Comparative Study on Impact of Eucalyptus Allelopathy on Different Sensitive and Resistant Crop Plants

Thesis Submitted to Midnapore City College
for the Partial Fulfillment of the Degree of
Master of Science in (Agriculture) Genetics and plant breeding

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Certificate

This is to certify that the project report entitled **Comparative study on impact of eucalyptus allelopathy on different sensitive and resistant crop plants** submitted by Subhadip Samanta, Roll PG/VUWGP29/GPB-IVS No.019 and Sarfaraj Jaman, Roll PG/VUWGP29/GPB-IVS No. 010 to the Midnapore City College, Midnapore, West Bengal, India during the year of 2023 in partial fulfillment for the award of the degree of M.Sc. in (Agriculture) Genetics and Plant Breeding is a bona fide record of project work carried out by them under our supervision. The contents of this report, in full or in parts, have not been submitted to any other Institution or University for the award of any degree.

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Declaration

I do hereby declare that the present Master thesis entitled '*Comparative study on impact of eucalyptus allelopathy on different sensitive and resistant crop plants*' embodies the original research work carried out by me in the Department of Agriculture, Midnapore City College, Paschim Medinipur, West Bengal, India under the supervision of Dr. Anulina Manna, Assistant Professor of Agriculture Department of Midnapore City College, Paschim Medinipur, West Bengal, India. No part thereof has been submitted for any degree or diploma in any University.

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Subhadip Samanta

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Abstract

The region (Midnapore) is bordered on the north and west by the river Kangsabati and the Rupnarayan Forest Division, which is located between 22º49' and 22º23' North Latitude and 87º30' and 87º00' East Longitude. This region's distinctive geology, laterite, covers a sizable portion of the landscape. Although the laterite's thickness varies from location to location, it is not believed to exceed 15 meters here. Eucalyptus species cover a significant area. Allelochemicals spontaneously generated by intact living or dead Eucalyptus tissues build up at high quantities in the soil rhizosphere, producing allelopathic effects. The effects of eucalyptus species' allelopathy on several plant species have been studied. Due to its allelopathic nature, eucalyptus prevents other plants from growing close to its occupied territory. Unused, large tracts of forest land are covered in eucalyptus plants. Comparison research between several crop plants and control plants was conducted to better understand the impacts of Eucalyptus allelopathy on plants. To carry out this task, four crops were used: chickpea, groundnut, sesame, and lathyrus. Three other eucalyptus sections, including root, new leaf, and abscission portions, were utilized as aqua extracts. The specimens were examined using a variety of parameters, and numerous characteristics were examined, including cytological oddities, chlorophyll content, estimates of the amount of protein etc. All characteristics have been examined under a variety of circumstances with the goal of developing a better cropping pattern or system for arid soils where Eucalyptus species are present.

Keywords: Allelopathy, Allelochemical, Cytological, Morphological, physiological, biochemical changes.

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List of Abbreviations

BSA	Bovine serum albumin
cm	centimeter
CO2	Carbon dioxide
CRD	Completely Randomized Design
DNA	Deoxyribonucleic acid
FAO	Food and Agriculture Organization
Fig……...Figure	
GDP	Gross Domestic Product
H2O2	Hydrogen Peroxide
HCl	Hydrochloric acid
MgCo3	Magnesium Carbonate
mha	Million Hectare
mM	millimolar
Nm	Nanometer
pH	Potential of Hydrogen
TCC	Total Chlorophyll Content

Chapter 1: Introduction

1. Introduction

The introduction and extensive planting of fast-growing exotic tree species have had detrimental effects on numerous farming areas. This has led to the risk of extinction for certain local species and a decline in the ability of native forests to provide essential ecosystem services (Islam *et al*., 1999; Foroughbakhch *et al*., 2001; Sangha and Jalota, 2005). For example, the ongoing monoculture planting of eucalyptus trees can result in the accumulation of phytotoxins in the soil, leading to soil deterioration and decreased agricultural productivity (El-Khawas and Shehata, 2005; Forrester *et al*., 2006).

Allelopathy, which refers to the chemical interactions between plants that affect their growth and development, has been recognized as a significant ecological mechanism impacting crop management, plant biodiversity, and vegetation dynamics in ecosystems (Chou, 1999). Recent studies have demonstrated the allelopathic effects of forest trees on soil diseases and vegetation suppression (Baltzinger *et al*., 2012; Hegab *et al*., 2016). Eucalyptus globulus, a commonly grown forest tree, is known for its fast growth, adaptability to various environments, and high productivity. However, when it expands into regions with native vegetation, it can become an invasive pest plant. Studies have shown that eucalyptus negatively affects the diversity of associated species and the productivity of understory crops (Sasikumar *et al*., 2002).

Allelochemicals, which are chemical compounds produced by intact living or dead eucalyptus tissues, accumulate in high quantities in the soil rhizosphere, leading to allelopathic effects. The allelopathic potential of many eucalyptus species has been investigated (Sasikumar *et al*., 2002; Zhang *et al*., 2010; Hegab *et al*., 2016). The leaves, bark, and roots of certain eucalyptus species release secondary metabolites, such as phenolic acids and volatile oils, which have been found to be toxic to other plant species. Numerous species, including both weeds and crops, have been studied to understand the possible mechanisms of eucalyptus' allelopathic effects on the growth of neighboring plants (Raj *et al*., 2016; Ashraf *et al*., 2016).

Numerous studies have explored the allelopathic effects of eucalyptus (El-Khawas and Shehata, 2005; Bajwa and Nazi, 2005; Willis, 1999; Sasikumar *et al*., 2002; Del Moral and Muller, 1969; Willis, 1999). Certain eucalyptus species have been found to have detrimental effects on other plant species when their phenolic acids and volatile oils are released from their leaves, bark, and roots (Sasikumar *et al*., 2002; Florentine and Fox, 2003). However, the effects of living root exudates, which are organic chemicals released by plant roots into the rhizosphere, have received

less attention compared to litter extracts (Bernhard Reversat, 1999; Malik, 2004; Singh *et al*., 2005; Bagavathy and Xavier, 2007). Nonetheless, living root exudates play a significant role in plant interactions, as plant roots have the unique ability to release organic chemicals into their surrounding soil (Bertin *et al*., 2003). While most bioassay research has been conducted in laboratory settings (Willis, 1985; Jose *et al*., 2006), field studies investigating allelopathic effects in natural environments are relatively rare. Therefore, there is a need for more field studies to examine the potential for integrative allelopathy among plants (Wardle *et al*., 1998).

Expanding understanding of the allelopathic effects of eucalyptus and other fast-growing exotic tree species can help inform better land management practices and mitigate the negative impacts on local plant species, crop productivity, and ecosystem functioning. By considering the ecological interactions and potential risks associated with introducing exotic species, It could be worked towards promoting more sustainable agricultural and forestry practices that support native ecosystems and local communities.

Chapter 2: Review of Literature

2. Review of Literature:

2.1. Allelopathy

One plant's allelopathic effect on another is so stated that competition for a shared resource does not seem to be a sufficient explanation for the observation. According to Putnam and Tang (1986), many species in communities of organisms appear to control one another through the production and release of chemical attractants, stimulants, or inhibitors.

Allelopathy is a term that comes from the Greek terms allelon, which means "of each other," and pathos, which means "to suffer" (Rizvi *et al*. 1992). Therefore, it literally means "mutual suffering." The biochemical interaction between microbes and plants known as allopathy can be both beneficial and harmful. According to Rice (1974), allelopathy refers to any direct or indirect impact on another plant, including microorganisms, caused by the release of chemical compounds into the environment, which then affect the growth and development of nearby plants. It contains reciprocal biological interactions that are both inhibiting and stimulating. The term "allelopathy" may consequently be used in a debatable manner. Chemicals that have been shown to stop the growth of a species at a particular concentration may, at a lower concentration, increase the growth of the same species or another (Rice 1984; Putnam and Tang 1986). Two kinds of allelopathy are described by Aldrich (1984):

- True type: The release into the environment of compounds those are toxic in the form in which they are produced.
- Functional type: The release into the environment of substances that is toxic as the result of transformation by micro-organisms.

2.2. Allelochemicals

Allelochemicals, mostly produced by plants as secondary metabolites or by microbes as byproducts of their decomposition, are the primary active agents in allelopathy. According to their molecular similarities, allelochemicals—which are made up of several chemical families—are divided into the following 14 categories: water-soluble organic acids, straight chain alcohols, aliphatic aldehydes, and ketones; simple unsaturated lactones; long- chain fatty acids and polyacetylenes, benzoquinone, anthraquinone and complex quinones; simple phenols, benzoic acid and its derivatives; cinnamic acid and its derivatives; coumarin; flavonoids; tannins; terpenoids and

steroids; amino acids and peptides; alkaloids and cyanohydrins; sulphide and glucosinolates; and purines and nucleosides. Salicylic acid, gibberellic acid, and ethylene are examples of plant growth regulators that are regarded as allelochemicals. Recent years have seen a fast advancement in analytical technology, enabling the isolation and identification of even minute amounts of allelochemicals as well as the performance of complex structural investigations on these molecules.

2.2.1. Sources

According to Radosevich and Holt (1984), the link between plant litter in or on the soil and allelopathy appears to be the main cause of this impact. Allelochemicals are said to be present in nearly every type of plant tissue, including leaves, fruit, stems, and roots, according to Rice (1984) and Putnam (1985). Such activities as volatilization, root exudation, leaching, and breakdown of plant wastes produce these allelochemicals. The most reliable source might be the leaves, but roots are thought to have fewer and weaker toxins. Allelochemicals must be concentrated in the leaves, stem, or roots as opposed to the fruit or flowers, according to Aldrich (1984). It is doubtful that it would be available in time to interfere with surrounding plants if it is concentrated in these organs. According to Rice (1984) and Putnam (1985), there are four ways in which the chemicals are released:

- Volatilization Give the environment a release. It only matters in dry or semi-arid environments. The substances may enter the soil and be ingested by the roots, be absorbed in vapor by nearby plants, or be absorbed from condensate in dew.
- Leaching Chemicals from the aerial sections of plants may be dissolved by rain, dew, or irrigation and then spread to the soil or other plants. Plant leftovers may also cause leaching. Their movement in soil water will be impacted by their solubility.
- Root shedding into the surroundings of the soil from plant roots. These substances are actively released, leak, or develop from dead cells that slough off the roots.
- The breakdown of plant remains it is difficult to tell whether harmful chemicals are created by microbes using the residues, rather than being contained in residues and merely released upon decomposition.

