

A SMART FARMING TECHNIQUE IN MODERN AGRICULTURE AND AN ANALYSIS OF INVITRO MICROPROPAGATION OF THE PLANT SPECIES

Submitted in partial fulfilment of the requirements for the award of
Bachelor of Engineering degree in Mechatronics Engineering

By

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**DEPARTMENT OF MECHATRONICS ENGINEERING
SCHOOL OF MECHANICAL ENGINEERING**

SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with Grade “A” by NAAC

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of Dhanaprasath G (38090005), Mani C (38090021) who carried out the project entitled "A Smart farming in modern agriculture and an analysis of invitro micropropagation of the plant species" under my supervision from 01.11.2021 to 10.05.2022.

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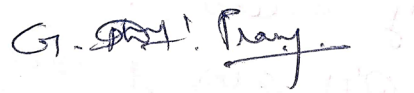
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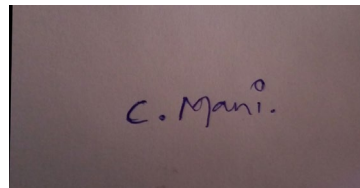
DECLARATION

I **Dhanaprasath G (38090021)** and **Mani C (38090015)** hereby declare that the Project Report entitled "A Smart farming in modern agriculture and an analysis of invitro micropropagation of the plant species." done by us under the guidance of Mr. **V. Jayaprakash, M.Tech., MIE., (Ph.D.)**, is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Mechatronics Engineering.

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ABSTRACT

The most basic essentials for human life are food, housing, and clothes, all of which are dependent on agriculture for their production. In day-by-day agriculture, farmers are facing more challenges such as lack of fertilizers, lack of irrigation, lack of mechanization, soil erosion, and small and fragmented landholdings. Our project is aimed to give solutions for all of the above challenges and tested in the land of the seed *Coriandrum sativum* (dhaniya). The objective of the project is to design a Smart farming kit in Arduino microcontroller and used in detecting the live data such as (pH, soil condition, temperature, water sources). Our farming consists of two modes, namely testing mode and sampling mode. Testing mode involves testing the soil nutrient in the land, checking the optimum temperature in the land, and checking the water level in the field. Sampling mode involves providing automatic irrigation for the crop, to provide fertilizers to the soil. Our main idea is to provide irrigation techniques through two kinds of methods. Borewell (priority1) and water tank (priority 2) can be used. If water can be taken from any of the water sources to the land for our choice using water pump motor. Excess fertilizers may results in the soil erosion and also indirectly affects the crop nutrients. We aim to provide two fertilizers (Calcium and Potassium) for the accurate level of the crop with water pump control. *Coriandrum sativum* is an annual herb belongs to Apiaceae family. The seed of the crop showed good results compared with the cereal crop seeds. The crop is generally grown in 20-25 days and this farming technique gives 100% success with higher accuracy and may help in large-scale farming in the future

There are around 300 genera and 7500 species in the Euphorbiaceae family. In terms of distribution, it spans the globe, but is notably well-represented in Africa and South America. *Acalypha* has consists of approximately 450 species. *Acalypha indica* is a common annual herb 1-3 feet high. We are developing an Invitro culture of the *Acalypha indica* explants from leaf nodes on MS medium with different combinations and concentrations of growth regulators for indirect organogenesis. The nodal explants showed a 62.3% percentage of callus tissue induction on ½ strength of MS medium augmented with 1.5mg/ml NAA on the light yellowish and soft friable callus. The highest frequency 63.2% of shoot regeneration with maximum no. of shoots is

noticed on $\frac{1}{2}$ strength of MS medium supplemented with 1mg/ml BAP and 0.5 mg/ml KIN. 62% frequency of shoot proliferation is noticed on $\frac{1}{2}$ strength of MS medium supplemented with 1mg/ml BAP and 0.5mg/ml NAA. For the greatest amount of rooting, 68% frequency of root regeneration is observed on $\frac{1}{2}$ strength of MS medium augmented with 1.5mg/ml IAA. Light is essential for plant growth. For the Incubation period, the light 2000-4000 lux intensity is available for the plant growth and regeneration. LDR with photoresistor is used for detecting the room light intensity of photoperiod (lightness period and darkness period) for plant growth. C program code is used for the result of this micropropagation. The Finite Element Analysis Method gives an approximate solution for certain problems in engineering and science. Here, the culture vessel used for the micropropagation is an axisymmetric object. Using Finite Element Analysis (FEA), the culture vessel can be analyzed and modelled in the ANSYS software. Thus, regenerated plantlets were gradually acclimated and successfully transferred to the field conditions with a 100% survival rate within 5 weeks after rooting. *Acalypha indica* is the most significant medicinal plant and this micropropagation will help for medicinal purposes and may help in the vast-scale propagation of plant species.

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LIST OF MAIN ABBREVIATIONS AND SYMBOLS

pH	Power of Hydrogen
LED	Light Emitting Diode
LCD	Light Crystal Display
LDR	Light Dependent Resistor
PIR	Passive Infra-Red
NPN	Negative-Positive- Negative
BJT	Bipolar Junction Transistor
LM	Linear Monolithic
AC	Alternating current
DC	Direct Current
V, K	Volts, Kilo
I/O	Input/Output
IDE	Integrated Development Environment
ICBN	International Code of Botanical nomenclature
UV	Ultra-Violet
HEPA	High-Efficiency Particulate Air
MS	Murashige and Skoog
PGR	Plant growth regulators
IAA	Indole 3-Acetic Acid
BAP	6-Benzylaminopurine
NAA	Naphthalene Acetic Acid
KIN	Kinetin
g/l	gram/litre
mg/l	milligram/litre
ml	millilitre
mg/ml	milligram/millilitre
Conc	Concentration
T.S	Transverse Section
±SE	Mean values of 25 repetitions treatment on explant

Linn

Carl Linnaeus

FEA

Finite Element Analysis

MOLECULAR FORMULAS FOR CHEMICALS

NH ₄ NO ₃	Ammonium nitrate
KNO ₃	Potassium nitrate
CaCl ₂ .2H ₂ O	Calcium chloride
MgSO ₄ .7H ₂ O	Magnesium sulphate
KH ₂ PO ₄	Potassium Dihydrogen Phosphate
KI	Potassium iodide
H ₃ BO ₃	Boric Acid
ZnSO ₄	Zinc sulfate
MnSO ₄ . 4H ₂ O	Manganese sulphate
NaMoO ₄	Sodium molybdate
CuSO ₄ . 5H ₂ O	Copper sulfate
CoCl ₂ .6H ₂ O	Cobalt Chloride
Na EDTA	Sodium Ethylene diamine tetraacetic acid
FeSO ₄ .7H ₂ O	Ferrous sulfate
C ₁₂ H ₂₂ O ₁₁	Sucrose (IUPAC name : Beta-D- fructo furanosyl Alpha -D- glycopyranoside)
C ₆ H ₁₂ O ₆	Myo-Inositol
NaOH	Sodium Hydroxide
HCl	Hydrochloric Acid
H ₂ O	Water
CO ₂	Carbon-di-oxide
O ₂	Oxygen

CHAPTER 1

INTRODUCTION

1.1 FARMING

The process of working on the land, planting seeds, and growing and producing edible plants is referred to as farming. The phrase "farming" is a wonderful way to describe how persons who operate in the agriculture business live and work. Agriculture is the activity of cultivating certain plants and raising domesticated animals for the purpose of providing food, feed, fibre, and a range of other useful products (livestock). Agriculture is referred to as "farming," while scientists, inventors, and others who work to improve farming methods and implements are referred to as "agriculturalists."

1.2 SMART FARMING

Smart farming is a management concept that aims to lay the groundwork for the agricultural industry to employ modern technology to track, monitor, automate, and evaluate activities. Precision agriculture, often known as smart farming, is managed by software and monitored by sensors. As the world's population rises, so does the need for improved agricultural yields, the need to protect natural resources, the expanded use and complexity of information and communication technologies, and the expanding demand for agricultural products [12].

1.2.1 Technologies in Smart farming

Smart farming technology is a set of instruments used in agriculture to gather, store, analyze, and distribute electronic data and/or information. GPS, soil scanning, data management, and Internet of Things (IoT) technologies are all available to farmers to analyze the information [1]. By carefully measuring changes within a field and altering their strategy accordingly, farmers may significantly increase the efficiency of herbicides and fertilizers and apply them more selectively. Similarly, by utilizing smart

agricultural technology, farmers may better monitor the demands of individual animals and adjust their feed appropriately, minimizing disease and boosting herd health. New farming technologies need the development of a greater number of professional skills. Agriculture currently uses robots, temperature and moisture sensors, aerial pictures, and GPS technologies. Businesses may be more profitable, productive, safe, and environmentally friendly as a result of modern technology, precision agriculture, and robotic systems. Farmers no longer require the use of water, fertilizer, or pesticides, resulting in lower food costs, reduced environmental effect, and reduced chemical runoff into rivers and groundwater, as well as enhanced worker safety. Robotic technologies also allow for more exact monitoring and control of natural resources like air and water quality. It also gives farmers and ranchers better control over plant and animal production, processing, distribution, and storage, leading to increased efficiency and lower costs, as well as safer growing conditions, safer foods, and fewer environmental and ecological effects. Plant growth accuracy has higher of these technologies [31].

1.2.2 Why Smart farming?

Precision agriculture reduces total costs, improves the quality and quantity of products produced, and improves the user experience by making farming more connected and intelligent. Increased production control leads to improved cost management and waste reduction. Multiple processes can be enabled at the same time using smart devices, and automated services improve product quality and volume by better regulating manufacturing operations. Smart agricultural technologies also allow for meticulous demand forecasting and timely delivery of goods to market, reducing waste. Precision agriculture focuses on controlling land supply and focusing on the proper growing characteristics – such as moisture, fertilizer, or material content – to give output for the right crop that is in demand, based on its condition [22]. The types of precision farming systems that are deployed are determined by the software that is used to operate the business. Control systems control sensor input, as well as the automation of machines and equipment for responding to developing difficulties and production assistance, as well as supplying distant information for supply and decision support.

1.3 WHAT WE WILL DO?

Our farming consists of two types of mode namely testing mode and sampling mode. Testing mode involves testing the soil nutrient in the land, checking the optimum temperature in the land, and checking the water level in the field. Sampling mode involves providing automatic irrigation for the crop, to providing fertilizers to the soil. Our main idea is to provide irrigation techniques through two kinds of methods. Borewell (priority1) and water tank (priority 2) can be used. If water can be taken to the land for my choice using a water pump. Here, we used two types of fertilizers (Calcium and Potassium) and the fertilizers can be given by the water pump. Sensors can play a vital role in providing irrigation techniques and evaluating soil nutrients and some other purposes in agriculture.

1.3.1 Monitoring Soil nutrient

The loose surface layer that covers the majority of the ground is known as soil. There are both inorganic and organic particles in it. Soil offers structural support as well as a source of water and nutrients for agricultural plants. Soil has a wide range of chemical and physical properties. Leaching, weathering, and microbiological activity all combine to produce a wide range of soil types. The relative proportions of the individual sand, silt, and clay particles that make up the soil influence the texture. Plants get their nutrients from soils, which are mostly held in place by clay and organic matter particles (colloids). The nutrients may be adsorbed on the surfaces of clay minerals, bonded within clay minerals (absorbed), or bound within organic molecules as part of living organisms or dead soil organic matter. Plants take up nutrients, salts are leached, or acids or alkalis are given when soils get wetter or dryer, and these bound nutrients interact with soil water to buffer the soil solution composition. Soil pH, which is a measure of hydrogen ion activity in the soil solution, has an impact on plant nutrient availability [25]. Soil pH is influenced by a variety of causes, and it is generally lower (acid) in areas where weathering is more advanced. So, in our technique, we provide the soil with two types of fertilizers: calcium and potassium. Fertilizers can be controlled using relays. The pH sensor is used to detect and assess soil nutrient levels

in the land. When fertilizer levels are low, a pH sensor detects this and sends fertilizer to the soil field via a water pump. If the soil calcium level is low and the sodium level is medium, calcium fertilizer is applied straight to the soil to increase crop output.

1.3.2 Automatic Irrigation

Irrigation, often known as watering, is the agricultural practice of applying controlled amounts of water to land to aid in the development of crops, as well as to produce landscaping plants and lawns. Irrigation assists in the development of agricultural crops, the upkeep of landscapes, and the revegetation of damaged soils in desert areas and during seasons of below-average rainfall. In addition to frost protection, weed suppression in grain fields, and soil compaction prevention, irrigation has other uses in crop cultivation [17]. Animal cooling, dust control, sewage disposal, and mining all use irrigation systems. Drip irrigation, also known as trickle irrigation, is a method of localized irrigation in which water droplets are given at a very low flow rate straight to or near the roots of a plant [26]. It is an efficient irrigation method because it reduces evaporation and water runoff. It's also great for many kinds of topography and soils, and it's ideal for locations with limited water supplies or high water prices.

We used drip irrigation to avoid such distortion for the crop yield. A soil moisture sensor is a device that can be able to detect the humidity of soil content in the land. Whenever moisture content is low in the soil, irrigation takes place automatically. We used two sources (borewell) and (water tank) to obtain water for irrigation. The water level sensor is connected to the two water sources when the moisture content is low, water level sensor detects the water level in the source and provides automatic irrigation by using a water pump motor. Whenever the water level is low in one source (borewell), automatically motor off by using the controller option [18]. The water can be taken from another source (water tank). Another water level sensor is connected in the soil field to detect the water level for soil grown. Due to heavy rainfall, the crops are wasted in the field due to wetter. For this purpose, a water level sensor is used to detect the water level in the field, if more water levels in the field, the solenoid valve is connected at the end of the field, the valve gets open and the remaining water can flow out of the field to protect crops. Thus, Water level sensors can play an important role in automatic irrigation.

1.3.3 Other sources

High temperatures are particularly damaging to crops during the reproductive and grain-filling/fruit maturation stages. Plant reactions to temperature variations, on the other hand, are species-specific and are mediated by photosynthetic activity for biomass accumulation, which is responsible for plant growth, as well as phenological and morphological changes that occur during plant development. The duration of the crop and overall plant productivity are affected differently by each type of temperature stress. The impact will be determined by how sensitive each species is at the time of the temperature change in their development.. The following are some of the findings from the few long-term phenological investigations on annual crops. Plants typically consume more energy for respiration and less for growth as the average temperature rises during the growing season. Yields of important food and cash crop species can drop by 5 to 10% with a 1°C increase in average temperatures. Plants typically consume more energy for respiration and less for growth as the average temperature rises during the growing season [9]. Climate is a very important role in growing crop yield. Likewise rain, temperature also plays a role in agriculture. Crops can grow at the optimum temperature and has most sensitive to high temperatures. More temperature occurs any living part of the plant can be affected and finally the whole plant dies. For this purpose, a Temperature sensor is connected below the crop in the soil. It is used to monitor the temperature up to the harvesting period. Animals like a cow, elephants, and birds are the most culprits for crop damage in the field. For this, we add PIR sensor in the out of field (connected in the fence). PIR sensor detects the object in the fence and buzzer is used for giving some noisy sound to making dread for animals whenever they enter into field.

1.4 CROP MODEL

Coriandrum sativum (Dhaniya) is our crop model in our smart farming technique. It is an annual herb belongs to Apiaceae family. The botanical name of Coriander is Coriandrum Sativum and its trade name is dhaniya [6]. It is also known as Chinese parsley, dhanial, cilantro, and kothamalli. All parts of the plants are edible, but the fresh leaves and dried seeds are the parts in coriander most traditionally used in daily cooking [13]. The crop Coriandrum sativum shows good result compared to other cereal crops, it takes 20-25 days of the growing period from the seed of Coriandrum Sativum.

1.5 PLANT TISSUE

Plant anatomy (Ana – under, tamnein – to cut) is the dissection and microscopic inspection of a plant's internal structure and organization, particularly of its parts. The interior structure of plants exposes a diverse range of tissues. A tissue is made up of group of cells that are similar in origin, form, and function morphologically. A tissue is made up of different cells that all serve the same job, such as food conduction and water and mineral salts conduction. The cells combine to generate a variety of tissues. Tissue systems are made up of two or more types of tissues. Organs are made up of many tissue systems. Each tissue has a distinct purpose. Meristematic tissue and permanent tissue are the two types of tissues that can be found in the body.

1.5.1 Meristematic tissue

Meristematic tissue (meristos – divisible feature) is a group of the identical cells that divide continuously. Meristematic tissue produces certain cells that stop proliferating and undergo specific modifications to become permanent plant tissues, a process known as differentiation. The meristem's surviving cells maintain their meristematic cells and are self-perpetuating. Meristematic cells come in a variety of shapes, including round, oval, polygonal, and rectangular. They are packed together with no intercellular gaps between them. They contain a big nucleus and thick cytoplasm.

Small vacuoles are seen throughout the cytoplasm of these cells. Their cell walls are formed of cellulose and are thin and stretchy. Based on its position, the meristem is divided into three types namely apical meristem, intercalary meristem, and lateral meristem. Apical (at the tips), intercalary or basal (in the middle), and lateral meristematic tissues are the three types of meristematic tissues (at the sides). The core zone, a small collection of slowly dividing cells at the meristem summit, is frequently referred to as the meristem summit.

1.5.2 Permanent tissue

In simple terms, a plant's permanent tissues are those that contain nondividing cells. In plants, the cells are also changed to execute certain functions. Meristematic tissue produces the cells that make up permanent tissue that is fully differentiated. The cells are massive and distinct in size and shape. The presence of intercellular gaps between the cells can be seen. Inside these cells, there are also large vacuoles. The metabolism of permanent tissue cells moves at a significantly slower pace. Permanent tissue is used by plants for a multitude of purposes, including support, protection, photosynthesis, and the movement of water, minerals, and nutrients. The cells that make up permanent tissue might be alive or dead. Permanent tissues are divided into two categories: simple permanent tissues and complex permanent tissues. All of the tissue's cells are comparable and have the same structure, as well as the same kind of parts. Simple permanent tissues are divided into three categories once more. Parenchyma, collenchyma, and sclerenchyma are the three types.

- Parenchyma – This tissue's cells are alive and have thin cell walls. Cells of parenchyma tissue are oval or round in shape. They feature a thick cytoplasm and a big central vacuole. Parenchyma tissue is found in the soft parts of the plant, such as the cortex and pith. Its main purpose is to serve as a packing tissue and to offer mechanical support. It also helps with food preservation. Parenchyma is divided into two categories depending on its functions: aerenchyma and chlorenchyma.
- Collenchyma – These cells have an elongated shape and are living cells. The cell wall's corners have thickened and has only a small amount of intercellular

spaces. The collenchyma tissue can be found in leaf stalks, beneath the epidermis, and in other places. Its primary function is to provide flexibility and mechanical support to the plants.

- Sclerenchyma – The sclerenchyma tissue's cells have died. Due to lignin deposition, the cell wall is extremely thick. The cells of this tissue come in a range of shapes and sizes. They're located in the veins of leaves, the hard coverings of seeds, and the vascular bundle. The sclerenchyma tissue's primary role is to provide rigidity and mechanical support to the plant body. They also stiffen and harden the plant.

Several kinds of the cells make up the complex permanent tissues. They work together in the plant body to conduct the same specific duties. They are divided into two categories: Xylem and Phloem.

- Xylem– The xylem tissue is a complex tissue that is mainly responsible for the conduction of water and mineral salts from roots to the leaves and stem. It also provides support to the plants. Xylem is classified into four kinds of cells. They are tracheids, vessels, xylem parenchyma, and xylem fibres. Xylem fibre is dead tissue.
- Phloem – Phloem tissue is also a complex tissue that conducts food materials to the main parts of the plant. Phloem is composed of four kinds of cells. They are Sieve elements, companion cells, phloem parenchyma, and phloem fibres. Except phloem fibres, all phloem elements are the living tissue.

1.6 PLANT TISSUE SYSTEM

Plant cells, like those of other organisms, are organized into tissues. These tissues might be simple (containing only one cell type) or complex (containing multiple cell types). Plants have a higher level of organization termed plant tissue systems that exists above and beyond tissues. Plant tissue systems are divided into three categories: cutaneous tissue, vascular tissue, and ground tissue. Plant tissue systems and plant cells support and protect a plant. Epidermal, vascular, and ground tissue systems are the three types of tissue systems. The epidermis and periderm make up the epidermal tissue system. The epidermis is a thin cell layer that protects and covers

the cells beneath it. A thick layer of nonliving cork cells makes up the exterior periderm or bark. Xylem and phloem make up the vascular tissue system. Water and nutrients are transported throughout the plant by these tube-like structures. Plant nutrients are generated and stored via the ground tissue system. This tissue is primarily made up of parenchyma cells, with some collenchyma and sclerenchyma cells thrown in for good measure. Meristems are the places where plants grow. Apical meristems are the sites of primary growth.

1.7 INVITRO CULTURE

In-vitro culture or plant tissue culture is the process of growing plant cells, tissues, and organs in a controlled environment on an artificial, synthetic media. Invitro means artificial. Thus, artificial plants can be grown by this technique. It is used in a procedure known as micropropagation to make clones of a plant [23]. Different techniques in plant tissue culture may have advantages over traditional methods of propagation, such as the ability to quickly produce mature plants from exact copies of plants that produce particularly good flowers, fruits, or have other desirable traits, the ability to produce multiples of plants in the absence of seeds or necessary pollinators to produce seeds, the regeneration of whole plants from genetically modified plant cells, and the regeneration of whole plants from plant cells that have been genetically modified. Plant tissue culture relies on the ability of multiple plant cells to regenerate an entire plant (Cellular totipotency). When given the necessary nutrients and plant hormones, single cells, plant cells without cell walls (protoplasts), fragments of leaves, stems, or roots can often be utilized to grow a new plant on culture media.

1.7.1 Origin and development of technique

Plant tissue culture got its start in 1898, when G. Haberlandt, a German scientist, successfully cultivated individual plants derived from various tissues. But it was only between 1934 and 1939 that three scientists (Gauthret, White, and Nobecourt) set the groundwork for the invitro culture technique, thanks to the discoveries of plant growth regulators like auxin and vitamins [19]. Various growth regulators, such as cytokinin, were discovered for their influence on cell division, growth, and differentiation

throughout the following twenty years (1940–60). Plant cells, tissues, and organs were relatively successfully grown in vitro after 1960. Prof. P. Maheshwari and Prof. S. Narayanaswamy of the University of Delhi's Department of Botany began research in this field in the early 1960s. As a result, media and culture techniques for a range of plant materials were known, and they are currently widely used in plant development initiatives across the board.

1.7.2 Status of the techniques in India

According to reports, India has one of the world's largest groups of tissue culture scientists. The majority of the study is focused on employing tissue culture technologies to generate enhanced plants for agriculture, horticulture, and forestry. The Government of India's Department of Biotechnology (DBT) in New Delhi is actively pushing research in the field of plant tissue culture. Several laboratories are receiving financial assistance for the development of tissue culture technologies for crop plant enhancement. The main Biotechnological centers are

- i) Indian Agricultural Research Institute (IARI), New Delhi.
- ii) Bhaba Atomic Research Centre (BARC), Mumbai.
- iii) Central Institute of Medicinal and Aromatic Plants (CIMAP), Lucknow.
- iv) Dr.M.S Swaminathan Research Institute (MSSRI), Chennai.

1.7.3 Technologies in invitro culture method

Plant tissue for tissue culture is prepared in an aseptic setting using HEPA-filtered air given by a laminar flow cabinet. The tissue is then grown in sterile containers such as Petri plates or flasks in a temperature and light-controlled environment. Because live plant materials from the environment are naturally contaminated with bacteria on their surfaces (and occasionally interiors), acceptable samples (known as explants) must be sterilized in chemical solutions (typically alcohol and sodium or calcium hypochlorite) [8]. The sterile explants are generally put on the surface of a sterile solid culture media when cell suspension cultures are required, but they can also be

placed directly into a sterile liquid medium. The majority of solid and liquid media are made up of inorganic salts, coupled with a few organic minerals, vitamins, and plant hormones. Solid media are created by mixing liquid media with a gelling agent, such as pure agar. The plant hormones and nitrogen supply (nitrate vs ammonium salts or amino acids) in the media have a significant impact on the shape of the tissues that grow from the original explant [29]. A surplus of auxin, for example, will frequently result in the multiplication of roots, whereas a surplus of cytokinin may result in the production of shoots. A balance of auxin and cytokinin will frequently result in an unstructured proliferation of cells or callus, however the form of the outgrowth will vary depending on the plant species and medium composition. To allow for development or to change the morphology of the culture, parts are routinely sliced off and subcultured into fresh medium as the culture grows.

1.7.4 Basic Concepts

The in-vitro culture technique's fundamental ideas are totipotency, differentiation, dedifferentiation, and redifferentiation.

- i) Totipotency – Any living plant cell has the ability to evolve into a whole organism. The plant cells will be the only ones who have this.
- ii) Differentiation – The process by which cells become specialized in shape and function through biochemical and structural changes. The meristematic tissue is further differentiated into permanent tissue (simple tissue or complex tissue).
- iii) Dedifferentiation – Reversion of mature cells into meristematic tissue that leads to the formation of callus is called dedifferentiation
- iv) Redifferentiation – The further differentiation of an already differentiated cell into another type of cell. Callus develops into shoot or root or embryoid from the explant.

