STANDARDIZATION OF IRRIGATION AND FERTIGATION REQUIREMENT FOR AMARANTH UNDER POLYHOUSE

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TAVANUR-679 573, MALAPPURAM
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PROJECT REPORT

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DECLARATION

We hereby declare that this project entitled “STANDARDIZATION OF IRRIGATION AND FERTIGATION REQUIREMENT FOR AMARANTH UNDER POLYHOUSE” is a bonafide record of project work done by us during the course of study and that the report has not previously formed the basis for the award to us of any degree, diploma, associate ship, fellowship or other similar title of another university or society.

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Place: Tavanur

Date: 08-03-2021
CERTIFICATE

Certified that this project report entitled “STANDARDIZATION OF IRRIGATION AND FERTIGATION REQUIREMENT FOR AMARANTH UNDER POLYHOUSE” is a record of project work done jointly by Anna Siya P M (2017-02-010), Mr. Nitin Kumar (2017-02-035), Ms. Sneha M (2017-02-040) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associate ship to them.

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### SYMBOLS AND ABBREVIATIONS

| SYMBOL  | ABBREVIATION                  |
|---------|-------------------------------|
| %       | Percentage                    |
| Asst.   | Assistant                     |
| &       | And                           |
| /       | Per                           |
| º       | Degree                        |
| ºC      | Degree Celsius                |
| Dept.   | Department                    |
| E.g.    | Example                       |
| Etc.    | Etcetera                      |
| et al   | And others                    |
| GM      | Genetically Modified          |
| Kg      | Kilogram                      |
| t/ha    | Tonne per hectare             |
| Viz     | Namely                        |
| Ie      | That is                       |
| ‘       | Minutes                       |
| N       | North                         |
| E       | East                          |
| RH      | Relative humidity             |
| PFDC     | Precision farming development centre |
|----------|--------------------------------------|
| Mm       | Millimetre                           |
| G        | Gram                                |
| Ph       | Pouvoir hydrogen                     |
| W        | Watt                                |
| CU       | Consumptive use                      |
| CWR      | Crop Water Requirement               |
| ER       | Effective rainfall                   |
| ET₀      | Reference crop evapotranspiration    |
| Kc       | Crop coefficient                     |
| RH       | Relative humidity                    |
| T        | Air temperature                      |
| NIR      | Net Irrigation Requirement           |
CHAPTER I

INTRODUCTION

Water is an essential input influencing the scale and pattern of agricultural growth and agriculture is the largest user of water among all human activities where irrigation water contributes almost 70% of the total anthropogenic use of renewable water. Water, mankind’s most vital and versatile resource is a basic human need and a precious national asset. It is essential for broad based agricultural and rural development in order to improve food security and poverty alleviation. The major source through which plants get water is rainfall. If the rainfall could not meet the requirements of crops, water is applied and this external application of water is known as irrigation.

Irrigation can be defined as the quantity and depth of water that need to be supplied in addition to the precipitation, to produce the desired crop yield and quality and to maintain acceptable salt balance in the root zone. With an ever increasing demand for water in municipal and industrial sectors, its allocation for agriculture is decreasing steadily. Therefore, many more interpretations and innovations are required to increase the efficiency of use of water that is available.

As far as the Indian agriculture is concerned, irrigation plays a crucial role in the various development projects of the country. The existing methods of surface irrigation are less efficient and we are confronted with many problems regarding soil and water. A major challenge is to develop systems for greater precision in water and plant nutrient control, so as to increase the use efficiencies of soil, water and energy resources and to improve the environment for mankind. With present potential of 114 M ha m of water, only 57 M ha (40 per cent) is under irrigation in India against the total cultivated area of 145 M ha. Therefore the effective management of water resources is essential to meet the increasing competition for water between agricultural and non-agricultural sectors.

All crops will be having a critical growth period during which a slight variation in the moisture content could affect its growth. This critical growth period varies from crop to crop. Sufficient care must be taken to ensure that crops do not undergo a stressed condition due to soil
moisture deficit. Irrigation scheduling involves determining the irrigation method, quantity of water to be provided and the frequency at which water need to be applied.

The micro irrigation system is one of the most efficient methods of water application directly into soil at the root zone of plants. About 4,00,000 ha of cultivated lands in India utilize this system of irrigation. About 55 per cent of the total area of Kerala State with a humid tropical climate is under agriculture. The irrigated area in Kerala is estimated to be 1,55,130 ha and the irrigated area in the plantation crops constitute only about 2.8 per cent of the total irrigated area in the State. The area under micro irrigation in Kerala is as low as 6000 ha. (Horticultural mission, 2010).

Micro irrigation which includes mainly drip and micro sprinklers is an effective tool for conserving water resources. It is an irrigation system with high frequency application of water in and around the root zone of plant system, which consists of a network of pipes along with suitable emitting devices. It permits a small uniform flow of water at a constant discharge, which does not change significantly throughout the field. It also permits the irrigation to limit the watering closely to the consumptive use of plants. Thus it minimizes the conventional losses such as deep percolation, runoff and soil evaporation. It also permits the utilization of fertilizer, pesticides and other water-soluble chemicals along with irrigation water for better crop response. As far as Indian economy is concerned, growing vegetable yields a much higher income per ha than any other type of farming. Tomato, brinjal, okra (Ladies Finger), cabbage, cucumber, amaranth etc. are some of the vegetables grown in India. In many areas of India, vegetable is taken as a third crop in paddy field in summer season.

Vegetable production in Indian agriculture has wider scope for increasing the income of the marginal and small farmers. Vegetables have vast potential in gaining foreign exchange through the export. The vegetable growers are looking for new ways to achieve superior quality produce with higher yields. Among the vegetables grown, amaranth is a vegetable crop of commercial importance. Amaranth \([Amaranthus hypochondriacus, A. cruentus (Grain type) & A. tricolor (Vegetable type)]\) is an herbaceous annual with upright growth habit, cultivated for both its seeds which are used as a grain and its leaves which are used as a vegetable or green.
Fertigation and drip irrigation is an effective method that can be resorted to improve the vegetable production. Fertigation was first started in the late 1960’s in Israel with the development of drip irrigation. Fertigation is the application of fertilizers, soil amendments, or other water-soluble products through an irrigation system. Benefits of fertigation over traditional broadcast or drop-fertilizing methods include: increased nutrient absorption by plants, reduction in fertilizer and chemicals needed, reduced leaching to the water table, reduction in water usage due to the plant's resulting increased root mass's ability to trap and hold water, application of nutrients at the precise time they are needed and at the rate they are utilized. The important components of a fertigation system include drip irrigation system of suitable layout and fertigation equipment. Crops are raised under fertigation system with the application of suitable mulch materials in order to reduce the water loss and weed infestation. The performance of crop may vary with the application rates and schedule of irrigation. The cost of the system will vary with the layout of the drip irrigation system as the use of laterals in each system of layout may vary.

Adequate data on irrigation water requirement for crops are not available in developing countries like India. This is the reason for the failure of irrigation projects in such countries. The present irrigation practices in the state of Kerala have a general nature and does not account for all types of soil, crop and climate in various zones. Lacunae of site specific information on irrigation requirement for various crops are one of the main reasons for the low irrigation efficiency in the state. Hence there is a need for regional scale information with respect to crop water needs to improve or sustain productivity. Fertilizer management is the most important agro-technique, which controls development, yield and quality of a crop. Appropriate fertigation schedule offers an opportunity to correct the nutrient status of plant regularly and thus protecting plant from nutrient deficiencies. In view of all the above facts an attempt was made to compute crop water requirement and irrigation schedules for Amaranth. The specific objectives of the study are:

1. To study the important physio chemical properties of the polyhouse soil.
2. To standardize the irrigation and fertigation requirement of amaranth under polyhouse.
3. To determine benefit cost ratio (B/C) of polyhouse amaranth cultivation
REVIEW OF LITERATURE
CHAPTER II
REVIEW OF LITERATURE

Micro-irrigation, also called localized irrigation, low volume irrigation, low-flow irrigation, or trickle irrigation, is an irrigation method with lower pressure and flow than a traditional sprinkler system. It conserves irrigation water easily, doubling the command area of a water resource with yield increase up to 50 per cent. Drip irrigation is a type of micro-irrigation system that has the potential to save water and nutrients by allowing water to drip slowly to the roots of plants, either from above the soil surface or buried below the surface. The goal is to place water directly into the root zone and minimize evaporation. Drip irrigation systems distribute water through a network of valves, pipes, tubing, and emitters. Depending on how well designed, installed, maintained, and operated it is, a drip irrigation system can be more efficient than other types of irrigation systems, such as surface irrigation or sprinkler irrigation. Micro irrigation coupled fertigation methods ensures the congruence of sustainability, productivity and profitability. The productivity of crops is based on effective utilization of water and fertilizer, along with other agricultural inputs. Fertigation provides flexibility of fertilizer application, which enables three specific nutritional requirements of the crop to be met at different stages of its growth. In comparison with the conventional methods, it appears that fertigation gives higher crop yields with substantial saving in fertilizer usage. Since micro irrigation greatly enhances water, fertilizer and energy use efficiency, the sustainability in agriculture could be achieved without the burden of environmental degradation.