2.3. Nature of allelopathy:

Commonly cited effects of allelopathy include reduced seed germination and seedling growth Like synthetic herbicides, there is no common mode of action or physiological target site for all allelochemicals. However, known sites of action for some allelochemicals includecell division,

pollen germination, nutrient uptake, photosynthesis, and specific enzyme function. For example, one study that examined the effect of an allelochemical known in velvetbean, 3-(3',4'-dihydroxyphenyl)-l-alanine (l-DOPA), indicated that the inhibition by this compound is due to adverse effects on amino acid metabolism and iron concentration equilibrium. Allelopathic inhibition is complex and can involve the interaction of different classes of chemicals, such as phenolic compounds, flavonoids, terpenoids, alkaloids, steroids, carbohydrates, and amino acids, with mixtures of different compounds sometimes having a greater allelopathic effect than individual compounds alone. Different plant parts, including flowers,leaves, leaf litter and leaf mulch, stems, bark, roots, soil, and soil leachates and their derived compounds, can have allelopathic activity that varies over a growing season. Allelopathic chemicals or allelochemicals can also persist in soil, affecting both neighboring plants as well as those planted in succession. Although derived from plants, allelochemicals may be more biodegradable than traditional herbicides, but allelochemicals may also have undesirable effects on non-target species, necessitating ecological studies before widespread use. Selective activity of tree allelochemicals on crops and other plantshas also been reported. Many invasive plants may have allelopathy as a feature for their ecological success. One study in China found that 25 out of 33 highly noxious weeds screened had significant allelopathic potential. Time, environmental conditions, and planttissue all factor into variations in allelochemical concentrations in the producer plant. Foliar and leaf litter leachates of Eucalyptus species, for example, are more toxic than bark leachates to some food crops.

2.4. Impact on subjects:

Since allelopathy has been investigated for a while, it has been established that allelochemicals have an impact on a variety of physiological and biochemical processes in plants (Zeng *et al*., 2001; Gniazdowska and Bogatek, 2005). Following are some examples of the physiological and biochemical alterations caused by allelochemicals in plants.

2.4.1. Cytological changes

Allelochemicals have an impact on the form and structure of plant cells. In addition to causing nuclear abnormalities and increasing the number of vacuoles, volatile eucalyptol can expand and shorten root cells (Bakkali *et al*., 2008; Pawlowski *et al*., 2012). Cell proliferation and DNA synthesis in plant meristems were altered by allelochemical monoterpenoids (-pinene, 1,8-cineole, -pinene, and limonene) (Nishida *et al*., 2005). Cai and Mu (2012) discovered that higher

concentrations of the extracts decreased root hair length and density, inhibited cell division in root tips, and increased the chromosomal aberration index and micronucleus index after treating chickpea (*Cicer arietinum*) with aqueous leaf extracts from Eucalyptus spp. Many biological substances work by altering the permeability of membranes. Because plant membranes can be difficult to examine, the exudation of chemicals from roots onto slices of root has been utilized as a permeability index (Harper and Balke 1981).

2.4.2. Physiological changes

Allelochemicals primarily impede or harm the machinery used in photosynthesis in plants and hasten the breakdown of pigments used in photosynthesis. Reduced photosynthetic pigment levels as a result prevent energy and electron transport (Meazza *et al*., 2002; Yu *et al*., 2003, 2006; Wu *et al*., 2004). Allelochemicals affect photosynthesis mainly by influencing the function of PS II (Weir *et al*., 2004; Wang *et al*., 2014). The synthesis of photosynthetic pigments is, however, inhibited by aqueous extracts of leaves from the allelopathic plant Eucalyptus spp. (Borella *et al*., 2014).

2.4.3. Biochemical changes

Allelochemicals affect the synthesis, operations, composition, and activities of numerous enzymes in a variety of ways. According to earlier research, catechol, caffeic acid, and chlorogenic acid may all inhibit the crucial enzyme phosphorylase involved in seed germination (Rice, 1984; Einhellig, 1995). According to Zhou *et al*. (2010), an aquatic extract of the chrysanthemum (Chrysanthemum indicium L.)'s above-ground parts and rhizospheric soil inhibited the activities of root dehydrogenase and nitrate reductase (NiR), reduced the contents of soluble sugar and soluble protein, and prevented the root growth of stem cuttings of the same species.

After a short review it was found that though *Eucalyptus* have a huge allelopathic effect, a suitable data sheet of specific effect of its allelochemicals on plant basis more specifically on legume crops was not clear. As legumes are well-known for their ability to withstand abiotic stress, it can be a potent group to experiment the anti-allelopathic property against allelochemicals of *Eucalyptus* which is totally unrevealed in this field.

Study area

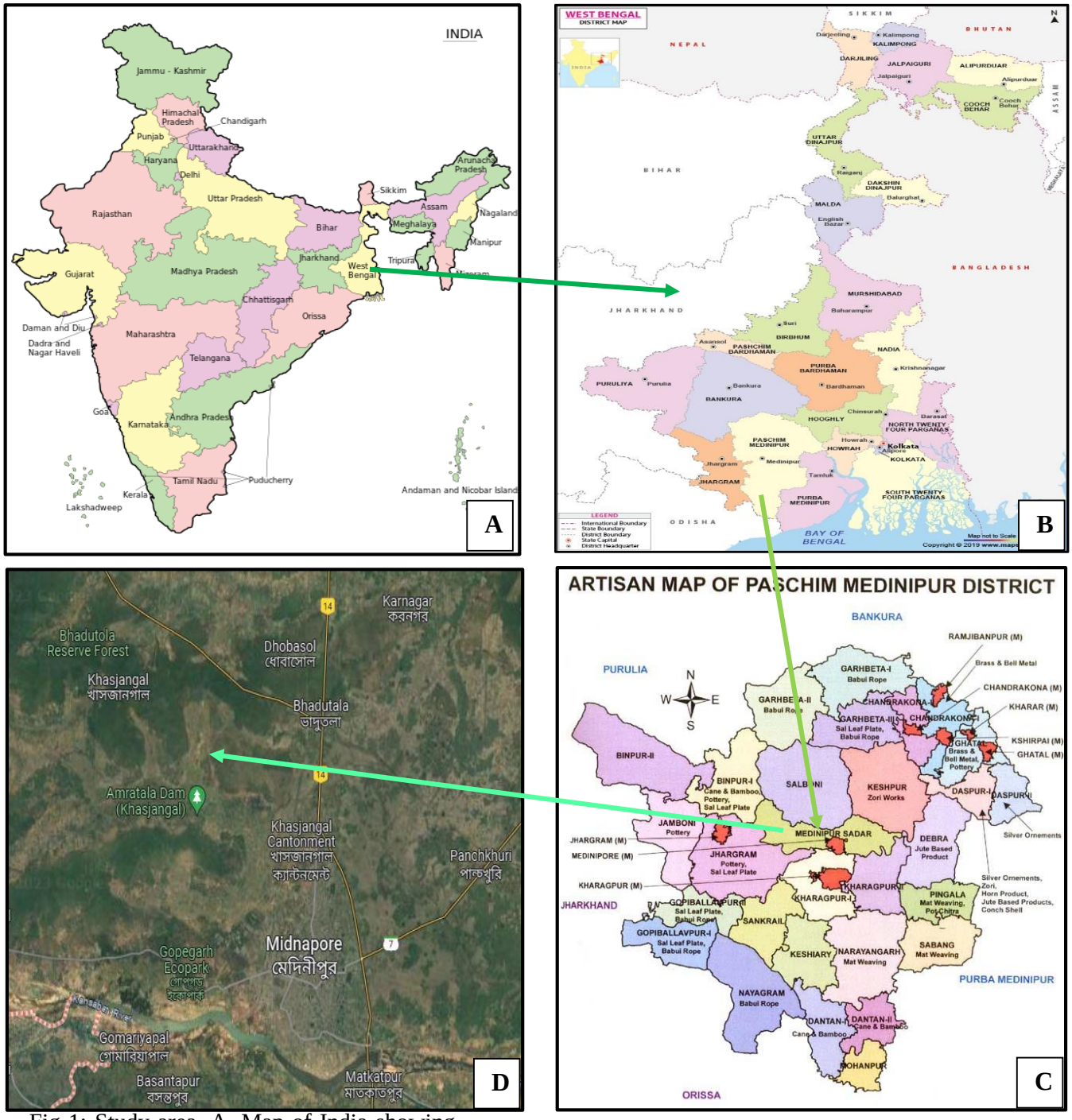

Fig 1: Study area. A. Map of India showing West Bengal state Courtesy (www.mapsofindia.com).

B. Map of West Bengal showing paschim medinipur district Courtesy: (www.d-maps.com).

C. Map of Paschim Medinipur showing Medinipur Sadar provision Courtesy: (www.mapsofindia.com).

D. Map showing Bhadutola reserve forest and Khasjangal Courtesy: Google Maps.

Chapter 3: Aims and Objective

3. Aims and Objectives:

3.1 Aims:

Lathyrus sativus, Cicer arietinum, Arachis hypogaea, and *Sesamum indicum* are the popular crop cultivated in West Midnapore district are well known for their efficacy to resistance abiotic stresses. The effect of allelochemicals of *Eucalyptus sp.* can be measured in these crops in comparative way to find out the better resistance to the allelopathic property and can be cultivated in barren land to develop a multi-cropping system as well as to increase the soil fertility.

To fulfil this aim following objectives are set:

3.2 Objectives:

- Comparative study on cytological and morphological changes by allelopathic effect on sample crops.
- Comparison of Agronomical traits.
- Comparative study on physiological and biochemical changes on allelopathy effected sample crops.