1.7.5 Applications of the technique

Micropropagation for various foliages is currently frequently used in some commercial organizations [10]. Ornamental plants are generated in vast numbers utilizing

invitro culture process, which uses bud proliferation and multiple shoot creation. The apical meristem produces virus-free germplasm. Banana, for example. The apical meristem is found at the root, stem, and branch tips. Somatic embryogenesis is used to create artificial synthetic seeds. For the generation of secondary metabolites, plant tissue culture is an essential approach. Tissue culture aids in the generation of haploidy in another culture, which is beneficial for mutant breeding, as well as triploidy (by endosperm culture) for producing parthenocarpic fruits and polyploidy (for increased biomass or yield). Numerical chromosomal aberration refers to changes in the number of chromosomes in the diploid set. Ploidy is another name for it. Mutation, also known as gene mutation, is a sudden change in an organism's genetic setup. The embryo culture technique is used to overcome embryo abortion, seed dormancy, and self-sterility in seeds. Plant tissue culture techniques have been utilised in recent years to introduce a foreign gene into plant cells using DNA coated microparticles and a gene gun to transport the particles into the host cell. Protoplasmic fusion allows incompatible crops' genomes to fuse, resulting in somatic hybrids. Protoplasts are cells without a cell wall but with a plasma membrane that connects them. Plant tissue culture is used in plant physiological and biochemical research to study the cell cycle, cell metabolism, nutrition, morphogenetics, and development. Plant tissue culture protocols were used to bring a potato and tomato plant cell together through protoplasmic fusion, and the hybrid cell was made to grow into a pomato plant. The tubers are stored in the stem of the pomato, while the branches produce tomatoes.

1.8 CULTURE MEDIUM

Murashige and Skoog medium (MS medium), Gamborg medium (B5 medium), White medium (W medium), and Nitsch medium are all significant media for all-purpose experiments. Seed, meristem, callus, and bud culture are examples of plant tissue that can be grown in the lab and require specialist plant culture media. Murashige and Skoog (also known as MS media, MSO, or MS0) and Gamborg's B5 medium are two of the most common plant-culturing media compositions. These media contain all of the micro-and macronutrients, vitamins, organic supplements, and plant growth regulators required for plant cell, tissue, and organ growth and multiplication in vitro [14]. The B5 medium from Gamborg is a specially designed culture media for in vitro

plant cell, tissue, and organ culture. It's made up of a combination of inorganic salts, vitamins, and carbs. Murashige and Skoog's media described more than 50 years ago are still used in many plant tissue cultures for research and biotechnology. Murashige and Skoog media, or MS media, is the most extensively used plant culture medium, and it comes in both basic salt combinations and organic media. MS media contains micronutrients and macronutrients, as well as sugar, vitamins, and growth regulators, regardless of format. Different MS media components can be mixed and matched to create the ideal media composition for any type of plant cell or tissue. There are two mediums in this technique namely liquid medium and solid medium or semi-solid medium. The liquid medium consists of micronutrients, macronutrients, vitamins, and growth regulators without agar. But the solid medium is prepared consisting all of the liquid medium components but with agar [4].

1.9 PLANT GROWTH HORMONES OR GROWTH REGULATORS

Plant growth regulators are applied to plants by humans, whereas hormones are produced naturally by plants. Plant hormones and growth regulators are compounds that control flowering, ageing, root growth, organ distortion and death, stem elongation prevention or promotion, fruit colour enhancement, leafing, leaf fall prevention or both, and a variety of other situations. Plant growth regulators (PGRs) are substances that are used to regulate plant growth in ways like boosting branching, limiting shoot growth, increasing return bloom, eliminating surplus fruit, and changing fruit maturity. The amount of chemical absorbed by the plant, tree vigour and age, dose, timing, cultivar, and weather conditions before, during, and after application are all factors that influence PGR efficacy. Plant growth regulators can be grouped into five classes are auxin, cytokinin, gibberellin, ethylene, and abscisic acid.

i) Auxin – Auxin is a group of plant hormones (or plant growth regulators) that resembles morphogens. Auxins are necessary for plant body development and play a key role in the coordination of various growth and behavioral processes in plant life cycles. Auxins and their role in plant growth were initially described in the 1920s by Dutch biologist Frits Warmolt Went. The discovery of auxins was the first of the primary plant hormones. As a result, auxin produces "patterns" of auxin concentration maxima and minima in the plant body, which regulate the development of individual cells and,

eventually, the entire plant. The (dynamic and environment responsive) pattern of auxin distribution inside the plant is a critical component in plant growth, environmental response, and, specifically, plant organ development (such as leaves or flowers). The ratio of auxin to cytokinin in some plant tissues, for example, controls whether root or shoot buds form [20].

The most important auxin is indole-3-acetic acid (IAA), which is the most potent native auxin and generates the majority of auxin actions in intact plants. And, as a native auxin, its equilibrium is regulated in plants in a variety of ways, ranging from synthesis to potential conjugation to molecular destruction, all depending on the environment.

- Indole-3-acetic acid, 4-chloroindole-3-acetic acid, phenylacetic acid, indole-3-butyric acid, and indole-3-propionic acid are five naturally occurring (endogenous) auxins in plants. However, most of what has been learned about auxin biology thus far, as well as what will be learned in the sections to follow, applies mostly to IAA; the other three endogenous auxins appear to be of minor consequence for intact plants in natural situations.
- Synthetic auxin include 1-naphthaleneacetic acid, 2,4-dichlorophenoxyacetic acid (2,4-D), and many others are used in plant development [28].

Herbicides containing synthetic auxins like 2,4-D and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) are available. Auxins are significantly more vulnerable to broad-leaf plants (dicots), such as dandelions than narrow-leaf plants (monocots), such as grasses and cereal crops, making these synthetic auxins useful as herbicides.

ii) Gibberlins - Gibberellins are plant hormones that control stem elongation, germination, dormancy, flowering, flower development, and leaf and fruit senescence, among other things. Gibberlins are one of the most well-known plant hormone classes. Gibberellins have a role in breaking dormancy and other elements of germination in the natural world. The stored energy reserves of starch sustain the seedling until the photosynthetic machinery develops adequately in the early stages of germination. The degradation of starch to glucose in the endosperm usually occurs immediately after the seed is exposed to water during germination. Cell elongation, breaking and blossoming, seedless fruits, and seed germination are all stimulated by them.

Gibberellins act as a chemical messenger, prompting seeds to germinate by breaking their dormancy.

iii) Cytokinin - Cytokinins are type of plant hormone that promotes cytokinesis (cell division) in plant roots and shoots. They play a role in cell proliferation and differentiation, as well as apical dominance, axillary bud development, and leaf senescence. Cytokinins regulate a variety of plant activities, including cell division and shoot and root growth [30]. They are known to control axillary bud formation and apical dominance. These effects, according to the "direct inhibition hypothesis," are caused by the cytokinin-to-auxin ratio. According to this notion, auxin from apical buds travels down shoots and inhibits the formation of axillary buds. This encourages shoot growth while limiting lateral branching. Cytokinin travels from the roots to the shoots, prompting the emergence of lateral buds [21]. This theory is supported by simple experiments. The axillary buds are uncontrolled when the apical bud is removed, resulting in more lateral growth and bushier plants. When auxin is applied to the cut stem again, lateral dominance is inhibited. Furthermore, it has been demonstrated that cytokinin has no effect on parenchyma cells on its own. They grow huge but do not divide when cultivated with auxin but not cytokinin. The cells grow and differentiate when cytokinin and auxin are combined. The parenchyma cells create an undifferentiated callus when cytokinin and auxin levels are equal. A higher cytokinin-to-auxin ratio promotes the growth of shoot buds, while a higher auxin-to-cytokinin ratio promotes root formation.

iv) Ethylene and Absciscic acid – Ethylene is a simple gaseous hormone. It is usually present in a minute quantity. It is synthesized in large amounts by tissues undergoing ageing and acts as a natural plant hormone. The importance of absciscic acid (ABA) in controlling abscission and bud dormancy was first recognised. It has numerous roles in plant development, similar to other plant hormones. Cytokinin hormones like BAP(6-Benzylaminopurine) and KIN(Kinetin) are used for this medium for shoot initiation and elongation. Auxin hormones like NAA(Naphthalene Acetic Acid) and IAA(Indole 3-Acetic acid) are used for callus initiation and maximum no. of roots in the medium.

1.10 CALLUS

In botany, callus is a soft tissue that grows over an injured or cut plant surface and promotes healing. A callus develops from cambium cells. Some of the cells in a callus may organize into growth points, some of which develop roots, while others produce stems and leaves. As a result, a callus might be able to regenerate a complete plant. A plant callus is a developing mass of unstructured plant parenchyma cells (plural calluses or calli) [5]. In live plants, callus cells are the cells that cover a wound. Callus formation is formed from plant tissue samples (explants) after surface sterilization planting into tissue culture media in vitro (in a closed culture vessel such as a Petri dish). To induce callus formation or somatic embryogenesis, the culture medium is supplied with plant growth regulators such as auxin, cytokinin, and gibberellin. For all main groups of terrestrial plants, callus initiation has been described. Auxin to cytokinin ratios in plant tissue culture medium cause callus cells to proliferate and divide in an unstructured manner. Callus cultures are frequently divided into two categories: compact and friable. Friable calluses are white to creamy yellow in colour, fall apart easily, and can be used to generate cell suspension cultures and somatic embryos. Compact calluses are typically green and sturdy, whereas friable calluses are white to creamy yellow in colour, fall apart easily, and can be used to generate cell suspension cultures and somatic embryos [11]. These two callus kinds in maize are referred to as type I (compact) and type II (large friable). Callus can go through direct organogenesis and/or embryogenesis, in which the cells form a completely new plant. Callus culture is the term for this procedure.

1.11 HOW TO CHOOSE AN EXPLANT?

An explant is a piece of tissue taken from a plant that will be cultured. Explants can be taken from a variety of plant parts, including shoots, leaves, stems, flowers, roots, single undifferentiated cells, and many different types of mature cells, as long as they still have living cytoplasm and nuclei and can de-differentiate and resume cell division. The concept of totipotency of plant cells was born as a result of this. This, however, is not true for all cells or plants. Explants of diverse organs vary in their rates of development and regeneration in several animals, with others not growing at all. The type of explant material used also impacts whether the tissue culture plantlets are

haploid or diploid. Inappropriate explants further raise the risk of microbiological infection. When compared to the other two methods, the first method involving meristems and multiple shoot induction is the preferred method for the micropropagation industry because the risks of somaclonal variation (genetic variation induced in tissue culture) are minimal. Somatic embryogenesis is a procedure that has the ability to increase multiplication rates by many times and can be handled in liquid culture systems such as bioreactors [21]. Tissue cultured plants are actually cloned plants.

1.11.1 Explant model

Acalypha indica belongs to the family Euphorbiaceae. The traditional name of Acalypha indica in tamil is kuppaimeni, poonamayakki and its trade name is Indian Acalypha. It is a common herb with oval leaves that grows up to 75cm tall [7]. Catkin inflorescence produces green, unisexual flowers [3]. This plant's leaves are ground into a paste that is used to cure burns. The juice obtained from the leaves is combined with lime and applied in the skin to treat ringworm disorders. Rheumatoid arthritis and scabies are treated with fresh leaf juice combined with oil and salt. This plant's powdered leaves are used to treat bedsores [9]. It is mainly attractive to the domestic cats and used for various medicinal purposes [16]. It grows in a variety of locations, including wastelands, roadside ditches, and wall fissures. It may also be found on rocky outcroppings, woodland margins, and riverbanks. It enjoys damp, shady environments. It grows from sea level to a height of 1350 metres.

1.12 IS ANY SENSOR USED FOR THIS TECHNIQUE?

Yes, for this biological process light incubation is the main process for plant growing. Naturally, Light is essential for plant growth. With the help of sunlight, plants can able to take photosynthesis. Mechanism of photosynthesis involves plants can able to take carbon dioxide with water and reacts with light energy in presence of chlorophyll to acquire food materials naturally [2].



In this technique, artificial light can be given at 16 hours and darkness can be given at 8 hours of the photoperiod. The light intensity is incubated at 2000-4000 lux intensity for plant growth [24]. An LDR sensor is a type of resistor which responds to the amount of light falling on it and changes its resistance according to it. When lightness period, light falling on LDR, the intensity gets increased with decreasing resistance in K ohms. When darkness period, resistance increases in Mega ohms, and light intensity gets decreased.

1.13 PLANT TAXONOMY

The word "taxonomy" comes from two Greek words: "taxis," which means "arrangement," and "nomos," which means "laws." Plant taxonomy is a method for the arrangement and classification of the plant species according to the certain rules. Plant taxonomy is a discipline of botany concerned with characterizing, identifying, classifying, and nomenclating plants based on their similarities and differences.

The following are the objectives of plant taxonomy:

- a) Identification - To determine the unknown species' traits and compare them to those recognized species.
- b) Characterization - It is the process of describing all of the features of a newly discovered species.
- c) Classification - It is the process of grouping and organizing known species into various groups or taxa based on their similarities and differences.
- d) Nomenclature - It is the process of assigning a scientific name based on a set of rules.

Plant organisms are organized into the different taxonomic classifications based on their similarities and different features. Systematic classifications are mainly classified as Kingdom, Class, Sub-Class, Series, Order, Family, Genus, and Species. Based on this classification, gives a clear idea about the morphological and anatomical structures of a plant species and helps to identify the unknown plant species compared with known species and this classification is mainly used in medicine, forestry, and agricultural studies.

1.14 INTERNATIONAL CODE OF BOTANICAL NOMENCLATURE

Botanical nomenclature is the practice of giving botanical name for the plants based on worldwide norms provided by botanists to create a stable and universal system. It is a necessary step in overcoming the challenges associated with popular names. The botanists came to an agreement on a set of norms and criteria. The major recommendation was that the language should be in Latin because it is neither a national language nor a living language. Many past works were written in Latin. The ICBN is a global agreement among botanists to use the Binomial method of nomenclature.

Basic principles of the International Code of Botanical nomenclature (ICBN) are

- a) Botanical nomenclature is distinct from that of zoological nomenclature.
- b) All names of taxonomic groupings that are recognized as plants are subject to the botanical nomenclature code.
- c) Nomenclatural types define the names of taxonomic groupings.
- d) When describing a new species, the author must specify the type specimen on which the new species is based.
- e) The priority of publication is used to determine the nomenclature of taxonomic groups.
- f) Except, in rare circumstances, any taxonomic group with a given circumscription, place, and route can only have one right name that follows the requirements.
- g) Regardless of their origin, scientific names are considered as Latin.
- h) Unless otherwise stated, nomenclature rules are retroactive.

1.14.1 Rules related to ICBN

The basic rules related to ICBN of the botanical name of the plant species has two names namely genus name and species name. Genus name is a first name and species name is a last name. Here, *Acalypha* is a genus name and *indica* is a species name. *Coriandrum* is a genus name and *sativum* is a species name. The first letter of

the genus name should be in capital letter and first letter of species name in small letter.

Acalypha indica – Coriandrum sativum

Botanical name only in the Latin language. A person who published the botanical name for a plant species, if the name is accepted, that person is considered as author of the plant. According to the rules of ICBN, author name should be abbreviated at the end of the botanical name of the plant species. Carl Linnaeus, also known as the father of modern taxonomy. He was a Swedish Botanist, zoologist, taxonomist and physician who formalized binomial nomenclature. He recognized the value of floral characteristics and categorized plants according to the number of stamens they contained. It's also known as the sexual categorization system. Linnaeus continued to add new works to his collection. He presented a brief account of all the species he knew in "Species Plantarum" (1753). It has roughly 7,300 plant species, according to him. According to ICBN, *Acalypha indica* and *Coriandrum sativum* name was published by him among 7300 species. So, the botanical name of *Acalypha indica* and *Coriandrum sativum* are *Acalypha indica* Linn, and *Coriandrum sativum* Linn.

1.15 OBJECTIVE

The objective of the project is to monitoring the soil nutrient and provide an automatic drip irrigation method whenever the soil moisture content is low and provide automatic fertilizers through the water pump. The result of this model will help farmers in crop production and their work time in the field is less span. In this project smart farming, we tested the seeds of *Coriandrum sativum*. The leaves and dry fruits of *Coriandrum sativum* is used in daily cooking. New prototype model for regenerating the plantlets in the in-vitro culture technique whereas the farmers were already harvesting the older crops. This in-vitro culture technique will help the farmers for planting new crops in the land and take a significant role in farming. In this project micropropagation, *Acalypha indica* is the most important medicinal plant and this micropropagation will help for medicinal purposes and may help in the large-scale propagation of plant species.

CHAPTER 2

LITERATURE SURVEY

2.1 INTRODUCTION

From our project, farming plays a important role with various types of sensors for detecting various sources in the land and make the farming process as an automated called as a smart farming. Plant growth is very important for every farmers. Only farming is not only a suitable way for this. Another technique in our project, a plant can grown in a suitable medium from the tissue or organ or cell of the plant called as invitro culture. We took a references as the below articles for how the farming done in the sensors, IoT system and Node MCU and some other microcontroller and devices and how the invitro culture technique done in the various growth regulators for callus growth and indirect organogenesis and also studied how the plantlets are economically important.

2.2 LITERATURE SURVEY

Adithya Vadapalli et al. (2020), 'Smart farming system using IoT technology – International Journal of Advance Research in Science and Engineering'. They discussed in this paper about the smart farming technology with an IoT system to provide and analyze the data such as forecast weather, soil conditions, fertilizers, and irrigation with the module Arduino UNO microcontroller. They also discussed about the artificial intelligence system for data optimization.

Ajay Kohli et al. (2020), 'Photosynthesis research: a model to bridge fundamental science, translational products, and socio-economic considerations in agriculture'. Upstream advances in photosynthesis science should be combined with a gap analysis for downstream translational applications that will affect farmers' and customers' lives and livelihoods. The goal of this review is to see how photosynthetic

demands in the lab, in the field, and in society might result in a transformational product.

Archan Bhattacharya et al. (2015), 'Allomorphic female flower in *Acalypha indica*: A case study of heterobathamy and neutral evolution. *Acalypha indica* develops a peculiar terminal monocarpellary flower at the tip of the inflorescence axis called allomorphic flower. Another female flower is called the tricarpellary female flower below the male flower. The case study in the flower for neutral evolution and description and a floral diagram for the flowers.

Asif Iqbal et al. (2019), 'The preparation of culture media and biochemical analysis'. The author described the preparation of culture media with different concentrations of chemical compounds. For the identification of bacteria essential to obtain a culture by growing the organisms on artificial media by using different chemical agars such as Mac CONKEY's agar, Muller Hinton Agar, Blood agar, and Luria agar.

Aysar M S Almemary et al. (2020), 'Callus induction and Differentiation (Review Article)'. They reviewed the callus initiation and growth of the plant through somatic embryogenesis. Callus tissue is a group of irregularly shaped parenchyma cells formed by the cutting or wound region of the plant. The measurement of the soft callus is a clear and the fast indicator for plant growth.

Azziah Abdul Hamid et al. (2012), ' Coriander (*Coriandrum sativum* L.): A potential source of High-value components for functional foods and Nutraceuticals – A Review'. Coriander (*Coriandrum sativum* L.), a herb from the Apiaceae family, is prized for its culinary and medicinal properties. In the folk medicine systems of several cultures, all portions of this herb are used as flavouring agents and/or traditional treatments for the treatment of various illnesses. The study investigated the medicinal uses, detailed phytochemistry on anatomical structure, and biological activities of *Coriandrum sativum*.

Brahma K., et al. (2015), 'Pharmacognostic studies of *Acalypha indica*, *Acalypha wikeisiana* milk white and *Acalypha wikeisiana* Tricolor: International Journal of Pharmaceutical, Chemical and Biological sciences'. They investigated the Pharmacognostic studies of *Acalypha indica*, *Acalypha wikeisiana* and *Acalypha wikeisiana* tricolor leaves are observed. The transverse section of these leaves are observed under a microscope and the structure is drawn.

Daud N. H., et al. (2012), 'An improved surface sterilization technique for introducing leaf, nodal and seed explants of *Aquilaria malaccensis* from field sources into tissue culture'. The study investigated different sterilization regimes for leaf and nodal explants from *Aquilaria malaccensis* grown in the shade house environment. Sterilize the explants by 0.1%HgCl₂ for 15-30 minutes.

Dinesh Kumar B., et al. (2010), 'Phyto pharmacology of *Acalypha indica*: A Review – International Journal of Biosciences, Alternative and Holistic Medicine'. *Acalypha indica* is an important Indian medicinal plant and widely used in Ayurveda and siddha for the management of various diseases. Different pharmacological experiments in both invitro and in vivo have been carried out and also identified the medicinally important phytoconstituents.

Emilio Magania et al. (2015), 'Crop Production and Temperature'. This study was investigated by NOVA University students and they provide information about yield limitations, and production for precision agriculture. They discussed totally about the temperature, cold climates, and rainfall factors are all how much providing and affecting the crop productivity.

Gaurav Kumar Sharma et al. (2015), 'General techniques of plant tissue culture and methods of micropropagation'. They discussed in this article how the techniques and methods are carried out in this micropropagation process. Plant biotechnology has an important role to play in solving problems related to the improvement of forest and fruit

trees. Invitro technique of micropropagation has the following distinct advantages over commercial methods of vegetative propagation, high multiplication rate, freedom from seasonal depending and freedom from microbes.

Ghouse Basha M(2014), 'Research article callus induction from a wild medicinal plant *Tephrosia hookeriana* wight and arn'. Their research was carried out in order to create a procedure for quick callus initiation. The leaf, node, and internode explants reacted to callus in 30 days. Calluses of various colors were developed including brown, green, greenish-white yellowish-green greenish-yellow, and brownish white.

Haritha Jeganathan et al. (2020), 'Water flow controller for precision agriculture'. They designed their system using the Arduino UNO microcontroller, LDR, moisture sensor, humidity sensor, and temperature sensors are used for monitoring the sunlight, humidity, and so on. Further, a Wifi module ESP8266 was connected such that the solenoid valve can be operated manually.

Ishan Ullah Khan et al. (2014), ' Taxonomical Aspect of Coriander (*Coriandrum sativum* L.)'. The paper reviewed the taxonomical classification of *Coriandrum sativum* and general description with the medicinal uses. Coriander is said to have originated in the Mediterranean region. Coriander (*Coriandrum sativum* L.) is an annual herb that may be grown as a summer or winter crop depending on the climate. The glabrous plant can reach heights of 0.20 to 1.40 m while blooming.

John E. Preece et al. (2010), 'Micropropagation in stationery liquid media for ornamental plants'. The author explained in the paper the importance of culture medium on liquid media. Successful micropropagation of many species is reduced as agar concentration in the medium increases. Eliminating agar or another gelling agent completely can improve micro shoot proliferation and growth.

Joseph J Kieber et al. (2014), ‘ Cytokinins – The Arabidopsis Book’. Cell division, shoot initiation and growth, leaf senescence, apical dominance, sink/source interactions, nutrient absorption, phyllotaxis, vascular, gametophyte, and embryonic development, as well as the response to biotic and abiotic influences, are all affected by cytokinins, N6 adenine substance. They fully reviewed the plant growth hormone cytokinin and its physiological effects.

Jothi Muneeswari S., et al. (2017), ‘Smart irrigation system using IoT’. They designed a system for making an automatic irrigation system for agriculture by using soil moisture sensors to monitor the soil humidity on Node MCU using IoT. They also described how to write the program for Node MCU in Arduino IDE software.

Juan F. Velasco Munoz et al. (2019), ‘ Sustainable irrigation in agriculture and an analysis of Global Research’. Issues addressed in the research were climate change, environmental impact, natural resources conservation, unconventional and water resources, irrigation technology, and water use efficiency. The study also reveals the existence of substantial differences related to sustainable irrigation in agriculture research undertaken by different countries.

Mala Gowda et al. (2019), ‘Smart farming floating:- The future is here’. They described the importance of smart floating farming. The development of urbanization is reducing the land region and has also become a major problem for farming. To implement smart floating farming by using the concept of hydroponics with the help of solar energy and IoT. The farming can be completely done on the ocean or aquatic surfaces in the absence of soil with increased yielding results.

Mousmi Gowda et al. (2013), ‘ Invitro propagation of *Acalypha indica* Linn: A medicinally important plant’. Rapid protocol micropropagation for direct and indirect shoot regeneration by the effect of cytokinin and root formation by the effect of auxin

provided in the MS culture medium from the nodal explants of *Acalypha indica* in solid medium (0.8% of agar). The growth index of the shoot and root can be estimated.

Munguatosha Samwel Ngomuo (2013), 'Effect of auxin and cytokinin on growth and development of *Musa* species variance "Yangambi" explants in tissue culture'. The author explained the effect of growth regulators in micropropagation of explants of *Musa*. When several living cells are isolated from a living plant and cultured in a medium containing both cytokinin and auxin, cell division proceeds, forming a mass of undifferentiated cells called callus. The callus is able to differentiate and produce both shoot and root and develop the entire root plant. Auxin favors root formation and cytokinin favors the growth of shoot.

Neiva Sanchez-Chiang et al. (2018), 'Explant type, Culture System, 6-Benzyladenine, Meta-Topolin and Encapsulation affect indirect somatic embryogenesis and regeneration in *Carica papaya* L.'. The study investigated that the propagation of *Carica papaya* from the explant through indirect somatic embryogenesis. Three explant types were assessed to induce embryogenic callus are hypocotyls, haf-cut seeds and isolated zygotic embryos.

Patil K. A., et al. (2016), 'A Model for Smart agriculture farming using IoT'. They developed a system in smart farming for real-time monitoring system for the soil properties like temperature, moisture, ph for soil nutrients in farming using IoT. A consolidated methodology with web and remote interexchanges, Remote Monitoring System was proposed. Temperature sensor, Humidity sensor, Soil moisture sensor, and Wifi modem are used for checking and monitoring the agricultural land.

