4.21). There was no significant difference in N, K, Ca and Mg% between all treatments (Table 4.21).

Table 4.21: Effect of arbuscular mycorrhiza fungi and endosperm condition on the % leaf nutrient contentof avocado (*Persea americana*) seedlings

	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
+ED, +AM	3.0 ± 0.2	0.6 ± 0.1	2.3 ± 0.1	3.1 ± 0.1	1.6 ± 0.1
-ED, +AM	2.9 ± 0.2	0.6 ± 0.1	2.3 ± 0.2	3.0 ± 0.1	1.5 ± 0.2
+ED, -AM	3.0 ± 0.2[z]	0.3 ± 0.1	1.8 ± 0.1	2.9 ± 0.2	1.4 ± 0.1
-ED, -AM	2.8 ± 0.1	0.3 ± 0.1	1.9 ± 0.2	2.9 ± 0.1	1.4 ± 0.2

[z]Means ±SE (N=6)

CHAPTER FIVE

DISCUSSION

5.1 Effect of arbuscular mycorrhizal inoculation on the survival and growth of tropical fruit seedlings under salt stress

In this study, mycorrhizal root colonisation occurred in only the inoculated treatments.Unstressed mycorrhizal seedlings recorded higher colonisation than their respective seedlings subjected to salt stress. This finding is consistent with research done in beans in Iran that indicated that mycorrhizal inoculation produced active colonisation in non-saline stressed seedlings. The level of colonisation in roots of mycorrhizal plants decreased as the NaCl concentration increased (Younesi & Moradi, 2014). Studies with citrus in India showed that increasing salt stress significantly decreased mycorrhizal root infection from 66.8% to 31.3% in Karna Khatta (*Citrus karna*) and from 62.4% to 39.7% in Troyer Citrange (Murkute *et al.*, 2006). In *Sesbania aegyptiaca* and *S. grandiflora* study in India, mycorrhizal root colonisation and sporulation was significantly higher in AM-inoculated than in uninoculated plants under salt-stressed soil (Giri and Mukerji, 2004). Similar results were reported in *Vicia faba* study in Egypt by Rabie & Almadini, 2005).

The decline in colonization could be caused by adverse conditions for sporulation and development of spores under unfavorable rhizosphere conditions induced by salt stress. However, despite mycorrhizal colonization being reduced at high salinity levels, it was not completely inhibited. This accounts for the improved performance of the inoculated plants in relation to non-mycorrhizal plants under salt stress.

In this study, a decline in plant height and leaf number occurred under salt stress. Despite this, mycorrhizal passion fruit plants had higher plant height and leaf number under both normal and moderate salt stress. Under extreme salt stress, there was no significant difference in plant height between mycorrhizal and non-mycorrhizal passion fruit seedlings. However, mycorrhizal passion fruits had higher leaf number than non-mycorrhizal plants even under extreme salt stress. This was due to less leaf abscission in mycorrhizal plants subjected to extreme salt stress, than non-mycorrhizal

plants subjected to similar extreme stress. This result is consistent with research in bananas undertaken in Brazil (Yano-Melo *et al.,* 1999).

In this study, the leaf chlorophyll content declined under salt stress. The leaf chlorophyll content was however significantly higher in mycorrhizal seedlings under both normal and moderate salt-stress. This result is consistent with studies in *Sesbania aegyptiaca* and *S. grandiflora* in India which indicated that the chlorophyll content was greater in leaves of seedlings inoculated with *Glomus macrocarpum* as compared to un-inoculated seedlings under saline soil conditions (Giri & Mukerji, 2004). Mycorrhizal seedlings also had higher chlorophyll content in *Lotus glaber* (Sannazzaro *et al.,* 2005), peppers in Turkey (Çekic *et al.,* 2012) and in trifoliate orange in China (Wu & Zou, 2012).

Like other growth parameters, leaf area and the fresh and dry weights of leaves, stems and roots declined under salt stress in both passion fruit and mango seedlings. The severity of decline increased as salt stress increased. Under extreme salt stress, AM inoculation had no effect on the leaf, stem and root fresh weights and the root dry weight. Research by Huang *et al.* (2013) in Taiwan indicated that the shoot fresh, and shoots and roots dry weights were significantly higher in AMF-treated Tomato variety TCAV10 subjected to salt stress, when compared with non-mycorrhizal control. In Egypt, Debouba *et al*. (2006) reported that tomato plants inoculated with AMF showed greater shoot and root dry matter accumulation when irrigated with saline water. In beans grown in Iran, mycorrhizal inoculation increased the shoot biomass under moderate salinity (Younesi & Moradi, 2014).The AMF symbiosis in studies done in Spain also improved dry weights and alleviated salt stress in maize (*Zea mays* L.) (Estrada *et al*., 2013).

In this study, the phosphorus level was significantly higher in mycorrhizal plants than in non-mycorrhizal plants under both non stress and salt-stress conditions. This result indicates that the improvement of phosphorus uptake by AM fungi constitutes one of the mechanisms for increasing plant tolerance to salinity. The result is consistent with findings in bean study in Iran which showed the highest foliar concentration of phosphorus under salinity conditions was observed in plants inoculated with *G.*

mosseae (Younesi & Moradi, 2014). Similarly, wheat research in Saudi Arabia showed that the phosphorus content declined under increased salinity in non-mycorrhizal treatments but in mycorrhizal treatments, the levels remained unchanged (El-Amri *et al.,* 2013). These results are also consistent with findings on *Sclerocarya birrea* research in Kitui Kenya by Muok and Ishii (2006) and *Vicia faba* research in Egypt by Rabie & Almadini (2005).

One of the roles played by phosphorus in plants is facilitation of photosynthesis. It can be concluded that AM fungi promoted phosphorus uptake, which in turn facilitated photosynthesis, resulting in better performance of inoculated plants. This improved well being is observed in increased plant height, leaf number, leaf area and the fresh and dry weights observed in inoculated plants, compared to non-inoculated plants.

In this study, increase in salinity caused an increase in the the sodium level in passion fruit and mango seedlings. The increase was however higher in non-mycorrhizal plants than in mycorrhizal plants. Lower sodium content in mycorrhizal plants under salinity stress was also reported in *Sesbania aegyptiaca* and *S. grandiflora* in India by Giri and Mukerji (2004), in Soybeans in Iran by Sharifi *et al.* (2007), lettuce in New Zealand by Zuccarini (2007), Zuchini in Italy by Colla *et al.* (2008) and wheat in Saudi Arabia by El-Amri *et al.*, (2013) suggesting that AM fungi protect plants from Na toxicity. Rabie and Almadini (2005) proposed that arbuscular mycorrhiza fungi protected *Vicia faba* plants in Egypt against Na toxicity either by regulating Na uptake from the soil or by accumulating it in roots, thereby delaying its translocation onto the shoot system.

While the Na level increased as salinity increased, the potassium level reduced in non-mycorrhizal plants but increased in mycorrhizal plants. The calcium levels however remained unchanged. This result is consistent with bean study in Iran that showed that the potassium content declined as salinity increased with mycorrhizal plants having higher potassium than non-mycorrhizal plants (Younesi & Moradi 2014). Reduction in K was also observed by Colla *et al.* (2008) in Zuchini in Italy; Sharifi *et al.* (2007) in Soybeans in Iran, Muok and Ishii (2006) in *Scleronchyma birrea* in Kenya and Rabie and Almadini (2005) in *Vicia faba* in Egypt. These authors reported that high sodium

uptake competed with the uptake of other nutrient ions, especially K, leading to K and other cations' deficiency.

In this study, it noted that mycorrhizal plants had increased K content with salinity treatment, while non-mycorrhizal plants had reduced K content. This indicates that mycorrhizal plants were able to uptake K inspite of the high Na levels. Other studies indicate that plants maintain high concentrations of K and low concentrations of Na in the cytosol under salt stress (Parida & Das, 2005). They do this by regulating the expression and activity of K and Na transporters and of H+ pumps that generate the driving force for transport (Parida & Das, 2005). It is therefore possible that AM fungi regulated the expression and activated K and Na transporters and H+ pumps that generate the driving force for transport. This possibility however requires further investigation to support it.

In this study, the level of magnesium declined with increased salinity in all passion fruit and mango seedlings. However, the decline in non-mycorrhizal plants was greater than in mycorrhizal plants under moderate salinity. Magnesium is a component of the chlorophyll molecule (Salisbury & Ross, 1991). In this study, reduced uptake of magnesium may explain the low chlorophyll content observed in non-mycorrhizal treatments under salt stress. This observation is consistent with findings that a reduction in Na uptake and a concomitant increase in Mg absorption and high chlorophyll content in mycorrhizal *Sesbania aegyptiaca* and *S. grandiflora* plants was an important salt-alleviating mechanism for plants growing in saline soil (Giri & Mukerji, 2004).

In this study, there was no significant difference in performance between the mycorrhizal treatments with/without the endosperm. However, non-mycorrhizal plants with the endosperm performed better than non-mycorrhizal plants without the endosperm. Presence of an endosperm provides a good start to the seedling after germination, by helping to nourish the seedling before it attains the photosynthetic ability. This allowed the seedlings containing the endosperm to have a good start, compared to those without, as happened in the non-mycorrhizal seedlings. However, in the mycorrhizal seedlings, the disadvantage of the absence of endosperm seemed to

have been compensated by the mycorrhizal inoculation, thereby allowing both the mycorrhizal plants with/without the endosperm to perform equally.

This study indicates that mycorrhizal inoculation improves growth and performance of mango and passion fruit seedlings under salt stress, as measured by growth parameters of plant height, leaf number and chlorophyll content, and biomass parameters of shoot, stem and root fresh and dry weights and leaf area. This is by enhancing the uptake of P, K and Mg, while reducing the detrimental effects of Na toxicity on seedling growth.

5.2 Effect of arbuscular mycorrhizal inoculation on the survival and growth of tropical fruit seedlings under flooding stress

In this study, an increase in plant height was observed in mycorrhizal treatments prior to the start of flooding stress (starting from the 8^{th} week). Likewise, the leaf area and fresh and dry weights were higher in mycorrhizal treatments at the start of flooding. These benefits could be attributed to the beneficial effect of mycorrhization on plant growth. Arbuscular mycorrhizal inoculation have also been reported to improve the growth, fresh and dry weight, yield and quality of soybeans in India (Suri and Choudhary, 2013), chick peas in Pakistan (Yaseen *et al.*, 2012), pigeon peas in China (Qiao *et al*., 2011), sour oranges in Jordan (Al-Karaki, 2013), Jews mallow in Nigeria (Nwangburuka *et al.*, 2012) and sunflower (Vaseghmanesh *et al.,* 2014) and temulawak in India (Samanhudi *et al.*, 2014).

Under flooding, plant growth (as measured by increase in height) ceased in both mycorrhizal and non-mycorrhizal treatments but continued under unflooded conditions. Mycorrhizal plants had higher plant heights compared to non-mycorrhizal plants, under both flooded and unflooded conditions. This is consistent with findings in rice seedlings in Iran which showed that plant height and chlorophyll content were positively affected by AMF inoculation in flooded but not in non-flooded plants (Hajiboland *et al.*, 2009). In a study of peach seedlings in Japan, the plant height declined under flooded conditions with non-mycorrhizal showing greater decline (Kipkoriony *et al.*, 2002).

Leaf growth (as measured by leaf number) continued under unflooded conditions but reduced under flooding. The reduction in leaf number under flooding could be attributed to leaf abscission that began 14 days after flooding. Leaf abscission also accounted for reduced leaf area observed under flooding. Leaf abscission occurred only in the non-mycorrhizal seedlings subjected to flooding. This observation is similar to that of peach study in Italy that showed the symptoms of flooding to be desiccation of the shoot apex, strong reddening of leaves followed by appearance of necrotic areas and senescence of almost all leaves (Lacona *et al.,* 2013). In *Prunus* spp. study in Italy, symptoms of flooding susceptibility included severe leaf damage and early plant mortality (Pimentel *et al.,* 2014).

In this experiment, there was a reduction in the fresh weight starting from the 14th day of flooding. The reduction in leaf fresh weight under flooding could be as a result of leaf abscission which reduced the leaf number. Reduction in root fresh weight could also be attributed to decay and death of roots that occur during flooding. In this study, reduction in lateral root formation and reduction in root length was observed in flooded, non-mycorrhizal treatments after 14 days and also in mycorrhizal seedlings after 21 days after flooding. Studies in *Betula platyphylla* (Tang & Koslowski, 1984), *Platanus occidentalis* (Tsukahara & Kozloswki, 1985) and *Acer platanoides* (Yamamoto & Koslowski, 1987) showed that flooding caused a loss of extent, reach and health of the roots resulting in decline, death and decay of roots over time. Generally under flooded conditions, the woody roots survive and non-woody roots die.

Mycorrhizal treatments had significantly higher root, stem and leaf dry weights compared to non-mycorrhizal seedlings under both flooded and unflooded conditions. Mycorrhizal inoculation was reported to enhance shoot and root dry weight in flooded rice in Iran (Hajiboland *et al.,* 2009) and snap beans in USA (Sah *et al.,* 2006).

In this study, the proline concentration was low at the start of flooding and remained constantly low in unflooded treatments. The proline concentration then increased under 14 and 21 days of flooding before falling back to the levels in unflooded treatments. This result is similar to a study in India of free proline accumulation in two maize genotypes that were subjected to waterlogging for three weeks at the knee high stage

(Singh & Singh, 1981). The results of this maize study indicated that the initial content of leaf free proline was similar in both genotypes but increased when the plants were subjected to waterlogging. Flooding also increased the proline content in sugar cane crop in India (Bajpai & Chandra, 2015) and in barley in Bulgaria (Yordanova & Popova 2001).

In this study, flooded mycorrhizal seedlings accumulated higher proline than non-mycorrhizal seedlings. This was also reported in *Aster tripolium* study in Portugal by Neto *et al.* (2006) who attributed the better tolerance to flooding by AM plants to improvement of osmotic adjustment promoted by proline. It can therefore be postulated from this study that proline concentration increased as a coping mechanism against flooding stress as reported by Ruiz-Lozano *et al.* (1995) and Neto *et al.* (2006). Mycorrhizal plants were able to accumulate higher proline, which improved the osmotic adjustment and maintained the membrane integrity among other physiological effects, thereby ensuring that the mycorrhizal plants coped better under flooding stress than non mycorrhizal plants.

In this study, the total chlorophyll and the chlorophyll a and b content remained constant or slightly increased in unflooded conditions. However, the chlorophyll content decreased under flooding. This is consistent with findings in sweet orange study in Poland in which continuous flooding reduced chlorophyll concentration of seedlings grafted onto rough lemon and sour orange rootstocks by 38% and 18%, respectively (Vu & Yelenosky, 2006). Reduction in total chlorophyll content as a result of flooding was also reported in wheat in USA (Collaku and Harrison, 2002), maize in India (Prasad *et al.,* 2004), sesame in Ghana (Mensah *et al.,* 2006) and onion in China (Yiu *et al.,* 2008).

In this study, the chlorophyll a content was higher than chlorophyll b content under both flooded and unflooded conditions. In maize study in Iran, chlorophyll b was more susceptible to water logging than chlorophyll a (Pourabdal *et al.,* 2008). In maize study in India, reduction in chlorophyll a compared to b occurred, and was attributed to the sensitivity of chlorophyll b against flooding which was more than that of chlorophyll a (Zaidi *et al.,* 2010).

The total chlorophyll and chlorophyll a and b levels were significantly lower under 7, 14 and 21 days of flooding in non-mycorrhizal treatments compared to flooded mycorrhizal treatments. This indicated that mycorrhization delayed the breakdown of chlorophyll under flooding. In a study in rice in Iran, chlorophyll content was increased by AMF inoculation in flooded but not in non-flooded plants (Hajiboland *et al.,* 2009).