Chapter 4: Materials and Methods

4. Materials and methods:

To satisfy above objectives an experiment will be conducted among Chickpea, Lathyrus, Sesame, and Groundnut.

4.1. Materials:

4.1.1. Crop samples:

Table 1. Classification of Crop samples:

Eucalyptus sp.	
Origin	Australia
Family	*Myrtaceae*
Genus	*Eucalyptus*
Allelochemicals	*chlorogenic, two ρ-coumaric derivatives, ellagic, hyperoside, rutin, quercitrin, and kaempferol 3-O-glucoside etc (Puig et al.,2018)*

Chickpea	
Origin	Mediterranean region
Family	*Leguminaceae (Fabaceae)*
Genus	*Cicer*
Cotyledon	Dicotyledonous
Scientific name	*Cicer arietinum (2n=14)*

Grass pea	
Origin	Southern Italy and Sicily
Family	*Leguminaceae*
Genus	*Lathyrus*
Cotyledon	Dicotyledonous
Scientific name	*Lathyrus sativus (2n=14)*

Sesame	
Origin	Sub-Saharan Africa, India
Family	*Pedaliaceae*
Genus	*Sesamum*
Cotyledon	Dicotyledonous
Scientific name	*Sesamum indicum L., (2n = 26)*

Groundnut	
Origin	Southern Bolivia and north-western Argentina
Family	*Fabaceae (or Leguminosae)*
Genus	*Arachis*
Cotyledon	Dicotyledonous
Scientific name	*Arachis hypogaea L. (2n = 2x = 40)*

4.1.2. Chemicals:

Table 2. Required chemicals:

Experiment	Chemical name	Trade name
Extract preparation	Distilled water	Distilled water
Root cell abnormalities	Acetic acid	Acetic acid
	Ethanol	Ethanol
	Aceto orcein	Aceto orcein
	Diluted Hydrochloric acid	HCl
Chlorophyll content	Acetone	Acetone
Protein content	Bovine serum albumin	BSA
	A. Sodium carbonate in sodium hydroxide B. Copper sulphate in potassium sodium tartrate	Lowry's reagent
	Sodium molybdate+ sodium tungstate	Folin–Ciocâlteu reagent

4.1.3. Instruments and grassroots':

Table 3. Required Instruments:

Experiment	Instruments	Glassware & equipment
Extract preparation	Burner	Beaker, Filter paper.
	Electric grinder	
Root cell abnormalities	Compound microscope	Bloating paper, Slide, Watch glass, Cover glass, Blade, Needle, Forceps, Scalpel, Dropper, Test tube.
Chlorophyll content	Electric grinder	Bloating paper, Slide, Watch glass, Cover glass, Blade, Needle, Forceps, Scalpel, Dropper, Test tube, Centrifuge tube.
	Centrifuge machine	
	spectrophotometer	
Protein content	Weighing machine	Bloating paper, Slide, Watch glass, Cover glass, Blade, Needle, Forceps, Scalpel, Dropper, Test tube, Centrifuge tube.
	Grinder	
	Spectrophotometer	
	Vortex mixer	

4.2. Methods:

4.2.1. Extract preparation of Eucalyptus leaf:

The fresh leaves of Eucalyptus spp. were washed and ground separately in an electric grinder and the extracts were prepared in each case by 75 gm grinded powder with 675 ml distilled water. After filtration with Whatman No.1 filter paper, stock solutions were prepared (Hossain *et al.*, 2020).

4.2.2. Morphological studies:

For morphological studies we took 20 seeds of each crop and washed with distilled water. With proper treatment placed all samples into Petri dish for germinating with the aqueous extract of Eucalyptus plant.

$$\text{Germination percentage} = \frac{Germinated\ seed}{Total\ seed} \times 100$$

4.2.3. Estimation of Chlorophyll content:

Collected leaf samples were cleaned up by using tap water followed by double distilled water to remove all the dust (Sarkar *et al*., 2020). One gram finely cut leaf sample was taken then gently mixed with a clean pestle and mortar. To this homogenized leaf material, 20ml of 80% acetone and 0.5gm MgCO3 powder was added. The materials were further grind gently. Then samples were put into a refrigerator at 400C for 4 hours. Thereafter, the samples were centrifuged at 5000 rpm for 5 minutes. Then the supernatants were transferred to 100 ml volumetric flak. The final volume was made up to 100 ml with addition of 80%acetone. The color absorbance of these solutions was estimated by a spectrophotometer using 645 and 663nm wavelength against the solvents. Acetone (80%) was used as a blank (Kamble *et al*., 2015).

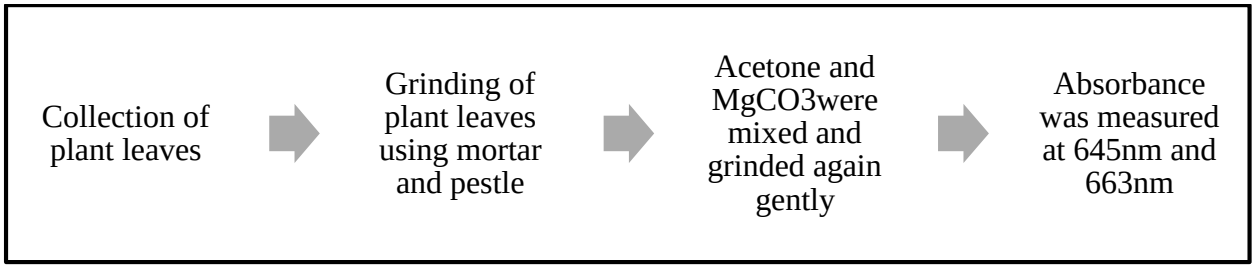

Fig 2: Diagrammatic representation for chlorophyll estimation.

Formula: (https://clu-in.org)

Total Chlorophyll a (mg/mL) = $12.7 \times A_{663} - 2.69 \times A_{645}$

Total Chlorophyll b (mg/mL) = $22.9 \times A_{645} - 4.68 \times A_{663}$

Total Chlorophyll = Chlorophyll a + Chlorophyll b (mg/mL)

4.2.4. Estimation of Protein content:

Protein content will be estimated by Lowry method. Fresh tissue accurately weighing 100 mg will be grinded well and the solution with 3 ml of phosphate buffer will be centrifuged at 10000r/min

for 30 min. The supernatant will be used for protein content estimation. Working standards, 0.2, 0.4, 0.6, 0.8 and 1.0 ml, will be pipette out into a series of test tubes. Sample extracts of 200 and 250 µL will be pipette out into other test tubes. The volume will be made up to 2.0 ml in all tubes with distilled water. Next, 2.0 ml of Lowry's reagent will be poured in each tube and vortexes well, and then kept for 10 min at room temperature. Subsequently, 200 µL of Folin–Ciocâlteu reagent will be added to all tubes and incubated at dark for 30 min. Absorbance will be measured at 660 nm (Lowry *et al.*, *1951*). The amount of protein was calculated as:

$$\text{Protein content (mg/g)} = \frac{\text{Concentration of protein} \times \text{Initial buffer} \times \text{dilution factor}}{\text{Supernatant volume} \times \text{Sample weight}} \text{x100}$$

4.2.5. Cytological Changes:

For cytological analysis of Root Tips Root tips were cut from specimen 1cm- 2cm long and washed with water then it was fixed by fixative solution of Acetic acid and Ethyl alcohol at 1:3 and kept for one overnight, followed by 5-7 min treatment of 45% acetic acid. Then root tips were hydrolyzed in 0.1 (N) HCl, followed by staining with 2% aceto-orcein (Paul *et al*., 2013).

4.2.6. Statistical Analysis:

All the experimental measurements were performed in replications and expressed as the average ± standard deviations. The magnitude of the means, standard curve, standard errors, and standard deviations were calculated by using MS Excel 2013 software. Results and discussions among all the 4 plant samples divided.

Fig 3. Spectrophotometer, Leaf Samples after centrifugation, Plot of study, Centrifuge Machine, Root Samples, Weight Machine.

Chapter 5 Result

5. Results:

Observation was taken from both, treated and non-treated plants. This study shows several morphological, biochemical, physiological and cytological changes occurred in treated plants as compared to normal plants. The following observations were noted.

5.1. Morphological changes: Several morphological changes were found between stress plant and control plant.

5.1.1. *Lathyrus sativus:*

Seeds are grown in petri plate and later transplanted to field. During germination in indoor condition found that stressed plants started germinating lately and the initial root and shoot are not that much stout and slightly greyish in color in compare with the control plant.

Stem: Stems are not strong in stress plants. Variation on length has been observed. In Control plant the average length of 19 ± 2.1cm whereas the average length of stressed plant was 14 ± 1.7cm.

Leaf: Leaves were not that much erected during the initial phases. The leaf area was very less as well as the leaf count was also less in stressed plants as compared to control plants.

Root: The average root size was 5.5 ± 1.15cm in control plants and 4 ± 0.9cm in stressed plants.

Fig 4: A) Lathyrus seeds are in control condition. B) Lathyrus seeds are in stressed condition.

5.1.2. *Cicer arietinum:*

Seeds are grown in petri plate and later transplanted to field. During germination in indoor condition found that stressed plants started germinating lately and the initial root and shoot are not that much stout and slightly greyish in color in compare with the control plant.

Stem: Stems are not strong in stress plants. Variation on length has been observed. In Control plant the average length of 22 ± 2.5cm whereas the average length of stressed plant was 14 ± 1.92cm.

Leaf: Leaves were not that much erected during the initial phases. The leaf area was very less as well as the leaf count was also less in stressed plants as compared to control plants.

Root: The average root size was 6 ± 1.5cm in control plants and 4 ± 1cm in stressed plants.

Fig 5: A) Chickpea seeds in control condition. B) Chickpea seeds in stressed condition.

5.1.3. *Arachis hypogaea:*

A variable, erect, stout or slender annual Groundnut with varying in height and form.

Stem: Erect, hollow and cylindrical stem which was strong and straight even in stress condition. In control plant the average length of plant was 18 ± 2.70cm and in stress condition 12 ± 2.13cm.