Rosa Maria Perez – Clemente et al. (2011), 'In vitro tissue culture, a tool for the study and breeding of plants subjected to abiotic stress conditions. They designed a paper how the invitro culture plays a significant role in the plant species. The most successful applied tools have been the somaclonal variation and invitro selection of

plants tolerant to different abiotic stresses and the development of transgenic genotypes.

Roshan Zamir et al. (2014), 'Effect of exposure time and incubation period of various sterilizants and antioxidants on the in vitro morphogenesis of guava explants'. They investigated the standard protocol for effects of growth regulators on growth of *Psidium guajava* L. Light incubation is the main process for this protocol Lightness allowed for 16 hours and darkness for 8 hours in the photoperiod. When cultures were held in the dark for 24 hours, the maximum browning eradication of 55 percent was seen in shoot tip explants. Control treatments, on the other hand, produced the worst outcomes, with just 6.7 and 16.7% browning in tips and nodal explants being removed.

Sachin Kumar et al. (2015), 'Soil pH Sensing Techniques and Technologies – A review'. The study published the low-cost sensor for pH measurements. They use a conductimetric pH sensor for analyzing the soil pH data. Soil pH is the power of hydrogen of soil (H^+) ion concentration to be tested and decide how much fertilizers used for apply a field. Excessive amount of fertilizers affects plant growth and cause soil erosion. pH meter is a key device for analyzing the soil for crop productivity.

Sanjay Kumar Allahawadi et al. (2020), 'Response of Okra (*Abelmoschus esculentus* Linn) under Drip irrigation with different levels of saline water'. Drip irrigation could be adopted for groundwater quality is marginal to hazardous quality to get high crop production and water use efficiency. They evaluate the economic feasibility of drip irrigation in combination with different types of mulches for an okra crop. Due to the conditions, drip irrigation requires a 72% increase in crop yields.

Sudhakar Chekuri et al. (2017), 'Cytotoxic activity of *Acalypha indica* L. hexane extract on breast cancer cell lines – The Journal of Phytopharmacology'. Cancer starts from primary tumour and it affects body systems, such as circulation, lymphatic and immune systems and blood circulations. *Acalypha indica* is anti-fungal, anti-bacterial,

anti oxidant, anti inflammatory, anti helminthic, anti ulcer, anti venom, anti cancerous and neuro protective activity. The study investigated to evaluate the anti-cancer properties of the extracts and also to isolate and characterize the active principles of *Acalypha indica*.

Sweety Majumder et al. (2016), 'Development of a successful protocol for Invitro callus induction and indirect plant regeneration of *Acalypha indica* L. – American International Journal of Research in Formal, Applied and Journal Sciences.' Their Investigation was aimed to standardize a protocol for rapid callus induction and indirect plantlets regeneration from leaf segments and nodal explants of *Acalypha indica* with a maximum percentage of light green compact callus induction was obtained from BAP and 2,4-D in culture medium.

Tang Chi Wai et al. (2016), 'A simple and easy method for solid and liquid media for plant culture'. The author prescribed the importance of culture medium preparation. Media preparation is one of the primary and most essential steps in tissue culture. Media is prepared on the type of tissue being cultured. Most media differentiate from each other based on the requirements of the growth of specimen it supports.

Zhuang Jiayu et al. (2015), 'Application of Intelligence Information fusion technology in agriculture monitoring and early warning research'. Their research was to develop a simulation system used to simulate and forecast the growth of crops. The system Agriculture monitoring and early-warning research (AMERS), research for the predicting the model crop's growth and yields more crop accurately. A growth index of crops was calculated by the monitoring data used to measure the crop growth.

CHAPTER 3

AIM AND SCOPE OF THE PROJECT

3.1 AIM OF THE PROJECT

The aim of this project is to provide an smart farming for analyzing and determining the real time monitoring data such as soil pH, moisture, temperature, water sources for providing an automatic irrigation and providing automatic fertilizers by using a water pump motors. This system provides a farming method with various types of sensors on the Arduino microcontroller connected with the various relay circuit.

Another aim of the project is to develop a successive culture medium for the plant grown from the nodal explants for indirect organogenesis. Various types of growth regulators are used in the callus initiation, shoot and root regeneration. The regenerated plantlets are transferred to the field up to 40-45 days. This system provides an invitro tissue culture method with various plant growth hormones and shown accurate plant growth

3.1.1 Block Diagrams of the system

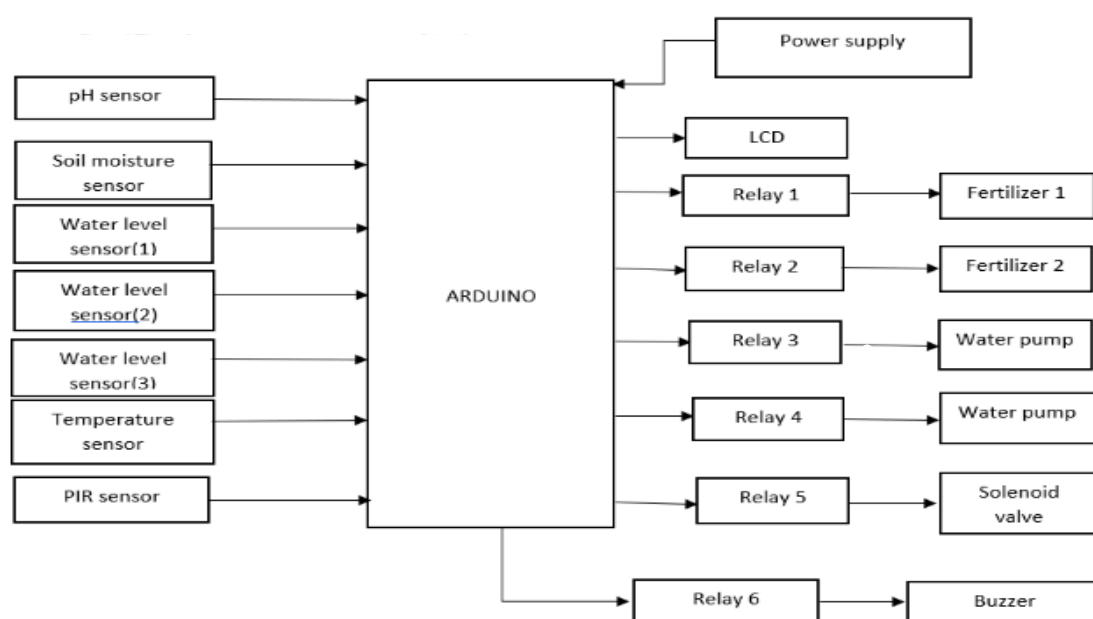


Fig: 3.1 : Block diagram for smart farming technique

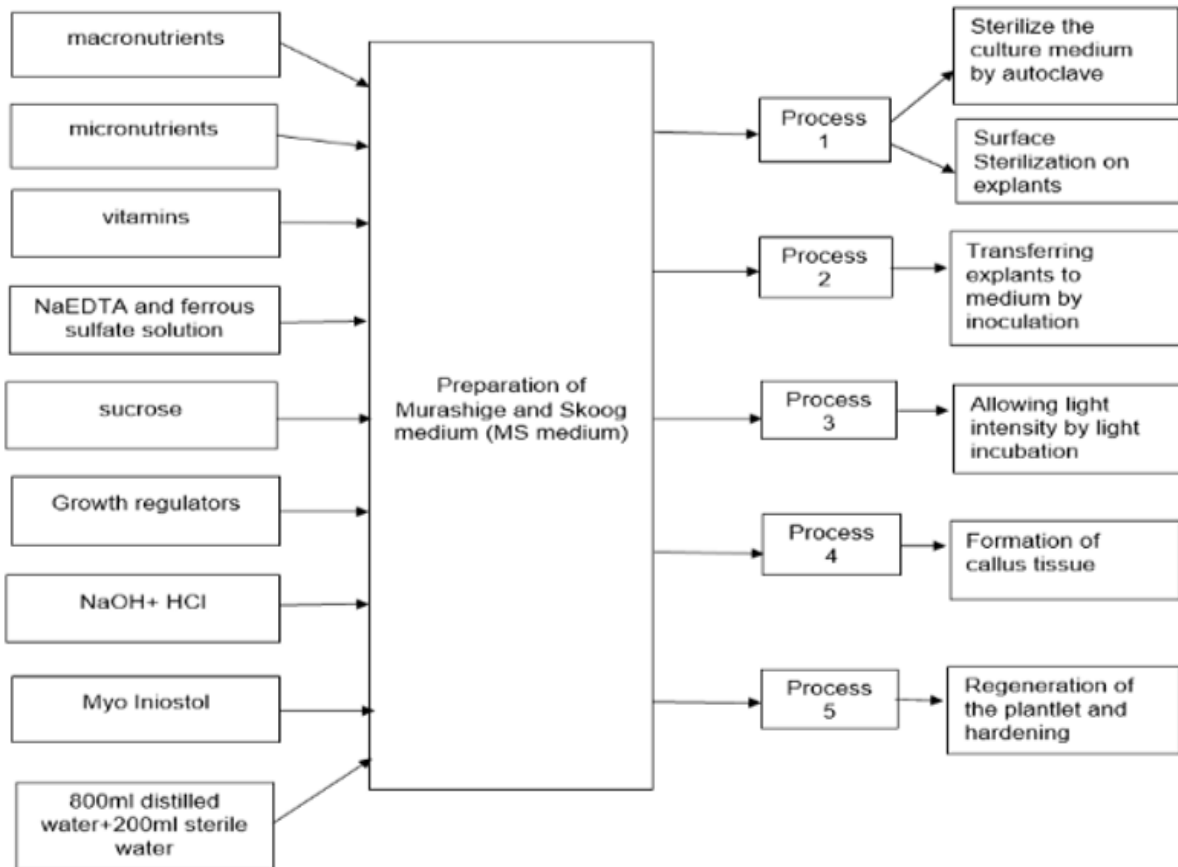


Fig: 3.2 : Block diagram for preparation of Murashige and Skoog (MS) culture medium

3.1.2 System Design

The preview design for this complete setup is published to monitoring the soil nutrient ph. This system design can be monitoring the pH and relay fertilizers can be used and check for the nutrient for soil and provide good fertilizer to the crop automatically through a water pump. We use two fertilizers sodium and calcium. The preview design was designed to make automatic drip irrigation when the moisture content is low. This system design addition to this, the water level sensor can be used in the borewell (first priority) and in the water tank (second priority). When the water content is low, sensors detect this and automatically off the motor using the controller option to reduce the motor lifetime. Flow sensors can be used to detect the water level for the crop grown. When the level comes high, the solenoid valve is used for arresting the more amount of water and automatically valve opens and water flows out of the field. In addition to

the previous design setup, PIR sensor can be used to vibrate the sound for making dread for animals when they enter the crop yield. Basic novelty in the whole system to make prototype model for the regeneration of plantlet by culture technique on controlled conditions in the home. Light is essential for a plant grown in a culture medium. LDR sensor module can be used for detecting light intensity in a room for plant regeneration. Basic precautions are carried in the process and the technique is most used for farmers, unlike the common one. This is our basic setup process and gives solutions to all other problems in the existing models.

3.1.3 Advantages of the System

- Our system is fully designed to the simple and easy way of farming and our system will give solutions for all major problems in agriculture.
- The cost is not much expensive.
- Besides farming, our system is designed to regenerate the plantlet from the tissue or organ of the plant called as invitro culture. The plantlet can be grown in the culture medium and artificial plantlet can be produced.
- Farming technique and Invitro tissue culture are two techniques like two eyes for farmers. Our system is designed the two techniques and plays an important role in farming.

3.2 SCOPE OF THE PROJECT

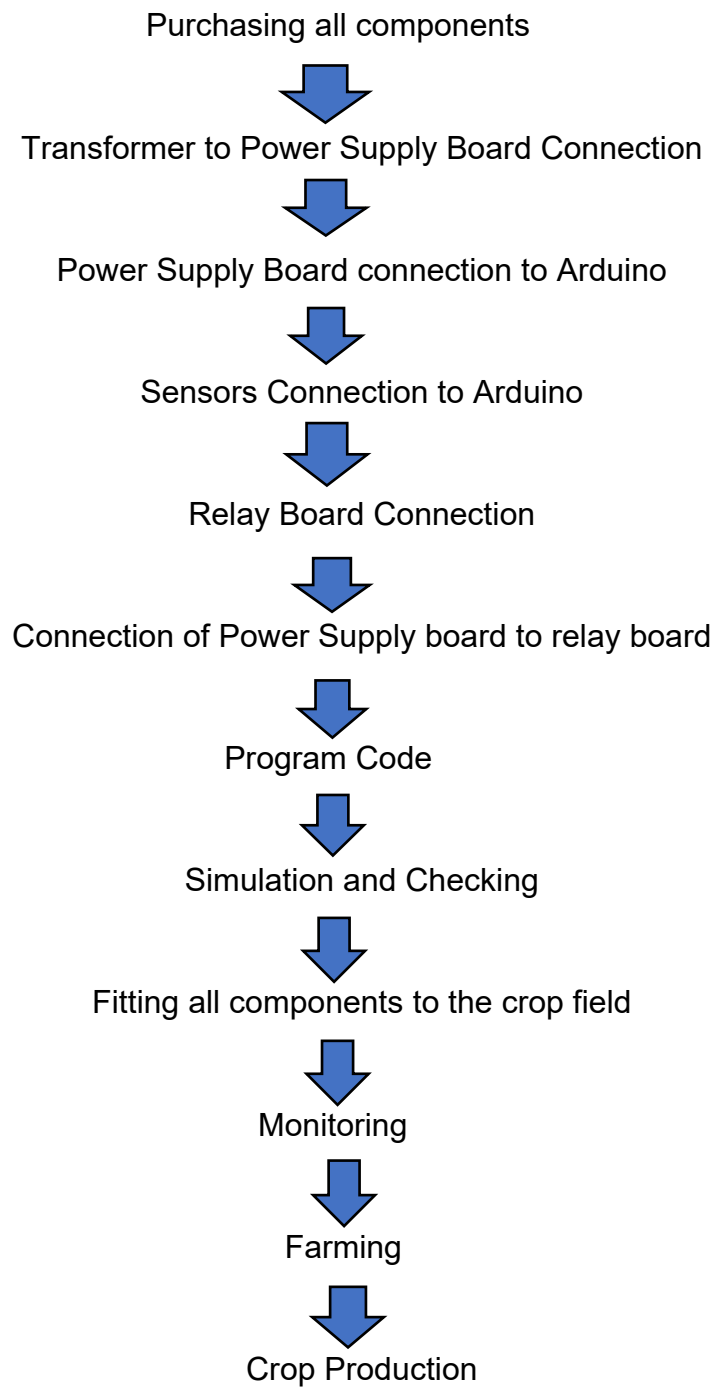
In the smart farming method, Our system will give success on the farming technology but in the future, this system also be implemented to add the relay for plowing the soil and also add another excess sensor to detect the crop disease and other pest diseases and also use IoT technology to this system for monitoring the output wherever can we. In invitro culture method, plant regeneration has more accurate proliferation but in a semi-solid medium, the plant growth shown a good result within a short period. Surface sterilization on this method Sodium hypochlorite is used but the toxic agent Mercuric chloride (HgCl_2) is also used in this sterilization.

CHAPTER 4

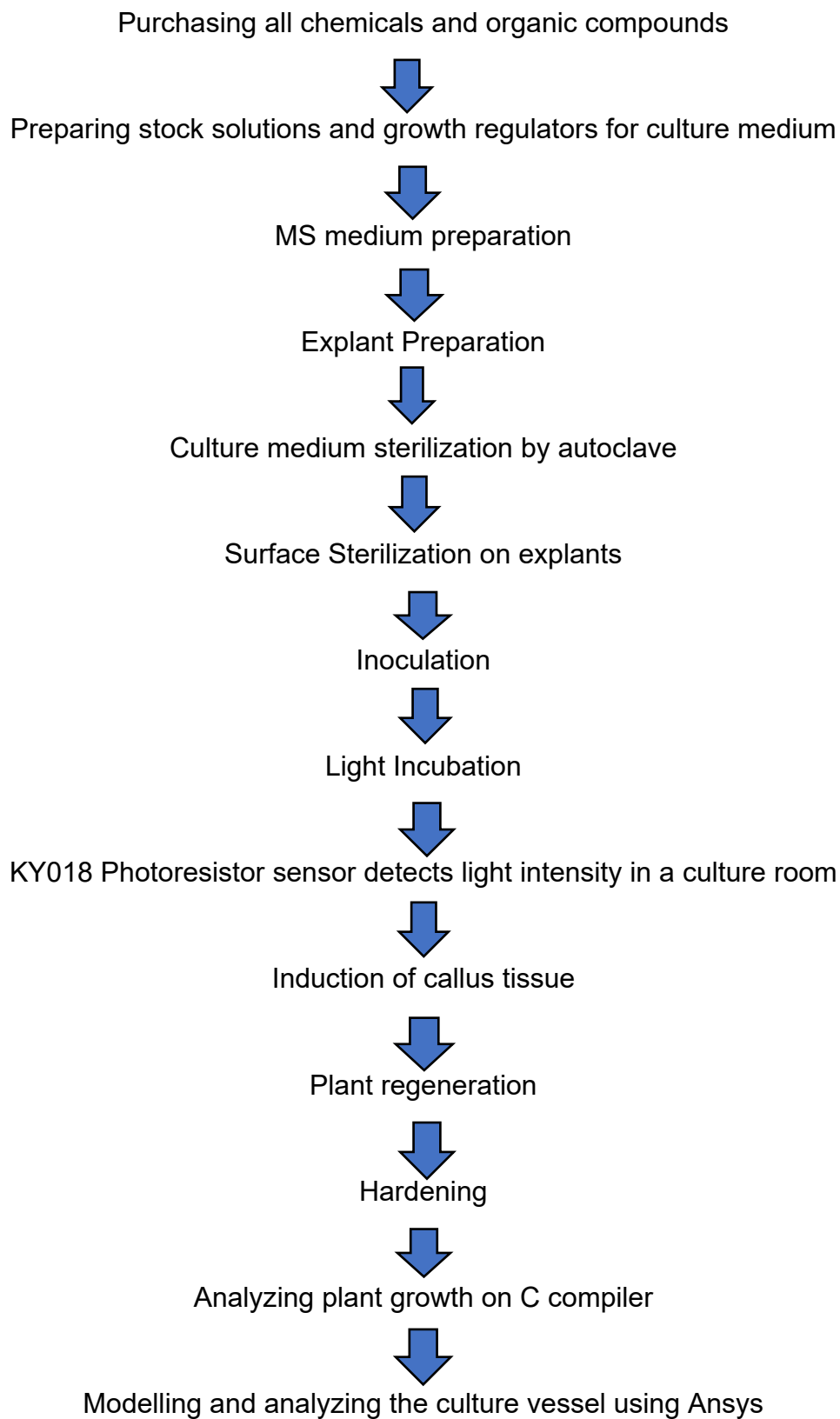
MATERIALS AND METHODS

4.1 RESEARCH METHODOLOGY

4.1.1 Methodology steps for smart farming technique



4.1.2 Methodology steps for invitro culture technique



4.2 POWER SUPPLY AND RELAY

Power supply 230V alternating current is used on the household properties and some other related factories. The transformer is an electrical device that transfers energy from one alternating circuits to one or more other circuits, whether increasing or reducing the voltage. Here, 12V AC transformer is used to reduce the 230volts. The transformer is connected to the power supply board. A multimeter is a device that can measure a variety of electrical characteristics. A conventional multimeter may measure voltage, resistance, and current, and is sometimes known as a volt-ohm-milliammeter (VOM) since it includes a voltmeter, an ammeter, and an ohmmeter. Here, we used a multimeter to check the voltage in the power supply board has shown 12V. A rectifier is a device that converts to direct current (DC) from the alternating current (AC). Here, we used bridge rectifier that converts 12V AC to 12V DC current supply. A bridge diode is a circuit combination of four diodes in a bridge configuration that provides the same polar output for every input. A Capacitor is a device that stores electrical energy in an electric field. While some capacitance exists between any two electrical circuits, a capacitor is a component designed to add capacitance to a circuit. The capacitor was originally known as condenser or condensator. Here Capacitor is used as a filter. The unwanted signals are filtered by the capacitor. Here we used one 1000Mega farad capacitor and two 10Mega farad capacitors. A voltage regulator is a component of the power supply unit that ensures that the voltage remains constant under all operating conditions. It maintains voltage during power fluctuations and load changes. It can control both AC and DC voltages. Here, we used the 7805 regulators and 7812 regulators for providing power supply to the Arduino board and relay board. Here diode is used and is a semiconductor device that essentially acts as a one-way switch for current permitting to flow freely in one direction while drastically restricting current flow in the other. Light Emitting Diode (LED) is used here and it emits light where an electric current passes through them.

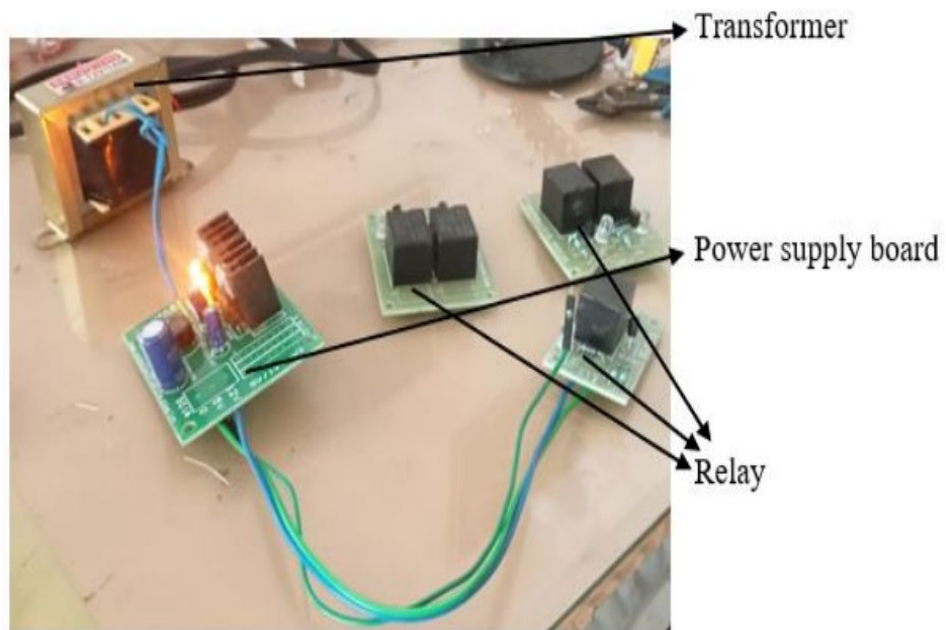


Fig: 4.1 : Connections showing transformer to power supply and power supply to relay

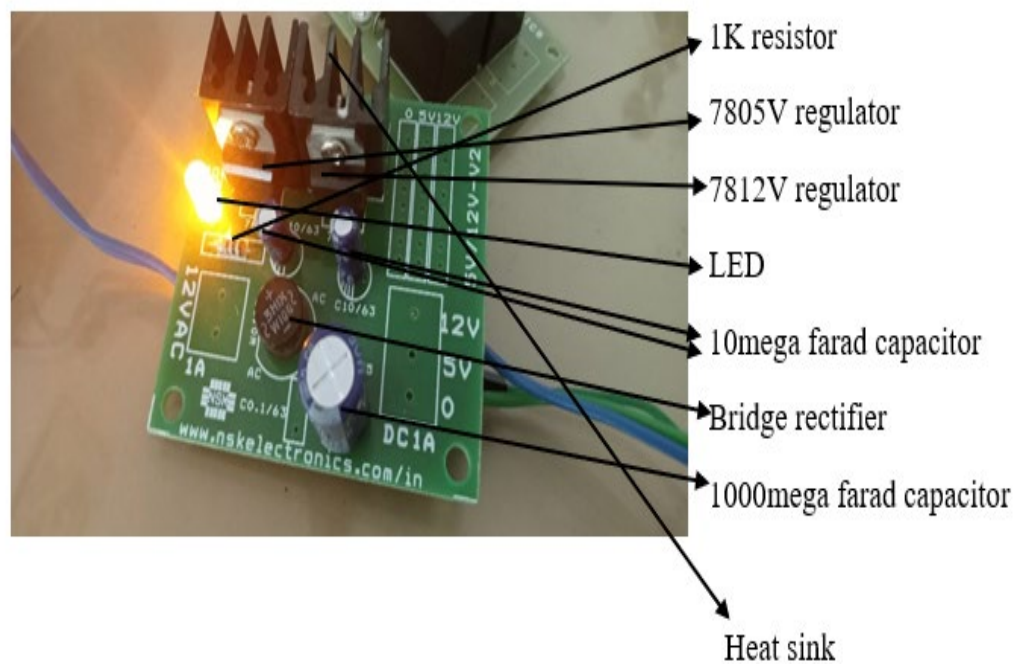


Fig:4.2 : Power supply board

A relay is an electrical switch that is controlled by another electrical circuit to open and close. The switch is actuated by an electromagnet to open or close one or more sets of contacts in its original configuration. Because a relay can control an output circuit of higher power than the input circuit, it can be considered, in a broad sense, to be a form of an electrical amplifier. Relays are operated which allow a low power circuit to switch a relatively high current on and off, or to control signals that must be electrically isolated from the controlling circuit itself. A relay is an electromagnetic switch.