2.1. DRIP IRRIGATION SYSTEM

Howell and Hiller (2005) reported that the flow conditions in the sub main and laterals of a drip irrigation system can be considered as steady and spatially varied with lateral outflows. The flow from the sub mains into the laterals or the outflow of each emitter from a lateral is controlled by the pressure distribution in the sub main and lateral lines. The variation of discharge from emitters along a lateral line is a function of the total length and inlet pressure, emitter spacing and total flow rate.
Kishor et al. (2005) tested the hydraulic performance of market available drippers. He used an automatic dripper testing set up for the study. The drippers were tested for pressure and discharge relation, pressure and coefficient of manufacturing variation, barb losses and uniformity coefficient. The pressure and discharge relations were developed for all drippers by fitting power equation to the data. The drippers had the Cv less than 5 % indicating the good performance, 5 to 10 % indicating the average performance while CV more than 10 % indicated the unacceptable range of performance. The uniformity coefficient of dripper was found to be more than 95 % at all operating pressure from 50 to 300 KPa.

Reddy et al. (2017) reported that many of the farmers have got benefited by the use of water saving through drip irrigation and cultivation of land holdings was increased about 55-60%. The drip irrigation system has not only lowered the water consumption but also increased the quality and quantity of the produce as the water is applied in a right quantity at the right time and the cost of cultivation was lowered by reducing the different operational costs by 25-40% such as weeding, quantity of fertilizer application, manpower for irrigation and fertiliser application.

2.2. MOISTURE DISTRIBUTION UNDER DRIP IRRIGATION

Sampathkumar et al. (2012) conducted experiments during 2007–2009 to study the effect of deficit irrigation practices through drip irrigation system on soil moisture distribution and root growth in cotton–maize cropping sequence. It is concluded that alternate watering imposed through Alternate deficit irrigation (ADI) at 100% ETc produced longer lateral roots with higher values for root dry mass ADI resulted uneven distribution of soil moisture content. Among the ADI treatments, ADI at 100% had less uneven distribution than ADI at 80% ETc.

Hicran et al. (2013) conducted experiments to determine the water needs and results of drip irrigation of mid-early potato cultivar Courage. Studies were carried out in central Poland in 2011–2013 on very light soil. Both the marketable yield and tuber weight, and the number of tubers per plant of ‘Courage’ potato, increased significantly after using drip irrigation combined with drip fertigation. On the drip irrigated plots with fertilization by drip fertigation, the irrigation water use efficiency increased compared with the drip irrigated plots with fertilization by broadcasting.
Bajpai and Kaushal (2020) studied about wetting pattern of soil under trickle (drip) irrigation. It is governed by soil texture, structure, initial water content, emitter spacing, discharge rate and irrigation frequency. For efficient management of trickle irrigation moisture distribution plays an important role. The degree of soil wetted volume in an irrigation system determines the amount of water required to wet the root zone. This study reveals that soil moisture distribution and uniformity within the soil profile were affected by the distance between emitters rather than the distance between drip lines. In drip irrigation systems, the less the dripper spacing, the greater the moisture distribution as well as water use efficiency and crop yield. The vertical movement of soil moisture was greater than the horizontal movement under surface as well as subsurface drip irrigation systems. Deeper drip tape installations had a potential risk of not providing moisture to shallow rooted crops.

2.3 FERTIGATION UNDER DRIP IRRIGATION

Kaniszewski et al. (2002) conducted a study on effect of drip irrigation and fertigation on growth and yield of celeriac. The effects of drip irrigation and traditional broadcast N fertilizer application were compared with those of drip fertigation in Polish field experiments. The yield of celeriac was highest with one-third of the N applied before planting and two-thirds applied through the drip irrigation system, and lowest with broadcast N application without drip irrigation. Fertigated plants had greater leaf area, dry matter production, nitrate-N and total N contents than those given broadcast N, with or without drip irrigation. There were no significant differences in yield, dry matter production and contents of nitrate-N and total N between surface and subsurface fertigation treatments.

Ueta et al., (2009) evaluated the effects of drip fertigation on yield and quality of leafy vegetables and found that yield of spring Chinese cabbage increased with drip fertigation, even when the N application rate was reduced by 25 per cent from that used in conventional culture.

Abouel-Magd et al. (2009) fade out an experiment on broccoli crop to find out the influence of fertigation on growth, yield and nutrition update the result indicated that fresh and dry weight of broccoli were significantly higher in fertigation method on the other hand stack number and hand weight were significantly higher in fertigation with 75% NPK plus humic substance while the head diameter was significantly higher in fertigation with 100% NPK plus humic substance.
Malunjkar et al. (2010) conducted a field experiment at water management project, Mahatma Phule Krishi Vidyapeeth, Rahuri during summer 2005 on clay loam soil with cucumber (cv. Himangi). Amongst growth attributes, number of leaves, vine length, number of primary branches, dry matter accumulation per plant, days required for first flowering and internodes at which first flower appear were significantly influenced by levels of nitrogen and number of splits. Significantly higher values of these parameters were recorded with 100% recommended dose of nitrogen (100 kg N/ha) through fertigation with 8 splits. The length, girth and density of fruits increased with increase in fertilizer levels and number of splits, while fruit weight did not show any remarkable difference. Number of fruits per plant (10.40), yield of fruits (2.166 kg/plant) and (255.03 q/ha) were recorded as significantly higher with 100% RDN through drip irrigation with 8 splits. Drip method of irrigation showed lower values of water requirement with an improvement in water use efficiency.

Tan et al. (2010) conducted a study on Farm-scale processing tomato production using surface and subsurface drip irrigation and fertigation. The result was no significant difference in average marketable tomato yield among drip or fertigated treatments. Drip irrigated and/or fertigated tomatoes increased water use efficiency by 25 and 17% relative to non-irrigated tomatoes for the light and the heavy soils, respectively. Drip fertigation increased P and N use.

Nadiya Nesthad (2012) conducted a study on impact of fertigation and drip system layout on performance of Chilli. She reported that maximum yield was obtained in 85% of the daily irrigation requirement, with one lateral in between two rows of crop in a bed.

2.4 EFFECT OF MULCH ON PLANT GROWTH AND YIELD

Raina et al. (2001) studied the advantages of drip irrigation coupled with black polyethylene mulch. It has been reported to improve the yield, quality and water use-efficiency of high value crop like tomato.

Rajbir et al. (2003) conducted a field experiment on sandy loam soil to investigate the effect of drip irrigation and black polyethylene mulch compared with surface irrigation on growth, yield and water use efficiency and economics of tomato. Drip irrigation at 80 per cent pan evapo transpiration applied gave significantly higher fruit yield compared with the surface irrigation. Use of black polyethylene mulch plus the drip irrigation further raised the fruit yield to 57.89 t/ha.
Tiwari et al. (2005) conducted experiments on pineapple crop grown in the lateritic sandy loam soil to study yield response and to evaluate the economic feasibility of its cultivation with drip irrigation and plastic mulch. The yield of pineapple was highest and recorded 81 t/ha in case of 100 per cent irrigation requirement met by drip plus plastic mulch. The net income was highest for the 100 per cent irrigation requirement met with drip plastic mulch.

Singh et al. (2009) reported the effect of drip irrigation and polyethylene mulch influence on growth, yield and water use efficiency of tomato in India. Among different irrigation levels, drip irrigation at 80 per cent ET resulted in higher fruit yield of 45.57 t/ha compared with surface irrigation.

Paul et al. (2013) conducted experiments on the loamy sand soil at Bhubaneswar in eastern coastal of India for two years (2007-08 and 2008-09) to evaluate the yield, water-use-efficiency and economic feasibility of capsicum grown under drip and surface irrigation with non-mulch and black Linear Low Density Poly Ethylene (LLDPE) plastic mulch. The study indicated better plant growth, more number of fruits per plant and enhancement in the yield under drip irrigation system with LLDPE mulch. The highest yield (28.7 t/ha) was recorded under 100% net irrigation volume with drip irrigation (VD) and plastic mulching as compared to other treatments.

Devi et al. (2020) carried out an investigation to evaluate the performance of tomato in polyhouse with drip and mulch at AICRP on Plasticulture Engineering and Technologies experimental field of College of Agricultural Engineering and Post Harvest Technology (CAEPHT), Ranipool, Sikkim. The study thus reveals that drip irrigation with mulch give better water use efficiency, increased yield and thereby achieving the prime objective of ‘more crop per drop’.