Leaf: In groundnut the leaves were smooth and brightly green in stressed plants also. The leaf count and leaf area also almost same in stressed and control plants. There was a minimum difference in leaflet sizes where stressed plants have smaller leaflets as compared to control plants.

Root: The average root size was 4 ± 1cm in control and 3 ± 1cm in stressed plants.

Fig 6: A) Groundnut seeds in control condition. B) Groundnut seeds in stressed condition.

5.1.4. *Sesamum indicum:*

Sesamum had germinated lately as compared to other crops but observation was noted at the time as other plants.

Stem: Very thin stem was seen. It was so vulnerable and having difficulties during early phases. Straight stem was observed. Average length of control plants was 9 ± 1cm and in stressed plants 5 ± 1cm.

Leaf: First leaves were emerged as soon as the plant were transferred to field. Leaf area was very low but leaves are perfectly green colored in control plant. The pair of flag leaf was perfectly opened in control plant as compared to stressed plants.

Root: Average root size in control was 4 ± 1.84cm and in stressed plants was 2 ± 0.75cm.

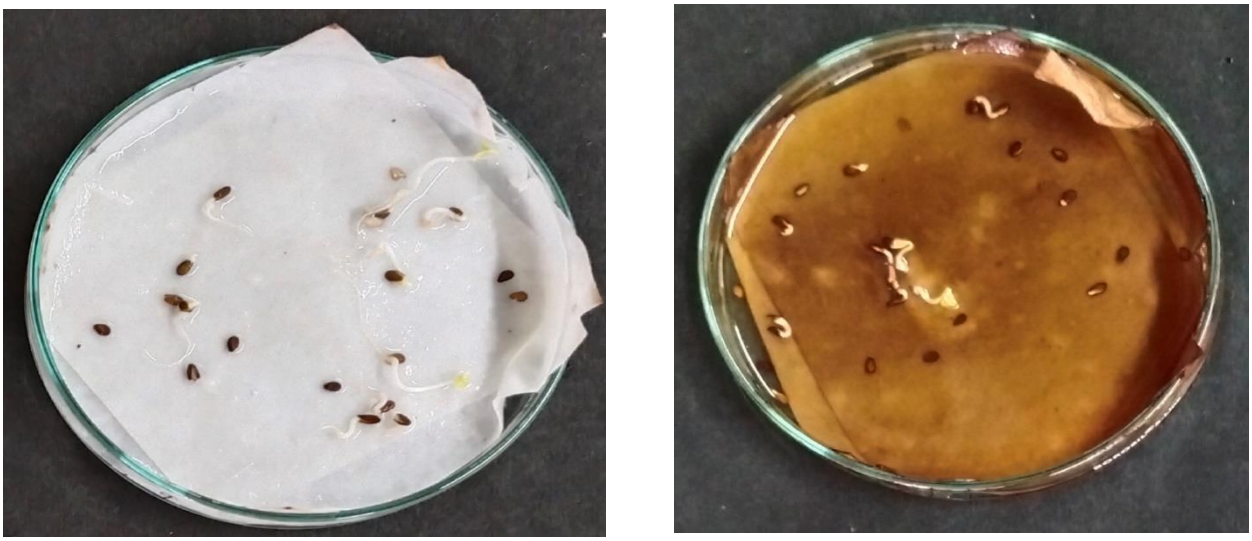

Fig 7. A) Sesame seeds in control condition. B) Sesame seeds in stressed condition.

5.2. Comparison of germination percentage:

5.2.1. Lathyrus germination percentage:

20 seeds of every crop were placed for germination on petri plates for every treatment individually. Seeds were placed for germination with 3 types of treatments (T_1 as Root extract, T_2 as New leaf extract and T_3 as Abscission extract) and those were divided at 30%(V_1), 60%(V_2) and 100%(V_3) concentration. Observation had been done on 8th day for after placing the seed. Total replication no. is 3. All compared charts and graphs are as follows:

Table 4. Germination Rate of Lathyrus:

Treatment	Germination Percentage (%) Mean ± S.D
Control	63.33 ± 2.88
T1V1	50.00 ± 0
T1V2	43.33 ± 2.88
T1V3	38.33 ± 2.88
T2V1	53.33 ± 2.88
T2V2	46.66 ± 2.88
T2V3	46.66 ± 2.88
T3V1	43.33 ± 2.88
T3V2	35.00 ± 0
T3V3	36.66 ± 2.88

T1V1:- 30% Root extract

T1V2:- 60% Root extract

T1V3:- 100% Root extract

T2V1:- 30% New leaf extract

T2V2:- 60% New leaf extract

T2V3:- 100% New leaf extract

T3V1:- 30% Abscission extract

T3V2:- 60%Abscession extract

T3V3:- 100% Abscission extract

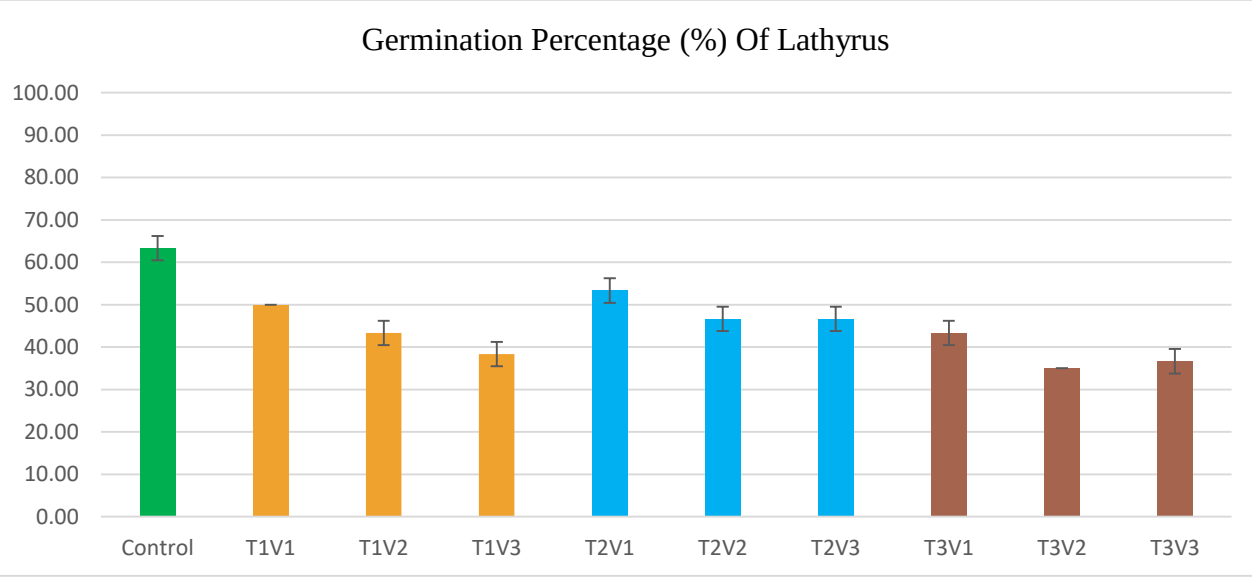

Fig.8. Comparison of germination rate of Lathyrus under various *Eucalyptus* extract.

5.2.2. Chickpea germination percentage:

20 seeds of every crop were placed for germination on petri plates for every treatment individually. Seeds were placed for germination with 3 types of treatments (T_1 as Root extract, T_2 as New leaf extract and T_3 as Abscission extract) and those were divided at 30%(V_1), 60%(V_2) and 100%(V_3) concentration. Observation had been done on 8th day for after placing the seed. Total replication no. is 3. All compared charts and graphs are as follows:

Table 5. Germination rate of Chickpea:

Treatment	Germination Percentage (%) Mean ± S.D
Control	98.33 ± 2.88
T1V1	88.33 ± 2.88
T1V2	85.0 ± 5.77
T1V3	83.33 ± 2.88
T2V1	90.00 ± 2.88
T2V2	90.00 ± 2.88
T2V3	86.66 ± 2.88
T3V1	76.66 ± 7.63
T3V2	73.33 ± 5.77
T3V3	68.33 ± 7.63

T1V1:- 30% Root extract

T1V2:- 60% Root extract

T1V3:- 100% Root extract

T2V1:- 30% New leaf extract

T2V2:- 60% New leaf extract

T2V3:- 100% New leaf extract

T3V1:- 30% Abscission extract

T3V2:- 60%Abscession extract

T3V3:- 100% Abscission extract

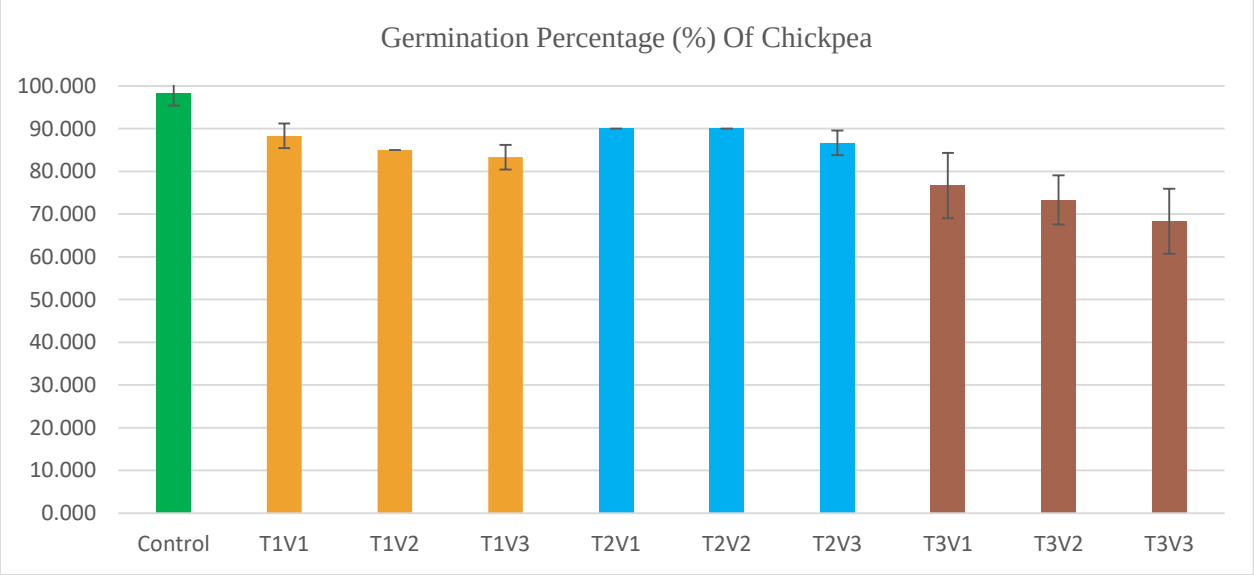

Fig.9. Comparison of germination rate of Chickpea under various *Eucalyptus* extract.