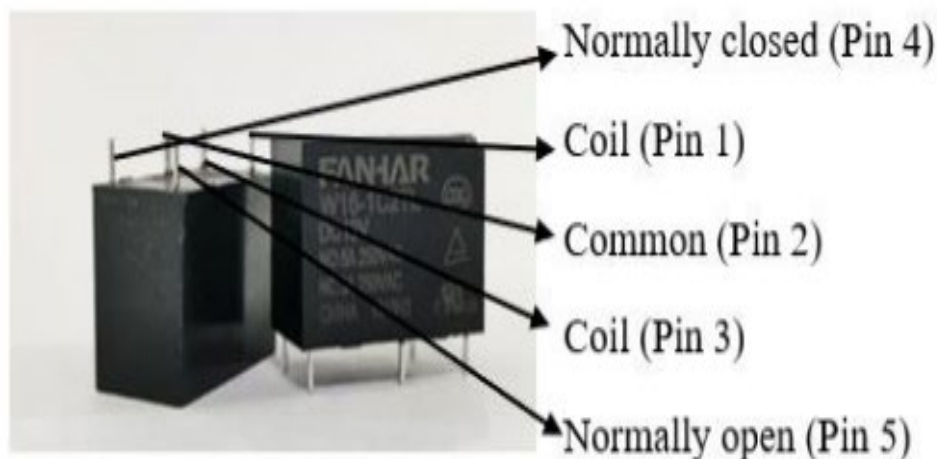


Fig: 4.3 : Relay pins

Relay is operated by the above diagram namely five pins are pin 1 and pin 3 are coil and pin 2 is common and pin 4 is normally closed and pin 5 is normally open. Power Supply +12V or +5V DC connected at the coils (pin 1 and pin 3) and the voltage 3.3V or 5V given from Arduino not directly to the Relay. Here, we used the NPN(Negative-Positive-Negative) transistor (BC547, BJT transistor) for giving the 5V from Arduino. 5V can be given from the base of the NPN transistor, the collector collects the current from the emitter (is ground). If the collector collects the current, the relay gets operated at normally closed or normally open conditions. However, Transistor is used as a controlled switch. The Relay board consists of an NPN transistor, LED, Diode, and two 1K resistors.

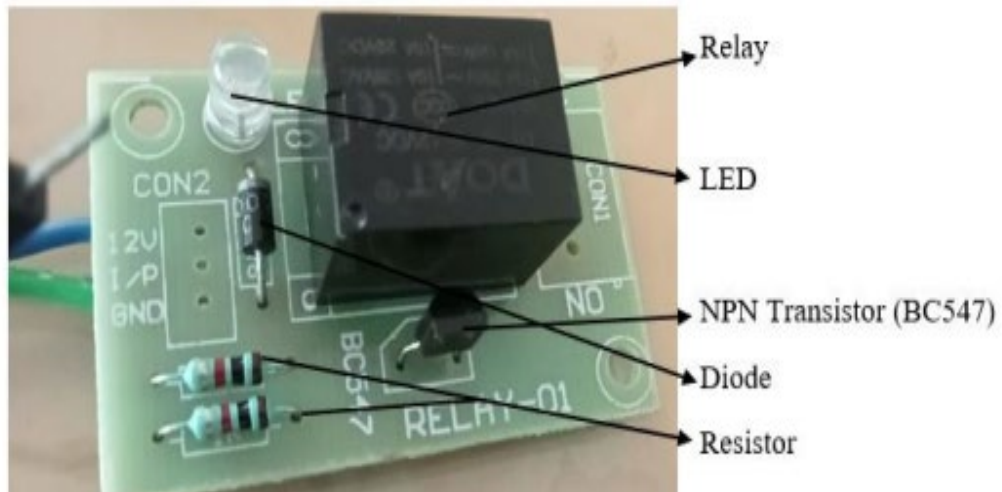


Fig: 4.4 : Relay Board

4.3 SENSORS USED

4.3.1 pH sensor

One of the most important tools for measuring water's pH (power of Hydrogen) is a pH sensor. Alkalinity and acidity can be measured by this type of sensor in water and other solutions. The pH sensor measures the difference in electrical potential between a pH electrode and a reference electrode, and so the pH meter is sometimes referred to as a potentiometric pH meter. The difference in electrical potential refers to the acidity or pH of the solution. A pH meter can be used for many purposes, including laboratory experiments and quality control. Here, a pH sensor is used to detect the soil nutrient (Hydrogen in soil). Here pH sensor is connected to the Arduino pin and works as an analog input. The output of the pH is displayed in LCD.



Fig: 4.5 : pH sensor dipped in the soil

4.3.2 Soil moisture sensor

Water content in the soil is measured by soil moisture sensors. Since the direct galvanometric measurement of free-soil moisture requires removing, drying, and weighing of a sample, soil moisture sensor measures the volumetric water content indirectly by using some other property of soil, such as electrical resistance, dielectric constant, or interaction with neutrons, as a proxy for the moisture content. Sensors are used in agricultural science, horticulture including irrigation planning, climate research, and environmental science. Here, a soil moisture sensor is used to detect the humidity of the soil. When it detects the water content, the output of the sensor is displayed on LCD.

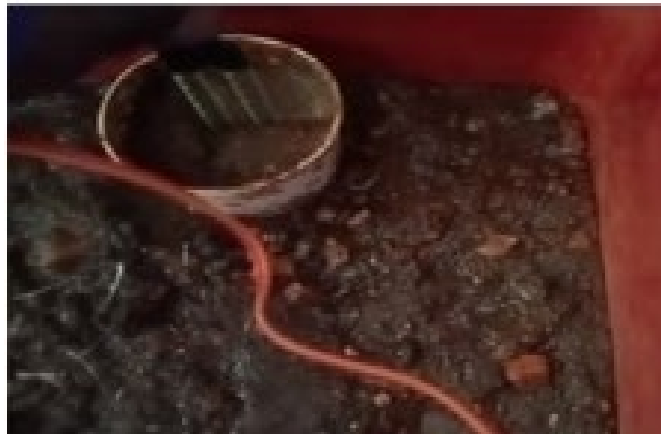


Fig: 4.6 : Soil moisture sensor dipped in the soil

4.3.3 PIR sensor

Passive Infrared Sensors (PIR Sensors) measure infrared light emanating from objects within their field of view. In the construction of PIR-based motion detectors, PIR sensors are often used. An infrared source of one temperature, such as a human, passes in front of an infrared source of another temperature, such as a wall, to indicate apparent motion. Here, PIR Sensor is used to detect the moving objects from out of the agricultural field. Because animals and birds can enter the field and damage the crops.

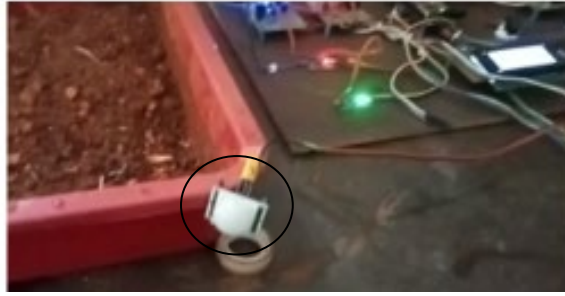


Fig: 4.7 : PIR Sensor connected at out of the field

4.3.4 Water level sensor

A water level sensor measures the level of liquid in a fixed container that is too low or too high. According to the method of measuring the liquid level, it can be divided into two types namely contact type and non-contact type. A contact measurement is an input type water level transmitter that turns the height of the liquid level into an electrical signal for output. It is now commonly used as a water level transmitter. The water level sensor works by converting the pressure on the sensor's front surface into the liquid level height when it is submerged to a specified depth in the liquid to be measured. Here, three water level sensors are used. Two water level sensors are connected to the water sources (borewell and water tank). Another remaining water level sensor is connected in the field.



Fig: 4.8 : Water level sensors connected at the water sources (borewell and water tank)



Fig: 4.9 : Water level sensor connected at the field

4.3.5 LM35 temperature sensor

The LM (Linear Monolithic)35 is an IC temperature sensor with a proportional output to the temperature (in degree Celsius). Because the sensor circuitry is sealed, it is not susceptible to oxidation or other processes. With LM35, the temperature can be measured more accurately compared with a thermistor. It also has a limited self-heating capability, causing a temperature rise of fewer than 0.1 degrees Celsius in still air. In industrial automation, the temperature is the most closely monitored process variable. A temperature sensor is commonly used to convert temperature values to electrical values. Temperature sensors are the key to reading temperatures correctly and to controlling the temperature in industrial applications.

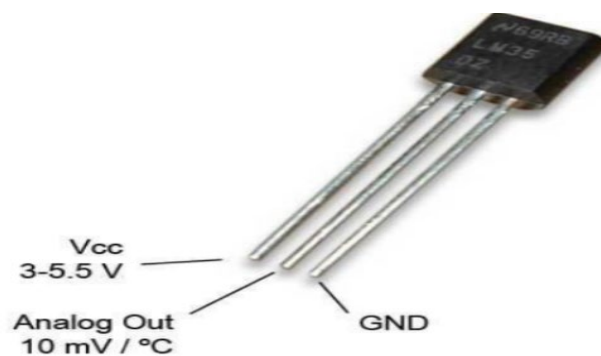


Fig: 4.10 : Pin Diagram of LM35 Temperature Sensor



Fig: 4.11 : Spacing needle to detect temperature from an LM35 temperature sensor

4.3.6 KY018 PHOTORESISTOR SENSOR

The culture medium with the inoculum is incubated at 26 ± 2 degrees Celsius with the light intensity at 2000 to 4000 lux intensity and allowing a photoperiod of 16 hours of lightness and 8 hours of darkness. LDR with a photoresistor sensor is used to detect the intensity of light in a culture room. Here, the KY018 photoresistor sensor module can be used. An LDR (Light Dependent Resistor) is a type of resistor that responds to the amount of light falling on it and then resistance is in the order of a few kilo Ohms and if it is dark then its resistance is in the order of Megaohms so the cell resistance falls with increasing light intensity. This sensor module consists of 10 kilos Ohm, 3 pins, and LDR. This is a Photoresistor module with an LDR sensor having Two Cadmium Sulphide (CdS) photoconductive cells and spectral responses like that of the human eye. The photoresistor module has applications such as smoke detection, Automatic lighting control in rooms, vehicles, and roadsides lights. Here, we used this sensor to detect the light intensity for plant growth.

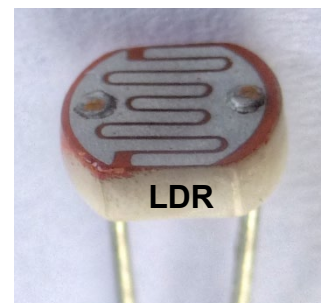


Fig: 4.12 : KY018 Photoresistor sensor

4.4 LIGHT CRYSTAL DISPLAY

A liquid crystal display (LCD) is a thin, flat display device composed of any number of colour or monochrome pixels positioned in front of a light source or reflector. Because it requires extremely little electric power, it is frequently used in battery-powered electronic gadgets. Each pixel of an LCD is made up of a layer of molecules placed between two transparent electrodes and two polarising filters, the transmission axes of which are perpendicular to each other in most situations. Light flowing through the first polarizing filter would be blocked by the second if there was no liquid crystal between them (crossed polarizer). Here, the Light Crystal device displayed the output of pH of soil and temperature in the land. Digital inputs such as soil moisture condition, water level source condition is displayed as output controlled by the Arduino program.



Fig: 4.13 : LCD displaying output

4.5 RELAYS USED

4.5.1 Water pump motors

Like electricity, water will always take the path of least resistance. The pump must create a channel (region of the low pressure or low resistance) through which the water will naturally seek to flow to elevate the water. It's crucial to understand the role of air pressure in generating lift. The atmosphere exerts a force of 14.7 lb/in² (PSI) on the earth's surface at sea level. Unless an area of low pressure is generated, the weight of the atmosphere on a body of water will prevent the lift from occurring. Three hollow tubes, each having a surface area of 1 square inch, rise from sea level into the atmosphere in the diagram below. Inside tube (A), the atmospheric pressure is the same as outside: 14.7 PSI. The water level inside the tube does not vary because the weight of the atmosphere is distributed evenly over the surface. A complete vacuum

is formed in the tube (B), increasing air pressure on the water outside the tube. Water flows naturally to the lowest pressure location and fills the tube until it reaches a height of 33.9 feet as a result of the pressure differential. Here, the water pump motor is connected in a relay to provide irrigation and fertilizers automatically. There are 4 water pump motors are used in the project.



Fig: 4.14 : Water pump motors for each two for providing irrigation and fertilizers

4.5.2 Solenoid valve

A solenoid valve, also known as a gate valve or sluice valve, is a valve that opens by removing a barrier from the fluid's course. When completely opened, the gate valve takes up very little space along the pipe axis and barely limits fluid flow. The faces might be parallel or wedge-shaped, but the latter is the most common. Here, also solenoid valve is used to store the water in the land (i.e., more no. of water due to rain) valve is in the closed condition, and valve gets open, the water can be removed from the valve and water is released out of the field.



Fig: 4.15 : Solenoid valve

4.5.3 Buzzer

A buzzer or beeper is a mechanical, electrochemical, or piezoelectric audio signalling device. Alarm clocks, timers, and confirmation of human input such as a mouse click or keystroke are all examples of buzzer and beeper applications. Here, the buzzer is used to produce a sound that can fear the animals and birds when they enter the field. PIR sensor detects the moving object and the buzzer will connect in the relay. If the PIR sensor detects the object, the buzzer operates to produce sound.



Fig: 4.16 : Buzzer

4.5.4 SWITCH

A switch is an electrical component that can break an electrical circuit by interrupting or dividing current between two conductors. A switch's mechanism can be controlled directly by a human operator to control a circuit. Here, also we use a switch to monitor the nutrient level displayed in LCD. Because farmers can't put fertilizers again and again to the crop. So, only one-time fertilizers can be provided to the crop with the help

of the switch. If we were on the switch, we noticed the accurate nutrient level in the soil. The switch is connected to the LCD.

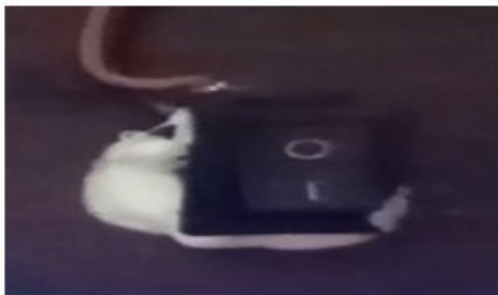


Fig: 4.17: Switch

4.6 CHEMICALS USED

4.6.1 *Explant preparation and Sterilization*

Acalypha indica is commonly found in a variety of locations, including wastelands, roadsides, and gaps in buildings. It grows on rocky slopes, woodland margins, and river banks, among other places. It enjoys damp, shady environments. So, the explant (leaf) can easily be taken from our garden itself. The explant is called inoculum. By treating the inoculum in chemical sterilizant as NaOCl for 20-25 minutes and wash repeatedly in sterile water up to 3 to 5 times.

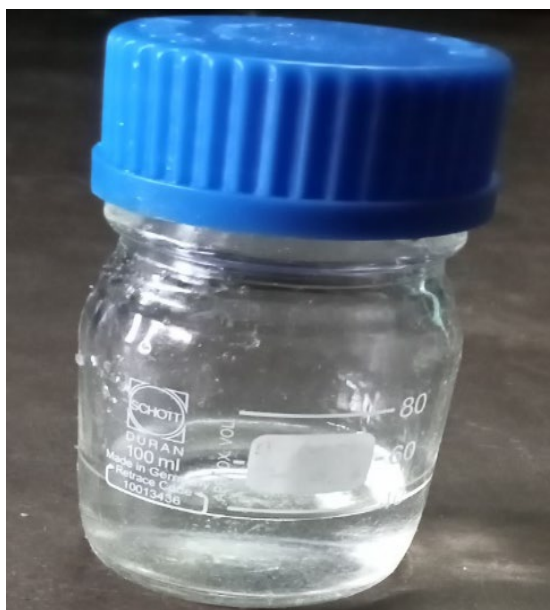


Fig: 4.18 : Chemical Sterilizant Sodium hypochlorite (NaOCl)

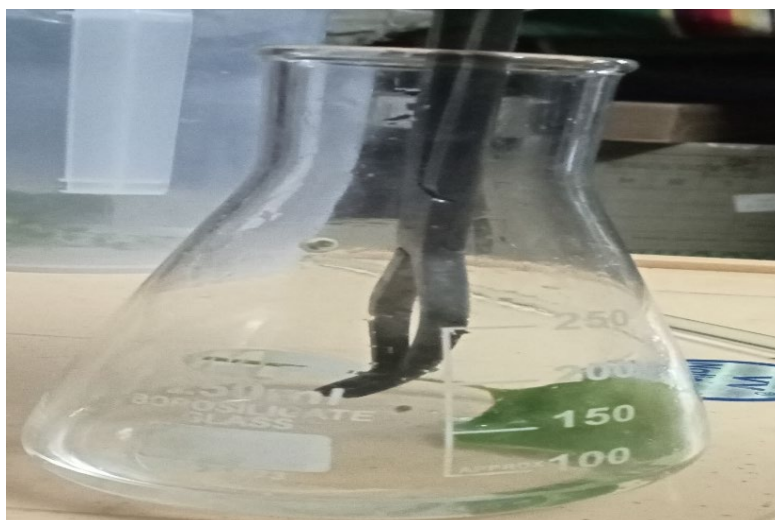


Fig: 4.19 : Surface Sterilization on explant in Sodium hypochlorite

4.6.2 Medium preparation and Inoculation

MS (Murashige and Skoog) medium was prepared by the stock solutions 100ml stock solution of macronutrients, 1ml stock solution of micronutrients, 1ml stock solution of vitamins, 10ml stock solution of NaEDTA and Ferrous sulfate. 30g of sucrose and 0.1g of Myo-Inositol are added in the medium and prepared without agar on a liquid medium. The culture medium is closed with a cotton plug or aluminium foil sheet. The pH of the medium is adjusted to 5.8 (acidic range) by adding 1 mole of NaOH and 1 mole of HCl. Growth regulator is a hormone-like synthetic organic compound. In small amounts, it modifies the growth and development either by promoting or inhibiting the growth. NAA (1.5mg/ml) was added in the culture medium for the induction of callus tissue on yellow compact friable colour. BAP (1mg/ml) and KIN (0.5mg/ml) were added to the culture medium for the initiation of shoot formation from callus tissue. BAP (1mg/ml) and NAA(0.5mg/ml) added in the culture medium for shoot proliferation. Cytokinin induces cell division and Auxin induces cell elongation by this process. IAA (1.5mg/ml) was added in the culture medium for a maximum number of roots. The culture medium can be sterilized by keeping it in an autoclave and maintaining the temperature of 121 degrees Celsius for 15-20 minutes. Now, the culture medium is sterilized.

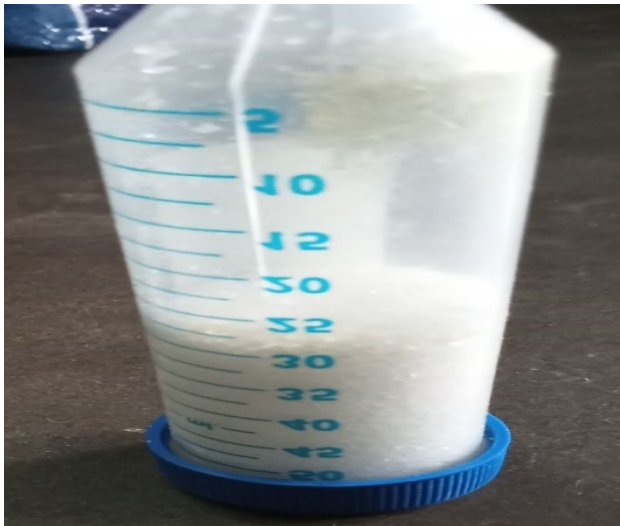


Fig: 4.20 : Sucrose



Fig: 4.21 : Sodium hydroxide (NaOH)



Fig: 4.22 : Preparation of stock solutions for macronutrients, micronutrients, vitamins, NaEDTA and Ferrous sulfate solutions

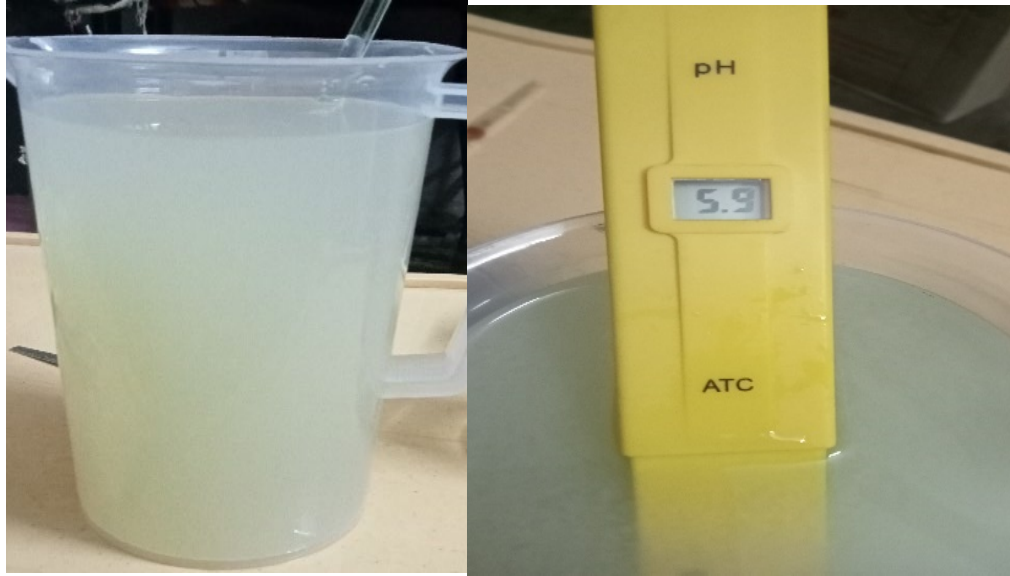


Fig: 4.23 : Preparation of Murashige and Skoog (MS) medium and the medium is adjusted to pH 5.9(acidic range) to add 1 mole of NaOH and 1 mole of HCl

Similar to a pressure cooker, the autoclave is a container. It's meant to hold objects destined for sterilization and then seal it up. A high-pressure stream of steam is then forced into the chamber under high temperatures, which displaces air. The irreversible coagulation and denaturation of enzymes and structural proteins occurs when moist heat is applied to microorganisms. According to the pressure and type of organism to be inactivated, the time and temperature to accomplish this will differ. As soon as the sterilized objects are removed from the steam, it is released. The entire process can take anywhere from 15 to 60 minutes. So, it is important to sterilize the culture medium to get free from bacteria and fungi on culture medium.



Fig: 4.24 : Sterilization on culture medium in autoclave machine

Transfer of explant (leaf of the plant) onto a culture medium is called inoculation. The process inoculation is carried out under aseptic conditions for which an apparatus called a laminar airflow chamber is used. Flamed and cooled forceps are used for the transfer of plant materials to different culture media kept in culture vessels. Chemicals involved in the stock solutions of macronutrients, vitamins, micronutrients, organic compounds, and mainly growth regulators are listed below as tables.



Fig: 4.25 : Petri plates are heated under an aseptic condition



Fig: 4.26 : Cooled and flamed Petri plates and forceps used for take explant (leaf) in inoculation process

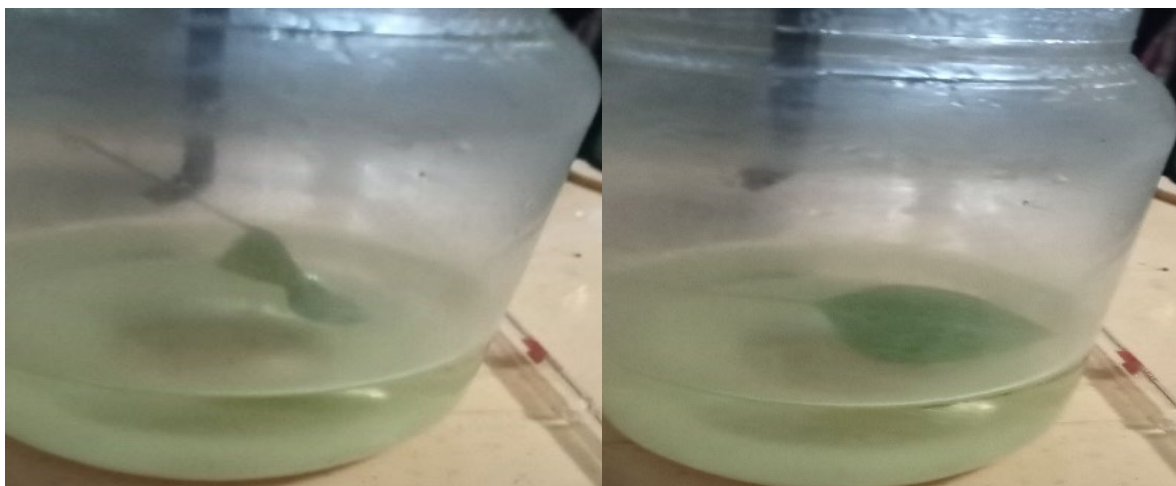


Fig: 4.27 : Transferring explants to the culture medium (inoculation)

After inoculation, culture medium is ready for plant growing. Then after 7 days culture medium is prepared repeatedly because nutrients are obtained from the callus initiation and organogenesis for even growth. The following methods are used in the inoculation process.

1. Culture medium must be provided in a laminar air flow chamber for destroying the remaining bacteria and fungi in culture medium on applying ultraviolet light (UV Light).
2. Explants must be transferred to a culture medium on aseptic condition. Petriplates are heated under this process and then cooled. Now, explants are ready to transferring in culture medium.
3. Now, incubation process takes place. Light incubation involves the photoperiod of plant development. Light need for photosynthesis process. Here, LED light does this process artificially. Light incubation is already explained in KY018 photoresistor sensor description.