In this study, there was a reduction in the leaf nitrogen content in non-mycorrhizal seedlings, compared to mycorrhizal seedlings subjected to flooding. The reduction in chlorophyll content observed in this study in non-mycorrhizal plants under flooding could be linked to the reduction of leaf nitrogen levels observed in non mycorrhizal seedlings. Similarly, the decrease in maize leaf chlorophyll contents under water-logging stress was identified as as being related to nitrogen deficiency caused by leaching and denitrification of the soil nitrogen (Rathore *et al*., 1996).

The carotenoid content was similar between treatments at the start of flooding. The unflooded treatments maintained low carotenoid content while the levels increased under flooding. This result was also reported in sugar cane (Bajpai & Chandra, 2015).

The increase in carotenoid content paralleled the reduction in the chlorophyll content. Studies have indicated that degradation of chlorophyll unmasks the carotenoids, resulting in higher carotenoid expression (Salisbury & Ross, 1991). Under 7, 14 and 21 day of flooding, the carotenoid level was significantly higher in non-mycorrhizal seedlings compared to mycorrhizal seedlings. This may have been related to the delay in chlorophyll breakdown observed in mycorrhizal seedlings.

Mycorrhizal root colonization of unflooded treatments remained unchangedover the experiment period. Under flooding, almost 50% decline in colonization was observed, 21 days after flooding. This finding is similar to reports in rice in Mexico which indicated that plants readily formed mycorrhizal associations under rainfed conditions, but under submerged conditions infection was rare due to the anoxic environment (Ilag *et al.,* 2007). However Purakayastha and Chhonkar (2001) in rice studies in India reported that AMF could survive in waterlogged conditions, and that *Glomus etunicatum* showed fairly high colonization and best survival under submerged

conditions. Similarly, a study in rice in Japan indicated that mycorrhizal colonization declined under continous flooding to 32% from 48% observed in upland rice. The colonization was significantly higher when the rice was flooded and then unflooded 30 days to maturity, compared with those that were continuously flooded upto maturity (Solaiman & Hirata (1995).

Adequate soil moisture favoured AM development but when soil moisture became too high or low, it suppressed colonization (Entry *et al.,* 2002). This is because arbuscular mycorrhiza fungi are obligate aerobes (Smith & Smith, 2011). Accordingly, a low colonization rate of roots under flooded conditions could be the result of lower oxygen availability to the fungi. However, in this study, the low colonization under flooding still conferred significant benefit to the passion fruit seedlings.

In this study, the leaf and root soluble sugar content remained constant in non-mycorrhizal or slightly increased in mycorrhizal seedlings in unflooded treatments. Under flooding, the total soluble sugars increased sharply and then dropped to the control level. Under flooding, non-mycorrhizal sugar content in both leaves and roots peaked in 7 days of flooding while in mycorrhizal seedlings, the peak occurred in the 14^{th} day. These findings agree with studies in maize in Iran which indicated that the amount of soluble sugars increased 1.5-2 times when compared with the controls during the early stage of flooding. However, increasing flooding period decreased this ratio and the amount of sugars gradually decreased and finally reached a level similar to the controls (Pourabdal *et al.,* 2008).

Various reasons are given to account for the increased sugar content in leaves under flooding. Increased sugars accumulation in the leaves could be attributed to reduced carbohydrate translocation to the roots as was reported in studies in alfalfa and *Lotus corniculatus* in USA (Barta, 1987). This reduction of photosynthate translocation to roots under flooding stress might also have been due to the reduction of carbohydrate utilization in roots as was reported in sunflowers in USA study (Wample and Davis, 1983) or to depression of the photosynthate transport system as reported in Pine in USA (Topa & Cheeseman, 1992).

In this study, the total soluble sugar content under flooding increased in mycorrhizal seedlings. The effect of AM inoculation on carbohydrate accumulation under flooding has not been widely studied in plants. However, Neto *et al.* (2006) in a study of *Aster tripolium* in Portugal showed that mycorrhizal plants had better tolerance to flooding that was mediated through improvement of the osmotic adjustment of the plant tissues via production of higher concentrations of soluble sugars.

In this study, mycorrhizal inoculation delayed peak soluble sugar increase under flooding. Whereas soluble sugars peaked in non-mycorrhizal treatments in 7 days of flooding, the peak occurred after 14 days of flooding in mycorrhizal seedlings. This may have been due to mycorrhizal inoculation facilitating translocation of photosynthates to the roots and/or preventing accumulation of photosynthates in the leaf tissues.

In this study, the leaf nitrogen content remained constant under unflooded conditions. Flooding however caused a reduction in the leaf nitrogen content. The total nitrogen content in plant tissue has been widely reported to decrease under flooding stress in various crop species, including apple (Olien, 1989) and pijuayo palms (Carvalho & Ishida, 2002).

The low nitrogen content can be attributed to inhibition of nitrogen uptake due to root damage under flooding. In general, substrate flooding causes disability in the absorption of macronutrients (Kozlowski & Pallardy, 1984).

Despite nitrogen reduction under flooding, mycorrhizal treatments maintained higher nitrogen content during the first 14 days in relation to non-mycorrhizal seedlings. This may be related to the greater root mass and greater root health observed in mycorrhizal seedlings under flooding. The better root health promoted by mycorrhization therefore facilitated uptake of nutrients, including nitrogen, and ensured higher nitrogen content in the leaves.

5.3 Effect of arbuscular mycorrhizal inoculation on growth and nutrient uptake of tropical fruit seedlings

Results from this study indicate that AM fungal inoculation improves growth of lemons, passion fruits, papaya, mango and avocado seedlings. The improvement occurred through increase in plant height, leaf number and leaf area, increased biomass accumulation (fresh and dry weights) and improved nutrient uptake.

Many researchers have also reported the benefits of arbuscular mycorrhiza on growth and biomass accumulation in plants.Mycorrhiza inoculation was found to increase the plant height, stem diameter and leaf number of sweet corn in USA (Tas, 2014). The shoot fresh weight was significantly increased by all three mycorrhiza fungi species, but only inoculation with *Glommusintraradices* and *G. fasciculatum* increased root dry weight. Rasouli-Sadaghiani *et al*., (2010) also showed that mycorrhizal basil plants had significantly higher shoot and root dry weight and plant height. Similar observations were made by Qiao *et al*., (2011) in pigeon peas, Al-Karaki (2013) in sour oranges and Suri & Choudhary (2013) in soybeans.

The improved performance of mycorrhizal seedlings can be attributed to improved efficiency of phosphorus uptake as evidenced by increased phosphorus accumulation in the leaves. In papaya study in India, leaf petiole of mycorrhizal plants recorded higher total phosphorus (0.42 – 0.63%) as compared to control (0.35%) plants (Kadhe & Rodrigues, 2009). A significant increase in shoot P concentration was also observed when *L. usitatissimum* was inoculated with *Glommusmosseae* or *G. intraradices* and their combination (Rydlová *et al*., 2011). Sukhada (1992) also reported two fold increase in leaf phosphorus concentration in papaya inoculated with *Glomus mosseae* and *Glomus fasiculatum* at lower levels of soil P (0g and 4.6g of triple super phosphate).Reports of improved phosphorus supply in low nutrient soils by mycorrhizal inoculation were also reported by Ishii et al (1996), Wamocho (1998), Cruz *et al*., (2000), Fidelibus *et al*., (2001), Kipkoriony *et al*. (2002); Muok and Ishii (2006) among other researchers.

The experiments were set up in either sand or a mixture composed of sand and nitrosol (1:1 vol/vol), both of which had low nutrient content. Research shows that under such conditions, AM fungi provides a very effective pathway by which P can be scavenged from large volumes of soil and rapidly being delivered to cortical cells within the root (Smith & Smith, 2011). This was attributed to individual fungal hyphae having much smaller diameters than roots, therefore allowing access to narrower soil pores and increasing the soil volume explored (Smith & Read, 2008; Schnepf *et al*., 2011).

In this study, mycorrhizal seedlings had greater root mass compared to un-inoculated seedlings, as indicated by greater root fresh weight. Likewise, the extent of mycorrhizal root infection was significantly greater in inoculated seedlings than in un-inoculated seedlings. It is expected that this greater mass of mycorrhizal roots corresponded to greater absorptive surface area for nutrients and water.

In experiments undertaken in sand culture under various P levels, mycorrhizal inoculation combined with moderate amount of P provided the highest growth response. Mycorrhizal plants subjected to high P content (1.68 ppm) initially had the highest increase in plant height. However, there was a reduction in plant height in the high P experiment at the end of the experiment period. At the end, there was no significant difference between the myorrhizal plants that received high P and the non-mycorrhizal plants that received similar high P or slightly lower P amount (0.44 and 0.88 ppm P). This indicates that the high phosphorus content in the presence of arbuscular mycorrhiza became deleterious to plant growth. A study in sunflower also found that treatment combination of mycorrhiza and 200 kg P/ha and nonmycorrhizal 200 kg P/ha combination did not show significant difference in terms of seed yield of sunflower (Vaseghmanesh*et al*., 2014).

Various reasons have been given for the adverse effect of high P on plant growth in the presence of mycorrhiza. Very high P application was found to alter root colonization (particularly reducing arbuscule development) and decrease AM fungal biomass per plant, including both biomass in roots and in soil (Smith & Read, 2008). Balzergue *et al*. (2011) also reported reduction in appressorium formation on pea (*Pisum sativum*) roots at high P. High P levels in the soil also reduced spore germination and hyphal

growth from the germinated spores and inhibited early colonization of the roots and growth of the extraradical mycelium (Smith & Smith, 2011).

In this study mycorrhizal inoculation increased the leaf nitrogen content in rough lemon seedlings. Nitrogen uptake was also significantly increased in mycorrhizal chickpea plants in Pakistan (Yaseen *et al.*, 2012). Like in the case of phosphorus, the major benefit of mycorrhiza in increasing uptake of N to plants was by availing greater soil exploration and supply to host roots (Sundar *et al.*, 2010).

In this study potassium uptake was increased in lemon, papaya and avocado seedlings. This is consistent with pawpaw study in India which showed that total potassium content of leaf petiole was higher in mycorrhizal plants and ranged from 2.68 - 4.39% as compared to non-mycorrhizal plants (2.26%) (Kadhe and Rodrigues, (2009). Uptake of K was also increased by AMF inoculation in cowpea and sorghum (Bagayoko *et al.*, 2000) and in finger millet by Rao *et al.*, (1983).

This can be attributed to greater soil exploration and increasing supply to host roots. Further increased K levels in mycorrhizal plants may be attributed to the fact that AM fungi binding soil particles to each other and to the roots, which is beneficial for the nutrient uptake (Estrada-Luna *et al.*, 2000).

In the study in sand: nitrosol media, mycorrhizal plants did not differ significantly, in all measured parameters, whether in sterilized or unsterilized media. This indicates that mycorrhizal inoculation played a greater role in the observed plant performance than media sterilization.Un-inoculated seedlings in this study performed poorly in both sterilized and un-sterilized media. However, un-inoculated seedlings held in sterilized media performed better that those held in unsterilized media. This could be attributed to elimination of all organisms in the media by sterilization. This can be an advantage through elimination of harmful micro-organisms in the media and could have contributed to the improved performance of un-inoculated seedlings in sterilized media.

On the other hand, lack of media sterilization can be an advantage because beneficial micro-organisms are not eliminated. In the un-sterilized seedlings, a small percentage

of mycorrhizal root infection was observed. This was expected to have proved beneficial by antagonizing against harmful microbes in the media as reported by Elsen *et al.,* (2003).

The presence of mycorrhizal infection in the roots of un-inoculated seedlings raised in un-sterilized media suggests the availability of AM fungi in native soils in the tropics. In this study, unsterilized media had a small quantity of mycorrhizal spores at the beginning of the experiment. This is an indication of the low level of mycorrhization of native soils in Kenya and explains why non mycorrhizal seedlings performed poorly This confirms the report by Wamocho (1998) that in fruit orchards in Kenya, AM fungal spores and the mycorrhizal infection of fruit tree roots are low. Likewise, evidence from a survey of 41 tree species in five nurseries in Ethiopia and Somalia suggest that naturally mycorrhizal formation, even in unsterilized soils can be sparse (Michelson, 1992).

Mycorrhizal inoculation in mango seedlings proved to be beneficial in the absence or presence of endosperm in the seed. This shows that in mango seedlings, mycorrhizal fungi played a more important role than endosperm presence. This can be attributed to the faster deterioration of the endosperm in mangoes, allowing the mycorrhiza to play a greater role in availing nutrients to the seedlings.

Unlike in mangoes, in avocados, mycorrhizal inoculation was not beneficial as compared to the endosperm condition. In avocados, the seedlings containing an endosperm performed better than those without, inspite of the mycorrhizal condition. In avocado seedlings, the endosperm was still intact at the time of termination of the experiment unlike in mangoes where the endosperm was exhausted. This explains why the mycorrhizal effect was not noticed in avocados, because the seedling could still obtain nourishment from the endosperm. In the absence of endosperm, mycorrhizal inoculation was beneficial in avocados, because the mycorrhizal seedlings without an endosperm performed better than the non-mycorrhizal seedlings without endosperm.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

This study indicated that mycorrhizal inoculation improved growth and performance of mango and passion fruit seedlings raised under salt stress conditions, as measured by growth parameters of plant height, leaf number and chlorophyll content, and biomass parameters of shoot, stem and root fresh and dry weights and leaf area. This is by enhancing the uptake of P, K and Mg, while reducing the detrimental effects of Na toxicity on seedling growth. As a low cost technology, arbuscular mycorrhizal technology is recommended for use to alleviate salinity stress in tropical fruit seedlings.

To build up on this study on salinity stress, it is recommemded that field study of the effect of arbuscular arbuscular mycorrhizal inoculation on the survival and growth of tropical fruit seedlings under salt stress conditions be undertaken. In particular, field studies should target fruit crops grown in salinity prone areas eg coconuts, cashew and mangoes.These studies by use of of native arbuscular mycorrhizal inocula found in the soils in ASAL areas where salinity is prevalent.

It is also recommended that studies targeting salinity induced by sodium carbonates and bicarbonates be undertaken both at field and greenhouse conditions. This is important because studies by Njue (2004) showed that salinity in Kenya's ASAL areas is not just due to sodium chloride, but also due to sodium carbonates and bicarbonates. In addition, studies should be undertaken to determine the interaction between arbuscular mycorrhizal fungi and calcium sulphates and carbonates in influencing NaCl-induced salinity. Studies have shown that calcium sulphates alleviate NaCl toxicity, while calcium carbonates exacerbates it (Njue, 2004).

This study indicated that under flooding stress, mycorrhizal inoculation improved growth and performance of passion fruit seedlings as measured by root, stem and leaf fresh and dry weights, leaf area. Under flooding conditions, AM fungi also slowed the decline in chlorophyll a,b concentration and total chlorophyll, and also delayed the onset of carotenoid rise in the leaves of flooded passion fruits. The beneficial effects of arbuscular mycorrhizal fungi in alleviating flooding stress is by inducing an increase

in the leaf proline concentration,stabilising soluble sugar levels in leaf tissues and facilitating uptake of phosphorus and nitrogen both in leaf and root tissues.

As a low cost technology, arbuscular mycorrhizal technology is recommended for use to alleviate flooding stress in tropical fruit seedlings. To build up on this study on flooding stress, it is recommended that field study be undertaken on the effect of arbuscular arbuscular mycorrhizal inoculation on the survival and growth of tropical fruit seedlings under flooding stress conditions. These studies should be taken by use of native arbuscular mycorrhizal inocula found in the soils in ASAL areas where flooding is prevalent in Kenya.