5.2.3. Groundnut germination percentage:

20 seeds of every crop were placed for germination on petri plates for every treatment individually. Seeds were placed for germination with 3 types of treatments (T_1 as Root extract, T_2 as New leaf extract and T_3 as Abscission extract) and those were divided at 30%(V_1), 60%(V_2) and 100%(V_3) concentration. Observation had been done on 8th day for after placing the seed. Total replication no. is 3. All compared charts and graphs are as follows:

Table 6. Germination rate of Groundnut:

Treatment	Germination Percentage (%) Mean ± S.D
Control	78.33 ± 2.88
T1V1	76.66 ± 5.77
T1V2	73.33± 2.88
T1V3	71.66 ± 5.77
T2V1	71.66 ± 2.88
T2V2	71.66 ± 2.88
T2V3	71.66 ± 2.88
T3V1	75.00 ± 0.00
T3V2	71.66 ± 2.88
T3V3	70.00 ± 0.00

T1V1:- 30% Root extract

T1V2:- 60% Root extract

T1V3:- 100% Root extract

T2V1:- 30% New leaf extract

T2V2:- 60% New leaf extract

T2V3:- 100% New leaf extract

T3V1:- 30% Abscission extract

T3V2:- 60%Abscession extract

T3V3:- 100% Abscission extract

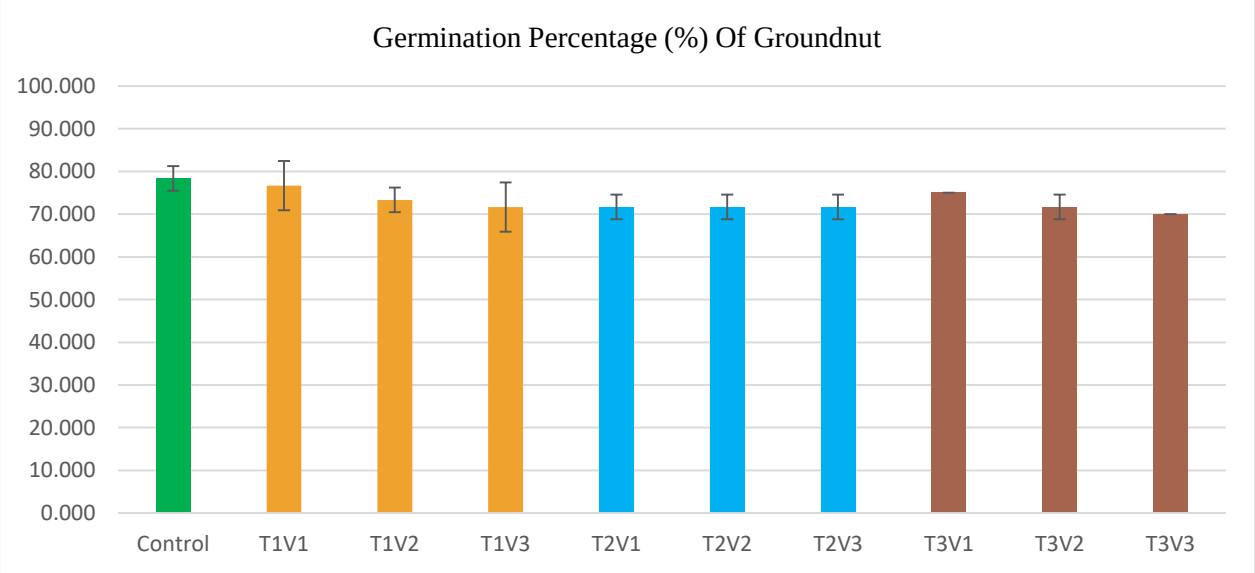

Fig.10. Comparison of germination rate of Groundnut under various *Eucalyptus* extract.

5.2.4. Sesame germination percentage:

20 seeds of every crop were placed for germination on petri plates for every treatment individually. Seeds were placed for germination with 3 types of treatments (T_1 as Root extract, T_2 as New leaf extract and T_3 as Abscission extract) and those were divided at 30%(V_1), 60%(V_2) and 100%(V_3) concentration. Observation had been done on 8th day for after placing the seed. Total replication no. is 3. All compared charts and graphs are as follows:

Table 7. Germination rate of Sesame:

Treatment	Germination Percentage (%) Mean ± S.D
Control	48.33 ± 2.88
T1V1	41.66 ± 5.77
T1V2	35.00 ± 5
T1V3	33.33 ± 2.88
T2V1	38.33 ± 5.77
T2V2	31.66 ± 2.88
T2V3	30.00 ± 0
T3V1	18.33 ± 2.88
T3V2	10.00 ± 0
T3V3	48.33 ± 2.88

T1V1:- 30% Root extract

T1V2:- 60% Root extract

T1V3:- 100% Root extract

T2V1:- 30% New leaf extract

T2V2:- 60% New leaf extract

T2V3:- 100% New leaf extract

T3V1:- 30% Abscission extract

T3V2:- 60%Abscession extract

T3V3:- 100% Abscission extract

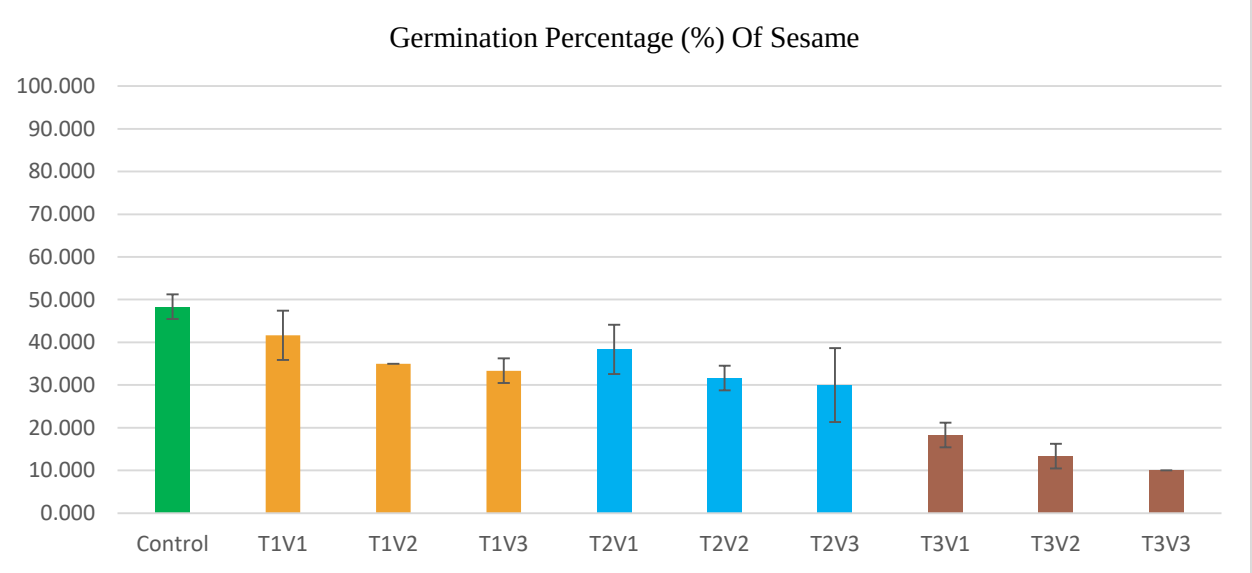

Fig.11. Comparison of germination rate of Sesame under various *Eucalyptus* extract.

5.3. Comparison of Root Length:

5.3.1. Lathyrus Root length:

Firstly, emerged root length is recorded here. Seeds germinated under 3 types of treatments (T_1 as Root extract, T_2 as New leaf extract and T_3 as Abscission extract) and those were divided at 30%(V_1), 60%(V_2) and 100%(V_3) concentration. Observation had been done on 6^{th} day for after placing the seed. Total replication no. is 3. Length was measured by a physical scale. All compared charts and graphs are as follows:

Table 8. Root length of Lathyrus:

Treatment	Root Length (Cm) Mean ± S.D
Control	2.90 ± 0.1
T1V1	2.26 ± 0.115
T1V2	2.20 ± 0
T1V3	2.03 ± 0.057
T2V1	2.50 ± 0
T2V2	2.33 ± 0.057
T2V3	2.30 ± 0.115
T3V1	2.23 ± 0.1
T3V2	2.00 ± 0.1
T3V3	1.90 ± 0.1