The below tables are listed the chemicals and preparation of stock solution for 1 litre of macronutrients, micronutrients, vitamins, Stock D solution, organic compounds, and growth regulators. The growth regulator table is also listed as the effect of the hormone in the plants and soluble components in the culture medium.

4.6.2.1 Stock Solutions B (micronutrients)

The below chemicals are used for the stock B solutions (micronutrients) measured in the gram/litre for the preparation of 1 litre Murashige and Skoog (MS) culture medium.

Table 4.1 : Stock Solution of micronutrients in culture medium

Micronutrients	Preparation (in litre)	Stock Solution (mg/l)	Stock Solution (g/l)	Stock Solution Conc (1000X)
Potassium iodide (KI)	1 Litre	0.83mg/l	0.83g/l	1ml
Boric Acid (H ₃ BO ₃)	1 Litre	6.2mg/l	6.2g/l	1ml
Zinc Sulfate (ZnSO ₄)	1 Litre	8.6mg/l	8.6g/l	1ml
Manganese Sulphate (MnSO ₄ . 4H ₂ O)	1 Litre	16.9mg/l	16.9g/l	1ml
Sodium molybdate (NaMoO ₄)	1 Litre	0.25mg/l	0.25g/l	1ml
Copper Sulfate (CuSO ₄ .5H ₂ O)	1 Litre	0.025mg/l	0.025g/l	1ml
Cobalt chloride (CoCl ₂ .6H ₂ O)	1 Litre	0.025mg/l	0.025g/l	1ml

4.6.2.2 Stock Solutions A (macronutrients)

The below chemicals are used for the stock A solutions (macronutrients) measured in the gram/litre for the preparation of 1 litre Murashige and Skoog (MS) culture medium.

Table 4.2 : Stock solutions of macronutrients in the culture medium

Macronutrients	Preparation (in litre)	Stock Solution (mg/l)	Stock Solution (g/l)	Stock Solution Conc (10X)
Ammonium nitrate (NH ₄ NO ₃)	1 Litre	1650 mg/l	16.5 g/l	100ml
Potassium nitrate (KNO ₃)	1 Litre	1900mg/l	1.90g/l	100ml
Calcium chloride (CaCl ₂ .2H ₂ O)	1 Litre	440mg/l	4.40g/l	100ml
Magnesium sulphate (MgSO ₄ .7H ₂ O)	1 Litre	370mg/l	3.7g/l	100ml
Potassium dihydrogen phosphate (KH ₂ PO ₄)	1 Litre	1700mg/l	1.70g/l	100ml

4.6.2.3 Stock solution C (vitamins)

The below chemicals are used for the stock C solutions (vitamins) measured in the gram/litre for the preparation of 1 litre Murashige and Skoog (MS) culture medium.

Table 4.3 : Stock Solutions of vitamins in culture medium

Vitamins	Preparation (in litre)	Stock Solution (mg/l)	Stock Solution (g/l)	Stock Solution Conc (1000X)
Glycine	1 Litre	2mg/l	2g/l	1ml
Thiamine	1 Litre	0.1mg/l	0.1g/l	1ml
Pyridoxine	1 Litre	0.5mg/ml	0.5g/l	1ml
Nicotonic acid	1 Litre	0.5mg/l	0.5mg/l	1ml

4.6.2.4 Stock Solutions D

The below chemicals are used for the stock D solutions measured in the gram/litre for the preparation of 1 litre Murashige and Skoog (MS) culture medium.

Table 4.4 : Stock Solutions of Sodium EDTA and Ferrous sulfate in culture medium

Solutions	Preparation (in litre)	Stock Solution (mg/l)	Stock Solution (g/l)	Stock Solution Conc (100X)
Sodium Ethylene diamine tetraacetic acid (Na EDTA)	1 Litre	37.30mg/l	3.73g/l	10ml
Ferrous sulfate (FeSO ₄ .7H ₂ O)	1 Litre	27.8mg/l	2.78g/l	10ml

4.6.2.5 Organic compounds

The below chemicals are used for the organic compounds measured in the gram/litre for the preparation of 1 litre Murashige and Skoog (MS) culture medium.

Table 4.5 : Stock solutions of organic compounds in the culture vessel

Organic Compounds	Preparation (in litre)	Measurement for stock solution
Sucrose (Beta-D-fructo furanosyl Alpha-D-glucopyranoside) (C ₁₂ H ₂₂ O ₁₁)	1 Litre	30g/l
Myo-Inositol(C ₆ H ₁₂ O ₆)	1 Litre	0.1g/l

4.6.2.6 Growth regulators or plant growth hormones

The below chemicals are used for the organic compounds measured in the gram/litre for the preparation of 1 litre Murashige and Skoog (MS) culture medium. Various auxin and cytokinin plant growth hormones are initiate the plant growth in callus induction, shoot and root regeneration and proliferation for indirect organogenesis from the *Acalypha indica* explant (leaf).

Table: 4.6 : Effect of various growth regulators from nodal explants of *Acalypha indica* added in culture medium

Phyto hormones	Synthetic Organic Compounds	Preparation (in litre)	Stock Solution (mg/ml)	Effect on the growth size	Soluble Components
Cytokinin	BAP (6-Benzylaminopurine)	1 Litre	1mg/ml	Initiates Shoot formation in callus tissue	H ₂ O+NaOH
Cytokinin	KIN (Kinetin)	1 Litre	0.5mg/ml	Initiates Shoot and bud formation in callus tissue	H ₂ O+HCl+ NaOH
Auxin	NAA (Naphthalene Acetic Acid)	1 litre	1.5mg/ml	Induction of callus in culture medium on yellow compact colour	H ₂ O
Cytokinin	BAP (6-Benzylaminopurine)	1 Litre	1mg/ml	Promotes cell division by initiating shoot multiplication	H ₂ O+NaOH

Auxin	NAA (Naphthalene Acetic Acid)	1 Litre	0.5mg/ml	Promotes cell elongation by initiating shoot and bud multiplication	H ₂ O
Auxin	IAA (Indole 3-Acetic Acid)	1 Litre	1.5mg/ml	Promotes cell elongation by initiating maximum roots in plant	HCl+NaOH

4.7 ARDUINO MICROCONTROLLER

4.7.1 Arduino mega 2560

The ATmega2560 microprocessor is used in the Arduino Mega 2560 development board. Because it has 16 analog pins and 54 digital I/O pins, 15 of which are used for PWM output, the board is an excellent fit for projects that require more GPIO pins and memory space. To power this unit, the board has a DC power jack, and we can also switch it on using the Vin pin on the board with the computer. The Arduino Mega 2560 is comparable to the Arduino UNO, but it has more GPIO pins, memory, and is larger. The ICSP header, which is used to program the board without detaching it from the main circuitry, is also supported by the unit. Two voltage regulators are incorporated on the board, allowing us to adjust the voltage as needed. Arduino Mega 2560 board is used for the smart farming technique method.

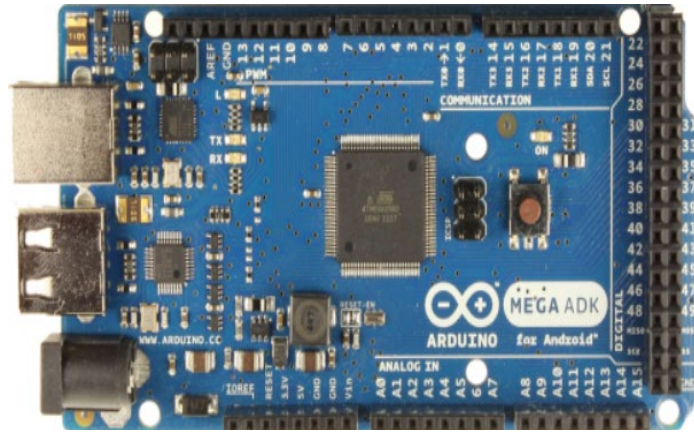


Fig: 4.28 : Arduino Mega 2560

4.7.2 Arduino UNO

The Arduino UNO microcontroller board is based on the Microchip AT mega 328P microcontroller and is developed by Arduino. cc. The board has a number of digital and analog input/output (I/O) pins that enable it to be interfaced with various expansion boards (shields) and other circuits. With 14 digital pins, 6 analog pins, and an operating voltage range of 3.3V to 5V, the board can be programmed with the Arduino IDE (Integrated Development Environment) using a USB Type B cable. Here we used Arduino UNO to connect the KY018 photoresistor sensor for detecting the light intensity in a culture room.



Fig: 4.29 : Arduino UNO

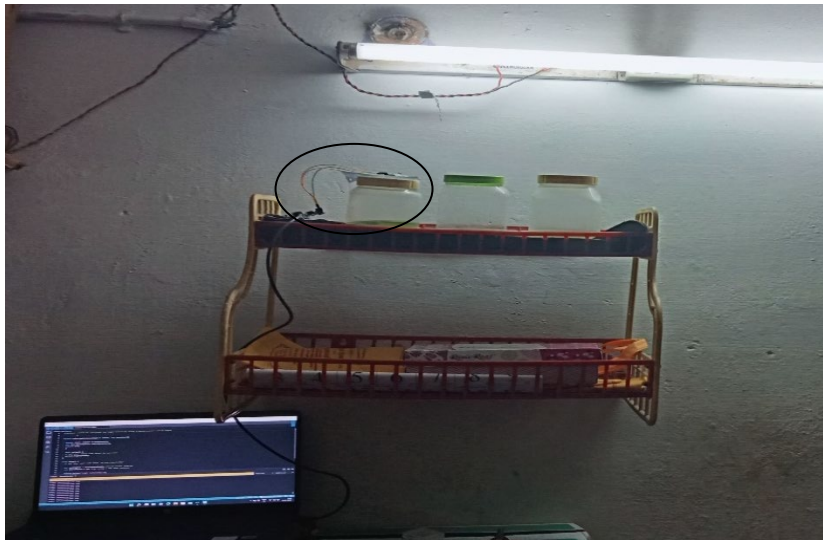


Fig -4.30 : KY018 photoresistor sensor is connected to Arduino UNO board for detecting the light intensity in a culture room

4.8 STUDY OF PLANT DESCRIPTION

4.8.1 Explant description (*Acalypha indica* Linn.,)

The above description of *Acalypha indica* is fully about morphological and anatomical features and discuss about its economic importance before doing this technique. It is important to know about the features of plant before preparing the culture medium.

4.8.1.1 Taxonomic classification

Class: Dicotyledonae

Sub-class: Monochlamyadae

Series: Unisexuales

Order: Malpighiales

Family: Euphorbiaceae

Genus: *Acalypha*

Species: *indica*

4.8.1.2 Morphological and anatomical features of explant

It is a common annual herb growing 75cm tall at 1-3 feet high. It grows in distributed places such as wastelands, roadsides, and crevices in walls. It also grows in rocky hillsides, forest edges, and river banks. It prefers moist and shaded places. It grows from sea level up to 1350m altitude. Generally, a branched tap root system is seen in *Acalypha indica*. Stem is aerial, erect, simple or branched, deep green in colour, angular, hirsute and deeply gloved in younger parts. Stem is generally herbaceous, more or less terete, glabrous, pubescent and faintly longitudinal striate in older. Latex is absent. Leaves are simple, alternate, stipulate and has mosaic phyllotaxy. Leaf has strong petiole and slender are about 3cm-9cm long. Leaves are ovate to rhomboid shape at 1.2cm-6.5cm long, sometimes obovate in shape, subacute or obtuse at apex, glabrous and serrate. The leaf base is rounded to attenuate shortly. Leaf margin is basically 5 nerved. Venation is multicostate reticulate venation. The leaves are dorsiventral. Stipules are small.

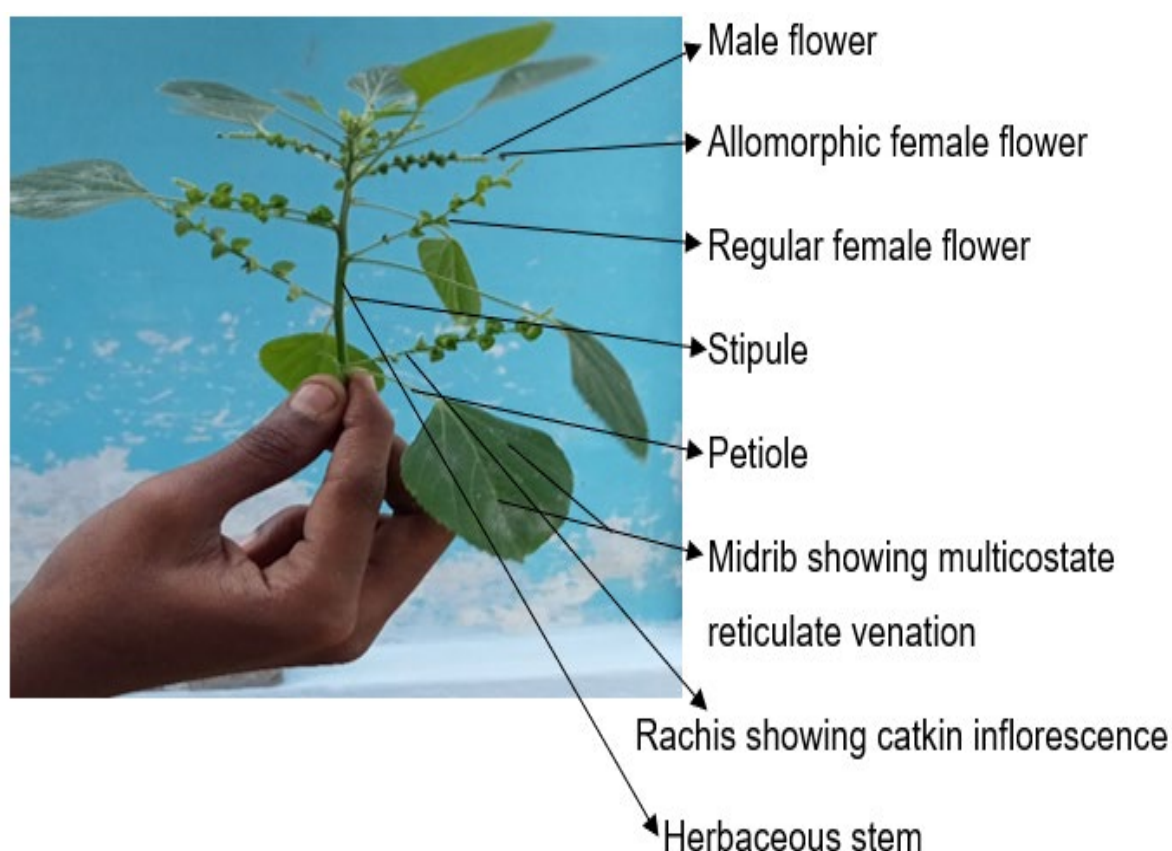


Fig: 4.31 : *Acalypha indica* twig

Leaves are very important vegetative organs because they are mainly concerned with photosynthesis and transpiration. Leaves have three tissue systems namely epidermal tissue system, ground tissue system, and vascular tissue system. The epidermal tissue system consists of an upper epidermis and lower epidermis. Stomata occur in both the epidermis but more frequently in the lower epidermis. The ground tissue system that lies between the epidermal layers of the leaf is known as mesophyll tissue. Often it is differentiated into palisade parenchyma on the upper side and spongy parenchyma on the lower side. A leaf showing this differentiation is designed as dorsiventral. It is common in dicot leaves. The mesophyll tissue, especially spongy parenchyma cells enclose a lot of air spaces. The presence of air spaces is a special feature of spongy cells. They facilitate the gaseous exchange between the internal photosynthetic tissue (mesophyll) and the external atmosphere through the stomata. The vascular tissue system is composed of vascular bundles. They are collateral and closed. The vascular tissue system forms the skeleton of the leaf and they are known as veins. The veins supply water and minerals to the photosynthetic tissue. Thus, the morphological and anatomical features of the leaf help in its physiological functions.

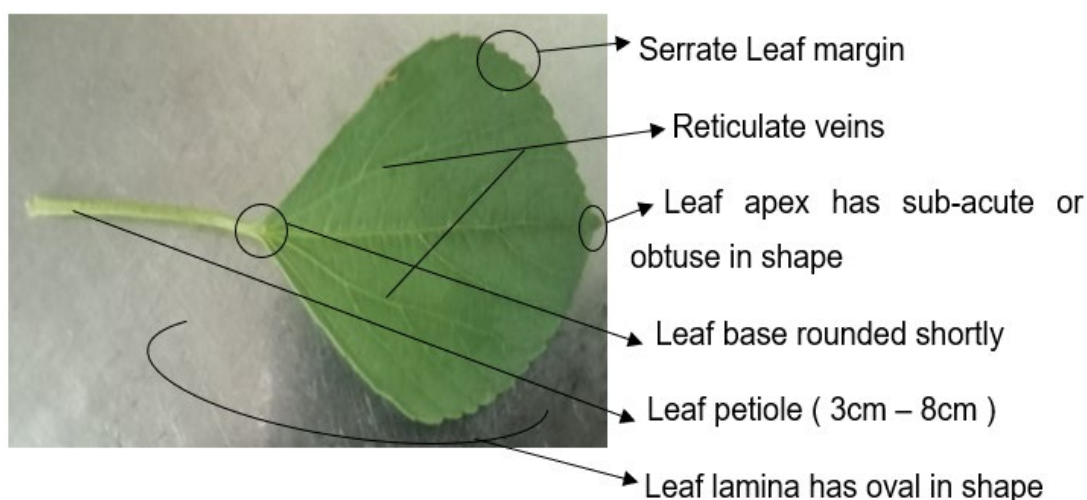


Fig: 4.32 : Morphological features of *Acalypha indica* leaf

a) Epidermis – A dicotyledonous leaf is generally dorsiventral. It has an upper and lower epidermis. The epidermis is usually made up of a single layer of cells that are closely packed. The cuticle on the upper epidermis is thicker than that of the lower epidermis. The minute opening found on the epidermis is called stomata. Stomata are more in number on the lower epidermis than on the upper epidermis. A stoma is

surrounded by a pair of bean-shaped cells called guard cells. Each stoma opens into an air chamber. These guard cells contain chloroplasts, whereas other epidermal cells do not contain chloroplasts. The main function of the epidermis is to give protection to the inner tissue called mesophyll. The cuticle helps to check transpiration. Stomata are used for transpiration and gas exchange.

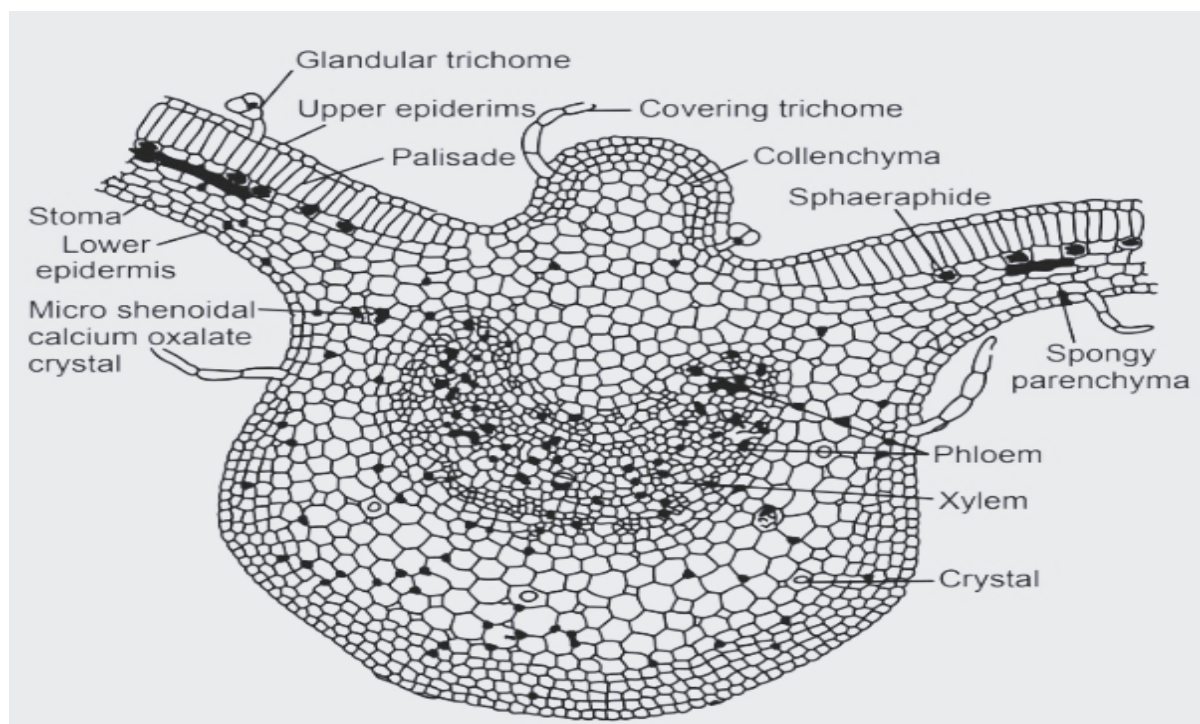


Fig: 4.33 : T.S [Transverse section] (Anatomy) of *Acalypha indica* leaf

b) Mesophyll – The entire tissue between the upper and lower epidermis is called the mesophyll (Greek word meso – in the middle; phyllome – leaf). There are two regions in the mesophyll. They are palisade parenchyma and spongy parenchyma. Palisade parenchyma cells are seen beneath the upper epidermis. It consists of vertically elongated cylindrical cells in one or more layers. These cells are compactly arranged without intercellular spaces. Palisade parenchyma cells contain more chloroplasts than spongy parenchyma cells. The function of palisade parenchyma is photosynthesis. Spongy parenchyma lies below the palisade parenchyma. Spongy cells are irregularly shaped. These cells are very loosely arranged with numerous airspaces. As compared to palisade cells, the spongy cells contain a lesser number of chloroplasts. Spongy cells facilitate the exchange of gases with the help of air spaces. The air space that is found next to the stoma is called the respiratory cavity or sub-stomatal cavity.

c) Vascular tissues – Vascular tissues are present in the veins of the leaf. Vascular bundles are conjoint, collateral and closed. Xylem is present towards the upper epidermis, while the phloem towards the lower epidermis. Vascular bundles are surrounded by a compact layer of parenchymatous cells called bundle sheath or border parenchyma. Xylem consists of metaxylem vessels and protoxylem vessels. Protoxylem vessels are present towards the upper epidermis. Phloem consists of sieve tubes, companion cells and phloem parenchyma. Phloem fibres are absent. Xylem consists of vessels and xylem parenchyma. Tracheids and xylem fibres are absent.

Explant (leaf) of *Acalypha indica* is the most important vegetative organ because they involved in photosynthesis and acquire food materials (glucose) for plant development. First, Carbon-di- oxide (CO_2) is released and enter into mesophyll tissue of the leaf by the small opening in the epidermis called stoma with the water. Then more amount of CO_2 and water entered in the palisade cells compared to the spongy cells. Because palisade parenchyma consists of more no. of chloroplasts. Chloroplasts consists of chlorophyll, carotenoid, xanthophyll, cytochrome, DNA, RNA, manganese, etc. CO_2 and water combined with the chlorophyll in palisade and spongy cells react with sunlight to produce more amount of food materials and air (O_2) and less amount of water. Food materials is directly entered into the vascular tissue through bundle sheath. Remaining air and water released out of the plant body by stroma. Stroma is opening and closed due to the high pressure in mesophyll region.

Found catkin (racemose) inflorescence in axillary spikes at 2.5cm-6.5cm long. Flowers are monoecious, rachis ending in a triradiate hood at the tip. Male flowers are found in the upper part of the tricarpellary female flower without bract, looks pale green to yellow in colour, small and clustered. Two female flowers are found in the plant. Tricarpellary regular female flower is found on the lower part of the male flower with toothed bracts subtended by foliaceous, cuneiform and looks thick green in colour. Bracts contains many nerved and has 6mm-8mm in diameter. Another female flower with only one carpel found triradiate hood in the tip of the inflorescence axis is called an allomorphic female flower or monocarpellary flower.



Fig: 4.34 : Catkin inflorescence in *Acalypha indica*

Perianth – Tepals 4, arranged in single whorl, gamophyllous, In *Euphorbia* species, the perianth in flowers is aphyllous (devoid of perianth), and fused by valvate aestivation. Tepals 3 and 4 in female flowers, arranged in single whorl, gamophyllous, valvate aestivation and odd tepal is posterior in position.

Androecium – Stamens 8, free or united, polyadelphous, filaments free or branched. They are fused into several bundles. Anthers are vermiculiform. Rudimentary ovary called pistillode is absent in male flower. Male flowers are Ebracteate, ebracteolate, pedicellate, actinomorphic and incomplete.

Gynoecium – Ovary superior, tricarpellary, trilocular, and syncarpous. Ovary with one or more ovules in each locule on axile placentation. Ovary hispid, distinctly 3 lobed. Styles 3, simple, filiform, and each ending in bifid stigma but in allomorphic flower, ovary superior, monocarpellary, unilocular and syncarpous. Ovary is cylindrical-like shaped inside the lateral open mouth in flower. Female flowers are Bracteate and Ebracteate, ebracteolate, pedicellate, actinomorphic, incomplete, and hypogynous.