It is recommended that greenhouse studies on effect of arbuscular mycorrhizal fungi on flooding stress on other tropical fruit seedlings of economic importance. This is because this particular study focused only on passion fruit seedlings. It is important to determine if other fruit seedlings will be affected in a similar manner as passion fruits. For laboratory studies, it is recommended that the following aspects should be determined: measures on potentially toxic compounds such as sulfides, CO_2, soluble Fe and Mn, ethanol, lactic acid, acetaldehyde, acetic and formic acid on both flooded and unflooded soils and and rhizosphere. This will help fill the gap left as these parameters could not be determined in the present study due to unavailability of equipments.

This study found out that arbuscular mycorrhizal fungi alleviated nutrient stress of lemons, passion fruits, papaya, mango and avocado seedlings as measured by plant height, leaf number and stem girth of seedlings.The alleviation occurred in experiments undertaken both in mycorrhizal treatments both in sterile and un-sterile sand/soil media and also in sand culture under low phosphorus regimes. Arbuscular mycorrhizal inoculation also increased the leaf area and the root, leaf and stem fresh and dry weights and induced an increase in the uptake of phosphorus, nitrogen and potassium in the leaf tissues of lemons, passion fruits, papaya, mango and avocado seedlings. As a result, AM fungi improved the capacity of tropical fruit to absorb and utilize plant nutrients possibly by increasing the effective root surface area from which available form of nutrients are absorbed and also by increasing access of roots by bridging the depletion zones.

In addition to the recommendations already presented, this study recommends the adoption of arbuscular mycorrhizal fungi as a regular practise in the nursery propagation of tropical fruit seedlings. This will help in the transfer of mycorrhizal seedlings into orchards at transplanting time. A suggestion for further study is to on incorporation of arbuscular mycorrhizae spores into the planting hole at transplanting time and/or introduction into fruit orchards as a regular practise, to replace those that are lost via tillage practices, soil erosion and fungicidal sprays.This is a regular practise in Japan were orchards are regularly introduced via sprinkler irrigation. In Kenya, the possibility of introducing AM spores into below plant canopy by use of a watering can should be investigated.

To bridge the knowledge gap, it is recommended that the government facilitates training of smallholder farmers, agro-dealers, fruit seedling propagators, extension service workers and policy makers on the beneficial aspects of arbuscular mycorrhizal technology. The training should include aspects of isolation, identification, examination and selection of improved strains having greater crop diversification and survival during transport, storage and after soil application. There should especially be emphasis on on-farm production of inoculum from locally isolated adapted species. These may turn out to be more effective than introduced ones which may not be locally adapted to the local environmental conditions. Training on on-farm production of mycorrhizal inoculum to avoids some of production and transportation costs. This will allow technology transfer and also solve the problem of expensive inoculum prices, poor delivery mechanisms and the resultant reduction in quality.

The government should also promote measures to address soil erosion problems in ASAL areas which lead to reduction of native arbuscular mycorrhizal inocula in the soil. There should also be promotion of flood control measures especially in areas that currently experience increased flooding. Better land management/conservation farming using improved methods of land husbandry to better conserve soil, water, and the integrity of natural and managed ecosystems is needed.

In addition to the research areas already recommended, there is need to carry out research on arbuscular mycorrhizal influence using single species instead of mized

inoculums that was used in this study. In addition, there is need to determine the effects of arbuscular mycorrhizal fungi and trichoderma interaction especially on alleviation of soil-borne diseases. Other studies that could be undertaken include to determine the effect of AM fungi on growt of tropical fruit seedlings in acidic, calcerous and alkaline soils in Kenya.

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APPENDICES

Appendix I: ANOVA table for effect of arbuscular mycorrhizal fungi and salt stress on the plant height (cm) of Passion fruit seedlings

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		5	4337.1	867.42	35.08	<.001
Contrast 1	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	147.92	147.92	5.98	0.025*
Contrast 2	Mycorrhizal, 0 dS/m EC VS Mycorrhizal, 4.9 dS/m EC	1	250.88	250.88	10.15	0.005**
Contrast 3	Mycorrhizal, 0 dS/m EC VS Mycorrhizal, 9 dS/m EC	1	2520.5	2520.5	101.93	<.001***
Contrast 4	Mycorrhizal, 4.9 dS/m EC VS Mycorrhizal, 9 dS/m EC	1	1180.98	1181	47.76	<.001***
Contrast 5	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	13.52	13.52	0.55	0.469NS
Contrast 6	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	364.5	364.5	14.74	0.001***
Contrast 7	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	1113.9	1113.9	45.05	<.001***
Contrast 8	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	1447.2	1447.2	58.53	<.001***
Contrast 9	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	233.28	233.28	9.43	0.007**
Contrast 10	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	0.98	0.98	0.04	0.844NS
Contrast 11	Non-Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	518.42	518.42	20.97	<.001***
Contrast 12	Non-Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	1372.9	1372.9	55.52	<.001***
Contrast 13	Non-Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	204.02	204.02	8.25	0.01**
Residual		18	445.1	24.73		
Total		23	4782.2			

Appendix II: ANOVA table for effect of arbuscular mycorrhizal fungi and salt stress on the leaf number of passion fruit seedlings

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		5	386.27	77.255	33.41	<.001
Contrast 1	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	0.5	0.5	0.22	0.647NS
Contrast 2	Mycorrhizal, 0 dS/m EC VS Mycorrhizal, 4.9 dS/m EC	1	6.48	6.48	2.8	0.111NS
Contrast 3	Mycorrhizal, 0 dS/m EC VS Mycorrhizal, 9 dS/m EC	1	32	32	13.84	0.002**
Contrast 4	Mycorrhizal, 4.9 dS/m EC VS Mycorrhizal, 9 dS/m EC	1	9.68	9.68	4.19	0.056NS
Contrast 5	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	3.38	3.38	1.46	0.242NS
Contrast 6	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	5.12	5.12	2.21	0.154NS
Contrast 7	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	208.08	208.08	89.99	<.001***
Contrast 8	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	24.5	24.5	10.6	0.004**
Contrast 9	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	0.72	0.72	0.31	0.584NS
Contrast 10	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	128	128	55.36	<.001***
Contrast 11	Non-Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	16.82	16.82	7.27	0.015**
Contrast 12	Non-Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	264.5	264.5	114.39	<.001***
Contrast 13	Non-Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	147.92	147.92	63.97	<.001***
Residual		18	41.62	2.312		
Total		23	427.89			

Appendix III: ANOVA table for effect of arbuscular mycorrhizal fungi and salt stress on the leaf area (cm^2) of passion fruit seedlings

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		5	830435	166087	135.3	<.001
Contrast 1	Mycorrhizal, 0 dS/m EC VS Mycorrhizal, 4.9 dS/m EC	1	63155	63155	51.45	<.001***
Contrast 2	Mycorrhizal, 0 dS/m EC VS Mycorrhizal, 9 dS/m EC	1	330224	330224	269	<.001***
Contrast 3	Mycorrhizal, 4.9 dS/m EC VS Mycorrhizal, 9 dS/m EC	1	104552	104552	85.17	<.001***
Contrast 4	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	23039	23039	18.77	<.001***
Contrast 5	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	203407	203407	165.7	<.001***
Contrast 6	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	608569	608569	495.74	<.001***
Contrast 7	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	9904	9904	8.07	0.011*
Contrast 8	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	39881	39881	32.49	<.001***
Contrast 9	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	279632	279632	227.79	<.001***
Contrast 10	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	178814	178814	145.66	<.001***
Contrast 11	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	15288	15288	12.45	0.002**
Contrast 12	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	42213	42213	34.39	<.001***
Contrast 13	Non-Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	89532	89532	72.93	<.001***
Contrast 14	Non-Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	394787	394787	321.59	<.001***
Contrast 15	Non-Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	108308	108308	88.23	<.001***
Residual		18	22097	1228		
Total		23	852532			

Appendix IV: ANOVA table for effect of arbuscular mycorrhizal fungi and salt stress on the chlorophyll content of passion fruit seedlings

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENTS		5	2810.4	562.07	46.34	<.001
Contrast 1	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	8	8	0.66	0.427NS
Contrast 2	Mycorrhizal, 0 dS/m EC VS Mycorrhizal, 4.9 dS/m EC	1	124.82	124.82	10.29	0.005**
Contrast 3	Mycorrhizal, 0 dS/m EC VS Mycorrhizal, 9 dS/m EC	1	1383.4	1383.4	114.05	<.001***
Contrast 4	Mycorrhizal, 4.9 dS/m EC VS Mycorrhizal, 9 dS/m EC	1	677.12	677.12	55.82	<.001***
Contrast 5	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	196.02	196.02	16.16	<.001***
Contrast 6	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	28.88	28.88	2.38	0.14NS
Contrast 7	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	518.42	518.42	42.74	<.001***
Contrast 8	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	1601.8	1601.8	132.05	<.001***
Contrast 9	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	426.32	426.32	35.15	<.001***
Contrast 10	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	10.58	10.58	0.87	0.363NS
Contrast 11	Non-Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	375.38	375.38	30.95	<.001***
Contrast 12	Non-Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	1352	1352	111.46	<.001***
Contrast 13	Non-Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	302.58	302.58	24.94	<.001***
Residual		18	218.34	12.13		
Total		23	3028.7			

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		7	1451.04	207.29	15.08	<.001
Contrast 1	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, Mycorrhizal, 4.9 dS/M EC	1	322.58	322.58	23.46	<.001***
Contrast 2	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non- Mycorrhizal, 0 dS/M EC	1	176.72	176.72	12.85	0.001***
Contrast 3	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	524.88	524.88	38.17	<.001***
Contrast 4	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	7.22	7.22	0.53	0.476NS
Contrast 5	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	486.72	486.72	35.4	<.001***
Contrast 6	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 0 dS/M EC	1	531.38	531.38	38.65	<.001***
Contrast 7	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	792.02	792.02	57.6	<.001***
Contrast 8	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs With Endosperm, non- Mycorrhizal, 0 dS/M EC	1	21.78	21.78	1.58	0.22NS
Contrast 9	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs With Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	59.95	59.95	4.73	0.04*
Contrast 10	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	233.28	233.28	16.97	<.001***
Contrast 11	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	16.82	16.82	1.22	0.28NS
Contrast 12	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	25.92	25.92	1.89	0.182NS
Contrast 13	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	103.68	103.68	7.54	0.011**
Contrast 14	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs With Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	92.48	92.48	6.73	0.016*
Contrast 15	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	112.5	112.5	8.18	0.009**
Contrast 16	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	76.88	76.88	5.59	0.026**
Contrast 17	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 0 dS/M EC	1	95.22	95.22	6.93	0.015**
Contrast 18	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	220.5	220.5	16.04	<.001***
Contrast 19	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	408.98	408.98	29.74	<.001***
Contrast 20	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	0.72	0.72	0.05	0.821NS
Contrast 21	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non Mycorrhizal, 0 dS/M EC	1	0.02	0.02	0	0.97NS
Contrast 22	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non Mycorrhizal, 4.9 dS/M EC	1	27.38	27.38	1.99	0.171NS
Contrast 23	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	375.38	375.38	27.3	<.001***
Contrast 24	Without Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 0 dS/M EC	1	414.72	414.72	30.16	<.001***
Contrast 25	Without Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	648	648	47.13	<.001***
Contrast 26	Without Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 0 dS/M EC	1	0.98	0.98	0.07	0.792NS
Contrast 27	Without Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	36.98	36.98	2.69	0.114NS
Contrast 28	Without Endosperm, non mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	25.92	25.92	1.89	0.182NS
Residual		24	330	13.75		
Total		31	1781.04			

Appendix V: ANOVA table for effect of Arbuscular Mycorrhizal Fungi, Endosperm attachment and salt stress on the Plant height of Mango seedlings

Appendix VI: ANOVA table for effect of arbuscular mycorrhizal fungi, endosperm attachment and salt stress on the leaf number of mango seedlings

	Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		7	265.355	37.908	20.72	<.001
Contrast 1	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, Mycorrhizal, 4.9 dS/M EC	1	44.18	44.18	24.15	<.001***
Contrast 2	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non- Mycorrhizal, 0 dS/M EC	1	16.82	16.82	9.2	0.006***
Contrast 3	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	141.12	141.12	77.15	<.001***
Contrast 4	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	7.22	7.22	3.95	0.058NS
Contrast 5	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	64.98	64.98	35.52	<.001***
Contrast 6	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 0 dS/M EC	1	44.18	44.18	24.15	<.001***
Contrast 7	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	51.84	51.84	28.34	<.001***
Contrast 8	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs With Endosperm, non- Mycorrhizal, 0 dS/M EC	1	6.48	6.48	3.54	0.072NS
Contrast 9	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs With Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	15.68	15.68	8.57	0.007***
Contrast 10	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	2	2	1.09	0.306NS
Contrast 11	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	0	0	0	1NS
Contrast 12	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	36.98	36.98	20.22	<.001***
Contrast 13	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	60.5	60.5	33.08	<.001***
Contrast 14	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs With Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	2	2	1.09	0.306NS
Contrast 15	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	15.68	15.68	8.57	0.007***

Contrast 16	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	6.48	6.48	3.54	0.072NS
Contrast 17	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	74.42	74.42	40.69	<.001***
Contrast 18	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	84.5	84.5	46.2	<.001***
Contrast 19	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	14.58	14.58	7.97	0.009***
Contrast 20	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	27.38	27.38	14.97	<.001***
Contrast 21	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non Mycorrhizal, 0 dS/M EC	1	0.72	0.72	0.39	0.536NS
Contrast 22	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non Mycorrhizal, 4.9 dS/M EC	1	28.88	28.88	15.79	<.001***
Contrast 23	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	15.68	15.68	8.57	0.007***
Contrast 24	Without Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 0 dS/M EC	1	100.82	100.82	55.12	<.001***
Contrast 25	Without Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	2	2	1.09	0.306NS
Contrast 26	Without Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	21.78	21.78	11.91	0.002***
Contrast 27	Without Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	36.98	36.98	20.22	<.001***
Contrast 28	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Non-Mycorrhizal, 0 dS/M EC	1	15.68	15.68	8.57	0.007**
Contrast 29	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	100.82	100.82	55.12	<.001***
Contrast 30	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	2	2	1.09	0.306NS
Contrast 31	With Endosperm, non- mycorrhizal 0 dS/M EC VS with Endosperm Mycorrhizal 4.9 dS/M EC	1	6.48	6.48	3.54	0.072NS
Contrast 32	Without Endosperm, non- mycorrhizal 0 dS/M EC VS without Endosperm Mycorrhizal 4.9 dS/M EC	1	2	2	1.09	0.306NS
Total		31	309.255			

Appendix VII: ANOVA table for effect of arbuscular mycorrhizal fungi, endosperm attachment and salt stress on the leaf area (cm^2) of mango seedlings

	Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		7	370906	52987	43.18	<.001
Contrast 1	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, Mycorrhizal, 4.9 dS/M EC	1	50010	50010	40.76	<.001***
Contrast 2	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 0 dS/M EC	1	16247	16247	13.24	0.001***
Contrast 3	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	129032	129032	105.16	<.001***
Contrast 4	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	309	309	0.25	0.62NS
Contrast 5	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	54127	54127	44.11	<.001***
Contrast 6	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	79896	79896	65.11	<.001***
Contrast 7	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	196853	196853	160.43	<.001***
Contrast 8	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs With Endosperm, non-Mycorrhizal, 0 dS/M EC	1	5424	5424	4.74	0.04*
Contrast 9	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	18382	18382	14.98	<.001***
Contrast 10	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	58181	58181	47.42	<.001***
Contrast 11	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	81	81	0.07	0.799NS
Contrast 12	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	3484	3484	2.84	0.105NS
Contrast 13	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	48423	48423	39.46	<.001***
Contrast 14	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	5424	5424	4.74	0.04*
Contrast 15	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	21037	21037	17.14	<.001***
Contrast 16	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	11065	11065	9.02	0.006***