T1V1:- 30% Root extract

T1V2:- 60% Root extract

T1V3:- 100% Root extract

T2V1:- 30% New leaf extract

T2V2:- 60% New leaf extract

T2V3:- 100% New leaf extract

T3V1:- 30% Abscission extract

T3V2:- 60%Abscession extract

T3V3:- 100% Abscission extract

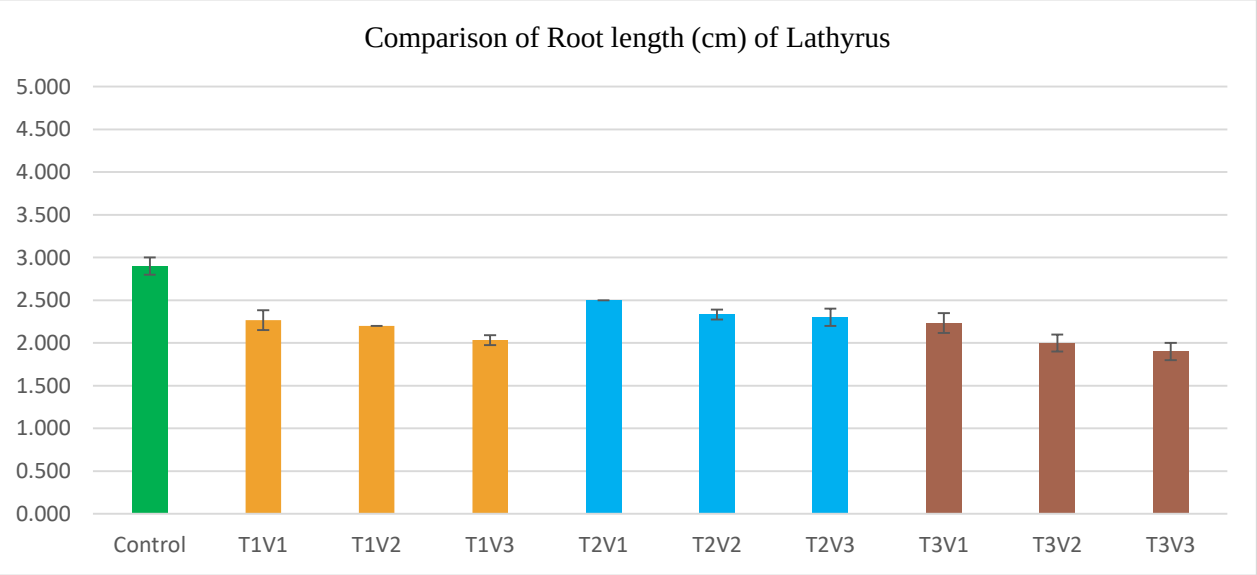

Fig. 12. Comparison of Root length of Lathyrus under various *Eucalyptus* extracts.

5.3.2. Chickpea Root length:

Firstly, emerged root length is recorded here. Seeds germinated under 3 types of treatments (T_1 as Root extract, T_2 as New leaf extract and T_3 as Abscission extract) and those were divided at 30%(V_1), 60%(V_2) and 100%(V_3) concentration. Observation had been done on 6th day for after placing the seed. Total replication no. is 3. Length was measured by a physical scale. All compared charts and graphs are as follows:

Table 9. Root length of Chickpea:

Treatment	Root length (Cm) Mean ± S.D
Control	4.6 ± 0.1
T1V1	2.63 ± 0.057
T1V2	2.4 ± 0.173
T1V3	2.43 ± 0.115
T2V1	2.93 ± 0.116
T2V2	2.86 ± 0.057
T2V3	2.83 ± 0.057
T3V1	2.5 ± 0.173
T3V2	2.46 ± 0.115
T3V3	2.36 ± 0.057

T1V1:- 30% Root extract

T1V2:- 60% Root extract

T1V3:- 100% Root extract

T2V1:- 30% New leaf extract

T2V2:- 60% New leaf extract

T2V3:- 100% New leaf extract

T3V1:- 30% Abscission extract

T3V2:- 60%Abscession extract

T3V3:- 100% Abscission extract

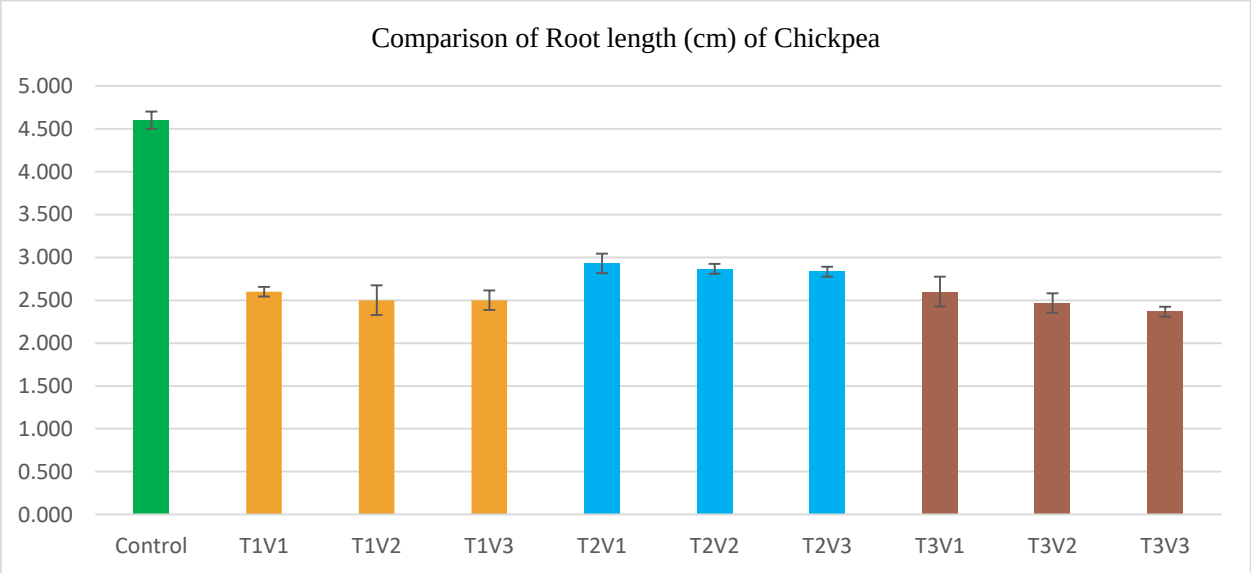

Fig. 13. Comparison of Root length of Chickpea under various *Eucalyptus* extracts.

5.3.3. Groundnut Root length:

Firstly, emerged root length is recorded here. Seeds germinated under 3 types of treatments (T_1 as Root extract, T_2 as New leaf extract and T_3 as Abscission extract) and those were divided at 30%(V_1), 60%(V_2) and 100%(V_3) concentration. Observation had been done on 6th day for after placing the seed. Total replication no. is 3. Length was measured by a physical scale. All compared charts and graphs are as follows:

Table 10. Root length of Groundnut:

Treatment	Root length (Cm) Mean ± S.D
Control	2.56 ± 0.057
T1V1	2.33 ± 0.115
T1V2	2.20 ± 0.1
T1V3	1.96 ± 0.152
T2V1	2.46 ± 0.115
T2V2	2.33 ± 0.057
T2V3	2.26 ± 0.208
T3V1	2.16 ± 0.057
T3V2	1.96 ± 0.115
T3V3	1.83 ± 0.152

T1V1:- 30% Root extract

T1V2:- 60% Root extract

T1V3:- 100% Root extract

T2V1:- 30% New leaf extract

T2V2:- 60% New leaf extract

T2V3:- 100% New leaf extract

T3V1:- 30% Abscission extract

T3V2:- 60%Abscession extract

T3V3:- 100% Abscission extract

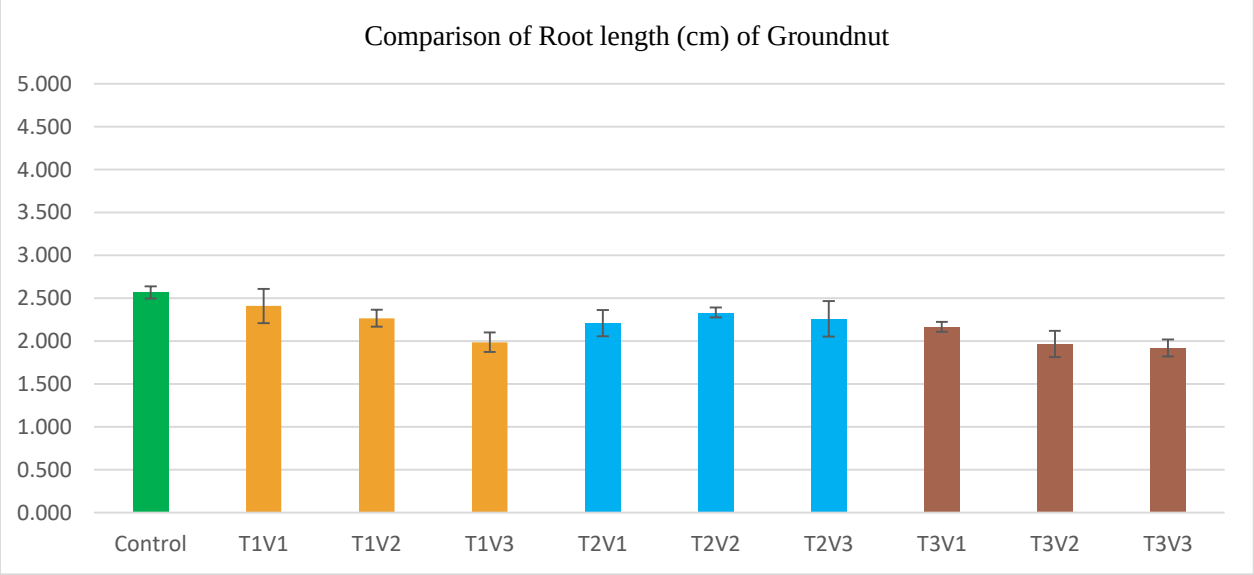

Fig. 14. Comparison of Root length of Groundnut under various *Eucalyptus* extracts.