Fig: 4.35: Clusters of male flowers found in the upper part of tricarpellary regular female flower



Fig: 4.36 : Regular female flower showing ovary three carpels with bract



Fig: 4.37 : Allomorphic female flower at tip of the inflorescence axis

In *Acalypha*, fruit is called as capsule. It is concealed inside the bract. Fruit has 1mm-2mm in diameter, 3-valved, hardly enlarged, green in colour, hispid, pubescent and dehiscent while in allomorphic flower, the upper part of the cylinder elongates, so the allomorphic fruit becomes triangular shape with downward apex. Seed 3, endospermous, lead coloured or pale brown in colour, glabrous, along ovoid and smooth. Seed has 1mm in diameter while in allomorphic fruit, single seed inside in the cylindrical ovary, mericarp, orange-red in colour and subglobose.

4.8.1.3 Economic importance

There are cyanogenic glycosides, such as acalyphine as well as flavonoids, such as mauritianin, clitorin, nicotiflorin, and biorobin in the aerial parts of the plant. The decoction of the leaves is used to promote the removal of mucous secretions from the bronchial tubes and promotes the flow of urine. The decoction of the leaves mixed with

common salt works as a laxative. The juice of the crushed leaves is applied externally to cure scabies. Children are treated with powdered leaves for deworming. Particularly in children, the juice of the leaves is reputed to cause vomiting. The juice of the leaves mixed with lime and applied to the skin to cure ringworm. The juice of the leaves mixed with oil and salt is used to cure arthritis, scabies and pneumonia. Earaches can be treated with the decoction of the leaves. The poultice of the leaves is applied externally to syphilitic ulcers and is also a means of relieving the pain of a non-poisonous snake bite and irritation caused by the bite of the centipede. Throughout the area where the plant grows, it is widely known for its effect on domestic cats, which react very favourably and strongly to the root of the plant. The plant is very attractive to cats. So, this plant in tamil is referred as poonamayakki. Iridoid compounds such as isodihdropetalactone and isoiridomyrmecin chemicals are present in *Acalypha indica*. These chemicals makes attract the cats.

4.8.2 Crop description (*Coriandrum sativum* Linn.,)

The above morphological and anatomical features of *Coriandrum sativum* is fully discussed and about the economic importance of the crop. Our crop in the smart farming technique is *Coriandrum sativum* and here we learnt its botanical nature.

4.8.2.1 Taxonomic classification

Class: Dicotyledonae

Sub-class: Rosidae

Series: Calyciflorae

Order: Apiales

Family: Apiaceae

Genus: *Coriandrum*

Species: *sativum*

4.8.2.2 Morphological and anatomical features of crop

Coriandrum sativum is an annual cultivated herb. The plant height is 12 -24 inches. It is a spice crop and has distinct flavouring substances. Tap root system is generally seen in *Coriandrum sativum*. Stem is generally herbaceous, aerial, erect, branched stem, cylindrical and green with a pleasant smell. Leaves are alternate, petiolate, exstipulate, compound, leaflets narrow, 2-3 lobed, unicostate reticulate venation, aromatic smell present. The plant's leaves have a variety of shapes, including large lobed leaves at the base and delicate and feathery leaves higher up on the flowering stalks. It's a hairless, squishy plant.

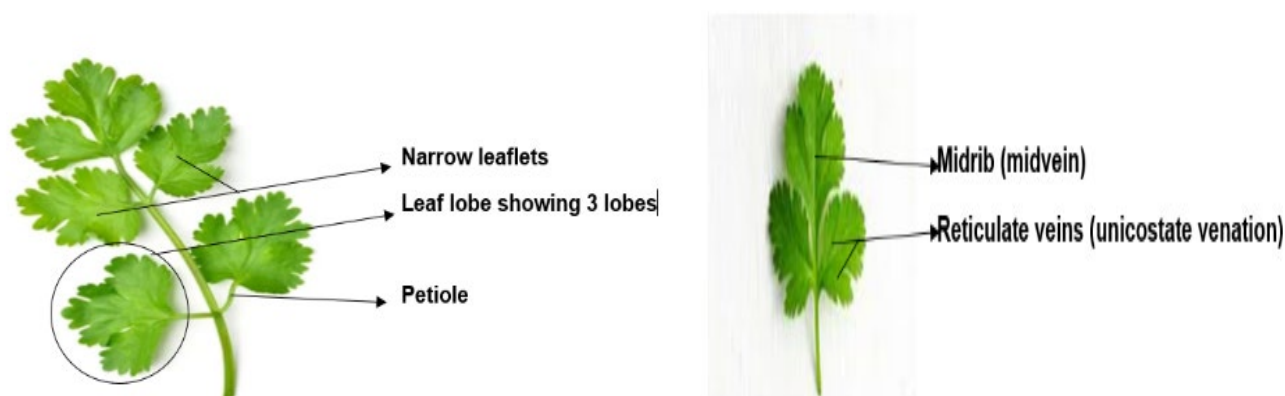


Fig: 4.38 : Leaf of *Coriandrum sativum*

Coriandrum sativum has compound umbel inflorescence (the group of flowers it looks like an umbrella) and each unit of the inflorescence is called umbellule. The primary branches of the flower are called as ray in umbel inflorescence. Bracts are found in the flower called involucler bracts and the bracts found in the inflorescence called involucre bracts and the single main stalk of the inflorescence called peduncle.



Fig: 4.39 : Umbel inflorescence in *Coriandrum sativum*

Flowers are Bracteate, Complete, bisexual, peripheral flowers are zygomorphic flowers and central flowers are actinomorphic flowers, epigynous flowers, small and light pink with white. The flowers are white or very pale pink in colour and are produced in tiny umbels, with the petals pointing away from the centre of the umbel being longer than those pointing towards it.

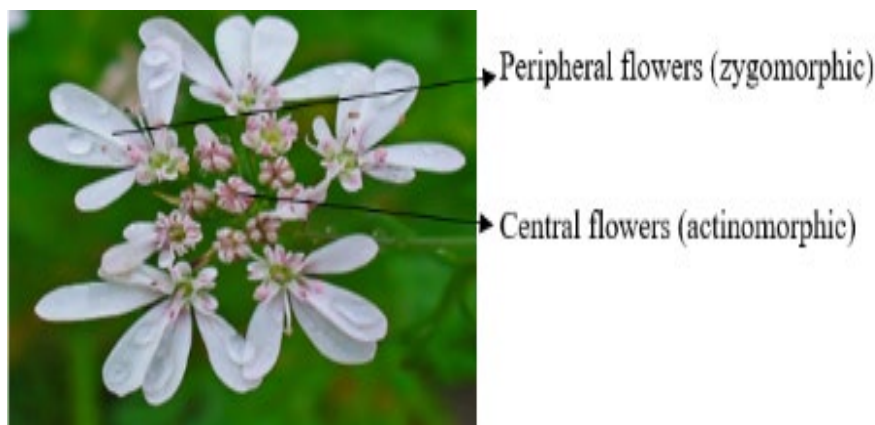


Fig: 4.40 : Flowers showing two types zygomorphic and actinomorphic

- a) Calyx - Sepals 5, gamosepalous, green, showing valvate aestivation, and odd sepal is posterior in position.
- b) Corolla - Petals 5, polypetalous, light pink and white, showing valvate aestivation and each petal bilobed, in zygomorphic flowers have one anterior petal with large equal lobes, two lateral petals with unequal lobes, two posterior petals with small equal lobes.
- c) Androecium - Stamens 5, polyandrous, filament long and slender, anthers are dithecous and dorsifixed anther and free.
- d) Gynoecium - Ovary inferior, bicarpellary, syncarpous, bilocular, and one ovule in each locule on axile placentation. Style two long and slender. Stigma two, a disc called stylopodium present below the style.

The dry fruits of *Coriandrum sativum* are seeds and have a spicy taste. The seeds contain from 0.1 to 1 percent essential oil and its principal component is coraindrol. Cremocarp split into two mericarps.

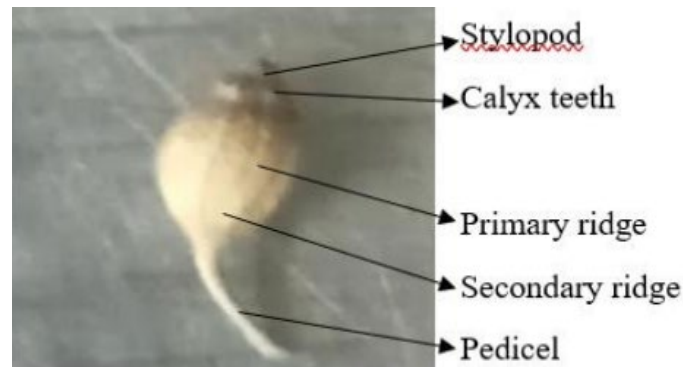


Fig: 4.41 : Complete seed of *Coriandrum sativum* (Cremocarp)

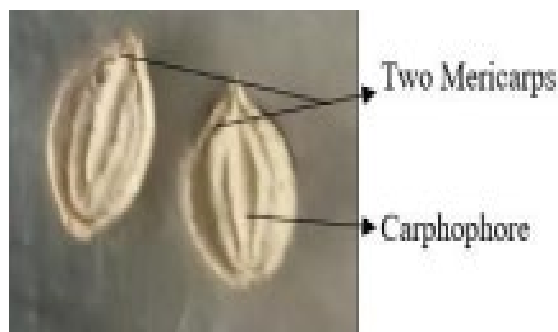


Fig: 4.42 : Mericarp separated *Coriandrum sativum* seed

A dorsal and commissural surface can be seen in the transverse slide of the coriander. Two vittae and a carpophore make up the dorsal surface. There are five basic ridges and four subsidiary ridges on the dorsal surface. The epicarp is made up of a single row of tiny cells with strong walls and calcium oxalate crystals. The mesocarp (Layer 1) comprises two layers: an exterior layer of loosely tangentially elongated parenchyma cells and an inner layer of sclerenchyma cells. The intermediate layer is separated again; longitudinally running fibres represent the outside region of sclerenchyma, while tangentially running fibres represent the inner region.

Below the major ridges are the vascular bundles. Polygonal, unevenly organized parenchyma cells make up the inner layer. The endocarp is laid out in a parquet pattern. The endosperm is thick, polygonal, colourless parenchyma with fixed oil and aleurone grains, while the testa has single-layered, yellowish cells.

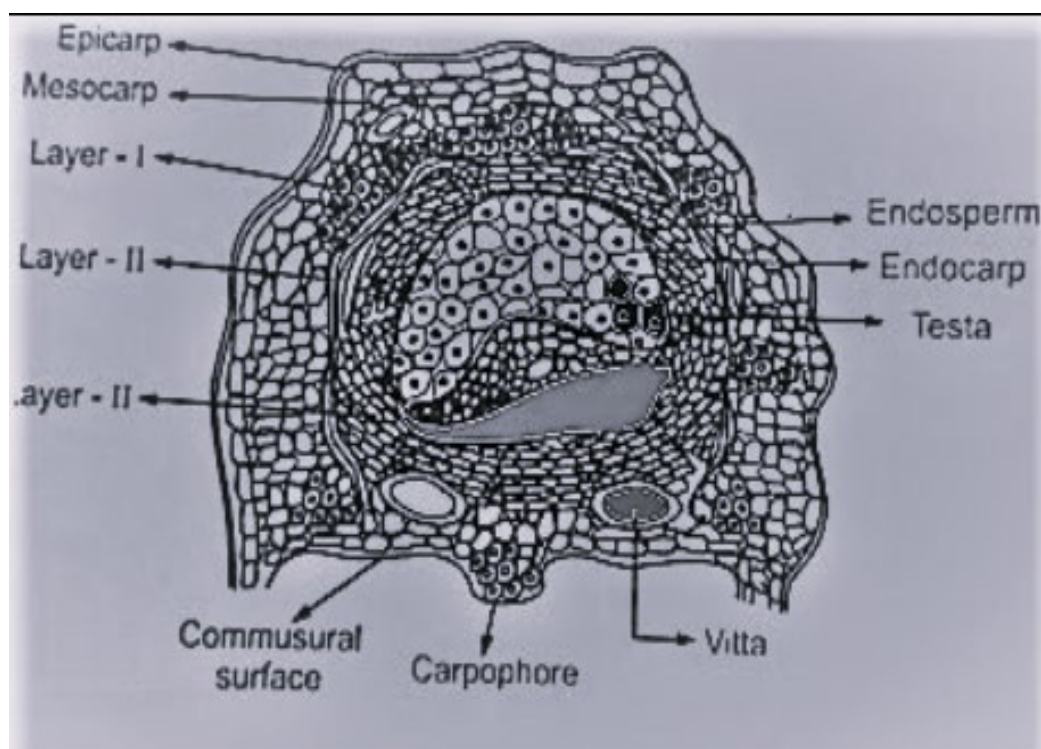


Fig: 4.43 : Transverse Section (Anatomy) of *Coriandrum sativum* fruit (Mericarp)

Mericarps are normally well-behaved. Each mericarp has 5 prominent, straight, longitudinal primary ribs and 4 indistinct, undulate secondary ribs; mericarps easily separated, deeply concave on the inner or commissural surface, and showing in transverse section 2 vittae (oil tubes) on the inner surface of each. Sections of *Coriandrum sativum* fruit show an epidermis of small cells with thick walls; a layer of several rows of thin-walled more or less collapsed parenchyma separated from a broad zone of strongly lignified, sclerenchymatous fibres (Layer 2) that extend as a continuous ring in the mesocarp of each of the mericarps; 2 or 3 layers of large, tangentially elongated, thin-walled par inner epidermis of big tabular cells, with thickened inner yellowish walls that are closely related to the seed coat's brownish cells; The cells of the pericarp detached from the seed coat and formed a big elliptical cavity; commissural surface with two enormous, elliptical vittae; endosperm with a reniform contour and tabular or polygonal thick-walled cells containing multiple big aleurone grains, each with a rosette aggregation or calcium oxalate prism.

The below table listed as the nutrients and chemical composition in single coriander leaf and single coriander seed for how we used coriander as a edible and flavouring herb.

Table 4.7 : Nutrient composition of Coriandrum sativum

NUTRIENTS	IN LEAF	IN SEED
Protein	21.93g	12.37g
Fat	4.78g	17.77g
Glucose	52.10g	54.99g
Calcium	1246mg	709mg
Iron	42.46g	16.32g
Magnesium	694mg	330mg
Phosphorous	481mg	409mg
Potassium	4466mg	1267mg
Sodium	211mg	35mg
Zinc	4.72mg	4.70mg
Vitamin C	566.7mg	21.0mg
Thiamine	1.252mg	0.239mg
Riboflavin	1.500mg	0.290mg
Niacin	10.707mg	2.130mg
Cholesterol	0mg	0mg

4.8.2.3 Economic importance

All parts of the plant are edible, but fresh leaves and dried seeds are the most commonly utilized. The essential oil of *Coriandrum sativum* stimulates gastric secretion. It contains carminative, eupeptic, estrogenic, and spasmolytic properties. It has antibacterial and antifungal properties as well. *Coriandrum sativum* is used to treat

hyposecretion, loss of appetite, gastrointestinal spasms, gastroenteritis, acute cystitis, urethritis, amenorrhea, and osteoarthritis due to its characteristics. In Chinese medicine, it is used to treat appetite loss, chickenpox and measles in their latter stages, hemorrhoids, and rectal prolapse. It is used to treat nosebleeds, cough, hemorrhoids, edema, bladder disease, vomiting, dizziness, and amoebic dysentery in Indian medicine. According to Ayurveda, *Coriandrum sativum* prevents flatulence and relieves spasmodic discomfort. Leaves of *Coriandrum sativum* is used as flavouring substance in traditional Indian foods such as sambar, rasam, poriyal, etc. The dry fruits of *Coriandrum sativum* is used to prepare a delicious Coriander powder and also used to prepare a sambar powder, garam masala and gives a spicy taste.

4.9 SIMULATION

4.9.1 Simulation in proteus

The circuit diagram of the system is shown below (Figure; 5.1.1(a)) that was simulated in Proteus 8 professional software. pH sensors and temperature sensors are analog inputs and the remaining sensors are connected in digital inputs values. pH sensor is connected at A0 pin of Arduino; Temperature sensor connected at A1 pin of Arduino; Soil moisture sensor connected at A2 pin of Arduino; PIR sensor connected at A3 pin of Arduino; Water level sensors connected at A4, A5, A6 pin of Arduino and the relay 1 connected at the 14 pins of Arduino; relay 2 connected at the 15 pins of Arduino; relay 3 connected at the 16 pins of Arduino; relay 4 connected at the 17 pins of Arduino; relay 5 connected at the 18 pins of Arduino and relay 6 connected at the 19 pins of Arduino and switch is connected at the 6 pins of Arduino. LCD is connected at the pin of 12, 11, 10, 9, 8, 7 of Arduino.

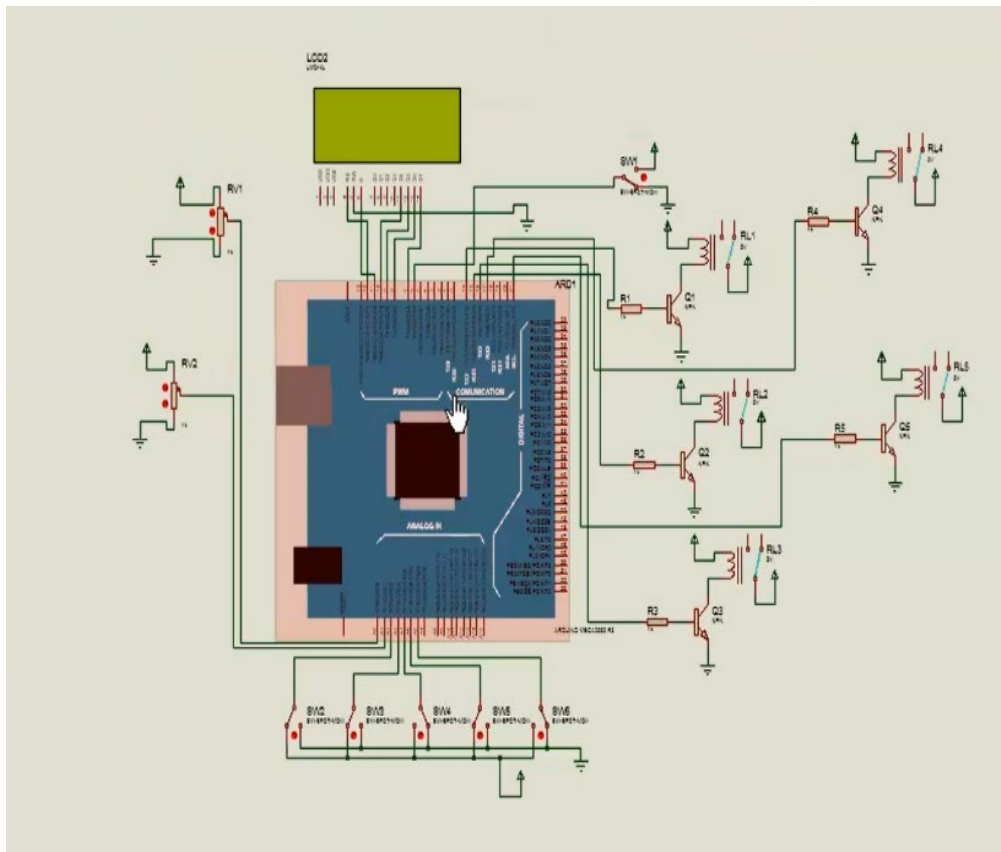


Fig: 4.44 : Circuit diagram for the smart farming technique

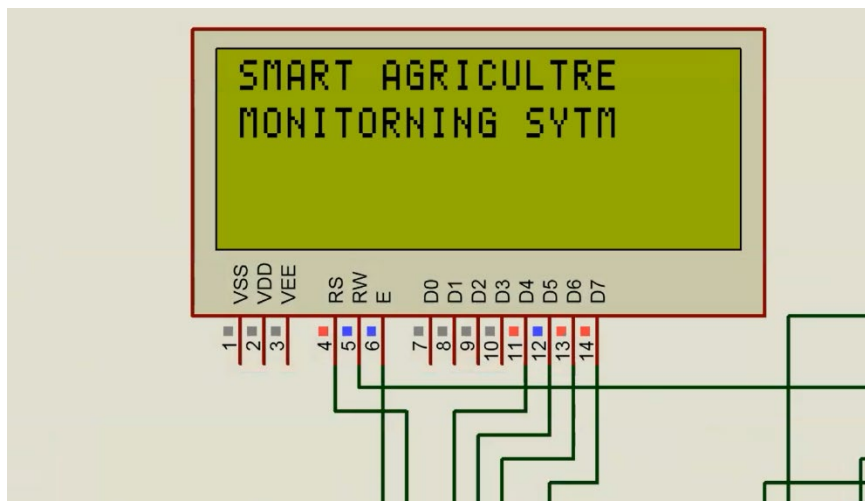
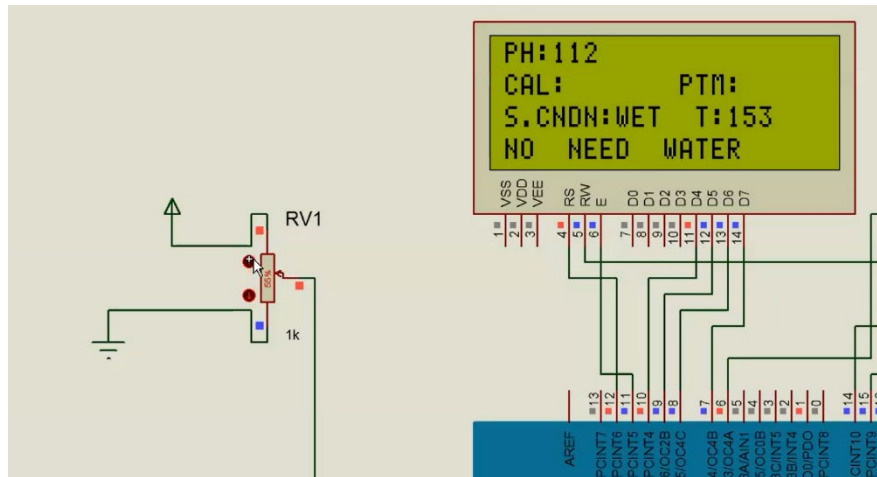
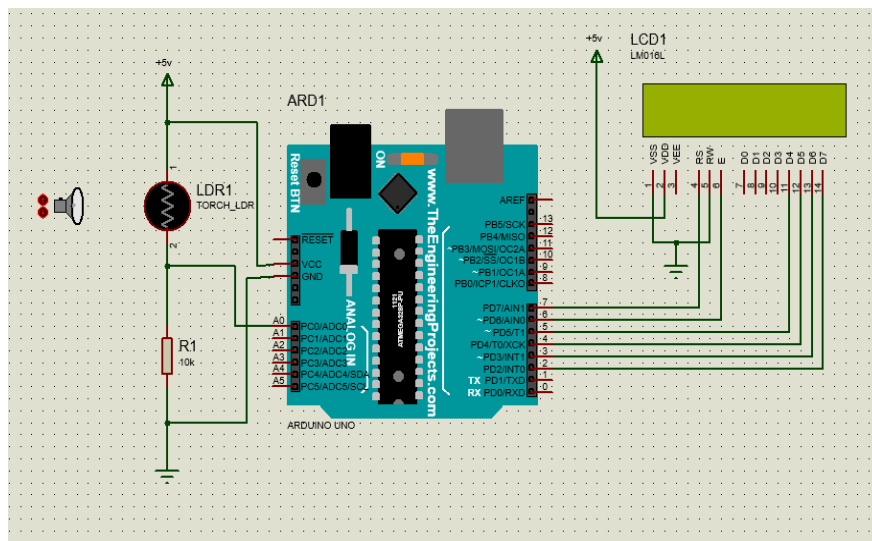


Fig: 4.45 : LCD displaying smart agriculture and monitoring system



In the technique invitro culture, we used KY018 photoresistor sensor module for the light incubation process. There are three pins in the sensor. An input pin (+ve) is connected to the A0 pin of Arduino and an output pin (-ve) is connected to the ground of the Arduino. Then voltage pin (Vcc) is connected to the 5V pin of Arduino. LCD is connected at the pin 7, 6, 5, 4, 3, 2 of Arduino. Result in the LCD displayed the intensity of lightness while a torch light on/off (Demonstration of Circuit diagram in Proteus).