Contrast 17	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	24086	24086	19.63	<.001***
Contrast 18	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	99994	99994	81.49	<.001***
Contrast 19	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	141970	141970	115.7	<.001***
Contrast 20	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	16017	16017	13.05	0.001***
Contrast 21	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non Mycorrhizal, 0 dS/M EC	1	5860	5860	4.78	0.039***
Contrast 22	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non Mycorrhizal, 4.9 dS/M EC	1	7135	7135	5.82	0.024***
Contrast 23	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	62616	62616	51.03	<.001***
Contrast 24	Without Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 0 dS/M EC	1	90143	90143	73.46	<.001***
Contrast 25	Without Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	212761	212761	173.39	<.001***
Contrast 26	Without Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	2501	2501	2.04	0.166NS
Contrast 27	Without Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	44533	44533	36.29	<.001***
Contrast 28	Without Endosperm, non mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	25928	25928	21.13	<.001***
Contrast 29	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	90143	90143	73.46	<.001***
Contrast 30	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	212761	212761	173.39	<.001***
Contrast 31	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	81	81	0.07	0.799NS
Residual		24	29449	1227		
Total		31	400355			

Appendix VIII: Anova table for effect of arbuscular mycorrhizal fungi, endosperm attachment and salt stress on the chlorophyll % of mango seedlings

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		7	3582.94	511.85	22.88	<.001
Contrast 1	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, Mycorrhizal, 4.9 dS/M EC	1	1021.52	1021.52	45.67	<.001***
Contrast 2	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non- Mycorrhizal, 0 dS/M EC	1	141.12	141.12	6.31	0.019***
Contrast 3	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	1260.02	1260.02	56.33	<.001***
Contrast 4	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	9.68	9.68	0.43	0.517NS
Contrast 5	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	882	882	39.43	<.001***
Contrast 6	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 0 dS/M EC	1	312.5	312.5	13.97	0.001***
Contrast 7	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	1946.88	1946.88	87.04	<.001***
Contrast 8	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs With Endosperm, non- Mycorrhizal, 0 dS/M EC	1	403.28	403.28	18.03	<.001***
Contrast 9	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs With Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	12.5	12.5	0.56	0.462NS
Contrast 10	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	832.32	832.32	37.21	<.001***
Contrast 11	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	5.12	5.12	0.23	0.637NS
Contrast 12	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	204.02	204.02	9.12	0.006***
Contrast 13	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	147.92	147.92	6.61	0.017***
Contrast 14	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	557.78	557.78	24.94	<.001***
Contrast 15	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	76.88	76.88	3.44	0.076NS
Contrast 16	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	317.52	317.52	14.2	<.001***

Contrast 17	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	33.62	33.62	1.5	0.232NS
Contrast 18	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	1039.68	1039.68	46.48	<.001***
Contrast 19	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	1048.82	1048.82	46.89	<.001***
Contrast 20	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	33.62	33.62	1.5	0.232NS
Contrast 21	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non Mycorrhizal, 0 dS/M EC	1	317.52	317.52	14.2	<.001***
Contrast 22	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non Mycorrhizal, 4.9 dS/M EC	1	74.42	74.42	3.33	0.081NS
Contrast 23	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	706.88	706.88	31.6	<.001***
Contrast 24	Without Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 0 dS/M EC	1	212.18	212.18	9.49	0.005***
Contrast 25	Without Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	1682	1682	75.2	<.001***
Contrast 26	Without Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	2	2	1.09	0.306NS
Contrast 27	Without Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	208.08	208.08	9.3	0.006**
Contrast 28	Without Endosperm, non mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	699.38	699.38	31.27	<.001***
Contrast 29	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Non Mycorrhizal, 0 dS/M EC	1	212.18	212.18	9.49	0.005**
Contrast 30	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	1682	1682	75.2	<.001***
Contrast 31	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	5.12	5.12	0.23	0.637NS
Residual		24	536.82	22.37		
Total		31	4119.76			

Appendix IX: Anova table for effect of arbuscular mycorrhizal fungi and salt stress on the leaf fresh weight (grams) of passion fruit seedlings

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		5	392.71	78.542	44.17	<.001***
Contrast 1	Mycorrhizal, 0 dS/m EC VS Mycorrhizal, 4.9 dS/m EC	1	19.22	19.22	10.81	0.004**
Contrast 2	Mycorrhizal, 0 dS/m EC VS Mycorrhizal, 9 dS/m EC	1	197.61	197.61	111.13	<.001***
Contrast 3	mycorrhizal, 4.9 ds/m ec vs mycorrhizal, 9 ds/m ec	1	93.571	93.571	52.62	<.001***
Contrast 4	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	14.58	14.58	8.2	0.01**
Contrast 5	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	65.208	65.208	36.67	<.001***
Contrast 6	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	259.01	259.01	145.67	<.001***
Contrast 7	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	0.32	0.32	0.18	0.676NS
Contrast 8	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	13.624	13.624	7.66	0.013**
Contrast 9	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	137.12	137.12	77.11	<.001***
Contrast 10	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	104.84	104.84	58.96	<.001***
Contrast 11	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	35.786	35.786	20.13	<.001***
Contrast 12	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	4.147	4.147	2.33	0.144NS
Contrast 13	Non-Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	18.12	18.12	10.19	0.005**
Contrast 14	Non-Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	150.69	150.69	84.74	<.001***
Contrast 15	Non-Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	64.298	64.298	36.16	<.001***
Residual		18	32.006	1.778		
Total		23	424.72			

Appendix X: Anova table for effect of arbuscular mycorrhizal fungi and salt stress on the stem fresh weight (grams) of passion fruit seedlings

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		5	41.497	8.2993	44.6	<.001
Contrast 1	Mycorrhizal, 0 dS/m EC VS Mycorrhizal, 4.9 dS/m EC	1	10.58	10.58	56.85	<.001***
Contrast 2	Mycorrhizal, 0 dS/m EC VS Mycorrhizal, 9 dS/m EC	1	28.125	28.125	151.13	<.001***
Contrast 3	Mycorrhizal, 4.9 dS/m EC VS Mycorrhizal, 9 dS/m EC	1	4.205	4.205	22.6	<.001***
Contrast 4	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	5.9858	5.9858	32.16	<.001***
Contrast 5	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	17.287	17.2872	92.89	<.001***
Contrast 6	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	29.338	29.3378	157.65	<.001***
Contrast 7	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	0.6498	0.6498	3.49	0.078NS
Contrast 8	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	0.8192	0.8192	4.4	0.05*
Contrast 9	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	4.6818	4.6818	25.16	<.001***
Contrast 10	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	8.1608	8.1608	43.85	<.001***
Contrast 11	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	1.3122	1.3122	7.05	0.016**
Contrast 12	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	0.0128	0.0128	0.07	0.796NS
Contrast 13	Non-Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	2.9282	2.9282	15.73	<.001***
Contrast 14	Non-Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	8.82	8.82	47.39	<.001***
Contrast 15	Non-Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	1.5842	1.5842	8.51	0.009**
Residual		18	3.3498	0.1861		
Total		23	44.846			

Appendix XII: Anova table for effect of arbuscular mycorrhizal fungi and salt stress on the root fresh weight (grams) of passion fruit seedlings

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		5	729.87	145.98	45.96	<.001
Contrast 1	Mycorrhizal, 0 dS/m EC VS Mycorrhizal, 4.9 dS/m EC	1	64.98	64.98	20.46	<.001***
Contrast 2	Mycorrhizal, 0 dS/m EC VS Mycorrhizal, 9 dS/m EC	1	420.5	420.5	132.4	<.001***
Contrast 3	Mycorrhizal, 4.9 dS/m EC VS Mycorrhizal, 9 dS/m EC	1	154.88	154.88	48.77	<.001***
Contrast 4	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	23.12	23.12	7.28	0.015***
Contrast 5	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	158.42	158.42	49.88	<.001***
Contrast 6	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	450	450	141.69	<.001***
Contrast 7	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	10.58	10.58	3.33	0.085NS
Contrast 8	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	20.48	20.48	6.45	0.021***
Contrast 9	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	172.98	172.98	54.47	<.001***
Contrast 10	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	246.42	246.42	77.59	<.001***
Contrast 11	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	62.72	62.72	19.75	<.001***
Contrast 12	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	0.5	0.5	0.16	0.696NS
Contrast 13	Non-Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	60.5	60.5	19.05	<.001***
Contrast 14	Non-Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	269.12	269.12	84.74	<.001**
Contrast 15	Non-Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	74.42	74.42	23.43	<.001***
Residual		18	57.166	3.176		
Total		23	787.04			

Appendix XII: Anova table for effect of arbuscular mycorrhizal fungi and salt stress on the leaf dry weight (grams) of passion fruit seedlings

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		5	23.7707	4.75415	68.95	<.001
Contrast 1	Mycorrhizal, 0 dS/m EC VS Mycorrhizal, 4.9 dS/m EC	1	2.4642	2.4642	35.74	<.001***
Contrast 2	Mycorrhizal, 0 dS/m EC VS Mycorrhizal, 9 dS/m EC	1	10.2152	10.2152	148.14	<.001***
Contrast 3	Mycorrhizal, 4.9 dS/m EC VS Mycorrhizal, 9 dS/m EC	1	2.645	2.645	38.36	<.001***
Contrast 4	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	0.6498	0.6498	9.42	0.007**
Contrast 5	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	7.605	7.605	110.29	<.001***
Contrast 6	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	16.5888	16.5888	240.57	<.001***
Contrast 7	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	0.5832	0.5832	8.46	0.009**
Contrast 8	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	1.4112	1.4112	20.47	<.001***
Contrast 9	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	6.2658	6.2658	90.87	<.001***
Contrast 10	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	5.7122	5.7122	82.84	<.001***
Contrast 11	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	0.1922	0.1922	2.79	0.112NS
Contrast 12	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	0.7688	0.7688	11.15	0.004**
Contrast 13	Non-Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	3.8088	3.8088	55.24	<.001***
Contrast 14	Non-Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	10.6722	10.6722	154.77	<.001***
Contrast 15	Non-Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	1.7298	1.7298	25.09	<.001***
Residual		18	1.2412	0.06896		
Total		23	25.0119			

Appendix XIII: Anova table for effect of arbuscular mycorrhizal fungi and salt stress on the stem dry weight (grams) of passion fruit seedlings

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		5	4.8808	0.97616	37.15	<.001
Contrast 1	Mycorrhizal, 0 dS/m EC VS Mycorrhizal, 4.9 dS/m EC	1	1.2482	1.2482	47.5	<.001***
Contrast 2	Mycorrhizal, 0 dS/m EC VS Mycorrhizal, 9 dS/m EC	1	2.8322	2.8322	107.78	<.001***
Contrast 3	Mycorrhizal, 4.9 dS/m EC VS Mycorrhizal, 9 dS/m EC	1	0.32	0.32	12.18	0.003**
Contrast 4	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	0.7688	0.7688	29.26	<.001***
Contrast 5	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	1.8818	1.8818	71.61	<.001***
Contrast 6	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	3.9762	3.9762	151.31	<.001***
Contrast 7	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	0.0578	0.0578	2.2	0.155NS
Contrast 8	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	0.0648	0.0648	2.47	0.134NS
Contrast 9	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	0.7688	0.7688	29.26	<.001***
Contrast 10	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	0.6498	0.6498	24.73	<.001***
Contrast 11	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	0.0968	0.0968	3.68	0.071NS
Contrast 12	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	0.0968	0.0968	3.68	0.071NS
Contrast 13	Non-Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	0.245	0.245	9.32	0.007**
Contrast 14	Non-Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	1.2482	1.2482	47.5	<.001***
Contrast 15	Non-Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	0.3872	0.3872	14.73	0.001***
Residual		18	0.473	0.02628		
Total		23	5.3538			

Appendix XIV: Anova table for effect of arbuscular mycorrhizal fungi and salt stress on the root dry weight (grams) of passion fruit seedlings

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		5	97.784	19.557	181.06	<.001
Contrast 1	Mycorrhizal, 0 dS/m EC VS Mycorrhizal, 4.9 dS/m EC	1	45.506	45.506	421.31	<.001***
Contrast 2	Mycorrhizal, 0 dS/m EC VS Mycorrhizal, 9 dS/m EC	1	64.98	64.98	601.6	<.001***
Contrast 3	Mycorrhizal, 4.9 dS/m EC VS Mycorrhizal, 9 dS/m EC	1	1.7298	1.7298	16.02	<.001***
Contrast 4	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	35.28	35.28	326.63	<.001***
Contrast 5	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	58.32	58.32	539.94	<.001***
Contrast 6	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	69.62	69.62	644.56	<.001***
Contrast 7	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	0.6498	0.6498	6.02	0.025*
Contrast 8	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	0.7938	0.7938	7.35	0.014*
Contrast 9	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	2.5538	2.5538	23.64	<.001***
Contrast 10	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	4.5	4.5	41.66	<.001***
Contrast 11	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	0.18	0.18	1.67	0.213NS
Contrast 12	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	0.08	0.08	0.74	0.401NS
Contrast 13	Non-Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	2.88	2.88	26.66	<.001***
Contrast 14	Non-Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	5.78	5.78	53.51	<.001***
Contrast 15	Non-Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	0.5	0.5	4.63	0.045*
Residual		18	1.9442	0.108		
Total		23	99.729			

Appendix XV: Anova table for effect of arbuscular mycorrhizal fungi, endosperm attachment and salt stress on the leaf fresh weight (grams of mango seedlings

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		7	209.2868	29.8981	42.69	<.001***
Contrast 1	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, Mycorrhizal, 4.9 dS/M EC	1	37.845	37.845	54.04	<.001***
Contrast 2	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 0 dS/M EC	1	13.7288	13.7288	19.6	<.001***
Contrast 3	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	80.1378	80.1378	114.44	<.001***
Contrast 4	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	0.1922	0.1922	0.27	0.605NS
Contrast 5	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	44.7458	44.7458	63.9	<.001***
Contrast 6	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	49.2032	49.2032	70.26	<.001***
Contrast 7	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	119.5058	119.505	170.65	<.001***
Contrast 8	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs With Endosperm, non-Mycorrhizal, 0 dS/M EC	1	0.2888	0.2888	0.55	0.465NS
Contrast 9	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	12.3008	12.3008	18.93	<.001***
Contrast 10	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	32.6432	32.6432	46.61	<.001***
Contrast 11	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	0.2888	0.2888	0.41	0.527NS
Contrast 12	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	4.8672	4.8672	9.27	0.006NS
Contrast 13	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	22.8488	22.8488	32.63	<.001***
Contrast 14	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	27.5282	27.5282	39.31	<.001***
Contrast 15	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	10.6722	10.6722	15.24	<.001***
Contrast 16	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	0.72	0.72	1.37	0.253NS
Contrast 17	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 0 dS/M EC	1	10.9512	10.9512	15.64	<.001***
Contrast 18	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	52.2242	52.2242	74.58	<.001***

Contrast 19	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	72.4808	72.4808	103.5	<.001***
Contrast 20	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	5.12	5.12	7.31	0.012***
Contrast 21	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non Mycorrhizal, 0 dS/M EC	1	3.7538	3.7538	5.36	0.029***
Contrast 22	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non Mycorrhizal, 4.9 dS/M EC	1	3.92	3.92	5.6	0.026*
Contrast 23	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	39.0728	39.0728	55.8	<.001***
Contrast 24	Without Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 0 dS/M EC	1	43.245	43.245	61.75	<.001***
Contrast 25	Without Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	110.1128	110.1128	157.24	<.001***
Contrast 26	Without Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 0 dS/M EC	1	3.5912	3.5912	6.84	0.015NS
Contrast 27	Without Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	18	18	25.7	<.001***
Contrast 28	Without Endosperm, non mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	15.3458	15.3458	21.91	<.001***
Contrast 29	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 0 dS/M EC	1	43.245	43.245	61.75	<.001***
Contrast 30	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	110.1128	110.1128	157.24	<.001***
Contrast 31	With Endosperm, Mycorrhizal, 4.9 dS/M EC VS Without Endosperm, mycorrhizal, 4.9 dS/M EC	1	0.2888	0.2888	0.46	0.505NS
Residual		24	16.8068	0.7003		
Total		31	226.0936			