5.3.4. Sesame Root length:

Firstly, emerged root length is recorded here. Seeds germinated under 3 types of treatments (T_1 as Root extract, T_2 as New leaf extract and T_3 as Abscission extract) and those were divided at 30%(V_1), 60%(V_2) and 100%(V_3) concentration. Observation had been done on 6th day for after placing the seed. Total replication no. is 3. Length was measured by a physical scale. All compared charts and graphs are as follows:

Table 11. Root length of Sesame:

Treatment	Root length (Cm) Mean ± S.D
Control	1.46 ± 0.057
T1V1	1.13 ± 0.115
T1V2	1.0 ± 0.173
T1V3	0.86 ± 0.057
T2V1	1.16 ± 0.057
T2V2	1.1 ± 0.1
T2V3	0.93 ± 0.152
T3V1	0.86 ± 0.152
T3V2	0.66 ± 0.115
T3V3	0.76 ± 0.152

T1V1:- 30% Root extract

T1V2:- 60% Root extract

T1V3:- 100% Root extract

T2V1:- 30% New leaf extract

T2V2:- 60% New leaf extract

T2V3:- 100% New leaf extract

T3V1:- 30% Abscission extract

T3V2:- 60%Abscession extract

T3V3:- 100% Abscission extract

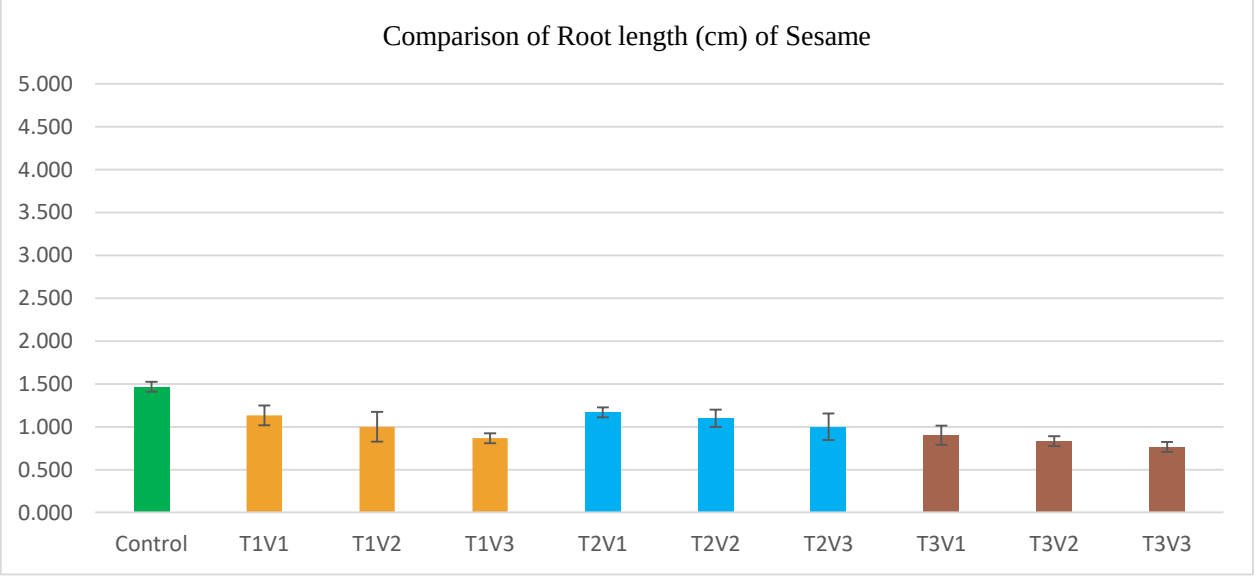

Fig. 15. Comparison of Root length of Sesame under various *Eucalyptus* extracts.

5.4. Chlorophyll Estimation:

5.4.1. Chlorophyll content in Lathyrus:

Chlorophyll was estimated from individually treated plants as well as compared plants. In low concentration treatments chlorophyll contents are like normal but in some treatments, it varies a much. All comparisons and graphs are given below:

Table12. Total Chlorophyll content of Lathyrus:

Treatment	Chlorophyll content (mg/gm.) Mean ± S.D
Control	19.36 ± 0.417
T1V1	17.76 ± 0.462
T1V2	16.910 ± 0.388
T1V3	15.234 ± 0.288
T2V1	15.77 ± 0.408
T2V2	14.83 ± 0.769
T2V3	13.54 ± 1.00
T3V1	14.81 ± 0.417
T3V2	13.742 ± 0.194
T3V3	12.14 ± 0.257

T1V1:- 30% Root extract

T1V2:- 60% Root extract

T1V3:- 100% Root extract

T2V1:- 30% New leaf extract

T2V2:- 60% New leaf extract

T2V3:- 100% New leaf extract

T3V1:- 30% Abscission extract

T3V2:- 60%Abscession extract

T3V3:- 100% Abscission extract

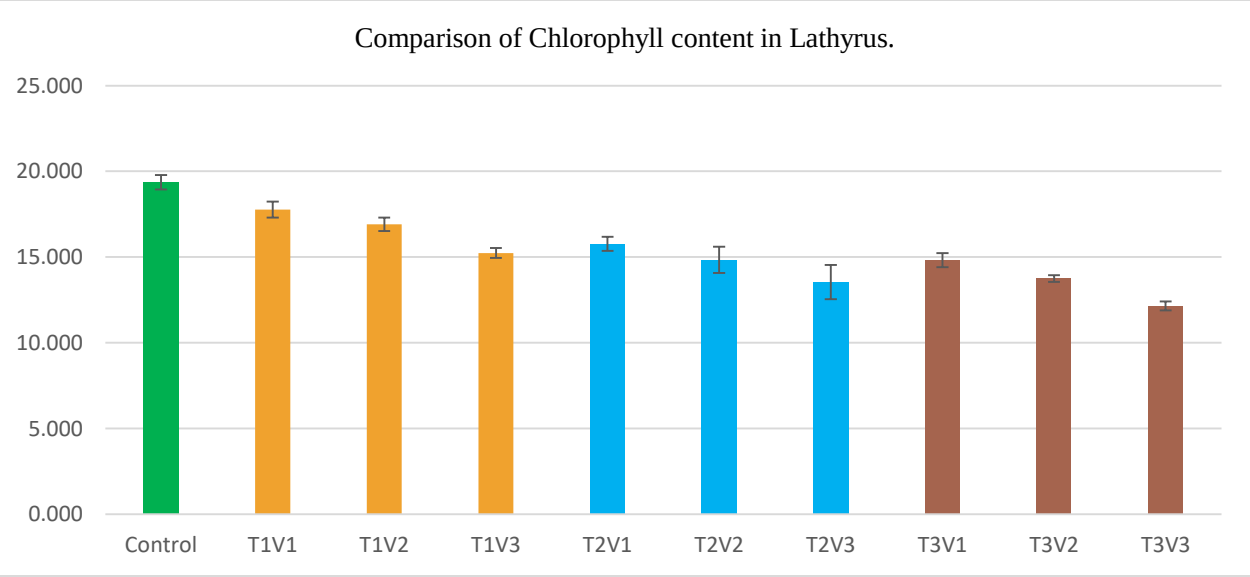

Fig. 16. Comparison of Chlorophyll content in Lathyrus under various *Eucalyptus* extracts.

5.4.2. Chlorophyll content in Chickpea:

Chlorophyll was estimated from individually treated plants as well as compared plants. In low concentration treatments chlorophyll contents are like normal but in some treatments, it varies a much. All comparisons and graphs are given below:

Table 13. Total Chlorophyll content of Chickpea:

Treatment	Chlorophyll content (mg/gm) Mean ± S.D
Control	23.42 ± 0.886
T1V1	15.12 ± 0.361
T1V2	14.36 ± 0.316
T1V3	13.34 ± 0.447
T2V1	14.04 ± 0.330
T2V2	13.613 ± 0.151
T2V3	12.43 ± 0.151
T3V1	13.071 ± 0.269
T3V2	12.269 ± 0.210
T3V3	11.289 ± 0.384

T1V1:- 30% Root extract

T1V2:- 60% Root extract

T1V3:- 100% Root extract

T2V1:- 30% New leaf extract

T2V2:- 60% New leaf extract

T2V3:- 100% New leaf extract

T3V1:- 30% Abscission extract

T3V2:- 60%Abscession extract

T3V3:- 100% Abscission extract

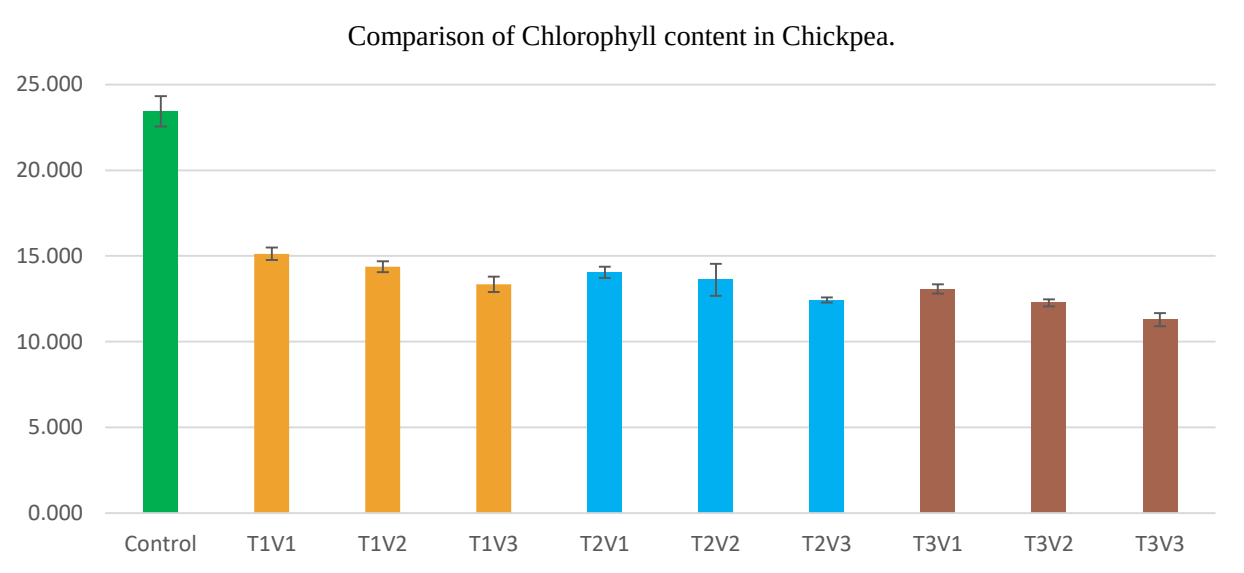

Fig. 17. Comparison of Chlorophyll content in Chickpea under various *Eucalyptus* extracts.