2.5 PERFORMANCE OF CROP UNDER POLYHOUSE

Sheeba (2015) conducted a field experiment on the performance evaluation of five leafy vegetables in naturally ventilated polyhouse in randomized block design during the rainy season (June- August 2014) revealed coriander, palak and green Amaranthus to establish and grow well with higher biomass production compared to lettuce and red Amaranthus. The results of the study reveal the feasibility of growing leafy vegetables under protected environments during the rainy season which is not possible under open conditions.
as experienced in the experiment during this cropping season. Among the five crops tried, green Amaranthus, Palak and coriander prove to be ideal, red Amaranthus is susceptible to disease and all the vegetable crops under protected conditions require a higher dose of nutrients compared to the recommended package for open cultivation.

Santosh et al. (2017) conducted a field experiment to investigate the effect of irrigation levels using drip irrigation system for Lettuce crop grown under polyhouse and in open field condition during winter season (November-February) for two consecutive years. Reference evapotranspiration was estimated using FAO56 Penman Monteith approach. The total water requirement of Lettuce crop was estimated to be 219 mm and 339 mm for polyhouse and open field condition respectively. The research trials showed that 100% of water requirement met with drip irrigation under polyhouse (T2) resulted in maximum plant height, head diameter, number of leaves, fresh and dry weight of leaves and crop yield. Open field cultivation produces lowest yield compares to all irrigation level treatments under polyhouse.

Thenmozhi and Kottiswaran (2017) conducted experiments in naturally ventilated polyhouse and open field conditions at PFDC farm, TNAU, Coimbatore to study the effect of drip fertigation with different polyethylene mulches in Capsicum crop under polyhouse and open field conditions. The result concluded that maximum yield obtained in polyhouse when compare to open field. Mulches increase the soil temperature, retard the loss of soil moisture and check the weed growth. The experiment concluded that 25 micron plastic mulch increased the soil temperature that prevent soil water evaporation and retains soil moisture, which leads to maximize the crop yield.

Kothari et al. (2019) carried out a study to determine the crop water requirement of capsicum (Capsicum annum L.) cultivated under polyhouse conditions. Precise estimation of reference evapotranspiration (ETo) and crop evapotranspiration (ETc) on a daily basis is important for scheduling irrigation to apply water through drip system for crops grown in the greenhouse. Reference evapotranspiration (ETo) was estimated using the method suggested by FAO-56. The crop ET was determined using soil moisture depletion method. Weekly reference evapotranspiration inside polyhouse was maximum in 16th week (after transplant) 6.25 mm/day. Total water requirement inside NVPH (Naturally ventilated Polyhouse) under
the different treatments over the growing period of capsicum were 411.11 (T1), 370 (T2), 328.88 (T3), 287.77 (T4), 246.66 (T5) and 525.11 mm (T6).

2.6 BIOMETRIC PROPERTIES OF PLANTS

Kiaei et al. (2007) investigated the effect of altitude difference on the wood dry density, fiber dimensions, and morphological properties of hornbeam wood. The study area was located in the province of Mazandaran, north of Iran. 18 mature trees were randomly selected and harvested at six altitude levels (300, 500, 700, 900, 1100, and 1300 m) in the north samples were prepared at diameter at breast height (DBH) to measure the wood dry density, fiber length, fiber diameter, cell wall thickness, Runkel coefficients, flexibility coefficients, and slenderness coefficients. The results indicated significant effects of altitude variations on the studied properties. The pattern variations of wood properties were very regular at different levels of height. The average fiber length and fiber diameter decreased while the wood dry density and cell wall thickness increased with increasing the altitude levels.

Pandirwar et al. (2015) investigated biometric properties of seedlings of three common varieties of onion viz. Pusa Red, Set-126 and Pusa Ridhi (50, 60, 70 days old). The parameters determined were weight of seedling without and with de-topping, bulb diameter, stem diameter, height, moisture content, compressive strength and coefficient of static friction. The weight of seedlings without de-topping ranged from 0.53 to 3.05 g while with de-topping ranged from 0.47 to 1.68 g for all the three cultivars. The moisture content at different age and for all cultivars ranged from 84.89 to 91.63 % (wb). The average coefficient of static friction for mild steel (MS), aluminum and galvanized iron (GI) varied from 0.63 to 0.79. The compressive strength of bulb and stem of seedlings were 9.76 to 19.54 N for bulb and 4.08 to 8.17 N for stem respectively for 50 to 70 days seedlings. This information was not available but is critical in designing and selection of different components of onion seedling transplanter.

Ayishaet al. (2017) conducted study on tomato for understanding the influence of biometric properties on mechanical harvesting. Knowledge of physical properties of crops and fruits like tomato plays an important role in the design and optimization of its machinery. Evaluation of these properties like plant height, leaf numbers, leaf length, leaf width, fruit
length and width were taken for observation. It was seen that, these properties had a direct impact on deciding the components of the harvester.

Matyka & Radzikowski (2020) presented the production potential and biometric features of 11 willow varieties bred and cultivated mainly in Europe. The dry matter yield of the examined willow varieties ranged from 6.5 to 13.8 Mg ha$^{-1}$ year$^{-1}$. Varieties Tur, Sven, Olof, Torhild, and Tordis were characterized by a relatively low level of yield (7.2–8.2 Mg ha$^{-1}$ year$^{-1}$). The highest dry matter yield was obtained for the varieties Ekotur and Zubr, respectively, of 11.5 and 13.8 Mg ha$^{-1}$ year$^{-1}$. The Zubr variety produced the smallest number of shoots (three), but with the greatest height (4.8 m) and diameter (29.6 mm). Varieties with high production potential develop fewer shoots, but are taller and have a larger diameter than other varieties.

### 2.7 PHYSICAL PROPERTIES OF SOIL

Guo et al. (2012) evaluated the spatial and temporal variability in cotton (Gossypium hirsutum L.) yield and determine the relationship between yield and soil ECa, topography, and bare soil brightness at a field level in multiple growing seasons. Yield was positively correlated with ECa ($0.08 \leq r \leq 0.29$ for 30-cm ECa and $0.28 \leq r \leq 0.44$ for 90-cm ECa). Combined, ECa, topographic attributes, and bare soil brightness explained up to 70.1% of cotton yield variability. Bare soil brightness and ECa were strongly related to soil texture. Brighter soils with low ECa values had lower clay content. Yield and soil properties had stronger correlation in dry growing seasons than in wet growing seasons. Cotton yield variability pattern was relatively stable across different growing seasons.

Sumita et al. (2017) studied the impact of intensive cultivation on soil health under polyhouse condition of mid hill zone of Himachal Pradesh. The soil samples were collected from polyhouses and adjacent open fields from three districts of Himachal Pradesh, India (Mandi, Solan and Sirmour) and were analysed for physical (bulk density, particle density and porosity), chemical (pH, EC, organic carbon, cation exchange capacity, bicarbonate, chloride, available N, P, K and biological (microbial biomass C)) properties. The soil health indicators like EC, OC, P, S, chloride and microbial biomass had more influence on soil health under polyhouse condition. Majority of the soils in polyhouse conditions were in high soil health (57%) of the surveyed samples, followed by very high (40%) and medium health soil (3%).
Kaberi et al. (2020) evaluated the long term cultivation effect on soil health under poly houses of varying age groups. It was observed that after 3-5 years of cultivation, the soils under the poly houses were deteriorated due to formation of soil acidity, nutrient imbalance and reduction in microbial diversity and enzyme activity. pH, organic carbon content and bulk density of poly house soil of varying age groups varied significantly with respect to open field soil. Significantly lower cation exchange capacity and total exchangeable bases were recorded in poly house of >10 years age irrespective of soil depth and seasons. The available N, P2O5, K2O in soils showed an increasing trend up to 3-5 years of poly house age, thereafter decreased significantly.

2.8 EVAPOTRANSPIRATION IN CROPS

Ghazala and Ghulam (2007) conducted a study to analyze the subsequent effects of increasing temperatures on the ETo and on the agricultural water demand in the Pakistan. This study helped in crop monitoring and in the assessment of how much water is available in future for crops and which type of crops would suit the climate. They found that better management and building of new water reservoirs may help to cope the situation for an improved agricultural growth.

Shekar (2012) explained evapotranspiration more broadly as a need of hour because in context of climate change as the average temperature is rising and certainly evaporative demand is shooting up. The different model for estimating ET differs in the effect of specific meteorological parameters on ET demand. The variations in temperature also caused variations in other parameters such as humidity, wind speed and vapour pressure which directly changed ET. In this study 10 years (2002-2011) weather data taken from ozone unit, Indian Meteorological Department, Banaras Hindu University (BHU), Varanasi had been analyzed for the change in temperature, wind speed and solar radiation.