Appendix XVI: ANOVA table for effect of Arbuscular Mycorrhizal Fungi, Endosperm attachment and salt stress on the Stem Fresh Weight (grams) of Mango seedlings

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		7	64.323	9.189	87.11	<.001***
Contrast 1	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, Mycorrhizal, 4.9 dS/M EC	1	23.943	23.943	226.9	<.001***
Contrast 2	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 0 dS/M EC	1	8.4872	8.4872	80.45	<.001***
Contrast 3	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	21.648	21.648	205.2	<.001***
Contrast 4	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	0.1568	0.1568	1.49	0.235NS
Contrast 5	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	17.880	17.880	169.4	<.001***
Contrast 6	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	21.912	21.912	207.7	<.001***
Contrast 7	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	32.320	32.320	306.3	<.001***
Contrast 8	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs With Endosperm, non-Mycorrhizal, 0 dS/M EC	1	0.259	0.2592	2.99	0.097NS
Contrast 9	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	1.5488	1.5488	17.41	<.001***
Contrast 10	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	20.224	20.224	191.7	<.001***
Contrast 11	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	0.4418	0.4418	4.19	0.052NS
Contrast 12	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	1.513	1.513	17.45	<.001
Contrast 13	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	0.6272	0.6272	5.95	0.023***
Contrast 14	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	3.0258	3.0258	28.68	<.001***
Contrast 15	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	6.3368	6.3368	60.07	<.001***
Contrast 16	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	0.540	0.540	6.23	0.02*
Contrast 17	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	3.125	3.125	29.62	<.001***

Contrast 18	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	7.6832	7.6832	72.83	<.001***
Contrast 19	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	18.120	18.120	171.77	<.001***
Contrast 20	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	0.18	0.18	1.71	0.204NS
Contrast 21	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non Mycorrhizal, 0 dS/M EC	1	0.0008	0.0008	0.01	0.931NS
Contrast 22	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non Mycorrhizal, 4.9 dS/M EC	1	1.0658	1.0658	10.1	0.004***
Contrast 23	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	14.688	14.688	139.4	<.001***
Contrast 24	Without Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 0 dS/M EC	1	18.361	18.361	174.0	<.001***
Contrast 25	Without Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	27.975	27.975	265.1	<.001***
Contrast 26	Without Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	1.008	1.008	11.62	0.002NS
Contrast 27	Without Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	2.1218	2.1218	20.11	<.001***
Contrast 28	Without Endosperm, non mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	1.0082	1.0082	9.56	0.005***
Contrast 29	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	18.361	18.361	174.0	<.001***
Contrast 30	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	27.975	27.975	265.1	<.001***
Contrast 31	With Endosperm, Mycorrhizal, 4.9 dS/M EC VS Without Endosperm, mycorrhizal, 4.9 dS/M EC	1	0.2312	0.2312	2.49	0.128NS
Residual		24	2.5318	0.1055		
Total		31	66.85			

Appendix XVII: Anova table for effect of arbuscular mycorrhizal fungi, endosperm attachment and salt stress on the root fresh weight (grams of mango seedlings)

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		7	174.742	24.9631	48.25	<.001***
Contrast 1	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, Mycorrhizal, 4.9 dS/M EC	1	39.0728	39.0728	75.53	<.001***
Contrast 2	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 0 dS/M EC	1	15.5682	15.5682	30.09	<.001***
Contrast 3	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	59.6232	59.6232	115.25	<.001***
Contrast 4	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	0.4418	0.4418	1.31	0.263NS
Contrast 5	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	65.6658	65.6658	126.93	<.001***
Contrast 6	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	94.3938	94.3938	182.47	<.001***
Contrast 7	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	125.136	125.1362	241.89	<.001***
Contrast 8	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs With Endosperm, non-Mycorrhizal, 0 dS/M EC	1	0.0098	0.0098	0.04	0.853NS
Contrast 9	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	9.7682	9.7682	17.05	<.001***
Contrast 10	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	1.4964	1.4964	2.89	0.102NS
Contrast 11	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	3.4322	3.4322	6.63	0.017***
Contrast 12	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	15.68	15.68	56.34	<.001***
Contrast 13	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	24.3602	24.3602	47.09	<.001***
Contrast 14	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	14.2578	14.2578	27.56	<.001***
Contrast 15	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	1.1705	1.1705	2.26	0.146NS
Contrast 16	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	0.3042	0.3042	1.09	0.306NS
Contrast 17	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	33.2928	33.2928	64.36	<.001***

Contrast 18	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	52.4288	52.4288	101.35	<.001***
Contrast 19	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	7.258	7.258	14.03	<.001***
Contrast 20	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	0.1458	0.1458	0.28	0.6NS
Contrast 21	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non Mycorrhizal, 0 dS/M EC	1	3.9762	3.9762	7.69	0.011***
Contrast 22	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non Mycorrhizal, 4.9 dS/M EC	1	12.005	12.005	23.21	<.001***
Contrast 23	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	9.4612	9.4612	18.29	<.001***
Contrast 24	Without Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 0 dS/M EC	1	21.9784	21.9784	42.49	<.001***
Contrast 25	Without Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	37.9321	37.9321	73.32	<.001***
Contrast 26	Without Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	10.9512	10.9512	39.35	<.001***
Contrast 27	Without Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	9.5048	9.5048	18.37	<.001***
Contrast 28	Without Endosperm, non mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	2.1632	2.1632	4.18	0.052NS
Contrast 29	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	21.9784	21.9784	42.49	<.001***
Contrast 30	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	37.9321	37.9321	73.32	<.001***
Contrast 31	With Endosperm, Mycorrhizal, 4.9 dS/M EC VS Without Endosperm, mycorrhizal, 4.9 dS/M EC	1	1.4792	1.4792	4.16	0.053NS
Residual		24	12.4157	0.5173		
Total		31	187.1577			

Appendix XVIII: Anova table for effect of arbuscular mycorrhizal fungi, endosperm attachment and salt stress on the leaf dry weight (grams) of mango seedlings

	Source of variation	d.f	s.s.	m.s.	v.r.	F pr.
TREATMENT		7	27.424	3.9177	27.04	<.001***
Contrast 1	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, Mycorrhizal, 4.9 dS/M EC	1	9.68	9.68	66.81	<.001***
Contrast 2	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 0 dS/M EC	1	3.1752	3.1752	21.92	<.001***
Contrast 3	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	9.9458	9.9458	68.65	<.001***
Contrast 4	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	0.1682	0.1682	1.16	0.292NS
Contrast 5	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	9.0738	9.0738	62.63	<.001***
Contrast 6	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	10.0352	10.0352	69.26	<.001***
Contrast 7	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	13.6242	13.6242	94.04	<.001***
Contrast 8	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs With Endosperm, non-Mycorrhizal, 0 dS/M EC	1	0.1058	0.1058	1.1	0.304NS
Contrast 9	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	0.8978	0.8978	6.47	0.018*
Contrast 10	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	7.2962	7.2962	50.36	<.001***
Contrast 11	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	0.0098	0.0098	0.07	0.797NS
Contrast 12	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	1.125	1.125	11.72	0.002*
Contrast 13	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	0.3362	0.3362	2.32	0.141NS
Contrast 14	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	1.8818	1.8818	12.99	0.001***
Contrast 15	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	1.8818	1.8818	12.99	0.001***
Contrast 16	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	0.2888	0.2888	3.01	0.096NS
Contrast 17	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	1.9208	1.9208	13.26	0.001***

Contrast 18	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	3.645	3.645	25.16	<.001***
Contrast 19	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	7.5272	7.5272	51.95	<.001***
Contrast 20	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	0.02	0.02	0.14	0.713NS
Contrast 21	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non Mycorrhizal, 0 dS/M EC	1	0.0002	0.0002	0	0.971NS
Contrast 22	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non Mycorrhizal, 4.9 dS/M EC	1	0.2888	0.2888	1.99	0.171NS
Contrast 23	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	6.7712	6.7712	46.74	<.001***
Contrast 24	Without Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 0 dS/M EC	1	7.605	7.605	52.49	<.001***
Contrast 25	Without Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	10.7648	10.7648	74.3	<.001***
Contrast 26	Without Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	0.72	0.72	7.5	0.011NS
Contrast 27	Without Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	0.4608	0.4608	3.18	0.087NS
Contrast 28	Without Endosperm, non mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	0.2738	0.2738	1.89	0.182NS
Contrast 29	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	7.605	7.605	52.49	<.001***
Contrast 30	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	10.7648	10.7648	74.3	<.001***
Contrast 31	With Endosperm, Mycorrhizal, 4.9 dS/M EC VS Without Endosperm, mycorrhizal, 4.9 dS/M EC	1	0.3042	0.3042	3.93	0.059NS
Residual		24	3.4772	0.1449		
Total		31	30.9012			

Appendix XIX: Anova table for effect of arbuscular mycorrhizal fungi, endosperm attachment and salt stress on the root dry weight (grams) of mango seedlings

Source of variation		df	s.s.	m.s.	v.r.	F pr.
TREATMENT		7	20.21165	2.88738	30.05	<.001***
Contrast 1	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, Mycorrhizal, 4.9 dS/M EC	1	5.85932	5.85932	60.98	<.001***
Contrast 2	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 0 dS/M EC	1	3.13188	3.13188	32.59	<.001***
Contrast 3	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	7.27044	7.27044	75.66	<.001***
Contrast 4	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	0.0589	0.0589	0.32	0.574NS
Contrast 5	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	8.45941	8.45941	88.04	<.001***
Contrast 6	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	10.68722	10.68722	111.22	<.001***
Contrast 7	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	15.44707	15.44707	160.76	<.001***
Contrast 8	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs With Endosperm, non-Mycorrhizal, 0 dS/M EC	1	0.1682	0.1682	0.88	0.356NS
Contrast 9	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	1.4792	1.4792	16.42	<.001***
Contrast 10	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	0.57192	0.57192	5.95	0.022***
Contrast 11	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	0.23805	0.23805	2.48	0.129NS
Contrast 12	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	1.0658	1.0658	5.61	0.026NS
Contrast 13	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	2.27911	2.27911	23.72	<.001***
Contrast 14	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	0.85871	0.85871	8.94	0.006***
Contrast 15	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	0.0111	0.0111	0.12	0.737NS
Contrast 16	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	0.5202	0.5202	2.74	0.111NS
Contrast 17	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	2.24826	2.24826	23.4	<.001***
Contrast 18	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	4.66804	4.66804	48.58	<.001***

Contrast 19	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	1.06507	1.06507	11.08	0.003***
Contrast 20	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	0.045	0.045	0.47	0.5NS
Contrast 21	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non Mycorrhizal, 0 dS/M EC	1	0.32805	0.32805	3.41	0.077***
Contrast 22	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non Mycorrhizal, 4.9 dS/M EC	1	1.52251	1.52251	15.84	<.001***
Contrast 23	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	1.54792	1.54792	16.11	<.001***
Contrast 24	Without Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 0 dS/M EC	1	2.57532	2.57532	26.8	<.001***
Contrast 25	Without Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	5.13441	5.13441	53.43	<.001***
Contrast 26	Without Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	0.5202	0.5202	2.74	0.111NS
Contrast 27	Without Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	1.04401	1.04401	10.86	0.003***
Contrast 28	Without Endosperm, non mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	0.43711	0.43711	4.55	0.043***
Contrast 29	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	2.57532	2.57532	26.8	<.001***
Contrast 30	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	5.13441	5.13441	53.43	<.001***
Contrast 31	With Endosperm, Mycorrhizal, 4.9 dS/M EC VS Without Endosperm, mycorrhizal, 4.9 dS/M EC	1	0.1152	0.1152	0.65	0.429NS
Residual					24	3.4772 0.1449
Total					31	30.9012

Appendix XXI: Anova table for effect of arbuscular mycorrhizal fungi and salt stress on the nitrogen content of passion fruit seedlings

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		5	1.3521	0.2704	0.91	0.498
Contrast 1	Mycorrhizal, 0 dS/m EC VS Mycorrhizal, 4.9 dS/m EC	1	0.2812	0.2812	0.94	0.344NS
Contrast 2	Mycorrhizal, 0 dS/m EC VS Mycorrhizal, 9 dS/m EC	1	0.1512	0.1512	0.51	0.485NS
Contrast 3	Mycorrhizal, 4.9 dS/m EC VS Mycorrhizal, 9 dS/m EC	1	0.02	0.02	0.07	0.799NS
Contrast 4	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	0.1013	0.1013	0.34	0.567NS
Contrast 5	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	0.4513	0.4513	1.51	0.234NS
Contrast 6	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	0.1512	0.1512	0.51	0.485NS
Contrast 7	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	0.72	0.72	2.41	0.138NS
Contrast 8	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	0.02	0.02	0.07	0.799NS
Contrast 9	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	0.02	0.02	0.07	0.799NS
Contrast 10	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	0.5	0.5	1.68	0.212NS
Contrast 11	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	0.08	0.08	0.27	0.611NS
Contrast 12	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	0	0	0	1NS
Contrast 13	Non-Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	0.98	0.98	3.29	0.087NS
Contrast 14	Non-Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	0.5	0.5	1.68	0.212NS
Contrast 15	Non-Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	0.08	0.08	0.27	0.611NS
Residual		18	5.3675	0.2982		
Total		23	6.7196			

AppendixXXI: Anova table for effect of arbuscular mycorrhizal fungi and salt stress on the phosphorus content of passion fruit seedlings

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		5	3.2333	0.6467	25.3	<.001
Contrast 1	Mycorrhizal, 0 dS/m EC VS Mycorrhizal, 4.9 dS/m EC	1	0.08	0.08	3.13	0.094NS
Contrast 2	Mycorrhizal, 0 dS/m EC VS Mycorrhizal, 9 dS/m EC	1	0.08	0.08	3.13	0.094NS
Contrast 3	Mycorrhizal, 4.9 dS/m EC VS Mycorrhizal, 9 dS/m EC	1	0	0	0	1NS
Contrast 4	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	0.32	0.32	12.52	0.002***
Contrast 5	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	0.72	0.72	28.17	<.001***
Contrast 6	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	0.98	0.98	38.35	<.001***
Contrast 7	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	0.72	0.72	28.17	<.001***
Contrast 8	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	1.28	1.28	50.09	<.001***
Contrast 9	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	1.62	1.62	63.39	<.001***
Contrast 10	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	0.72	0.72	28.17	<.001***
Contrast 11	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	1.28	1.28	50.09	<.001***
Contrast 12	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	1.62	1.62	63.39	<.001***
Contrast 13	Non-Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	0.08	0.08	3.13	0.094NS
Contrast 14	Non-Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	0.18	0.18	7.04	0.016**
Contrast 15	Non-Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	0.02	0.02	0.78	0.388NS
Residual		18	0.46	0.0256		
Total		23	3.6933			

Appendix XXII: Anova table for effect of arbuscular mycorrhizal fungi and salt stress on the potassium content of passion fruit seedlings

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		5	372.27	74.455	27.41	<.001
Contrast 1	Mycorrhizal, 0 dS/m EC VS Mycorrhizal, 4.9 dS/m EC	1	36.98	36.98	13.61	0.002***
Contrast 2	Mycorrhizal, 0 dS/m EC VS Mycorrhizal, 9 dS/m EC	1	76.88	76.88	28.3	<.001***
Contrast 3	Mycorrhizal, 4.9 dS/m EC VS Mycorrhizal, 9 dS/m EC	1	7.22	7.22	2.66	0.12NS
Contrast 4	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	0.02	0.02	0.01	0.933NS
Contrast 5	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	27.38	27.38	10.08	0.005**
Contrast 6	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	46.08	46.08	16.96	<.001***
Contrast 7	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	38.72	38.72	14.25	0.001***
Contrast 8	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	128	128	47.12	<.001***
Contrast 9	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	165.62	165.62	60.96	<.001***
Contrast 10	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	79.38	79.38	29.22	<.001***
Contrast 11	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	196.02	196.02	72.15	<.001***
Contrast 12	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	242	242	89.08	<.001***
Contrast 13	Non-Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	25.92	25.92	9.54	0.006**
Contrast 14	Non-Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	44.18	44.18	16.26	<.001***
Contrast 15	Non-Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	2.42	2.42	0.89	0.358NS
Residual		18	48.9	2.717		
Total		23	421.17			