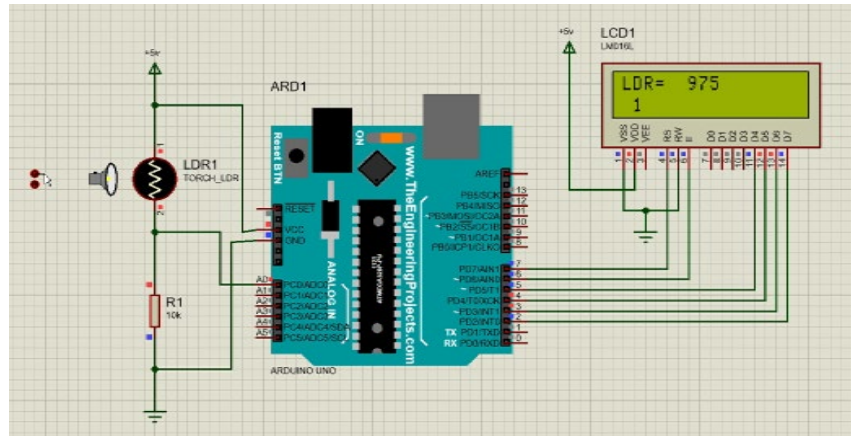


Fig:4.48 : Intensity of Lightness when torchlight is ON near LDR

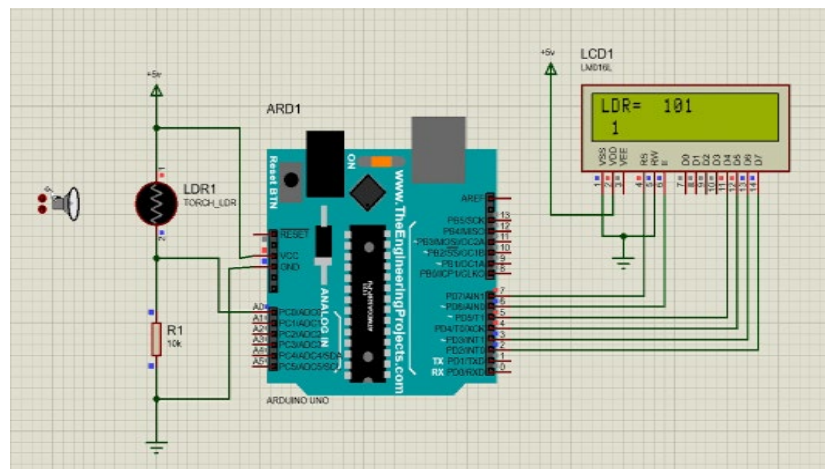


Fig: 4.49 : Intensity of Lightness when torchlight is ON at a distance

4.9.2 Simulation in Arduino IDE

Circuit diagram of Smart farming technique in Proteus 8 Professional (Figure 4.1.1(a)) as per the same connections in the hardware setup. The working of the sensor detection and working of Arduino and relay circuit is simulated by the program have been given in Arduino IDE. But, the second simulation of Proteus (Light incubation in the culture room), is a demonstration in LCD. But, in the hardware connection of the KY018 photoresistor sensor, the output is displayed in the Serial monitor. The serial monitor shows the Light intensity of the photoperiod of lightness and darkness.

```
Light Intensity:3888 lux
Light Intensity:3607 lux
Light Intensity:3150 lux
Light Intensity:3363 lux
Light Intensity:3150 lux
Light Intensity:3150 lux
Light Intensity:2961 lux
Light Intensity:3150 lux
Light Intensity:3150 lux
Light Intensity:3150 lux
Light Intensity:3150 lux
```

Fig: 4.50 : Intensity of Light in a photoperiod of Lightness

```
Light Intensity:0 lux
Light Intensity:0 lux
Light Intensity:0 lux
Light Intensity:0 lux
Light Intensity:0 lux
Light Intensity:0 lux
Light Intensity:0 lux
Light Intensity:0 lux
Light Intensity:0 lux
Light Intensity:0 lux
Light Intensity:0 lux
```

Fig: 4.51 : Intensity of Light in a photoperiod of Darkness

4.10 ANALYSIS

4.10.1 Analysis of plant growth

C program is used to analyze plant growth and regeneration. C plays a significant role as mother language for all computer programs and this result analysis may help for writing and knowing any of the programming code and the result is observed that the regenerated plantlet is transferred to the field conditions with a 100% survival rate successfully. C compiler is used here to write code for the analysis of plant growth and this analysis help to imagine and analyze the plant regeneration. (Note: This is an imaginary initial analysis of growth of the plant). Here we use a while statement for analyzing the one-by-one part of the growth. Then we use a choice statement to analyze any part of the growth of the plant.

```

/tmp/UJUTr1SvIT.o
****  AN INVITRO MICROPROPAGATION OF ACALYPHA INDICA LINN***
~~~~~
Analysis of Callus initiation, Shoot initiation and Root initiation in Murashige
and Skoog medium
1. Leaf of the plant[explant](PL)
2. Callus initiation(C)
3. Shoot initiation(SI)
4. Root initiation(R)
5. Plant growth period(T)
6. Relative Plant growth rate(RR)
7. Absolute Plant growth rate(AR)
8. Net Plant growth rate(PGR)
9. Result of the experiment(RES)
10.EXIT
ENTER MY CHOICE <1-10>|

```

Fig: 4.52 : Output of program code showing 10 choices

```

ENTER MY CHOICE <1-10>9
****9.Result of the experiment***

Value for the Result of the experiment(RES)===>

Result of the experiment is
REGENERATED PLANTLETS OF ACALYPHA INDICA IS TRANSFERRED TO THE FIELD
CONDITIONS WITH 100 PERCENT SURVIVAL RATE|

```

Fig: 4.53 : Final output for the program code

4.10.2 Finite element analysis and modelling of culture vessel

The Finite Element Analysis (FEA) method involves simulating goods and systems in a virtual environment in order to identify and resolve potential structural or performance problems. A finite element is formed by discretizing or dividing the material on that small divided part is called as an element. The element may be classified as a one-dimensional element, two-dimensional element, and three-dimensional element in Finite element analysis. Triangular and rectangular elements are two-dimensional elements. Axisymmetric elements are also two-dimensional

elements. An axisymmetric element may be defined as that the discretize the body or material into vertical y-axis, both the section gets similar in shape and structure. Cylinder, cone, sphere are examples of axisymmetric objects. Here, the culture vessel is cylindrical in shape. So, this material is an example of Axisymmetric. So, this material can be analyzed and modelling in Ansys software (one of the FEA software). Here we used Ansys Mechanical APDL (R2 Version).

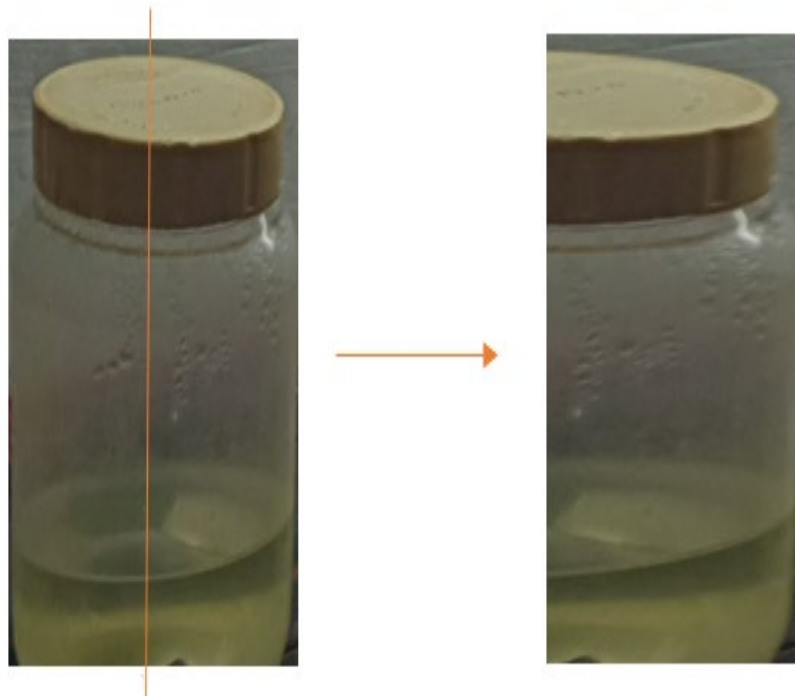
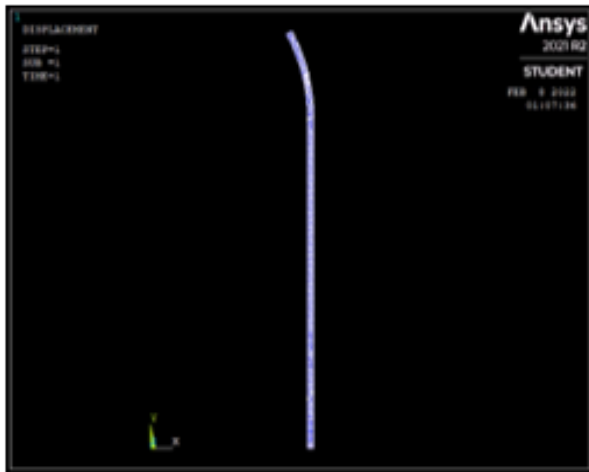
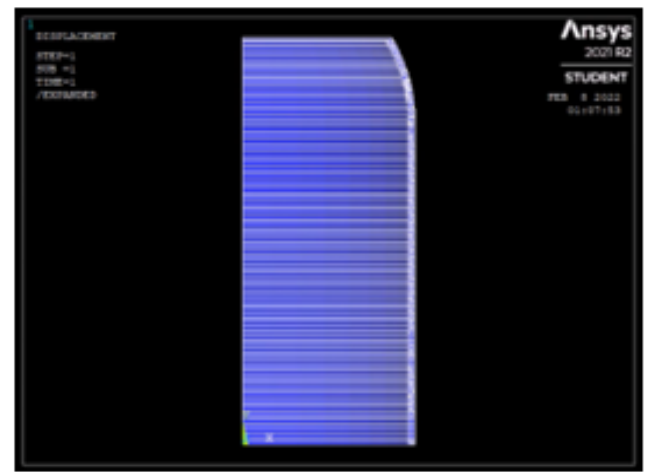


Fig: 4.54 : Culture vessel is an axisymmetric material

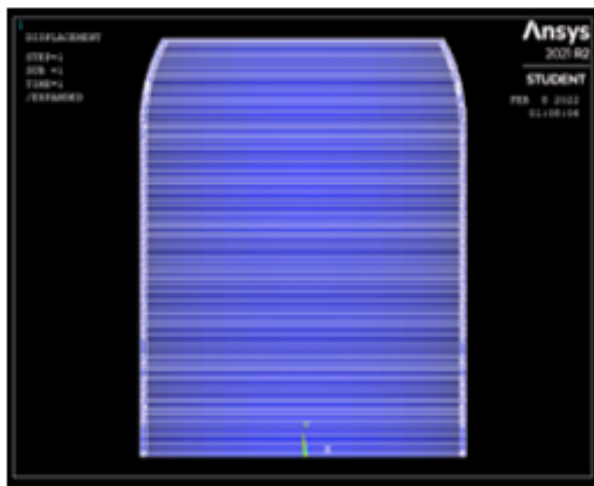
Preprocessor, Analysis, and Post-processing are the three methods to answer the solutions in Finite Element Analysis. The preprocessor includes the input value of the material such as material properties, modelling inputs, and element type, etc. The analysis involves analyzing the solution. Postprocessing is the process to view the analyzing result. Below Figure (Figure: 5.2.2(b)) 1 shows that the result of the modelling of the culture vessel and all pictures show the axisymmetric material and expansion of the axisymmetric material and isometric view of the culture vessel. Expansion of the culture vessel (axisymmetric object) shown in Figure is $\frac{1}{4}$ expansion, $\frac{1}{2}$ expansion, $\frac{3}{4}$ expansion, and full expansion and the full modelling and analysis of material for isometric view.



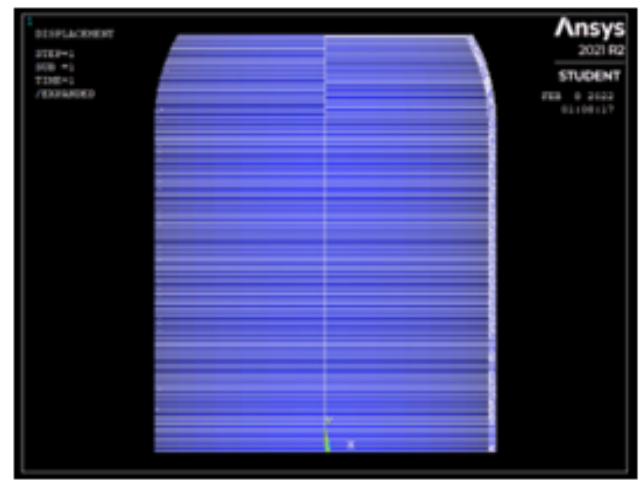
Axisymmetric material (culture vessel)



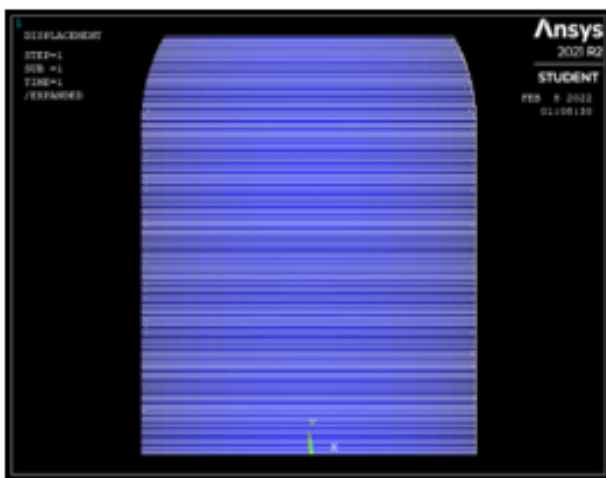
$\frac{1}{4}$ expansion of culture vessel



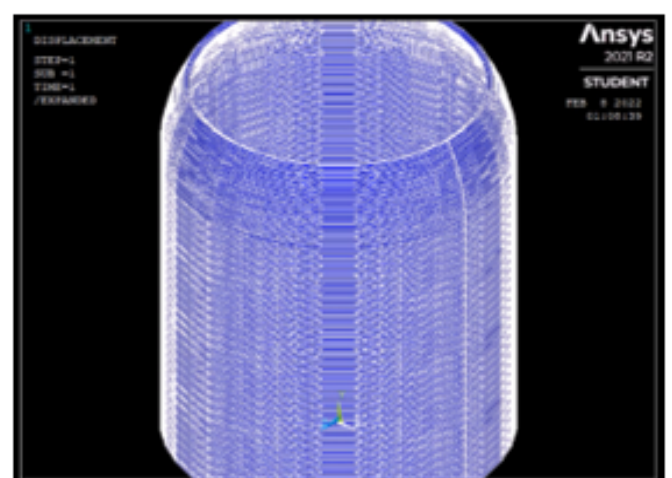
$\frac{1}{2}$ expansion of culture vessel



$\frac{3}{4}$ expansion of culture vessel



Full expansion of culture vessel



Isometric view of culture vessel

Fig: 4.55 : Results in the modelling of Culture vessel

CHAPTER 5

RESULTS AND DISCUSSIONS

5.1 RESULTS IN SMART FARMING TECHNIQUE

The above technologies and hardware combinations are used to design this system and are extensively used as farming technology and results showing higher accuracy and become a success. All hardware components are fitted in a small board called kit and the connection wire of relay and sensor are larger because in working may be water and some other sources are affecting indirectly the electronic components like power supply board, Arduino board, and relay board. So, the project looks massive with longer wires and more hardware components and the project is not expensive. Farmers easily understand how the sensors will work and output will show even uneducated farmers also learn this system easily and quickly.

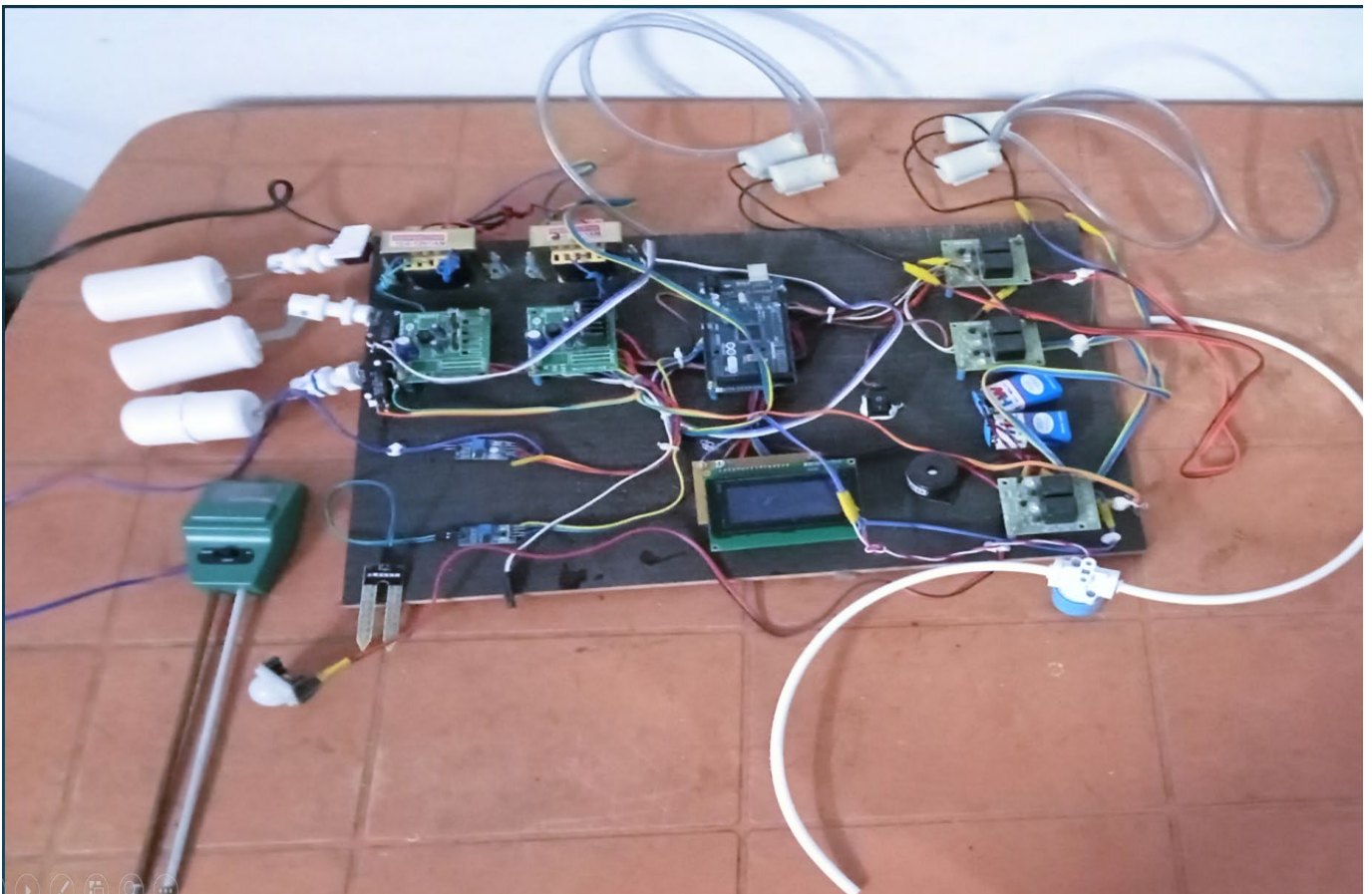


Fig: 5.1 : Final connection of the proposed system

There are two modes in the smart farming technique namely sampling mode and testing mode. Our farming consists of two modes, namely testing mode and sampling mode. Sampling mode involves testing the soil nutrient in the land, checking the optimum temperature in the land, and checking the water level in the field. Testing mode involves providing automatic irrigation for the crop, to provide fertilizers to the soil.

5.1.1 Sampling mode

The results of the Sampling mode and the output of the sensors displayed in the LCD are shown in the below figure (Figure. 6.1.1). Soil pH in the land 6, then the calcium and potassium in the soil has 5.2% and 10.9%. So, calcium fertilizers is take more level to the land compared to the potassium fertilizer. If soil condition is dry, irrigation takes place by any of the water sources, water level in the source is high. So, displayed water level of the source 1 (borewell) and source 2 (watertank). Here C and P refers to Calcium and Potassium.



Fig: 5.2 : LCD displaying pH value, nutrient values in the soil, soil moisture condition, level in the water sources, and displaying water taken from the source.

5.1.2 Testing mode

The results of the Testing mode and the output of the sensors displayed in the LCD are shown in the below figure (Figure: 5.2). Irrigation is tested from the water sources by the water pump when water level sensor detects the water level. Automatic fertilizers (Calcium and Potassium) are tested by the water pump when pH sensor

detects soil moisture. If more water level in the field, water level sensor detects, water removed by the solenoid valve.



Fig: 5.3 : Providing irrigation to the land



Fig: 5.4 : Providing fertilizers to the soil



Fig: 5.5 : More water level in the field and water removed by a solenoid valve

5.1.3 Crop production

The crop *Coriandrum sativum* (Dhaniya) is our model. The seed of the *Coriandrum sativum* is a dicot seed we split the seed into the two cotyledons cremocarp into the 2 mericarps. Seed is sown into clay containing tray and take a farming method by using this system and the crop *Coriandrum sativum* is grown on 20-25 days with longleaf with stem and has an aromatic pleasant. Thus, our farming method is completed by growing this crop and the crop is useful in daily cooking and most edible crop.



Fig: 5.6 : Coriander seeds cremocarp split into two mericarps



Fig: 5.7 : Seed sewn into the soil



Fig: 5.8 : *Coriandrum sativum* crop grown by farming system

5.2 RESULTS IN INVITRO CULTURE TECHNIQUE

When compared to the full MS culture medium, the $\frac{1}{2}$ strength of MS medium demonstrated good shoot proliferation and root regeneration in this case study on in vitro micropropagation of *Acalypha indica*. Explants of leaf nodes from the mother plant of *Acalypha indica* are placed on the $\frac{1}{2}$ strength of MS medium supplemented with the concentrations of NAA(1.5mg/ml) for the induction of callus tissue on yellow compact colour at the highest percentage of 62.3% (Table-5.1). Explants of leaf nodes showed the highest percentage of the shoot (63.2%) supplemented with the concentrations of BAP (1 mg/ml) and KIN (0.5mg/ml) on $\frac{1}{2}$ strength of MS medium. Cytokinin hormones involved in shoot regeneration BAP showed 59% of the shoot with a length of 3.4cm and KIN showed 57% of the shoot with the length of 5.3cm with 4.1 shoots per explant. (Table-5.2). The highest frequency 62% of shoot proliferation is observed on the $\frac{1}{2}$ strength of MS medium supplemented with the concentrations of BAP (1mg/ml) and NAA (0.5mg/ml). Cytokinin plays an important role in inducing bud proliferation and shoot proliferation from the explant of leaf nodes and this concentration showed 2.8 shoots per explant and 3.9cm shoot length (Table-5.3). The invitro regenerated shoots were augmented with the concentrations of IAA (1.5mg/ml) on $\frac{1}{2}$ strength of MS medium with 68% on average numbers of roots (23.3) and the maximum length of roots (3.4cm) (Table-5.4).

Table 5.1 : Effect of Auxin and Cytokinin growth regulators on the induction of callus tissue from explants of leaf nodes of *Acalypha indica*

BAP (mg/ml)	NAA (mg/ml)	2,4-D (mg/ml)	No. of days on callus induction from nodal explants	(%) of response from nodal explants	Callus colour and type
0	1.5	0.0	15-30	62.3	Sh, Ye, Fr
1.0	0.0	0.0	15-30	52.1	Sh, Ye
2.0	0.0	0.0	15-30	54.9	Sh, Wh
3.0	0.0	0.0	15-25	65.2	Sh, Gr
0.0	0.0	0.5	15-30	63.6	Gr, Wh
0.0	0.0	1.0	15-30	74.3	Gr, Wh
0.0	0.0	1.5	15-20	81.5	Gr
0.0	0.5	0.0	15-25	57.6	Ye, Fr
0.0	1.0	0.0	15-30	68.8	Ye, Fr

Note: Sh – induced shoot; Ye – light yellow compact callus; Fr – Soft friable callus; Wh – white compact callus; Gr – green compact callus

Table 5.2 : Effect of Cytokinin hormones on the shoot initiation from the explants of leaf nodes of *Acalypha indica*

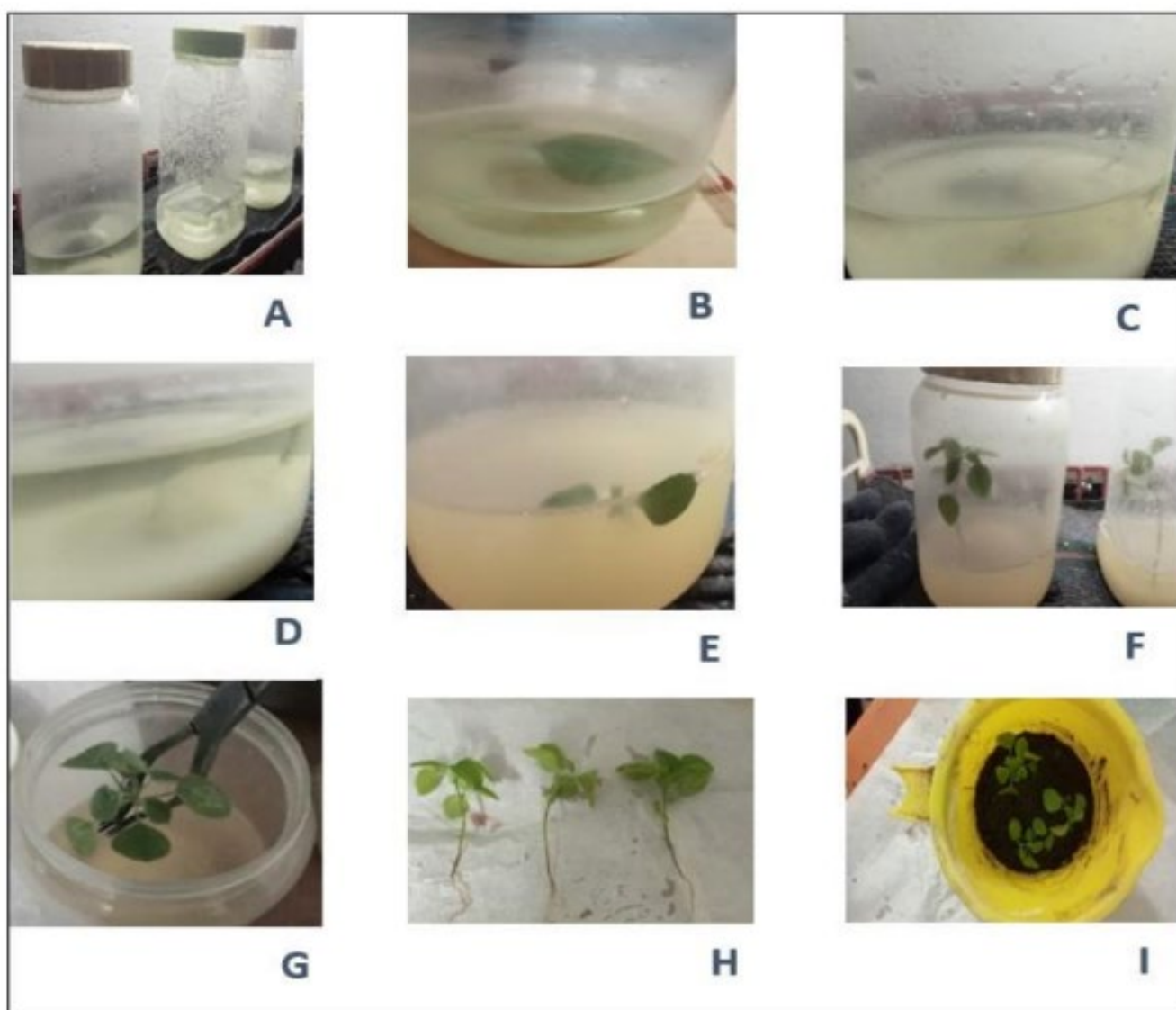
BAP (mg/ml)	KIN (mg/ml)	(%) of response from nodal explants	Average no. of shoots ($\pm$ SE)	Average no. of Shoots ($\pm$ SE)
0.5	0.0	47.6	1.4 $\pm$ 0.10	1.8 $\pm$ 0.06
1.0	0.0	59.5	3.2 $\pm$ 0.06	3.4 $\pm$ 0.10
1.5	0.0	57.3	2.8 $\pm$ 0.09	2.9 $\pm$ 0.10
2.0	0.0	45.4	1.2 $\pm$ 0.11	2.3 $\pm$ 0.12
0.0	0.5	56.8	2.4 $\pm$ 0.10	3.2 $\pm$ 0.10
0.0	1.0	55.1	2.3 $\pm$ 0.12	3.3 $\pm$ 0.12
0.0	1.5	50.4	1.6 $\pm$ 0.12	2.9 $\pm$ 0.10
0.0	2.0	46.8	1.3 $\pm$ 0.10	2.3 $\pm$ 0.12
1.0	0.5	63.2	4.1$\pm$0.11	5.3$\pm$0.04

1.5	0.5	50.5	3.7 $\pm$ 0.11	4.0 $\pm$ 0.10
0.5	1.0	49.1	2.6 $\pm$ 0.12	3.9 $\pm$ 0.10
0.5	1.5	53.7	2.2 $\pm$ 0.11	3.3 $\pm$ 0.12

$\pm$ SE represents the mean values of 25 replicates per treatment.

Fig: 5.9 : Results in the invitro micropropagation of *Acalypha indica* Linn

Note: A and B in Fig -6.2 shows that the culture vessel with explant; C and D in Fig -



5.9 shows that the callus initiation with an induced shoot; E and F in Fig -6.2 shows that the shoot initiation and shoot proliferation; G and H in Fig -6.2 shows that the plant regeneration with root formation and I in Fig -6.2 shows that the hardening process.

Table 5.3 : Effect of auxin and cytokinin on the shoot proliferation from the explants of leaf nodes of *Acalypha indica*

BAP (mg/ml)	NAA (mg/ml)	(%) of Shoot initiation	Mean no. of shoots ($\pm$ SE)	Mean Length of shoots ($\pm$ SE)
0.5	0.5	41.2	1.7 $\pm$ 0.11	2.0 $\pm$ 0.06
1.0	0.5	62.8	2.8$\pm$0.09	3.9$\pm$0.10
1.5	0.5	57.6	2.2 $\pm$ 0.05	2.4 $\pm$ 0.10
0.5	1.0	55.8	1.7 $\pm$ 0.08	2.3 $\pm$ 0.12
1.0	1.0	56.4	1.6 $\pm$ 0.12	1.7 $\pm$ 0.12
1.5	1.0	45.1	1.3 $\pm$ 0.10	1.8 $\pm$ 0.12

$\pm$ SE represents the mean values of 25 replicates per treatment

Table 5.4 : Effect of auxin hormones on the initiation of maximum no. of roots from the explants of leaf nodes of *Acalypha indica*

IAA (mg/ml)	IBA (mg/ml)	(%) of response from nodal explants	Average no. of roots ($\pm$ SE)	Average Length of Roots ($\pm$ SE)
0.5	0.0	63.2	12.4 $\pm$ 0.10	2.1 $\pm$ 0.06
1.0	0.0	57.9	13.9 $\pm$ 0.06	2.4 $\pm$ 0.09
1.5	0.0	68.0	19.1$\pm$0.06	3.4$\pm$0.11
0.0	0.5	74.4	15.5 $\pm$ 0.06	4.0 $\pm$ 0.06
0.0	1.0	70.5	23.3 $\pm$ 0.12	4.5 $\pm$ 0.10
0.0	1.5	68.1	21.6 $\pm$ 0.11	3.8 $\pm$ 0.10

$\pm$ SE represents the mean values of 25 replicates per treatment

The regenerated shoots are transferred to MS medium (1/2 strength) treated with various concentrations of IAA and IBA [0.5-.5mg/ml] for rooting. In the fourth week, observations at the root of culture media are made. Well-rooted shoots were washed in sterile water and transferred to plastic cups holding moisture content of soil or moisture content of soil or a mixture of sand and garden soil (1:1:1), which were then covered with plastic and left in direct sunlight to hardening. The plantlets were moved to pots containing garden soil and kept in a greenhouse for acclimatization after one month.

CHAPTER 6

SUMMARY AND CONCLUSIONS

6.1 SUMMARY

This study reveals that the Smart farming technology on monitoring the soil nutrient, providing automatic irrigation, providing fertilizers and detecting atmospheric temperature and detecting the moving object and detecting the water level, detecting the moisture level of soil from sensors. *Coriandrum sativum* seed shown a good result and the crop can be grown at least 20-25 days from the seed. The crop is used for our daily use cooking. The growth of the crop shows a good result compared to the other cereal crops and some other crops. This study also describes the invitro micropropagation from explants of leaf nodes of *Acalypha indica*. This micropropagation will help for commercial-scale propagation and some medicinal properties. Additionally, Light Dependent resistor with a photoresistor sensor module will help for detecting the light intensity and will use for this light incubation process. C code helps the imaginary analysis and this code improves our programming knowledge. As we are Mechatronics students, our aim is to model the material. Here, the culture vessel is an axisymmetric material. We analyzed the material properties and modelled the material using Ansys software.

6.2 CONCLUSION

Our aim in the project is planting in agriculture. Our output of the plant showing 100% success in farming as well as an artificial method (invitro method). Our project is completed by showing the output of plants grown.

- a) *Coriandrum sativum* crop grown from the seed by smart farming method successfully. (Figure: 6.1)
- b) *Acalypha indica* plant grown from the explant of leaf nodes of invitro micropropagation successfully. (Figure: 6.1)



Fig: 6.1 : Conclusion in the project by plant Coriandrum sativum grown from the seed by smart farming technique (a) and Acalypha indica plantlet grown from explant(leaf) by invitro culture technique (b)

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APPENDICES

The following Arduino code is written and simulated in Arduino IDE software for monitoring the soil pH, monitoring atmospheric temperature, providing irrigation and fertilizers through an automatic water pump by controlling this program code.

//Arduino code for smart farming technique