Arunadevi et al. (2019) conducted experiments on green chilli cultivated in the polyhouse and open field. In order to give precise amount of irrigation through drip irrigation system, it is important to estimate the reference evapotranspiration (ETo) and crop evapotranspiration (ETc) for any crops. In this study, crop evapotranspiration (ETc) was determined for the Green chilli cultivated in the polyhouse and open field for the semi-arid
climatic condition in Kumulur, Tamil Nadu, as it changes with the crop characteristics, climatic conditions and management practices. The chilli variety chosen was TNAU Hybrid CO1. The ETo value was determined by the Penman Moneith method mentioned in the FAO-56 using ETo calculator. The ETc value was calculated by the soil water balance method as the change in soil moisture. The soil moisture data was obtained from the tensiometer readings. From the study, the ETc (mm/day) value of green chilli obtained was 2.2, 3.1, 3.2, 1.4 in polyhouse and 2.6, 3.5, 3.6, 1.6 in open field condition for the initial, developmental, middle and end season stages respectively.
MATERIALS AND METHODS
CHAPTER III
MATERIALS AND METHODS

This chapter describes the materials used and the methods employed for the study entitled “Standardization of irrigation and fertigation requirement for amaranth under polyhouse” conducted at the Institutional Farm, Kelappaji College of Agricultural Engineering and Technology (KCAET), Tavanur, Malappuram, Kerala during the period of 2020-2021.

3.1 STUDY AREA

The field experiment was conducted inside the saw tooth type polyhouse in the research plot of Precision Farming Development Centre (PFDC) situated near the farm, KCAET, Tavanur. The area lies in the cross point of 10.85° N latitude and 75.98° E longitude. The area was selected due to the availability of all parameters needed for this study. The selected plot for the study was located in the western side of the farm which was nearer to the Bharathapuzha river basin. The soil in the selected plot was sandy loam. The land preparation was done before the installation of the system in the field. The field experiment was conducted during November to February 2020-21.

3.2 LOCATION AND CLIMATE

The experiment was conducted in the Instructional Farm, KCAET, Tavanur, in Malappuram district, Kerala. Location map of KCAET, Tavanur is given in Plate 3.1. Agro climatically, the area falls within the border line of Northern zone and Central Zone of Kerala. Major part of the rainfall in this region is obtained from South West monsoon. Average annual rainfall of the region varies from 2500 to 2900 mm. Climatological data of the experimental area is shown below.

Mean maximum temperature: 30.7° C
Mean minimum temperature: 23.5° C
Average relative humidity: 70%
Average annual rainfall: 2700 mm
Monthly evapotranspiration: 6.35 mm/day

Mean solar radiation: 24.9 MJ/m²/day

Wind speed: 4-6 km/hr

3.3 EXPERIMENTAL DETAILS

Crop: Amaranth

Family: Amaranthaceae

Variety: CO 1 (Mulaikereai and Thandukeerai)

Growing structures/ condition: Naturally ventilated polyhouse

Design: CRD

Replications: seventeen (three in each treatment)

Spacing: 0.6×0.4 m
## Table 3.1 Specifications of naturally ventilated polyhouse

| SL NO | PARTICULARS            | SPECIFICATION                                                                 |
|-------|------------------------|------------------------------------------------------------------------------|
| 1     | **Green House type**   | Naturally ventilated, tropical with corridor, fixed roof vent, (saw tooth type) |
| 2     | **Column height**      | 3 m                                                                           |
| 3     | **Centre height**      | 6 m                                                                           |
| 4     | **Inside area**        | 292 m²                                                                        |
| 5     | **Structure**          |                                                                               |
|       | External column pipe   | 2” diameter, 2 mm thick galvanized steel B class                              |
|       | Internal column pipe   | 1.5” diameter, 2 mm thick galvanized steel B class                             |
|       | Arch                   | 1.5” diameter, 2 mm thick galvanized steel B class                             |
|       | Gutter                 | 2 mm galvanized                                                              |
|       | Entrance               | Double door sliding with sealing brushes                                      |
| 6     | **Ventilation**        |                                                                               |
|       | Side walls             | Covered with 40 mesh UV stabilized net                                         |
|       | Roof covering          | UVA 205 N clear, Thermic anti drip, 5 layer, antivirus, 200 micron polythene with 85% light transmission |
|       | Roof vent              | At least 0.75 m width covered with 40 mesh UV stabilized insect proof net      |
|       | Shade net screen inside| Black 50% UV stabilized movable                                               |
3.4 FIELD EXPERIMENT

Growth and yield parameters of Amaranth with different irrigation and fertigation schedules were studied. The experiment was conducted inside the naturally ventilated polyhouse during 2020 (November 15th) – 2021 (February 13th) and the crop duration was three months (90 days). The polyhouse was oriented east–west with an area of 292 m² (36.5 m length and 8 m width). A view of the polyhouse is shown in plate 3.2.

3.4.1 Land Preparation

Polyhouse was cleaned inside out. Land preparation was done inside the naturally ventilated polyhouse using an alligator. Nursery was prepared and CO-1 variety of Amaranth was sown.
3.4.2 Bed preparation

Seed beds were formed and cow dung was applied. Main, submain and laterals were laid. Mulching is done and holes were drilled. Emitters were connected to the lateral. Poly house was divided into beds and each bed was applied with a different irrigation and fertigation schedule. Beds were of the dimensions 7 m length, 0.7 m width and 0.25m height. Layout of the field experiment is shown in figure 3.9.

3.4.3 Installation of drip and fertigation units

The plants were irrigated daily through drip irrigation system. Irrigation water was pumped using 5hp monoblock pump set and conveyed through the main line of 68 mm diameter PVC pipes after filtering through the disc filter. From the main pipe, sub main of PVC pipes (50 mm) were installed. From the sub mains water is conveyed to LDPE laterals.
of diameter 16 mm. Online drippers at spacing of 90 cm were used for irrigation. Discharge rate of single dripper is 2 lph. Venturi injector was installed along with irrigation unit for fertigation.

![Fig. 3.2 Layout of the experimental field](image)

**3.5 MULCH**

Mulch is a layer of material applied to the surface of soil. Reasons for applying mulch include conservation of soil moisture, improving fertility and health of the soil, reducing weed growth and enhancing the visual appeal of the area.
### Table 3.2 Specification of mulch

| Sl no. | SPECIFICATIONS       | DESCRIPTION |
|--------|----------------------|-------------|
| 1      | Colour               | Grey        |
| 2      | Length               | 5.5m        |
| 3      | Width                | 1.5m        |
| 4      | Thickness (microns)  | 30microns   |
| 5      | Packaging type       | Roll        |

### 3.6 NURSERY

Amaranthus variety CO-1 was chosen for cultivation. Seeds were sown in a nursery bed of dimensions 3.5 m length and 0.7 m width and ten days old seedlings were transplanted to the main field.

### 3.7 TRANSPLANTING

Transplanting was done on 15th November 2020. There were 17 plants in each bed with a plant spacing of 0.4 m. The total plant population was 170 numbers. Row to row distance is 60 cm. The view of the plot after transplanting is given in Fig 3.5

![Plate 3.5 Amaranth seedling after transplanting](image)
3.8 EXPERIMENT DESIGN

The experiment was designed under Factorial Completely Randomized Block Design. The design details are as furnished in the Table 3.3

Table 3.3 Experiment Design Details

| Crop variety | CO-1 |
|--------------|------|
| Experiment design | Factorial CRD |
| Factors | R – Fertigation levels |
| | R1- 100% fertigation |
| | R2- 125% fertigation |
| | R3- 150% fertigation |
| T – Irrigation levels | T1- 60% irrigation |
| | T2-80% irrigation |
| | T3-100% irrigation |
| No. of replications | 3 |
| No of treatment combinations | 9 |
### Table 3.4 Treatment details

| Treatment | Details |
|-----------|---------|
| T1R1      | Crop with 60% irrigation and 100% fertigation |
| T1R2      | Crop with 60% irrigation and 125% fertigation |
| T1R3      | Crop with 60% irrigation and 150% fertigation |
| T2R1      | Crop with 80% irrigation and 100% fertigation |
| T2R2      | Crop with 80% irrigation and 125% fertigation |
| T2R3      | Crop with 80% irrigation and 150% fertigation |
| T3R1      | Crop with 100% irrigation and 100% fertigation |
| T3R2      | Crop with 100% irrigation and 125% fertigation |
| T3R3      | Crop with 100% irrigation and 150% fertigation |

### 3.9 IRRIGATION SYSTEM

Irrigation water source was tube well from which water was pumped to a sand filter and conveyed through the main line of 1.5” diameter. One end of the venturi injector is connected to the main and the other end to disc filter. PVC sub main of 1.5” diameter was connected to the disc filter to which, Low density polyethylene laterals of 16 mm diameter were connected. End caps were provided at the end of laterals. Each lateral was provided with individual cut off valves for controlling irrigation. Along the laterals, online drippers of 8 lph were placed at fixed intervals. Venturimeter was also used. Fig 3.5 depicts the irrigation system layout in the poly house.