Appendix XXIII: Anova table for effect of arbuscular mycorrhizal fungi and salt stress on the calcium content of passion fruit seedlings

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		5	0.7733	0.1547	0.66	0.661
Contrast 1	Mycorrhizal, 0 dS/m EC VS Mycorrhizal, 4.9 dS/m EC	1	0.32	0.32	1.36	0.259NS
Contrast 2	Mycorrhizal, 0 dS/m EC VS Mycorrhizal, 9 dS/m EC	1	0.5	0.5	2.12	0.162NS
Contrast 3	Mycorrhizal, 4.9 dS/m EC VS Mycorrhizal, 9 dS/m EC	1	0.02	0.02	0.08	0.774NS
Contrast 4	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	0.02	0.02	0.08	0.774NS
Contrast 5	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	0.18	0.18	0.76	0.394NS
Contrast 6	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	0.02	0.02	0.08	0.774NS
Contrast 7	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	0.18	0.18	0.76	0.394NS
Contrast 8	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	0.02	0.02	0.08	0.774NS
Contrast 9	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	0.18	0.18	0.76	0.394NS
Contrast 10	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	0.32	0.32	1.36	0.259NS
Contrast 11	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	0.08	0.08	0.34	0.567NS
Contrast 12	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	0.32	0.32	1.36	0.259NS
Contrast 13	Non-Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	0.08	0.08	0.34	0.567NS
Contrast 14	Non-Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	0	0	0	1NS
Contrast 15	Non-Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	0.08	0.08	0.34	0.567NS
Residual		18	4.24	0.2356		
Total		23	5.0133			

Appendix XXIV: Anova table for effect of arbuscular mycorrhizal fungi and salt stress on the magnesium content of passion fruit seedlings

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		5	12.273	2.4547	10.18	<.001
Contrast 1	Mycorrhizal, 0 dS/m EC VS Mycorrhizal, 4.9 dS/m EC	1	0.98	0.98	4.06	0.059NS
Contrast 2	Mycorrhizal, 0 dS/m EC VS Mycorrhizal, 9 dS/m EC	1	5.78	5.78	23.97	<.001***
Contrast 3	Mycorrhizal, 4.9 dS/m EC VS Mycorrhizal, 9 dS/m EC	1	2	2	8.29	0.01**
Contrast 4	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	0.18	0.18	0.75	0.399NS
Contrast 5	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	1.28	1.28	5.31	0.033*
Contrast 6	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	8	8	33.18	<.001***
Contrast 7	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	0.32	0.32	1.33	0.264NS
Contrast 8	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	0.02	0.02	0.08	0.777NS
Contrast 9	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	3.38	3.38	14.02	0.001***
Contrast 10	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	3.92	3.92	16.26	<.001***
Contrast 11	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	1.62	1.62	6.72	0.018**
Contrast 12	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	0.18	0.18	0.75	0.399NS
Contrast 13	Non-Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	0.5	0.5	2.07	0.167NS
Contrast 14	Non-Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	5.78	5.78	23.97	<.001***
Contrast 15	Non-Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	2.88	2.88	11.94	0.003**
Residual		18	4.34	0.2411		
Total		23	16.613			

Appendix XXV ANOVA table for effect of Arbuscular Mycorrhizal Fungi and salt stress on the Sodium content of Passion fruit seedlings

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		5	237.25	47.451	54.4	<.001
Contrast 1	Mycorrhizal, 0 dS/m EC VS Mycorrhizal, 4.9 dS/m EC	1	18	18	20.64	<.001***
Contrast 2	Mycorrhizal, 0 dS/m EC VS Mycorrhizal, 9 dS/m EC	1	76.88	76.88	88.14	<.001***
Contrast 3	Mycorrhizal, 4.9 dS/m EC VS Mycorrhizal, 9 dS/m EC	1	20.48	20.48	23.48	<.001***
Contrast 4	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	0.08	0.08	0.09	0.765NS
Contrast 5	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	84.5	84.5	96.88	<.001***
Contrast 6	Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	118.58	118.58	135.95	<.001***
Contrast 7	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	20.48	20.48	23.48	<.001***
Contrast 8	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	24.5	24.5	28.09	<.001***
Contrast 9	Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	44.18	44.18	50.65	<.001***
Contrast 10	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 0 dS/m EC	1	81.92	81.92	93.92	<.001***
Contrast 11	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	0.18	0.18	0.21	0.655NS
Contrast 12	Mycorrhizal, 9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	4.5	4.5	5.16	0.036NS
Contrast 13	Non-Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 4.9 dS/m EC	1	89.78	89.78	102.93	<.001***
Contrast 14	Non-Mycorrhizal, 0 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	124.82	124.82	143.11	<.001***
Contrast 15	Non-Mycorrhizal, 4.9 dS/m EC VS Non-mycorrhizal, 9 dS/m EC	1	2.88	2.88	3.3	0.086NS
Residual		18	15.7	0.8722		
Total		23	252.95			

Appendix XXVI: Anova table for effect of arbuscular mycorrhizal fungi, endosperm attachment and salt stress on the nitrogen content of mango seedlings

	Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		7	0.744	0.1063	0.67	0.693NS
Contrast 1	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, Mycorrhizal, 4.9 dS/M EC	1	0.1682	0.1682	1.06	0.313NS
Contrast 2	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non- Mycorrhizal, 0 dS/M EC	1	0.0578	0.0578	0.37	0.551NS
Contrast 3	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	0.0018	0.0018	0.01	0.916NS
Contrast 4	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	0.005	0.005	0.03	0.86NS
Contrast 5	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	0.0648	0.0648	0.41	0.528NS
Contrast 6	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 0 dS/M EC	1	0.02	0.02	0.13	0.725NS
Contrast 7	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	0.08	0.08	0.51	0.484NS
Contrast 8	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs With Endosperm, non- Mycorrhizal, 0 dS/M EC	1	0.4232	0.4232	2.68	0.115NS
Contrast 9	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs With Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	0.2048	0.2048	1.3	0.266NS
Contrast 10	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	0.2312	0.2312	1.46	0.238NS
Contrast 11	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	0.0242	0.0242	0.15	0.699NS
Contrast 12	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	0.3042	0.3042	1.92	0.178NS
Contrast 13	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	0.0162	0.0162	0.1	0.752NS
Contrast 14	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs With Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	0.0392	0.0392	0.25	0.623NS
Contrast 15	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	0.0288	0.0288	0.18	0.673NS
Contrast 16	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	0.245	0.245	1.55	0.225NS
Contrast 17	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	0.0098	0.0098	0.06	0.806NS
Contrast 18	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	0.2738	0.2738	1.73	0.201NS

Contrast 19	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	0.0008	0.0008	0.01	0.944NS
Contrast 20	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	0.0882	0.0882	0.56	0.462NS
Contrast 21	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non Mycorrhizal, 0 dS/M EC	1	0.0098	0.0098	0.06	0.806NS
Contrast 22	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non Mycorrhizal, 4.9 dS/M EC	1	0.1058	0.1058	0.67	0.421NS
Contrast 23	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	0.1058	0.1058	0.67	0.421NS
Contrast 24	Without Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 0 dS/M EC	1	0.005	0.005	0.03	0.86NS
Contrast 25	Without Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	0.125	0.125	0.79	0.383NS
Contrast 26	Without Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	0.1568	0.1568	0.99	0.329NS
Contrast 27	Without Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	0.0008	0.0008	0.01	0.944NS
Residual		18	15.7	0.8722		
Total		23	252.95			

Appendix XXVII: Anova table for effect of arbuscular mycorrhizal fungi, endosperm attachment and salt stress on the phosphorus content of mango seedlings

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		7	19.0772	2.7253	18.78	<.001***
Contrast 1	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, Mycorrhizal, 4.9 dS/M EC	1	1.4964	1.4964	10.31	0.004***
Contrast 2	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non- Mycorrhizal, 0 dS/M EC	1	0.1513	0.1513	1.04	0.318NS
Contrast 3	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	6.09	6.09	41.96	<.001***
Contrast 4	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	0.0264	0.0264	0.18	0.673NS
Contrast 5	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	1.98	1.98	13.64	0.001***
Contrast 6	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 0 dS/M EC	1	0.076	0.076	0.52	0.476NS
Contrast 7	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	7.4884	7.4884	51.59	<.001***
Contrast 8	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs With Endosperm, non-Mycorrhizal, 0 dS/M EC	1	2.5992	2.5992	17.91	<.001***
Contrast 9	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	1.5488	1.5488	10.67	0.003***
Contrast 10	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	1.125	1.125	7.75	0.01**
Contrast 11	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	0.0338	0.0338	0.23	0.634NS
Contrast 12	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	0.8978	0.8978	6.19	0.02**
Contrast 13	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	2.2898	2.2898	15.78	<.001***
Contrast 14	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	8.1608	8.1608	56.22	<.001***
Contrast 15	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	0.3042	0.3042	2.1	0.161NS
Contrast 16	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	3.2258	3.2258	22.22	<.001***
Contrast 17	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	0.4418	0.4418	3.04	0.094NS
Contrast 18	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	9.7682	9.7682	67.3	<.001***
Contrast 19	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	5.3138	5.3138	36.61	<.001***
Contrast 20	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	1.125	1.125	7.75	0.01**

Contrast 21	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non Mycorrhizal, 0 dS/M EC	1	4.805	4.805	33.1	<.001***
Contrast 22	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non Mycorrhizal, 4.9 dS/M EC	1	0.0722	0.0722	0.5	0.487NS
Contrast 23	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	1.5488	1.5488	10.67	0.003***
Contrast 24	Without Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 0 dS/M EC	1	0.0128	0.0128	0.09	0.769NS
Contrast 25	Without Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	6.6248	6.6248	45.64	<.001***
Contrast 26	Without Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	1.28	1.28	8.82	0.007***
Contrast 27	Without Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	1.7672	1.7672	12.18	0.002***
Contrast 28	Without Endosperm, non mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	6.0552	6.0552	41.72	<.001***
Contrast 29	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	0.0128	0.0128	0.09	0.769NS
Contrast 30	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	6.6248	6.6248	45.64	<.001***
Contrast 31	With Endosperm, Mycorrhizal, 4.9 dS/M EC VS Without Endosperm, mycorrhizal, 4.9 dS/M EC	1	1.98	1.98	13.64	0.001***
Residual		24	3.4835	0.1451		
Total		31	22.5607			

Appendix XXVIII: ANOVA table for effect of Arbuscular Mycorrhizal Fungi, Endosperm attachment and salt stress on the Potassium content of Mango seedlings

	Source of variation	d.f	s.s.	m.s.	v.r.	F pr.
TREATMENT		7	170.6598	24.38	30.09	<.001***
Contrast 1	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, Mycorrhizal, 4.9 dS/M EC	1	40.1408	40.1408	49.54	<.001***
Contrast 2	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non- Mycorrhizal, 0 dS/M EC	1	0.0882	0.0882	0.11	0.744NS
Contrast 3	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	6.6978	6.6978	8.27	0.008**
Contrast 4	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	0.0242	0.0242	0.03	0.864NS
Contrast 5	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	35.1122	35.1122	43.34	<.001***
Contrast 6	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 0 dS/M EC	1	0.0242	0.0242	0.03	0.864NS
Contrast 7	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	9.245	9.245	11.41	0.002***
Contrast 8	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs With Endosperm, non- Mycorrhizal, 0 dS/M EC	1	36.4658	36.4658	45.01	<.001***
Contrast 9	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs With Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	79.6322	79.6322	98.29	<.001***
Contrast 10	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	42.1362	42.1362	52.01	<.001***
Contrast 11	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	0.1682	0.1682	0.21	0.653NS
Contrast 12	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	38.1938	38.1938	47.14	<.001***
Contrast 13	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	87.9138	87.9138	108.51	<.001***
Contrast 14	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs With Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	8.3232	8.3232	10.27	0.004***
Contrast 15	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	0.2048	0.2048	0.25	0.62NS
Contrast 16	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	31.6808	31.6808	39.1	<.001***
Contrast 17	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 0 dS/M EC	1	0.02	0.02	0.02	0.876NS
Contrast 18	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	11.1392	11.1392	13.75	0.001***
Contrast 19	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	5.9168	5.9168	7.3	0.012**
Contrast 20	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	72.4808	72.4808	89.46	<.001***
Contrast 21	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non Mycorrhizal, 0 dS/M EC	1	7.5272	7.5272	9.29	0.006**
Contrast 22	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non Mycorrhizal, 4.9 dS/M EC	1	0.2048	0.2048	0.25	0.62NS
Contrast 23	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	36.98	36.98	45.64	<.001***

Contrast 24	Without Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 0 dS/M EC	1	0.0968	0.0968	0.12	0.733NS
Contrast 25	Without Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	8.3232	8.3232	10.27	0.004***
Contrast 26	Without Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 0 dS/M EC	1	33.2928	33.2928	41.09	<.001***
Contrast 27	Without Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	80.3912	80.3912	99.22	<.001***
Contrast 28	Without Endosperm, non mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	10.2152	10.2152	12.61	0.002***
Contrast 29	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 0 dS/M EC	1	0.0968	0.0968	0.12	0.733NS
Contrast 30	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	8.3232	8.3232	10.27	0.004***
Contrast 31	With Endosperm, Mycorrhizal, 4.9 dS/M EC VS Without Endosperm, mycorrhizal, 4.9 dS/M EC	1	35.1122	35.1122	43.34	<.001***
Residual		24	19.4448	0.8102		
Total		31	190.1046			

Appendix XXIX Anova table for effect of arbuscular mycorrhizal fungi, endosperm attachment and salt stress on the calcium content of mango seedlings

	Source of variation	df	s.s.	m.s.	v.r.	F pr.
TREATMENT		7	2.95635	0.42234	7.99	<.001***
Contrast 1	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, Mycorrhizal, 4.9 dS/M EC	1	0.08	0.08	1.57	0.222
Contrast 2	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non- Mycorrhizal, 0 dS/M EC	1	0.0338	0.0338	0.64	0.432NS
Contrast 3	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	0.245	0.245	4.64	0.042*
Contrast 4	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	0.1458	0.1458	2.76	0.11NS
Contrast 5	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	0.08	0.08	1.57	0.222
Contrast 6	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 0 dS/M EC	1	0.0288	0.0288	0.54	0.468NS
Contrast 7	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	0.1682	0.1682	3.18	0.087NS
Contrast 8	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs With Endosperm, non- Mycorrhizal, 0 dS/M EC	1	0.1058	0.1058	2.64	0.117NS
Contrast 9	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs With Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	0.045	0.045	1.12	0.3NS
Contrast 10	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	0.0018	0.0018	0.04	0.834NS
Contrast 11	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	0.0098	0.0098	0.19	0.671NS
Contrast 12	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	0.0162	0.0162	0.4	0.531NS
Contrast 13	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	0.02	0.02	0.57	0.458
Contrast 14	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs With Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	0.0968	0.0968	1.83	0.189NS
Contrast 15	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	0.0392	0.0392	0.74	0.398NS
Contrast 16	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	0.125	0.125	3.19	0.087
Contrast 17	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 0 dS/M EC	1	0.0002	0.0002	0	0.951NS
Contrast 18	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	0.0512	0.0512	0.97	0.335NS
Contrast 19	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	0.0128	0.0128	0.24	0.627NS
Contrast 20	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	1.2168	1.2168	23.02	<.001***
Contrast 21	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non Mycorrhizal, 0 dS/M EC	1	0.1058	0.1058	2	0.17NS