```
#include <LiquidCrystal.h>
```

```
LiquidCrystal lcd(12, 11, 10, 9, 8, 7);
```

```
int mode_key = 6;
```

```
int ph_sensor = A0;
```

```
int temp_sensor = A1;
```

```
int soil_sensor = A2;
```

```
int pir_sensor = A3;
```

```
int level1_sensor = A4;
```

```
int level2_sensor = A5;
```

```
int level3_sensor = A6;
```

```
int fertilizer1 = 14;
```

```
int fertilizer2 = 15;
```

```
int pump1 = 16;
```

```
int pump2 = 17;
```

```
int valve = 18;
```

```
int buzzer = 19;
```

```
int flag1 = 0;
```

```
int flag2 = 0;
```

```
int sensor,mode,ph,temperature,soil,pir,source1,source2,field,ph_value,temp_value  
;
```

```
void setup()
```

```

{
  lcd.begin(20, 4);
  Serial.begin(9600);
  pinMode(mode_key, INPUT);
  pinMode(ph_sensor, INPUT);
  pinMode(temp_sensor, INPUT);
  pinMode(soil_sensor, INPUT);
  pinMode(pir_sensor, INPUT);
  pinMode(level1_sensor, INPUT);
  pinMode(level2_sensor, INPUT);
  pinMode(level3_sensor, INPUT);

  pinMode(fertilizer1, OUTPUT);
  pinMode(fertilizer2, OUTPUT);
  pinMode(pump1, OUTPUT);
  pinMode(pump2, OUTPUT);
  pinMode(valve, OUTPUT);
  pinMode(buzzer, OUTPUT);

  digitalWrite(buzzer, LOW);
  digitalWrite(fertilizer1, LOW);
  digitalWrite(fertilizer2, LOW);
  digitalWrite(pump1, LOW);
  digitalWrite(pump2, LOW);
  digitalWrite(valve, LOW);
  delay(100);

  lcd.setCursor(0, 0);
  lcd.write("SMART AGRICULTRE");
  lcd.setCursor(0, 1);
  lcd.write("MONITORNING SYTM");
  delay(200);
}

```

```

    lcd.clear();
}
void loop()
{
    mode = digitalRead(mode_key);
    ph = analogRead(ph_sensor);
    temperature = analogRead(temp_sensor);

    soil = digitalRead(soil_sensor);
    pir = digitalRead(pir_sensor);
    source1 = digitalRead(level1_sensor);
    source2 = digitalRead(level1_sensor);
    field = digitalRead(level1_sensor);

    ph_value=(ph/5);
    temp_value=(temperature/5);

        lcd.setCursor(12, 2);
        lcd.write("T:");
        lcd.print(temp_value);
        lcd.setCursor(0, 0);
        lcd.write("PH:");
        lcd.print(ph_value);
        lcd.setCursor(0, 2);
        lcd.write("S.CNDN:");
        lcd.setCursor(0, 1);
        lcd.write("CAL:");
        lcd.setCursor(11, 1);
        lcd.write("PTM:");

    if(ph_value >= 1 && ph_value <= 5 ) // mode == HIGH &&
    {

        lcd.setCursor(4, 1);

```

```

        lcd.write("5.2%");
        lcd.setCursor(16, 1);
        lcd.write("10.9%");
    }
    else if( ph_value >= 6 && ph_value <= 15)
    {

        lcd.setCursor(4, 1);
        lcd.write("20.2%");
        lcd.setCursor(16, 1);
        lcd.write("9.9%");
    }

//    else
//    {
//        lcd.setCursor(0, 0);
//        lcd.write("PH:");
//        lcd.print(ph_value);
//        lcd.setCursor(0, 1);
//        lcd.write("CAL:    ");
//        lcd.setCursor(7, 1);
//        lcd.write("PTM:    ");
//    }

    else if(soil == LOW && source1 == HIGH && source2 == LOW)
    {
        lcd.setCursor(7, 2);
        lcd.write("DRY");
        lcd.setCursor(0, 3);
        lcd.write("FROM SOURCE 1");
        digitalWrite(pump1, HIGH);
        digitalWrite(pump2, LOW);
    }

    else if(soil == LOW && source1 == LOW && source2 == HIGH)

```

```

{
    lcd.setCursor(7, 2);
    lcd.write("DRY");
    lcd.setCursor(0, 3);
    lcd.write("FROM SOURCE 2");
    digitalWrite(pump1, LOW);
    digitalWrite(pump2, HIGH);
}

else if(soil == LOW && source1 == HIGH && source2 == HIGH)
{
    lcd.setCursor(7, 2);
    lcd.write("DRY");
    lcd.setCursor(0, 3);
    lcd.write("FROM SOURCE 2");
    digitalWrite(pump1, HIGH);
    digitalWrite(pump2, LOW);
}

else if(soil == LOW && source1 == LOW && source2 == LOW)
{
    lcd.setCursor(0, 3);
    lcd.write(" - NO WATER - ");
    digitalWrite(pump1, LOW);
    digitalWrite(pump2, LOW);
}

else if(soil == HIGH && source1 == LOW && source2 == LOW )
{
    lcd.setCursor(7, 2);
    lcd.write("WET");
    lcd.setCursor(0, 3);
    lcd.write("NO NEED WATER ");
    digitalWrite(pump1, LOW);
    digitalWrite(pump2, LOW);
}

```

```

}
else if(soil == HIGH && source1 == LOW && source2 == HIGH )
{
    lcd.setCursor(7, 2);
    lcd.write("WET");
    lcd.setCursor(0, 3);
    lcd.write("NO  NEED  WATER ");
    digitalWrite(pump1, LOW);
    digitalWrite(pump2, LOW);
}
else if(soil == HIGH && source1 == HIGH && source2 == LOW )
{
    lcd.setCursor(7, 2);
    lcd.write("WET");
    lcd.setCursor(0, 3);
    lcd.write("NO  NEED  WATER ");
    digitalWrite(pump1, LOW);
    digitalWrite(pump2, LOW);
}
else if(soil == HIGH && source1 == HIGH && source2 == HIGH )
{
    lcd.setCursor(7, 2);
    lcd.write("WET");
    lcd.setCursor(0, 3);
    lcd.write("NO  NEED  WATER ");
    digitalWrite(pump1, LOW);
    digitalWrite(pump2, LOW);
}
else if(field == HIGH)
{
    lcd.setCursor(0, 3);
    lcd.write("F.WATER LVL HGH");

```

```

        delay(200);
        lcd.setCursor(0, 3);
        lcd.write("F.VALVE OPEN");
        digitalWrite(valve, HIGH);
    }
    else if(field == LOW)
    {
//        lcd.setCursor(0, 3);
//        lcd.write("F.WATER LVL LOW");
//        delay(200);
//        lcd.setCursor(0, 3);
//        lcd.write("F.VALVE CLS ");
        digitalWrite(valve,LOW);
    }
}

```

The following Arduino code is written in Arduino code for detecting light intensity for proteus simulated circuit in LCD demonstration. This code is differ from the original simulation.

```

// Arduino code for detecting light intensity in Proteus (LCD demonstration)
#include<liquidcrystal.h>
LiquidCrystal lcd(7,6,5,4,3,2);

void setup() {
    lcd.begin(14,2);
    lcd.setCursor(0,0);
    lcd.print("LDR");
    lcd.setCursor(1,1);
    lcd.print(1,1);
}

void loop() {
    The following c

```

```

int valeur = analogRead(A0);
lcd.setCursor(6,0);
lcd.print (valeur);

}

```

The following Arduino code is written and simulated for detecting light intensity in a culture room on culture medium for light incubation process in the invitro culture technique.

// Arduino sketch to calculate the light intensity using a photoresistor sensor KY018

```

double calcLightIntensity (int AnVal, int Resistor) {

    double Vout = AnVal* 0.0048828125;
    int lux = ((2500/Vout-500)/Resistor);
    return lux;
}

void setup() {
    // put your setup code here, to run once:
    Serial.begin(9600);
}

void loop() {
    // put your main code here, to run repeatedly:

    int analogVal = analogRead(A0); //read values from Ao
    int Resistance = 10; //We using a 10k ohms resistor

    Serial.print ("Light Intensity:");
    Serial.print (int(calcLightIntensity(analogVal, Resistance)));
}

```

```

Serial.println (" lux");
delay(1000);

}

```

The following C code is written and simulated for the plant growth from explants of *Acalypha indica*. This code gives full results of Invitro micropropagation of the plant *Acalypha indica*. The code is an initial or imaginary analysis of the plant.

```

// C code for analysis of plant growth
#include <stdio.h>
#include <math.h>
void main()
{
    int PL; /* Leaf of the plant[explant]*/
    int C; /* Callus initiation*/
    int t1; /* Time periods for callus initiation*/
    int t2,t3; /* Time periods for shoot and root formation*/
    int SI; /* Shoot initiation*/
    int l1,l2; /* Elongated lengths for shoot initiation*/
    int RI; /* Root initiation*/
    int l3,l4; /* Elongated lengths for root initiation*/
    int T; /* Plant growth period*/
    int RR; /* Relative Plant growth rate*/
    int L1,L2; /* Parameters in Relative Plant growth rate*/
    int AR; /* Absolute Plant growth rate*/
    int L3,L4; /* Parameters in Absolute Plant growth rate*/
    int PGR; /* Net Plant growth rate*/
    int RES; /* Result of the experiment*/
    int kk, choice = 0;
    // while statement start
    while(choice!=10)
    {

```

```

printf("\n\t\t\t****    AN INVITRO MICROPROPAGATION OF ACALYPHA
INDICA LINN****\n");

printf("\t\t\t\t~~~~~\n");

printf("\t Analysis of Callus initiation, Shoot initiation and
Root initiation in Murashige and Skoog medium\n");

printf("\t\t 1. Leaf of the plant[explant](PL)\n");
printf("\t\t 2. Callus initiation(C)\n");
printf("\t\t 3. Shoot initiation(SI)\n");
printf("\t\t 4. Root initiation(R)\n");
printf("\t\t 5. Plant growth period(T)\n");
printf("\t\t 6. Relative Plant growth rate(RR)\n");
printf("\t\t 7. Absolute Plant growth rate(AR)\n");
printf("\t\t 8. Net Plant growth rate(PGR)\n");
printf("\t\t 9. Result of the experiment(RES)\n");
printf("\t\t 10.EXIT\n");
printf("\n\t ENTER MY CHOICE <1-10>");
scanf("%d", &choice);
switch(choice) /*choice an expansion*/
{
    case 1: /*For Leaf of the plant[explant]*/
    {
        printf("\n\t\t\t****1.Leaf of the plant[explant]***\n");
        printf("\n\t\t\t Input value for the Leaf of the
plant[explant](PL)==>\n");
        printf("\n\t\t\t Enter the input value for Leaf of the
plant[explant]");
        scanf("%ls", &PL);
        printf("\n\t\t\t Leaf of the plant[explant] is %ls", &PL);
        break;
    }
}

```

```

case 2:    /* For Callus initiation*/
{
    printf("\n\t\t****2.Callus initiation***\n");
    printf("\n\t\t Input value for Callus
initiation(C)==>\n");
    printf("\n\t\t Enter the initial time period for callus
initiation at time t1");
    scanf("%ls", &t1);
    C = 0+t1;
    printf("\n\t\t Callus initiation is %ls", &C);
    break;
}
case 3:    /* For Shoot initiation*/
{
    printf("\n\t\t****3.Shoot initiation***\n");
    printf("\n\t\t Input value for Shoot
Initiation(SI)==>\n");
    printf("\n\t\t Enter the initial elongated length of
shoot at length l1");
    scanf("%ls", &l1);
    printf("\n\t\t Enter the final elongated length of shoot
at length l2");
    scanf("%ls", &l2);
    SI = l1+l2;
    printf("\n\t\t Shoot initiation is %ls", &SI);
    break;
}
case 4:    /* For Root initiation*/
{
    printf("\n\t\t****4.Root initiation***\n");
    printf("\n\t\t Input value for Root
initiation(RI)==>\n");

```

```

        printf("\n\t\t Enter the initial elongated length of root
at length l3");
        scanf("%ls", &l3);
        printf("\n\t\t Enter the final elongated length of root
at length l4");
        scanf("%ls", &l4);
        RI = l3+l4;
        printf("\n\t\t Root initiation is %ls", &RI);
        break;
    }
    case 5:      /* For Plant growth period*/
    {
        printf("\n\t\t****5.Plant growth period(T)***\n");
        printf("\n\t\t Input value for Plant growth
period(T)===>\n");
        printf("\n\t\t Enter the initial time period for shoot
formation from callus at time t2");
        scanf("%ls", &t2);
        printf("\n\t\t Enter the final time period for root
formation from callus at time t3");
        scanf("%ls", &t3);
        T = t2+t3;
        printf("\n\t\t Plant growth period is %ls", &T);
        break;
    }
    case 6:      /* For Relative Plant growth rate*/
    {
        printf("\n\t\t****6.Relative Plant growth rate***\n");
        printf("\n\t\t Input value for Relative Plant growth
rate(RR)===>\n");
        printf("\n\t\t Enter the initial elongated length of
shoot formation from callus at length l1");

```

```

scanf("%ls", &l1);
printf("\n\t\t Enter the final elongated length of shoot
formation from callus at length l2");
scanf("%ls", &l2);
L1 = (l1+l2)/5;
printf("\n\t\t L1 is %ls", &L1);
{
    printf("\n\t\t Enter the initial elongated length of
root formation from callus at length l3");
scanf("%ls", &l3);
printf("\n\t\t Enter the final elongated length of
root formation from callus at length l4");
scanf("%ls", &l4);
L2 = (l3+l4)/5;
printf("\n\t\t L2 is %ls", &L2);
{
    RR = (L1+L2);
    printf("\n\t\t Relative Plant growth rate is
%ls", &RR);

    break;
}
}
}
case 7: /* Absolute Plant growth rate*/
{
    printf("\n\t\t***7.Absolute Plant growth rate***\n");
    printf("\n\t\t Input value for Absolute Plant growth
rate(AR)===>\n");

    printf("\n\t\t Enter the initial elongated length of
shoot formation from callus at length l1");
scanf("%ls", &l1);
printf("\n\t\t Enter the final elongated length of shoot

```

```

formation from callus at length l2");
        scanf("%ls", &l2);
        L3 = (l1+l2)/2;
        printf("\n\t\t L3 is %ls", &L3);
        {
            printf("\n\t\t Enter the initial elongated length of
root formation from callus at length l3");
            scanf("%ls", &l3);
            printf("\n\t\t Enter the final elongated length of
root formation from callus at length l4");
            scanf("%ls", &l4);
            L4 = (l3+l4)/2;
            printf("\n\t\t L4 is %ls", &L4);
            {
                AR = (L3+L4);
                printf("\n\t\t Absolute Plant growth rate is
%ls", &AR);

                break;
            }
        }
    }
    case 8: /* Net Plant growth rate*/
    {
        printf("\n\t\t***8.Net Plant growth rate***\n");
        printf("\n\t\t Input value for Net Plant growth
rate(PGR)==>\n");

        int RI = 10;
        int SI = 16;
        {
            if(RI>5)
            if(SI>10)
            {

```

```

        printf("\n\t\t Net Plant growth rate is
SUCCESS");

        scanf("%ls", &PGR);
    }
    else
    {
        printf("\n\t\t Net Plant growth rate is NOT
SUCCESS");

        scanf("%ls", &PGR);
        break;
    }
}

case 9:    /* Result of the experiment */
{
    printf("\n\t\t****9.Result of the experiment***\n");
    printf("\n\t\t Value for the Result of the
experiment(RES)==>\n");

    int PGR = 100; /* Net Plant growth rate is 100 percent
success*/

    int RES;
    printf("\n\t\t Result of the experiment is %ls", &RES);
    {
        if(PGR = 100)
            printf("\n\t\t REGENERATED PLANTLETS OF ACALYPHA
INDICA IS TRANSFERRED TO THE FIELD CONDITIONS WITH 100 PERCENT SURVIVAL
RATE");

        scanf("%ls", &PGR);
        {
            if(PGR != 100)
                printf("\n\t\t REGENERATED PLANTLET IS FAILED TO
THE RESULT OF THE EXPERIMENT");

```

```

        break;
    }
}

}

}

}

```

Procedure to modelling the material (culture vessel)

The following procedure is explained for modelling the culture vessel is used in an invitro micropropagation of *Acalypha indica*. Culture vessel is an axisymmetric material, the material properties are analyzed and modelled using ansys software.

Outer diameter of the culture vessel – 104mm

Inner diameter of the culture vessel – 100mm

Thickness of the culture vessel – 2mm

Height of the culture vessel – 152mm

Install Ansys R2 version (or any version). Then go to Ansys Mechanical APDL. The procedure can be explained below.

i) Preference – Structural – Ok

ii) Preprocessor – Element type – Add/Edit/Delete – Add – Solid – Quad 4 node 182 – Options – K3 for axisymmetric – Ok

Material properties – Material model – Structural – Linear – Elastic – Isotropic

{EX: 2e5

PRXY: 0.3} – Ok

Modelling – Create – Areas – Rectangle – by dimensions {X1, X2: 50, 52

Y1, Y2: 0, 100} – Ok

Modelling – Create – Areas – Circle – by dimensions – {Outer radius – 52

Inner radius – 50

Starting angle – 0

Ending angle – 30} – Ok

Modelling – Create – Areas – Areas – (pick circle area) – {X offset => 0

Y offset => 100

Z offset => 0} - Ok

Modelling - Create - Operate - Booleans - Add - Areas - (pick the rectangle and circle)-Ok

Meshing - Mesh tool - Choose Smart size on 3 - Mesh - (pick the areas) - Ok

Loads - Define loads - Apply - Structural - Displacement - on keypoint - (pick the 1st node) - DOF: UY - Value of displacement - 0 - Ok

Loads - Define loads - Apply - Structural - Displacement - on keypoint - (pick the 2nd node) - DOF: UX - Value of displacement: 0 - Ok

iii) Solution - Solve - Current LS - (Solution is done) - Close

iv) General postproc - Plot results - Deformed shape - Def + undeformed - Ok
(Result)

(For the expansion of material)

PlotCtrls - Style - Symmetric expansion - 2D Axisymmetric - {1/4 expansion

1/2 expansion

3/4 expansion

Full expansion} - Ok

For full modelling and analysis of material select an isometric view.

PLAGIARISM CHECKER RESULT

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