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Plate 3.7 Pump  Plate 3.8 Bypass assembly  Plate 3.9 Disc filter
3.10 ESTIMATION OF CROP WATER REQUIREMENT

The water requirement of crops is the amount of water that is required to meet the evapotranspiration rate so that crops may thrive. The evapotranspiration rate is the amount of water that is lost to the atmosphere through the leaves of the plant, as well as the soil surface.

Therefore, in order to estimate the water requirement of a crop we first need to measure the evapotranspiration rate. The reference rate, ET0, is the estimate of the
amount of water that is used by a well-watered grass surface that is roughly 8 to 15 centimetres in height. Once ET0 is known, the water requirement of the crop can be calculated.

Consumptive use (CU) is used to designate the losses due to ET and water that is used for its metabolic activities of plants. Thus CU exceed ET by the amount of water used for digestion, photosynthesis, transport of minerals and photosynthates, structural support and growth. Since this difference is usually less than 1%, ET and CU are normally assumed to be equal. The crop water need mainly depend on the climate, crop type and stage of growth of crop. The crop evapotranspiration can be directly estimated by the mass balance or energy transfer methods. It can also be determined by from lysimeters or from the studies of soil water balance. Sometimes Penman – Monteith equation is also applied for the estimation of crop water requirement directly but the lack of consolidate information on the aerodynamic and canopy features of the cropped area restricts its use.

Nowadays, the crop water requirement is usually calculated from the crop coefficient approach. The formula used is as follows:

\[ ETC = Kc \times ET0 \]

Where,

\[ Kc = \text{crop coefficient} \]

\[ ET0 = \text{reference crop evapotranspiration (mm)} \]

\[ ETC = \text{crop evapotranspiration (mm)} \]
Crop evapotranspiration (ETo) refers to the amount of water that is lost through evapotranspiration, while crop water requirement (ETc) refers to the amount of water need to be supplied.

3.10.1 Crop coefficient (kc)

The crop coefficient is generally the ratio of crop evapotranspiration to the reference crop evapotranspiration. Kc values mainly depend upon type of crop, climate and growth stage of crop. The crop coefficient predicts ETc under standard conditions, i.e, conditions where there are no limitations on crop growth due to water shortage, crop density, disease, weed, insect or salinity pressures. This represents the upper envelope of evapotranspiration.

In order to determine Kc it is necessary to determine the total growing period of each crop, various growth stages of each crop and the value of Kc in different growth stages.

![Variation of crop coefficient with crop growth stages](image)

**Fig. 3.4 Variation of crop coefficient with crop growth stages**

(Source: Allen et al. 1998)

3.10.2 Estimation of reference crop evapotranspiration (ETo)

Evapotranspiration is a combination of two processes- evaporation and transpiration. Crop evapotranspiration from an extensive surface of green grass of uniform height(0.12m), actively growing, completely shading the ground with an albedo of 0.23 and having ample water supply is called reference crop evapotranspiration and is denoted by ETo. Various methods are in use for the determination of ETo.

FAO-56 Penman – Monteith method
\[ ETo = 0.408 \Delta (Rn - G) + \gamma 900 U_2 (es - ea) \]
\[
\frac{1}{(T+273)} \Delta + \gamma (1 + 0.34 U_2)
\]

Where,

\( ETo \) = Reference crop evapotranspiration (mm/day)

\( Rn \) = Net radiation at the crop surface (MJ/m^2/day)

\( G \) = Soil heat flux density (MJ/m^2/day)

\( T \) = Air temperature at 2 m height (°C)

\( U_2 \) = Wind speed at 2 m height (m/s)

\( es \) = Saturation vapour pressure (kPa)

\( ea \) = actual vapour pressure [kPa],

\( es - ea \) = saturation vapour pressure deficit [kPa],

\( \Delta \) = slope vapour pressure curve [kPa °C\(^{-1}\)],

\( \gamma \) = psychrometric constant [kPa °C\(^{-1}\)].

The Penman-Monteith equation is used widely for the estimation of \( ETo \).

### 3.11 NET IRRIGATION REQUIREMENT (NIR)

Irrigation is necessary when rainfall could not meet the evapotranspiration demands of the crops. Irrigation should apply the right quantity of water at the right time. The timing and depth of future irrigations can be planned by calculating soil water balance in the root zone on a daily basis. The irrigation requirement, expressed in mm is calculated for the specified interval. Net irrigation requirement is the variation between concerned crop evapotranspiration growing under standard conditions with the effective rainfall for the specified time interval. It indicatively represents the fraction of crop water requirements that
needs to be satisfied through irrigation contribution in order to ensure optimum crop growing conditions.

\[ \text{NIR} = \text{WR} - \text{ER} - \text{Ge} \]

Where,

\( \text{WR} \) = Water Requirement (ETc)

\( \text{ER} \) = Effective Rainfall

\( \text{Ge} \) = Groundwater contribution from the water table (not considered in the study as this is negligible).

### 3.12 IRRIGATION SCHEDULING

CROPWAT model handles irrigation scheduling of each crop individually. The schedule not only enables the efficient management of water but also develop effective water delivery schedules under restricted supply conditions. The irrigation scheduling option in CROPWAT provides a number of options depending on user’s objectives, available water sources the conditions of the irrigation system.

### 3.13 DURATION OF IRRIGATION

The quantity of water for irrigation to be applied was computed for every day. For known discharge rate of emitters (2 lph), the duration of irrigation water was calculated by

\[ T = \frac{V_n}{N_e \times N_p \times q} \]

Where,

\( V_n \) = Net water requirement

\( N_e \) = No of emitters per plant

\( N_p \) = No of plants

\( q \) = Emitter discharge L/h

### 3.14 FERTIGATION

In all modern systems, fertilization and irrigation are integrated into one system which enables supply of fertilizers and water at the same time (fertigation). Once it
became evident that all nutrients essential for crops (macro- and micronutrients) could be supplied through hydro soluble fertilizer salts, systems were developed with fertilizers dissolved at relatively high concentrations in special stock solutions. Stoke solution was prepared by dissolving the following minerals in 10 litres of water.

Table 3.5 Fertilizer schedule

| Application stages | Fertilizers | 100% fertigation | 125% fertigation | 150% fertigation |
|-------------------|-------------|------------------|------------------|------------------|
| Initial stage     | 19:19:19    | 10 g             | 12.5 g           | 15 g             |
|                   | 13:0:45     | 10 g             | 12.5 g           | 15 g             |
|                   | Urea        | 13.33 g          | 16.66 g          | 20 g             |
| Final stage       | 19:19:19    | 9.33 g           | 11.6 g           | 14 g             |
|                   | 13:0:45     | 3.33 g           | 4.1 g            | 5 g              |
|                   | Urea        | 18 g             | 22.5 g           | 27 g             |

Plate 3.15 NPK 19:19:19
Plate 3.16 Pottassium nitrate 13-00-45

3.15 FIELD OBSERVATIONS

Three plants from each treatment were selected at random and tagged for observations on growth and yield characters.
3.15.1 Plant growth parameters

3.15.1.1 Plant height
The height of the plant from base level of shoot to the tip was measured at one week interval and expressed in centimetres for each treatment.

3.15.1.2 Number of leaves
Number of leaves per plant was noted at one week interval in selected plants.

3.15.1.3 Stem girth
The width (diameter) of stem was recorded at one week interval.

Plate 3.17 Amaranth crop inside the poly house

3.15.2 Soil properties

To evaluate the effect of plastic mulches in soil properties, soil parameters such as soil moisture content, soil pH and soil temperature were measured thrice in a day (8.30 am, 1.30 pm and 5.30 pm) for each bed. Soil moisture content was recorded using soil moisture meter (Fig 3.10), soil pH was recorded by pH meter (Fig.3.11) and soil temperature by using thermometer (Fig.3.12).

Plate 3.18 soil moisture meter  Plate 3.19 pH meter
3.15.3 Yield parameters

Harvesting was started twenty seven days after transplanting at an interval of four or five days. The weight of crop harvested was noted from the tagged plants for each harvest. The average value of crop weight per plant was accordingly computed from the data of all harvests. Total seven harvests were done and total yield was taken. The crop period was not over and harvest was continuing when the experiment was stopped. The results reported are upto the seven harvest of the crop.