Contrast 22	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non Mycorrhizal, 4.9 dS/M EC	1	0.0072	0.0072	0.14	0.715NS
Contrast 23	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	0.98	0.98	18.54	<.001***
Contrast 24	Without Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 0 dS/M EC	1	0.045	0.045	0.85	0.365NS
Contrast 25	Without Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	0.0008	0.0008	0.02	0.903NS
Contrast 26	Without Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 0 dS/M EC	1	0.0722	0.0722	1.84	0.187NS
Contrast 27	Without Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	1.0368	1.0368	19.62	<.001***
Contrast 28	Without Endosperm, non mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	0.0578	0.0578	1.09	0.306NS
Contrast 29	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 0 dS/M EC	1	0.045	0.045	0.85	0.365NS
Contrast 30	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	0.0008	0.0008	0.02	0.903NS
Contrast 31	With Endosperm, Mycorrhizal, 4.9 dS/M EC VS Without Endosperm, mycorrhizal, 4.9 dS/M EC	1	0	0	0	1
Residual		24	1.2684	0.05285		
Total		31	4.22475			

Appendix XXX: Anova table for effect of arbuscular mycorrhizal fungi, endosperm attachment and salt stress on the magnesium content of mango seedlings

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		7	6.3347	0.905	5.22	0.001
Contrast 1	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, Mycorrhizal, 4.9 dS/M EC	1	0.6962	0.6962	4.01	0.057NS
Contrast 2	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non- Mycorrhizal, 0 dS/M EC	1	0.3698	0.3698	2.13	0.157NS
Contrast 3	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	2.42	2.42	13.95	0.001***
Contrast 4	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	0.0288	0.0288	0.17	0.687NS
Contrast 5	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	0.3698	0.3698	2.13	0.157NS
Contrast 6	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 0 dS/M EC	1	0.845	0.845	4.87	0.037*
Contrast 7	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	3.125	3.125	18.01	<.001***
Contrast 8	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs With Endosperm, non- Mycorrhizal, 0 dS/M EC	1	0.0512	0.0512	0.3	0.592NS
Contrast 9	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs With Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	0.5202	0.5202	3	0.096NS
Contrast 10	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	1.0082	1.0082	5.81	0.024**
Contrast 11	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	0.0512	0.0512	0.3	0.592NS
Contrast 12	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	0.0072	0.0072	0.04	0.84NS
Contrast 13	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	0.8712	0.8712	5.02	0.035*
Contrast 14	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs With Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	0.8978	0.8978	5.18	0.032*
Contrast 15	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	0.605	0.605	3.49	0.074NS
Contrast 16	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	0	0	0	1NS
Contrast 17	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 0 dS/M EC	1	0.0968	0.0968	0.56	0.462NS
Contrast 18	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	1.3448	1.3448	7.75	0.01**
Contrast 19	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	2.9768	2.9768	17.16	<.001***
Contrast 20	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	0.8978	0.8978	5.18	0.032*
Contrast 21	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non Mycorrhizal, 0 dS/M EC	1	0.405	0.405	2.33	0.14NS
Contrast 22	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non Mycorrhizal, 4.9 dS/M EC	1	0.045	0.045	0.26	0.615NS
Contrast 23	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	0.605	0.605	3.49	0.074NS
Contrast 24	Without Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 0 dS/M EC	1	1.1858	1.1858	6.84	0.015**
Contrast 25	Without Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	3.7538	3.7538	21.64	<.001***
Contrast 26	Without Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 0 dS/M EC	1	0.0968	0.0968	0.56	0.462NS
Contrast 27	Without Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	1.3448	1.3448	7.75	0.01**

Contrast 28	Without Endosperm, non mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	0.72	0.72	4.15	0.053NS
Contrast 29	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 0 dS/M EC	1	1.1858	1.1858	6.84	0.015**
Contrast 30	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	3.7538	3.7538	21.64	<.001***
Contrast 31	With Endosperm, Mycorrhizal, 4.9 dS/M EC VS Without Endosperm, mycorrhizal, 4.9 dS/M EC	1	0.3698	0.3698	2.13	0.157NS
Residual		24	4.1636	0.1735		
Total		31	10.4983			

Appendix XXXI: Anova table for effect of arbuscular mycorrhizal fungi, endosperm attachment and salt stress on the sodium content of mango seedlings

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		7	105.4862	15.0695	78.94	<.001***
Contrast 1	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, Mycorrhizal, 4.9 dS/M EC	1	9.68	9.68	50.71	<.001***
Contrast 2	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non- Mycorrhizal, 0 dS/M EC	1	0.0018	0.0018	0.01	0.923NS
Contrast 3	With Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	34.2792	34.2792	179.57	<.001***
Contrast 4	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	0.005	0.005	0.03	0.873NS
Contrast 5	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	8.6528	8.6528	45.33	<.001***
Contrast 6	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 0 dS/M EC	1	0.0002	0.0002	0	0.974NS
Contrast 7	With Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	42.5042	42.5042	222.65	<.001***
Contrast 8	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs With Endosperm, non- Mycorrhizal, 0 dS/M EC	1	9.4178	9.4178	49.33	<.001***
Contrast 9	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs With Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	7.5272	7.5272	39.43	<.001***
Contrast 10	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	10.125	10.125	53.04	<.001***
Contrast 11	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	0.0288	0.0288	0.15	0.701NS
Contrast 12	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	9.5922	9.5922	50.25	<.001***
Contrast 13	With Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	11.6162	11.6162	60.85	<.001***
Contrast 14	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs With Endosperm, non- Mycorrhizal, 4.9 dS/M EC	1	33.7842	33.7842	176.97	<.001***
Contrast 15	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	0.0128	0.0128	0.07	0.798NS
Contrast 16	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	8.405	8.405	44.03	<.001***
Contrast 17	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	0.0008	0.0008	0	0.949NS
Contrast 18	With Endosperm, non-mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	41.9528	41.9528	219.76	<.001***
Contrast 19	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 0 dS/M EC	1	35.1122	35.1122	183.93	<.001***
Contrast 20	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	8.4872	8.4872	44.46	<.001***

Contrast 21	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non Mycorrhizal, 0 dS/M EC	1	34.1138	34.1138	178.7	<.001***
Contrast 22	With Endosperm, non-mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non Mycorrhizal, 4.9 dS/M EC	1	0.4418	0.4418	2.31	0.141NS
Contrast 23	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, Mycorrhizal, 4.9 dS/M EC	1	9.0738	9.0738	47.53	<.001***
Contrast 24	Without Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 0 dS/M EC	1	0.0072	0.0072	0.04	0.848NS
Contrast 25	Without Endosperm, mycorrhizal, 0 dS/M EC Vs With Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	43.4312	43.4312	227.51	<.001***
Contrast 26	Without Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	8.5698	8.5698	44.89	<.001***
Contrast 27	Without Endosperm, mycorrhizal, 4.9 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	12.8018	12.8018	67.06	<.001***
Contrast 28	Without Endosperm, non mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	42.32	42.32	221.69	<.001***
Contrast 29	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 0 dS/M EC	1	0.0072	0.0072	0.04	0.848NS
Contrast 30	Without Endosperm, mycorrhizal, 0 dS/M EC Vs Without Endosperm, non-Mycorrhizal, 4.9 dS/M EC	1	43.4312	43.4312	227.51	<.001***
Contrast 31	With Endosperm, Mycorrhizal, 4.9 dS/M EC VS Without Endosperm, mycorrhizal, 4.9 dS/M EC	1	8.6528	8.6528	45.33	<.001***
Residual		24	4.5816	0.1909		
Total		31	110.0678			

Appendix XXXII: ANOVA table for effect of AM fungi and flooding on the leaf number of passion fruit seedlings: Day 0 of flooding

Variate:
Day_0

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		3	11.96	3.99	0.35	0.79NS
Contrast 1	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	0.08	0.08	0.01	0.935NS
Contrast 2	Mycorrhizal, flooded VS Non-Mycorrhiza flooded	1	3.92	3.92	0.34	0.568NS
Contrast 3	Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	6.48	6.48	0.57	0.465NS
Contrast 4	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	5.12	5.12	0.45	0.515NS
Contrast 5	Mycorrhizal, unflooded VS Non-Mycorrhiza, unflooded	1	8	8	0.7	0.418NS
Contrast 6	Non-Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	0.32	0.32	0.03	0.87NS
Residual		12	136.46	11.37		
Total		15	148.42			

Appendix XXIII: ANOVA table for effect of AM fungi and flooding on the leaf number of passion fruit seedlings: Day 7 of flooding

Variate:
Day_7

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		3	11.96	3.987	1.14	0.371NS
Contrast 1	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	0.08	0.08	0.02	0.882NS
Contrast 2	Mycorrhizal, flooded VS Non-Mycorrhiza flooded	1	3.92	3.92	1.12	0.31NS
Contrast 3	Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	6.48	6.48	1.86	0.198NS
Contrast 4	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	5.12	5.12	1.47	0.249NS
Contrast 5	Mycorrhizal, unflooded VS Non-Mycorrhiza, unflooded	1	8	8	2.3	0.156NS
Contrast 6	Non-Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	0.32	0.32	0.09	0.767NS
Residual		12	41.82	3.485		
Total		15	53.78			

Appendix XXIV: ANOVA table for effect of AM fungi and flooding on the leaf number of passion fruit seedlings: Day 21 of flooding

Variate:
Day_21

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		3	400.19	133.397	64.49	<.001***
Contrast 1	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	106.58	106.58	51.53	<.001***
Contrast 2	Mycorrhizal, flooded VS Non-Mycorrhiza flooded	1	67.28	67.28	32.53	<.001***
Contrast 3	Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	46.08	46.08	22.28	<.001***
Contrast 4	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	343.22	343.22	165.94	<.001***
Contrast 5	Mycorrhizal, unflooded VS Non-Mycorrhiza, unflooded	1	54.08	54.08	15.65	<0.002***
Contrast 6	Non-Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	224.72	224.72	108.65	<.001***
Residual		12	24.82	2.068		
Total		15	425.01			

Appendix XXXV: ANOVA table for effect of AM fungi and flooding on the leaf number of passion fruit seedlings: Day 28 of flooding

Variate:
Day_28

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		3	587.63	195.877	54.69	<.001***
Contrast 1	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	224.72	224.72	62.74	<.001***
Contrast 2	Mycorrhizal, flooded VS Non-Mycorrhiza flooded	1	40.5	40.5	11.31	0.006***
Contrast 3	Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	128	128	35.74	<.001***
Contrast 4	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	456.02	456.02	127.32	<.001***
Contrast 5	Mycorrhizal, unflooded VS Non-Mycorrhiza, unflooded	1	25.92	25.92	7.5	<0.018**
Contrast 6	Non-Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	312.5	312.5	87.25	<.001***
Residual		12	42.98	3.582		
Total		15	630.61			

Appendix XXXVI: ANOVA table for effect of AM fungi and flooding on the leaf area (cm^2) of passion fruit seedlings: Day 0 of flooding

Variate:
Day_0

		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		3	215305	71768	44.08	<.001***
Contrast 1	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	873	873	0.54	0.478NS
Contrast 2	Mycorrhizal, flooded VS Non-Mycorrhiza flooded	1	111969	111969	68.77	<.001***
Contrast 3	Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	122127	122127	75.01	<.001***
Contrast 4	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	93070	93070	57.17	<.001***
Contrast 5	Mycorrhizal, unflooded VS Non-Mycorrhiza, unflooded	1	102351	102351	62.87	<.001***
Contrast 6	Non-Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	220	220	0.14	0.719NS
Residual		12	19537	1628		
Total		15	234842			

Appendix XXXVII: ANOVA table for effect of AM fungi and flooding on the leaf area (cm^2) of passion fruit seedlings: Day 7 of flooding

Variate: Day_7						
		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		3	198222	66074	44.63	<.001***
Contrast 1	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	12	12	0.01	0.93NS
Contrast 2	Mycorrhizal, flooded VS Non-Mycorrhiza flooded	1	104745	104745	70.75	<.001***
Contrast 3	Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	95528	95528	64.52	<.001***
Contrast 4	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	102532	102532	69.25	<.001***
Contrast 5	Mycorrhizal, unflooded VS Non-Mycorrhiza, unflooded	1	93416	93416	63.09	<.001***
Contrast 6	Non-Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	212	212	0.14	0.712NS
Residual		12	17767	1481		
Total		15	215989			

Appendix XXXVIII: ANOVA table for effect of AM fungi and flooding on the leaf area (cm^2) of passion fruit seedlings: Day 14 of flooding

Variate:
Day_14

		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		3	226797	75599	47.26	<.001***
Contrast 1	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	7276	7276	4.55	0.054NS
Contrast 2	Mycorrhizal, flooded VS Non-Mycorrhiza flooded	1	115685	115685	72.32	<.001***
Contrast 3	Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	44889	44889	28.06	<.001***
Contrast 4	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	180985	180985	113.14	<.001***
Contrast 5	Mycorrhizal, unflooded VS Non-Mycorrhiza, unflooded	1	88309	88309	55.21	<.001***
Contrast 6	Non-Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	16449	16449	10.28	0.008**
Residual		12	19196	1600		
Total		15	245993			

Appendix XXXIX: ANOVA table for effect of AM fungi and flooding on the leaf area (cm^2) of passion fruit seedlings: Day 21 of flooding

Variate: Day_21

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		3	400756	133585	88.29	<.001***
Contrast 1	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	136138	136138	89.98	<.001***
Contrast 2	Mycorrhizal, flooded VS Non-Mycorrhiza flooded	1	64283	64283	42.49	<.001***
Contrast 3	Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	13239	13239	8.75	0.012**
Contrast 4	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	387517	387517	256.13	<.001***
Contrast 5	Mycorrhizal, unflooded VS Non-Mycorrhiza, unflooded	1	64469	64469	42.61	<.001***
Contrast 6	Non-Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	135866	135866	89.8	<.001***
Residual		12	18156	1513		
Total		15	418912			

Appendix XL: ANOVA table for effect of AM fungi and flooding on the leaf area (cm^2) of passion fruit seedlings: Day 28 of flooding

Variate: Day_28

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		3	490074	163358	87.58	<.001***
Contrast 1	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	217774	217774	116.75	<.001***
Contrast 2	Mycorrhizal, flooded VS Non-Mycorrhiza flooded	1	38442	38442	20.61	<.001***
Contrast 3	Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	49732	49732	26.66	<.001***
Contrast 4	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	439209	439209	235.46	<.001***
Contrast 5	Mycorrhizal, unflooded VS Non-Mycorrhiza, unflooded	1	59368	59368	31.83	<.001***
Contrast 6	Non-Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	175623	175623	94.15	<.001***
Residual		12	22384	1865		
Total		15	512458			

Appendix XLI: ANOVA table for effect of AM fungi and flooding on the leaf Fresh Weight (grams) of passion fruit seedlings: Day 0 of flooding

Variate: Day_0

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		3	110.595	36.865	31.67	<.001***
Contrast 1	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	0.029	0.029	0.02	0.878NS
Contrast 2	Mycorrhizal, flooded VS Non-Mycorrhiza flooded	1	54.08	54.08	46.46	<.001***
Contrast 3	Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	58.97	58.97	50.66	<.001***
Contrast 4	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	51.613	51.613	44.34	<.001***
Contrast 5	Mycorrhizal, unflooded VS Non-Mycorrhiza, unflooded	1	56.392	56.392	48.45	<.001***
Contrast 6	Non-Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	0.106	0.106	0.09	0.768NS
Residual		12	13.967	1.164		
Total		15	124.562			

Appendix XLII: ANOVA table for effect of AM fungi and flooding on the leaf Fresh Weight (grams) of passion fruit seedlings: Day 7 of flooding