3.16 DETERMINATION OF IRRIGATION WATER USE EFFICIENCY

Water use efficiency was calculated for each treatment. It is the ratio of yield of crop in kg/ha and total water applied in mm.

\[ WUE = \frac{Y}{W.A} \]
Where,

WUE = Water use efficiency (kg/ha mm) of water used.

Y = Yield of the crops (kg ha\(^{-1}\))

W.A = Total water applied (mm)
RESULTS AND DISCUSSION
CHAPTER IV

RESULTS AND DISCUSSION

Results obtained from the study “Standardization of irrigation and fertigation requirement for amaranth under polyhouse” are discussed in this chapter after analyzing the observations taken during the course of work.

Average $ET_0$ was found to be 3.62 mm/day. Water requirement for amaranth was found as 194.2 mm and the gross irrigation requirement as 276.4 mm at a 100% irrigation efficiency. Due to the lack of data availability during this corona pandemic situation the value of average $ET_0$, water requirement for amaranth and gross irrigation requirement have been taken from previous year PFDC collected data where the values are derived by the help of CROPWAT 8.0 SOFTWARE. (Malavika, v.k et al., unpublished data, 2020; unreferenced).

Results of various parameters of Amaranth are observed and evaluated during different stages of crop growth. The influence of alternate growing systems and irrigation interval on the crop growth and yield parameters are discussed in the following sections. The major parameters are given below;

1. Effect of various treatments on growth
   a) Stem girth (cm)
   b) Plant height (cm)
   c) Number of leaves

2. Soil parameters effect on yield of crop
   a) soil temperature (°C)
   b) Soil pH
   c) Soil moisture

3. Yield parameters for each treatment
   a) Amount harvested (kg)

Each bed is supplied with different levels of fertigation and irrigation for example; T1R1 60% irrigation and 100% fertigation. Two replicates are randomly chosen from each
bed for the measurement of parameters. The measurements are taken after each week. The average value of parameters are calculated and plotted against levels of treatment.

4.1 OBSERVATIONS ON CROP GROWTH PARAMETERS

Data on observations viz, number of leaves, plant height, stem girth, for each treatment were observed during different stages crop growth. The data were statistically analyzed and results are enumerated under various headings.

The influence of alternate growing systems and irrigation interval on the crop growth and yield parameters are discussed in the following sections.

Table 4.1 shows effect of alternate growing systems and irrigation interval on plant height, stem girth, no of leaves, during first day of transplanting.

Table 4.1 Plant growth parameters after 1st week of transplanting (22/11/2020)

| Treatment | Plant Height cm | Stem Girth cm | No of Leaves |
|-----------|----------------|---------------|--------------|
| CONTROL   |                |               |              |
| P1        | 10             | 2.2           | 8            |
| P2        | 15             | 2.1           | 12           |
| P3        | 16             | 2             | 17           |
| T1R1      |                |               |              |
| P1        | 11             | 2.1           | 11           |
| P2        | 8              | 2             | 8            |
| P3        | 12             | 2             | 14           |
| T1R2      |                |               |              |
| P1        | 11             | 1.9           | 7            |
| P2        | 15             | 2.2           | 9            |
| P3        | 14             | 2.1           | 11           |
| T1R3      |                |               |              |
| P1        | 16.6           | 2.4           | 13           |
| P2        | 16.8           | 2.2           | 11           |
| P3        | 16             | 2.5           | 14           |
| T2R1      |                |               |              |
| P1        | 11             | 2.2           | 12           |
| P2        | 15             | 2.2           | 11           |
Fig. 4.1 Observation of plant height after 1st week of transplanting

In the first week highest plant height was observed in treatment T3R3 and lowest plant height was observed in T1R1.
Fig. 4.2 Observation of plant girth after 1<sup>st</sup> week of transplanting

In the first week highest plant girth was observed in treatment T2R3 and lowest plant girth was observed in T1R1.

Fig. 4.3 Observation of no of leaves after 1<sup>st</sup> week of transplanting

In the first week highest number of leaves was observed in treatment T3R3 and lowest plant height was observed in T1R1.

Table 4.2 Plant growth parameters after 2<sup>nd</sup> week of transplanting (29/11/2020)

| Treatment | Plant Height cm | Stem Girth cm | No of Leaves |
|-----------|-----------------|---------------|--------------|
| CONTROL   | 21              | 3             | 15           |
| T1R1      | 28              | 3.5           | 22           |
| T1R2      | 28              | 3.5           | 22           |
| T1R3      | 28              | 3.5           | 22           |
| T2R1      | 28              | 3.5           | 22           |
| T2R2      | 28              | 3.5           | 22           |
| T2R3      | 28              | 3.5           | 22           |
| T3R1      | 28              | 3.5           | 22           |
| T3R2      | 28              | 3.5           | 22           |
| T3R3      | 28              | 3.5           | 22           |
|     | T\(_1\)R\(_1\) |     | T\(_1\)R\(_2\) |     | T\(_1\)R\(_3\) |     | T\(_2\)R\(_1\) |     | T\(_2\)R\(_2\) |     | T\(_2\)R\(_3\) |     | T\(_3\)R\(_1\) |     | T\(_3\)R\(_2\) |     | T\(_3\)R\(_3\) |
|-----|----------------|-----|----------------|-----|----------------|-----|----------------|-----|----------------|-----|----------------|-----|----------------|-----|----------------|-----|----------------|
| P3  | 31             | 3.9 | 28             | 3.6 | 33             | 2.4 | 24             | 4.3 | 29.5           | 3.1 | 24             | 3.5 | 31             | 3.5 | 31             | 4.1 |
| P1  | 24             | 3.1 | 21             | 1.9 | 31             | 2.4 | 24             | 4.3 | 31             | 3.5 | 24             | 2.9 | 31             | 3.6 | 31             | 4.3 |
| P2  | 20             | 3   | 18             | 2.2 | 33             | 2.2 | 30             | 3.6 | 30             | 3.6 | 33             | 3.5 | 31             | 3.8 | 32             | 2.2 |
| P3  | 28             | 3.6 | 26             | 2.1 | 33             | 2.5 | 25             | 2.1 | 30             | 3.7 | 26             | 3.7 | 29             | 3.8 | 32             | 4.2 |

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**Fig. 4.4 Observation of plant height after 2\textsuperscript{nd} week of transplanting**

In the second week highest plant height was observed in treatment T3R2 and lowest plant height was observed in T1R1.

**Fig. 4.5 Observation of plant girth after 2\textsuperscript{nd} week of transplanting**

In the second week highest plant girth was observed in treatment T3R3 and lowest plant girth was observed in T1R1.
Fig. 4.6 Observation of number of leaves after 2nd week of transplanting
In the second week highest number of leaves was observed in treatment T3R3 and lowest plant height was observed in T2R1.

Table 4.3 observation of plant growth parameters after 3rd week of transplanting

| Treatment | Plant height cm | Stem girth Cm | No of leaves |
|-----------|-----------------|---------------|--------------|
| CONTROL   | P1 23           | 4             | 12           |
|           | P2 31           | 4.5           | 23           |
|           | P3 33           | 4.6           | 30           |
| T1R1      | P1 28.5         | 3.6           | 12           |
|           | P2 22           | 4.2           | 21           |
|           | P3 29.5         | 4.3           | 25           |
| T1R2      | P1 32           | 4             | 14           |
|           | P2 36           | 4.2           | 28           |
|           | P3 33           | 4.2           | 25           |
| T1R3      | P1 30.5         | 5             | 15           |
|           | P2 27           | 4.4           | 31           |
|           | P3 33           | 5.1           | 35           |
| T2R1      | P1 30           | 4.2           | 14           |
|           | P2 30           | 5.9           | 25           |
|           | P3 31           | 5.1           | 33           |
| T2R2      | P1 32           | 4.4           | 12           |
In the third week highest plant height was observed in treatment T3R3 and lowest plant height was observed in T1R1.
Fig. 4.8 Observation of plant girth after 3\textsuperscript{rd} week of transplant

In the third week highest plant girth was observed in treatment T3R3 and lowest plant girth was observed in T1R1.

Fig. 4.9 Observation of number of leaves after 3\textsuperscript{rd} week of transplant

In the third week highest number of leaves was observed in treatment T3R3 and lowest number of leaves was observed in T1R1.
4.2 OBSERVATION OF SOIL PROPERTIES OF VARIOUS TREATMENTS IN FIELD

Table 4.4 soil properties at the time of transplanting

| Sl. No. | Treatment | Soil ph | Soil temperature | Moisture content |
|---------|-----------|---------|------------------|-----------------|
| 1       | CONTROL   | 6.8     | 32.5             | 17.5            |
| 2       | T1R1      | 6.5     | 32.2             | 19.3            |
| 3       | T1R2      | 6.6     | 32.2             | 17.3            |
| 4       | T1R3      | 6.8     | 32.5             | 17.4            |
| 5       | T2R1      | 6.7     | 32               | 18.6            |
| 6       | T2R2      | 6.5     | 32               | 19.5            |
| 7       | T2R3      | 6.7     | 31.9             | 19.5            |
| 8       | T3R1      | 6.7     | 32               | 19.6            |
| 9       | T3R2      | 6.8     | 32.1             | 18.9            |
| 10      | T3R3      | 6.8     | 32.7             | 24.1            |

Fig 4.10 Soil properties of transplanting
Table 4.5 soil properties after 1st week of transplanting

| Sl. No. | Treatment | Soil PH | Soil temperature | Moisture content |
|---------|-----------|---------|------------------|-----------------|
| 1       | CONTROL   | 7.1     | 35.1             | 17              |
| 2       | T₁R₁      | 6.7     | 33.2             | 20              |
| 3       | T₁R₂      | 6.8     | 33.5             | 20.9            |
| 4       | T₁R₃      | 6.8     | 33.4             | 21.5            |
| 5       | T₂R₁      | 6.7     | 33.2             | 16.4            |
| 6       | T₂R₂      | 6.5     | 33.2             | 17.5            |
| 7       | T₂R₃      | 6.7     | 33.2             | 20.9            |
| 8       | T₃R₁      | 6.7     | 33.4             | 17.9            |
| 9       | T₃R₂      | 6.8     | 33.4             | 19.9            |
| 10      | T₃R₃      | 6.8     | 33.5             | 22.7            |

Fig 4.11 Soil properties after 1st week of transplanting
Table 4.6 soil properties after 2nd week of transplanting

| Sl. No | Treatment | Soil pH | Soil temperature | Moisture content |
|--------|-----------|---------|------------------|------------------|
| 1      | CONTROL   | 8       | 36.4             | 17.1             |
| 2      | T₁R₁      | 6.8     | 36.8             | 20.7             |
| 3      | T₁R₂      | 6.6     | 36.4             | 17.2             |
| 4      | T₁R₃      | 6.7     | 36.5             | 17.3             |
| 5      | T₂R₁      | 6.7     | 36.2             | 19.3             |
| 6      | T₂R₂      | 6.8     | 36.3             | 18.3             |
| 7      | T₂R₃      | 6.8     | 36.2             | 19.2             |
| 8      | T₃R₁      | 6.9     | 36.1             | 22.3             |
| 9      | T₃R₂      | 6.8     | 35.3             | 21.2             |
| 10     | T₃R₃      | 6.8     | 35.4             | 24.3             |

Fig 4.12 Soil properties after 2nd week of transplanting
Table 4.7 soil properties after 3\textsuperscript{rd} week of transplanting

| Sl. No | Treatment | Soil Ph | Soil temperature | Moisture content |
|--------|-----------|---------|------------------|-----------------|
| 1      | CONTROL   | 7.8     | 31.8             | 17              |
| 2      | T\textsubscript{1}R\textsubscript{1} | 6.8     | 32.1             | 20.2            |
| 3      | T\textsubscript{1}R\textsubscript{2} | 6.7     | 32               | 18.7            |
| 4      | T\textsubscript{1}R\textsubscript{3} | 6.6     | 32               | 15.7            |
| 5      | T\textsubscript{2}R\textsubscript{1} | 6.9     | 32.1             | 18.1            |
| 6      | T\textsubscript{2}R\textsubscript{2} | 6.9     | 32               | 16.2            |
| 7      | T\textsubscript{2}R\textsubscript{3} | 7.0     | 32.2             | 20.6            |
| 8      | T\textsubscript{3}R\textsubscript{1} | 6.8     | 32.1             | 20.4            |
| 9      | T\textsubscript{3}R\textsubscript{2} | 6.9     | 32.9             | 18.3            |
| 10     | T\textsubscript{3}R\textsubscript{3} | 6.9     | 32.5             | 23.7            |

Fig 4.13 Soil properties after 3\textsuperscript{rd} week of transplanting
4.3 Observation of Yield From Various Treatments in The Field

Observations of yield from various treatments in the field at different harvest were taken. The data were statistically analyzed and results are enumerated under various headings.

Table shows yield from various treatment in the field during respective harvest.

Table 4.8 Yield from various treatment in the field during respective harvest.

| Treatments | Yield from 1st harvest (kg/ha) x 10^4 | Yield from 2nd harvest (kg/ha) x 10^4 | Yield from 3rd harvest (kg/ha) x 10^4 | Yield from 4th harvest (kg/ha) x 10^4 | Yield from 5th harvest (kg/ha) x 10^4 | Yield from 6th harvest (kg/ha) x 10^4 | Yield from 7th harvest (kg/ha) x 10^4 |
|------------|--------------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|
| CONTROL    | 0.354                                | 0.309                                | 0.485                                | 0.419                                | 0.264                                | 0.440                                | 0.240                                |
| T1R1       | 0.273                                | 0.238                                | 0.373                                | 0.321                                | 0.202                                | 0.338                                | 0.185                                |
| T1R2       | 0.326                                | 0.285                                | 0.450                                | 0.385                                | 0.242                                | 0.407                                | 0.223                                |
| T1R3       | 0.380                                | 0.333                                | 0.523                                | 0.450                                | 0.283                                | 0.473                                | 0.259                                |
| T2R1       | 0.326                                | 0.285                                | 0.450                                | 0.385                                | 0.242                                | 0.407                                | 0.223                                |
| T2R2       | 0.380                                | 0.333                                | 0.423                                | 0.450                                | 0.283                                | 0.473                                | 0.259                                |
| T2R3       | 0.426                                | 0.337                                | 0.583                                | 0.502                                | 0.316                                | 0.528                                | 0.290                                |
| T3R1       | 0.369                                | 0.321                                | 0.504                                | 0.433                                | 0.273                                | 0.457                                | 0.250                                |
| T3R2       | 0.464                                | 0.444                                | 0.635                                | 0.547                                | 0.345                                | 0.576                                | 0.316                                |
| T3R3       | 0.519                                | 0.454                                | 0.714                                | 0.614                                | 0.388                                | 0.647                                | 0.354                                |
| TOTAL      | 3.8                                  | 3.33                                 | 5.24                                 | 4.50                                 | 2.84                                 | 4.75                                 | 2.6                                  |
Fig. 4.14 Yield from the 1\textsuperscript{st} harvest in kilograms per hectare

In the first harvest highest yield was observed in treatment T\textsubscript{3}R\textsubscript{3} and lowest yield was observed in T\textsubscript{1}R\textsubscript{1}.

Fig. 4.15 Yield from the 2\textsuperscript{nd} harvest in kilograms per hectare

In the second harvest highest yield was observed in treatment T\textsubscript{3}R\textsubscript{3} and lowest yield was observed in T\textsubscript{1}R\textsubscript{1}.
Fig. 4.16 Yield from the 3\textsuperscript{rd} harvest in kilograms per hectare

In the third harvest highest yield was observed in treatment T\textsubscript{3}R\textsubscript{3} and lowest yield was observed in T\textsubscript{1}R\textsubscript{1}.

Fig. 4.17 Yield from the 4\textsuperscript{th} harvest in kilograms per hectare

In the fourth harvest highest yield was observed in treatment T\textsubscript{3}R\textsubscript{3} and lowest yield was observed in T\textsubscript{1}R\textsubscript{1}. 
Fig. 4.18 Yield from the 5th harvest in kilograms per hectare

In the fifth harvest highest yield was observed in treatment T3R3 and lowest yield was observed in T1R1.

Fig. 4.19 Yield from the 6th harvest in kilograms per hectare

In the sixth harvest highest yield was observed in treatment T3R3 and lowest yield was observed in T1R1.
Fig. 4.20 Yield from the 7\textsuperscript{th} harvest in kilograms per hectare

In the seventh harvest highest yield was observed in treatment T\textsubscript{3}R\textsubscript{3} and lowest yield was observed in T\textsubscript{1}R\textsubscript{1}.

4.4 ECONOMIC ANALYSIS

The economic aspects of project preparation and analysis require a determination of the likelihood that a proposed project will contribute significantly to the development of the total economy and that its contribution will be great enough to justify using the scarce resources it will need. Economic analysis is done in order to find the feasibility of the project

- Life expectancy of greenhouse structure assumed as 10 years.
- Life expectancy of irrigation system components assumed as 10 years.
- Life expectancy of plastic mulching sheet assumed as 2 years.
- Benefit cost ratio= (total returns/total expenditure).
- Duration of 1 season Amaranthus crop taken as 3 months.