Variate: Day_7

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		3	103.138	34.379	28.89	<.001***
Contrast 1	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	0.001	0.001	0	0.98NS
Contrast 2	Mycorrhizal, flooded VS Non-Mycorrhiza flooded	1	56.392	56.392	47.39	<.001***
Contrast 3	Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	46.08	46.08	38.72	<.001***
Contrast 4	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	56.818	56.818	47.74	<.001***
Contrast 5	Mycorrhizal, unflooded VS Non-Mycorrhiza, unflooded	1	46.465	46.465	39.04	<.001***
Contrast 6	Non-Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	0.52	0.52	0.44	0.521NS
Residual		12	14.281	1.19		
Total		15	117.419			

Appendix XLIII: ANOVA table for effect of AM fungi and flooding on the leaf Fresh Weight (grams) of passion fruit seedlings: Day 14 of flooding

Variate:
Day_14

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		3	173.0907	57.6969	86.77	<.001***
Contrast 1	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	0.1458	0.1458	0.22	0.648NS
Contrast 2	Mycorrhizal, flooded VS Non-Mycorrhiza flooded	1	120.7458	120.7458	181.6	<.001***
Contrast 3	Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	31.205	31.205	46.93	<.001***
Contrast 4	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	129.2832	129.2832	194.44	<.001***
Contrast 5	Mycorrhizal, unflooded VS Non-Mycorrhiza, unflooded	1	35.6168	35.6168	53.57	<.001***
Contrast 6	Non-Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	29.1848	29.1848	43.89	<.001***
Residual		12	7.979	0.6649		
Total		15	181.0697			

Appendix XLIV: ANOVA table for effect of AM fungi and flooding on the leaf Fresh Weight (grams) of passion fruit seedlings: Day 21 of flooding

Variate:
Day_21

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		3	251.5556	83.8519	129.23	<.001***
Contrast 1	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	54.2882	54.2882	83.67	<.001***
Contrast 2	Mycorrhizal, flooded VS Non-Mycorrhiza flooded	1	71.0432	71.0432	109.49	<.001***
Contrast 3	Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	1.9602	1.9602	3.02	0.108NS
Contrast 4	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	249.5378	249.5378	384.59	<.001***
Contrast 5	Mycorrhizal, unflooded VS Non-Mycorrhiza, unflooded	1	76.88	76.88	118.49	<.001***
Contrast 6	Non-Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	49.4018	49.4018	76.14	<.001***
Residual		12	7.786	0.6488		
Total		15	259.3416			

Appendix XLV: ANOVA table for effect of AM fungi and flooding on the leaf Fresh Weight (grams) of passion fruit seedlings: Day 28 of flooding

Variate:
Day_28

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		3	343.7811	114.5937	161.14	<.001***
Contrast 1	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	158.42	158.42	222.77	<.001***
Contrast 2	Mycorrhizal, flooded VS Non-Mycorrhiza flooded	1	29.1848	29.1848	41.04	<.001***
Contrast 3	Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	0.52	0.52	0.44	0.521NS
Contrast 4	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	323.5968	323.5968	455.04	<.001***
Contrast 5	Mycorrhizal, unflooded VS Non-Mycorrhiza, unflooded	1	77.1282	77.1282	108.46	<.001***
Contrast 6	Non-Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	84.7602	84.7602	119.19	<.001***
Residual		12	8.5336	0.7111		
Total		15	352.3147			

Appendix XLVI: ANOVA table for effect of AM fungi and flooding on the root Fresh Weight (grams) of passion fruit seedlings: Day 0 of flooding

Variate:
Day_0

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		3	110.595	36.865	31.67	<.001***
Contrast 1	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	0.029	0.029	0.02	0.878NS
Contrast 2	Mycorrhizal, flooded VS Non-Mycorrhiza flooded	1	54.08	54.08	46.46	<.001***
Contrast 3	Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	58.97	58.97	50.66	<.001***
Contrast 4	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	51.613	51.613	44.34	<.001***
Contrast 5	Mycorrhizal, unflooded VS Non-Mycorrhiza, unflooded	1	56.392	56.392	48.45	<.001***
Contrast 6	Non-Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	0.106	0.106	0.09	0.768NS
Residual		12	13.967	1.164		
Total		15	124.562			

Appendix XLVII: ANOVA table for effect of AM fungi and flooding on the root Fresh Weight (grams) of passion fruit seedlings: Day 7 of flooding

Variate:
Day_7

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		3	103.138	34.379	28.89	<.001***
Contrast 1	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	0.001	0.001	0	0.98NS
Contrast 2	Mycorrhizal, flooded VS Non-Mycorrhiza flooded	1	56.392	56.392	47.39	<.001***
Contrast 3	Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	46.08	46.08	38.72	<.001***
Contrast 4	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	56.818	56.818	47.74	<.001***
Contrast 5	Mycorrhizal, unflooded VS Non-Mycorrhiza, unflooded	1	46.465	46.465	39.04	<.001***
Contrast 6	Non-Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	0.52	0.52	0.44	0.521NS
Residual		12	14.281	1.19		
Total		15	117.419			

Appendix XLVIII: ANOVA table for effect of AM fungi and flooding on the root Fresh Weight (grams) of passion fruit seedlings: Day 14 of flooding

Variate: Day_14

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		3	173.0907	57.6969	86.77	<.001***
Contrast 1	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	0.1458	0.1458	0.22	0.648NS
Contrast 2	Mycorrhizal, flooded VS Non-Mycorrhiza flooded	1	120.7458	120.7458	181.6	<.001***
Contrast 3	Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	31.205	31.205	46.93	<.001***
Contrast 4	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	129.2832	129.2832	194.44	<.001***
Contrast 5	Mycorrhizal, unflooded VS Non-Mycorrhiza, unflooded	1	35.6168	35.6168	53.57	<.001***
Contrast 6	Non-Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	29.1848	29.1848	43.89	<.001***
Residual		12	7.979	0.6649		
Total		15	181.0697			

Appendix XLIX: ANOVA table for effect of AM fungi and flooding on the root Fresh Weight (grams) of passion fruit seedlings: Day 21 of flooding

Variate: Day_21

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		3	251.5556	83.8519	129.23	<.001***
Contrast 1	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	54.2882	54.2882	83.67	<.001***
Contrast 2	Mycorrhizal, flooded VS Non-Mycorrhiza flooded	1	71.0432	71.0432	109.49	<.001***
Contrast 3	Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	1.9602	1.9602	3.02	0.108NS
Contrast 4	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	249.5378	249.5378	384.59	<.001***
Contrast 5	Mycorrhizal, unflooded VS Non-Mycorrhiza, unflooded	1	76.88	76.88	118.49	<.001***
Contrast 6	Non-Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	49.4018	49.4018	76.14	<.001***
Residual		12	7.786	0.6488		
Total		15	259.3416			

Appendix L: ANOVA table for effect of AM fungi and flooding on the root Fresh Weight (grams) of passion fruit seedlings: Day 28 of flooding

Variate: Day_28

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		3	343.7811	114.5937	161.14	<.001***
Contrast 1	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	158.42	158.42	222.77	<.001***
Contrast 2	Mycorrhizal, flooded VS Non-Mycorrhiza flooded	1	29.1848	29.1848	41.04	<.001***
Contrast 3	Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	14.4722	14.4722	20.35	<.001***
Contrast 4	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	323.5968	323.5968	455.04	<.001***
Contrast 5	Mycorrhizal, unflooded VS Non-Mycorrhiza, unflooded	1	77.1282	77.1282	108.46	<.001***
Contrast 6	Non-Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	84.7602	84.7602	119.19	<.001***
Residual		12	8.5336	0.7111		
Total		15	352.3147			

Appendix LI: ANOVA table for effect of AM fungi and flooding on the root length (cm) of passion fruit seedlings: Day 0 of flooding

Variate: Day_0

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		3	856.91	285.637	69.22	<.001***
Contrast 1	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	8.82	8.82	2.14	0.169NS
Contrast 2	Mycorrhizal, flooded VS Non-Mycorrhiza flooded	1	343.22	343.22	83.17	<.001***
Contrast 3	Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	386.42	386.42	93.64	<.001***
Contrast 4	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	462.08	462.08	111.97	<.001***
Contrast 5	Mycorrhizal, unflooded VS Non-Mycorrhiza, unflooded	1	512	512	124.07	<.001***
Contrast 6	Non-Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	1.28	1.28	0.31	0.588NS
Residual		12	49.52	4.127		
Total		15	906.43			

Appendix LII: ANOVA table for effect of AM fungi and flooding on the root length (cm) of passion fruit seedlings: Day 7 of flooding

Variate: Day_7

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		3	783.07	261.023	91.69	<.001***
Contrast 1	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	3.38	3.38	1.19	0.297NS
Contrast 2	Mycorrhizal, flooded VS Non-Mycorrhiza flooded	1	332.82	332.82	116.92	<.001***
Contrast 3	Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	375.38	375.38	131.87	<.001***
Contrast 4	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	403.28	403.28	141.67	<.001***
Contrast 5	Mycorrhizal, unflooded VS Non-Mycorrhiza, unflooded	1	450	450	158.08	<.001***
Contrast 6	Non-Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	1.28	1.28	0.45	0.515NS
Residual		12	34.16	2.847		
Total		15	817.23			

Appendix LII: ANOVA table for effect of AM fungi and flooding on the root length (cm) of passion fruit seedlings: Day 14 of flooding

Variate: Day_14

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		3	1159.16	386.387	95.13	<.001***
Contrast 1	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	23.12	23.12	5.69	0.034*
Contrast 2	Mycorrhizal, flooded VS Non-Mycorrhiza flooded	1	551.12	551.12	135.69	<.001***
Contrast 3	Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	359.12	359.12	88.42	<.001***
Contrast 4	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	800	800	196.96	<.001***
Contrast 5	Mycorrhizal, unflooded VS Non-Mycorrhiza, unflooded	1	564.48	564.48	138.98	<.001***
Contrast 6	Non-Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	20.48	20.48	5.04	0.044*
Residual		12	48.74	4.062		
Total		15	1207.9			

Appendix LIV: ANOVA table for effect of AM fungi and flooding on the root length (cm) of passion fruit seedlings: Day 21 of flooding

Variate: Day_21

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		3	1159.16	386.387	95.13	<.001***
Contrast 1	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	23.12	23.12	5.69	0.034*
Contrast 2	Mycorrhizal, flooded VS Non-Mycorrhiza flooded	1	551.12	551.12	135.69	<.001***
Contrast 3	Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	359.12	359.12	88.42	<.001***
Contrast 4	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	5.12	5.12	1.03	0.33NS
Contrast 5	Mycorrhizal, unflooded VS Non-Mycorrhiza, unflooded	1	564.48	564.48	138.98	<.001***
Contrast 6	Non-Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	20.48	20.48	5.04	0.044*
Residual		12	48.74	4.062		
Total		15	1207.9			

Appendix LV: ANOVA table for effect of AM fungi and flooding on the root length (cm) of passion fruit seedlings: Day 28 of flooding

Variate: Day_28

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		3	1714.16	571.387	115.24	<.001***
Contrast 1	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	640.82	640.82	129.24	<.001***
Contrast 2	Mycorrhizal, flooded VS Non-Mycorrhiza flooded	1	246.42	246.42	49.7	<.001***
Contrast 3	Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	246.42	246.42	49.7	<.001***
Contrast 4	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	1682	1682	339.23	<.001***
Contrast 5	Mycorrhizal, unflooded VS Non-Mycorrhiza, unflooded	1	531.38	531.38	107.17	<.001***
Contrast 6	Non-Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	322.58	322.58	65.06	<.001***
Residual		12	59.5	4.958		
Total		15	1773.66			

Appendix LVI: ANOVA table for effect of AM fungi and flooding on the Leaf Dry Weight (cm) of passion fruit seedlings: Day 0 of flooding

Variate:
Day_0

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		3	4.2923	1.43077	51.47	<.001***
Contrast 1	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	0.0072	0.0072	0.26	0.62NS
Contrast 2	Mycorrhizal, flooded VS Non-Mycorrhiza flooded	1	2.2472	2.2472	80.83	<.001***
Contrast 3	Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	2.2898	2.2898	82.37	<.001***
Contrast 4	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	2	2	71.94	<.001***
Contrast 5	Mycorrhizal, unflooded VS Non-Mycorrhiza, unflooded	1	2.0402	2.0402	73.39	<.001***
Contrast 6	Non-Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	0.0002	0.0002	0.01	0.934NS
Residual		12	0.3336	0.0278		
Total		15	4.6259			

Appendix LVII: ANOVA table for effect of AM fungi and flooding on the Leaf Dry Weight (cm) of passion fruit seedlings: Day 8 of flooding

Variate:
Day_7

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		3	4.6696	1.55653	65.58	<.001***
Contrast 1	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	0.0008	0.0008	0.03	0.857NS
Contrast 2	Mycorrhizal, flooded VS Non-Mycorrhiza flooded	1	2.3762	2.3762	100.12	<.001***
Contrast 3	Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	2.205	2.205	92.91	<.001***
Contrast 4	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	2.4642	2.4642	103.83	<.001***
Contrast 5	Mycorrhizal, unflooded VS Non-Mycorrhiza, unflooded	1	2.2898	2.2898	96.48	<.001***
Contrast 6	Non-Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	0.0032	0.0032	0.13	0.72NS
Residual		12	0.2848	0.02373		
Total		15	4.9544			

Appendix LVIII: ANOVA table for effect of AM fungi and flooding on the Leaf Dry Weight (cm) of passion fruit seedlings: Day 14 of flooding

Variate:
Day_14

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		3	2.5083	0.8361	23.13	<.001***
Contrast 1	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	10.3968	10.3968	371.76	<.001***
Contrast 2	Mycorrhizal, flooded VS Non-Mycorrhiza flooded	1	1.3122	1.3122	36.3	<.001***
Contrast 3	Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	0.405	0.405	11.2	0.006**
Contrast 4	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	2.0808	2.0808	57.56	<.001***
Contrast 5	Mycorrhizal, unflooded VS Non-Mycorrhiza, unflooded	1	0.8712	0.8712	24.1	<.001***
Contrast 6	Non-Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	0.2592	0.2592	7.17	0.02**
Residual		12	0.4338	0.03615		
Total		15	2.9421			

Appendix LIX: ANOVA table for effect of AM fungi and flooding on the Leaf Dry Weight (cm) of passion fruit seedlings: Day 21 of flooding

Variate:
Day_21

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		3	7.7099	2.56997	59.31	<.001***
Contrast 1	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	1.805	1.805	41.65	<.001***
Contrast 2	Mycorrhizal, flooded VS Non-Mycorrhiza flooded	1	2.0402	2.0402	47.08	<.001***
Contrast 3	Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	10.3968	10.3968	371.76	<.001***
Contrast 4	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	7.6832	7.6832	177.3	<.001***
Contrast 5	Mycorrhizal, unflooded VS Non-Mycorrhiza, unflooded	1	1.5488	1.5488	35.74	<.001***
Contrast 6	Non-Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	2.3328	2.3328	53.83	<.001***
Residual		12	0.52	0.04333		
Total		15	8.2299			

Appendix LX: ANOVA table for effect of AM fungi and flooding on the Leaf Dry Weight (cm) of passion fruit seedlings: Day 28 of flooding

Variate:
Day_28

Source of variation		d.f.	s.s.	m.s.	v.r.	F pr.
TREATMENT		3	11.2416	3.7472	133.99	<.001***
Contrast 1	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	4.7432	4.7432	169.6	<.001***
Contrast 2	Mycorrhizal, flooded VS Non-Mycorrhiza flooded	1	1.0952	1.0952	39.16	<.001***
Contrast 3	Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	0.8192	0.8192	29.29	<.001***
Contrast 4	Mycorrhizal, flooded VS Mycorrhiza unflooded	1	10.3968	10.3968	371.76	<.001***
Contrast 5	Mycorrhizal, unflooded VS Non-Mycorrhiza, unflooded	1	1.62	1.62	57.93	<.001***
Contrast 6	Non-Mycorrhizal, flooded VS Non-Mycorrhiza unflooded	1	3.8088	3.8088	136.19	<.001***
Residual		12	0.3356	0.02797		
Total		15	11.5772			