Table 4.9 Calculation of cost

| SL.NO | Item description                                      | Quantity(unit) | Rate  | Total  | Number of useful seasons | Cost/season |
|-------|-------------------------------------------------------|----------------|-------|--------|--------------------------|-------------|
| 1     | Structure and irrigation components (fixed cost)      |                |       |        |                          |             |
|   |   |   |   |   |
|---|---|---|---|---|
| 1.1 | Polyhouse structure | 150000 | 60 | 2500 |
| 1.2 | Drip lateral Od 16 mm CL 11×100 mtr | 284 (m) | 15 | 4620 | 40 | 115.5 |
| 1.3 | Drip poly grommet take off 16 ×13 mm | 16 (no) | 6.5 | 104 | 40 | 24 |
| 1.4 | Drip lateral end stop 8 shape 16 mm | 16 (no) | 3.5 | 56 | 40 | 16 |
| 1.5 | Disc filter armas 50 mm | 1 (no) | 2650 | 2650 | 40 | 66.5 |
| 1.6 | Mulching sheet 400 metre 30 micron 1.2m silver/black | 1(284 m) | 3350 | 2378.5 | 8 | 297.5 |
| 1.7 | Mini valve | 16 (no) | 40 | 640 | 40 | 16 |
| 1.8 | Drip j-loc dripper 8 lhp | 630 (no) | 3.6 | 2268 | 40 | 56.7 |
| 1.9 | Extra fitting bend, tee and solvent | | 500 | 40 | 12.5 |
| 1.10 | 1.5” PVC pipe | 25.5 (6 m) | 200 | 850 | 40 | 21.25 |
| 1.11 | Venturi injector | | 500 | 40 | 12.5 |
| Sl no | Treatments | Average yield (kg) | No of yield | Rate per kg | Total revenue | Benefit cost ratio |
|-------|------------|-------------------|-------------|-------------|---------------|------------------|
| 1     | CONTROL    | 1.50              | 18          | 26          | 702           | 0.94             |
| 2     | T1R1       | 1.16              | 18          | 26          | 543           | 0.724            |
| 3     | T1R2       | 1.39              | 18          | 26          | 650           | 0.867            |
| 4     | T1R3       | 1.56              | 18          | 26          | 730           | 0.973            |
Fig. 4.21 Benefit cost ratio for different treatments

Highest benefit cost ratio was found in T3R3.

4.5 WATER USE EFFICIENCY

Water use efficiency was calculated for each treatment. It is the ratio of yield of crop in kg/ha and total water applied in mm.

\[ \text{WUE} = \frac{Y}{W} \]

Where,
WUE=Water use efficiency (kg/ha mm) of water used.
Y= Yield of the crops (kg ha\(^{-1}\))
W.A = Total water applied (mm)

Table 4.11 Irrigation and water use efficiency

| Treatment combinations | Yield (g/plant) | Gross depth of irrigation water applied in mm | WUE (kg/ha mm) |
|------------------------|-----------------|---------------------------------------------|----------------|
| T₁R₁                   | 502             | 166.86                                      | 89.5           |
| T₁R₂                   | 512             | 166.86                                      | 91.3           |
| T₁R₃                   | 523             | 166.86                                      | 93.3           |
| T₂R₁                   | 510             | 222.48                                      | 68             |
| T₂R₂                   | 518             | 222.48                                      | 69.3           |
| T₂R₃                   | 516             | 222.48                                      | 69.05          |
| T₃R₁                   | 524             | 278.1                                       | 56.1           |
| T₃R₂                   | 558             | 278.1                                       | 52.1           |
| T₃R₃                   | 587             | 278.1                                       | 58.1           |

Irrigation water use efficiency was found higher for the treatment T₃R₃.

The treatment T₃R₃ (Irrigation 100% of ETc and Fertigation 150% of RDF) showed comparatively better performance in yield as compared to the other treatments. T₁R₁ (60% irrigation and 100% fertigation) resulted in significantly lowest yield among other treatments.

T₃R₃ resulted in higher yield in all levels of treatments. The highest plant height (41.3 cm), highest number of leaves (38 nos), highest stem girth (5.7) was noticed in the irrigation 100% of irrigation and 150% dose of nutrients in the form of water soluble fertilizers led to higher yield. The 150% dose of nutrients and 100% of irrigation has resulted in higher yield per plant (0.176 kg). 100% of irrigation and 150% dose of nutrients might have served as optimum doses among these treatments.
The results obtained could be attributed better growth and yield associated with optimum treatment. Hence drip fertigation with 100% of ETc and Fertigation of 150% of RDF has been standardized for cultivation of amaranth under polyhouse of PFDC, KCAET, Tavanur, Kerala. Study on lettuce by Santhosh et al., (2017) reported that biometric and yield parameters are significantly superior in the treatment T₂ (100% crop water requirement through drip irrigation in poly house).
CHAPTER-V

SUMMARY AND CONCLUSION

Growth and yield parameters of Amaranth with different irrigation and fertigation schedules were studied. The experiment was conducted inside the saw tooth type polyhouse in the research plot of precision farming center situated near the farm, Tavanur. The area lies at the intersection of 10.85°N latitude and 75.98° longitude. During 2020 (November 15th) – 2021 (February 13th) and the crop duration was 3 months (90 days). The polyhouse was oriented east–west with an area of 292 m² (36.5 m length and 8 m width). In present study, data on climate, plant growth yield, parameters were recorded. The summary of results obtained from the experiments and the conclusions drawn out of the field experimentation are presented in this chapter.

Amaranth variety CO-1 was chosen for cultivation. Seeds were sown in a nursery bed of dimensions 3.5 m length and 0.7 m width and ten days old seedlings were transplanted to the main field. There were 17 plants in each bed with a plant spacing of 40 cm. The total plant population was 170 numbers. Row to row distance is 60 cm.

The experiment was designed under Factorial completely randomized block design. Two factors was considered.

- **R – Fertigation**: R₁- 100% fertigation, R₂- 125% fertigation, R₃- 150% fertigation.
- **T - Irrigation schedules**: T₁- 60% irrigation, T₂- 80% irrigation, T₃- 100% irrigation.
- **No of treatment combinations are 9**: T₁R₁, T₁R₂, T₁R₃, T₂R₁, T₂R₂, T₂R₃, T₃R₁, T₃R₂, T₃R₃.

CONTROL.

The experiment revealed that the irrigation and fertilizer management is an important factor in crop production. Higher water application and inefficient fertilizer application is the current farming scenario. Water use efficiency of the crops has to be increased in order to reduce the water loss from the field. Drip irrigation system is considered as the most effective micro irrigation method, as water is applied directly to the crop root zone. Hence it can be concluded that drip fertigation with 100% of ETc and Fertigation of 150% of RDF is best suited for cultivation of Amaranth under polyhouse. The total yield obtained from all beds under study was 11.4 tonnes/ha.
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ABSTRACT

The study entitled “Standardization of irrigation and fertigation requirement for Amaranth under polyhouse” was taken up to compute the crop water requirement, irrigation schedule and fertigation schedule of amaranth (*Amaranthus retroflexus*) crop and to find out the best treatment which gives maximum yield under polyhouse conditions in Tavanur region. The CROPWAT 8.0 model studied in previous year Precision Farming Development Center project. The required soil, crop and climate data inputs were given to the model and the crop water demand and irrigation schedule for amaranth was obtained. Average ET₀ was found to be 3.62 mm/day. Water requirement for amaranth was found as 194.2 mm and the gross irrigation requirement as 276.4 mm at a 100% irrigation efficiency.

Field experiment was conducted inside the naturally ventilated polyhouse in the research plot of Precision Farming Development Centre situated at KCAET, Tavanur, during the period November 2020 to February 2021. In the present study, 60%, 80% and 100% of ETc were selected as irrigation treatments and 100%, 125% and 150% of RDF were selected as fertigation treatment.

The plot was divided into 10 beds having 9 treatments with three replications. Fertigation include both macro and micro nutrients applied as water soluble fertilizers through fertigation system with venturimeter. Analysing the effect of different treatments, it was found that in amaranth crop, better performance was found in the treatment T₃R₃ (irrigation 100% of ETc and fertigation 150% of RDF). The highest plant height (41.3 cm), number of leaves (38 nos), stem girth (5.7 cm) and yield from plant (0.176 kg) was noticed in T₃R₃. The lowest yield was for T₁R₁ (irrigation 60% of ETc and fertigation 100% of RDF). The highest IWUE (Irrigation water use efficiency) was for T₁R₃ (93.3 kg/ha.mm) and lowest was for T₃R₂ (52.1 kg/ha.m). On economic analysis, Benefit Cost Ratio was found to be 1.15

Hence drip fertigation with 100% of ETc and fertigation of 150% of RDF has been standardized for cultivation of amaranth under poly house of PFDC, KCAET, Tavanur, Kerala. The results of the study can be used as a guide for the farmers to plan their irrigation and cropping pattern. Also the results can be extrapolated to the future to analyse the trends in future crop water demands.