5.4.3. Chlorophyll content in Ground Nut:

Chlorophyll was estimated from individually treated plants as well as compared plants. In low concentration treatments chlorophyll contents are like normal but in some treatments, it varies a much. All comparisons and graphs are given below:

Table 14. Total Chlorophyll content of Groundnut:

Treatment	Chlorophyll content (mg/gm) Mean ± S.D
Control	22.068 ± 0.070
T1V1	19.351 ± 0.217
T1V2	18.550 ± 0.150
T1V3	17.843 ± 0.450
T2V1	15.536 ± 0.042
T2V2	14.997 ± 0.112
T2V3	14.134 ± 0.114
T3V1	14.098 ± 0.248
T3V2	15.347 ± 0.255
T3V3	13.403 ± 0.015

T1V1:- 30% Root extract

T1V2:- 60% Root extract

T1V3:- 100% Root extract

T2V1:- 30% New leaf extract

T2V2:- 60% New leaf extract

T2V3:- 100% New leaf extract

T3V1:- 30% Abscission extract

T3V2:- 60%Abscession extract

T3V3:- 100% Abscission extract

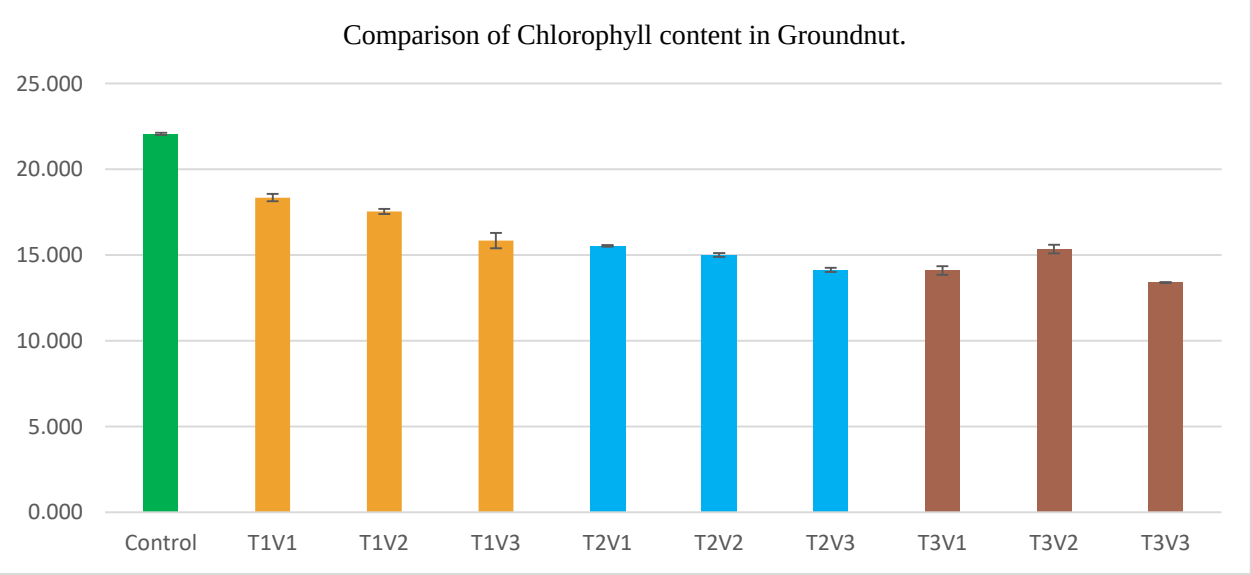

Fig. 18. Comparison of Chlorophyll content in Groundnut under various *Eucalyptus* extracts.

5.4.4. Chlorophyll content in Sesame:

Chlorophyll was estimated from individually treated plants as well as compared plants. In low concentration treatments chlorophyll contents are like normal but in some treatments, it varies a much. All comparisons and graphs are given below:

Table 15. Total Chlorophyll content of Sesame:

Treatment	Chlorophyll content (mg/gm) Mean ± S.D
Control	16.24 ± 0.424
T1V1	13.624 ± 0.267
T1V2	13.297 ± 0.524
T1V3	10.40 ± 0.386
T2V1	11.13 ± 0.061
T2V2	12.68 ± 0.489
T2V3	9.516 ± 0.164
T3V1	8.696 ± 0.118
T3V2	8.178 ± 0.276
T3V3	7.47 ± 0.415

T1V1:- 30% Root extract

T1V2:- 60% Root extract

T1V3:- 100% Root extract

T2V1:- 30% New leaf extract

T2V2:- 60% New leaf extract

T2V3:- 100% New leaf extract

T3V1:- 30% Abscission extract

T3V2:- 60%Abscession extract

T3V3:- 100% Abscission extract

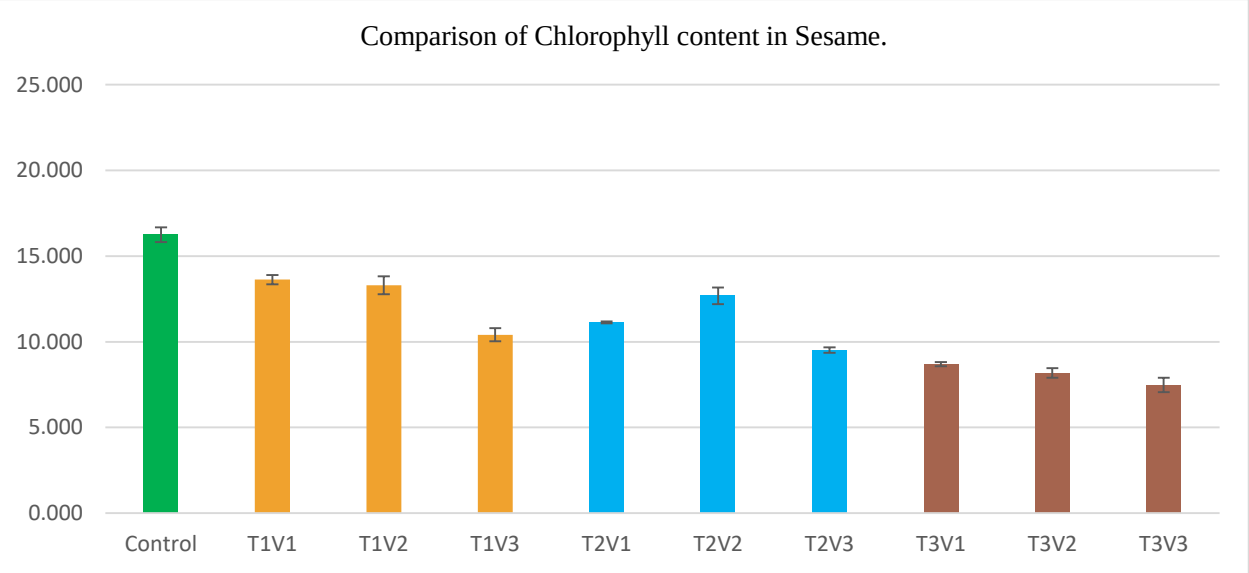

Fig. 19. Comparison of Chlorophyll content in Sesame under various *Eucalyptus* extracts.

5.7 Protein Estimation:

Here we observed protein content in the leaves of each sample from each treatment of every variety by using Lowry method. Made a BSA standard solution and then divided into different concentrations. Take absorbance of different BSA concentration by using spectrophotometer. Made a standard curve of BSA by using following data presented in table no. 16. Calculated protein content of every sample by using absorbance of samples supernatant and standard curve. The data of protein content presented as tabular form below:

Table-16 Concentration of standard protein sample

BSA (mg/mL)	Concentration (µg/mL)	OD value (660 nm)
Blank	0	0.000
0.2	200	0.151
0.4	400	0.269
0.6	600	0.421
0.8	800	0.466
1.0	1000	0.598

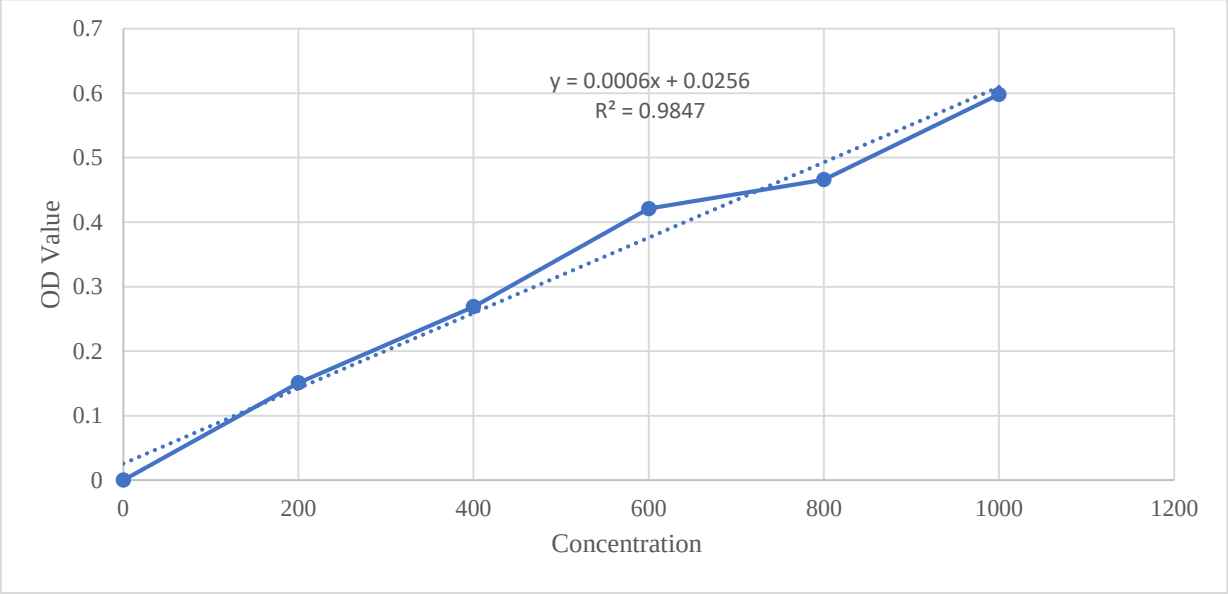

Fig 20. Standard graph for protein estimation using BSA solution.

5.5.1. Protein Estimation in Lathyrus:

Table 17. Total protein content in leaves of Lathyrus:

Treatment	Protein content () Mean ± S.D
Control	5.37 ± 0.105
T1V1	5.148 ± 0.046
T1V2	4.534 ± 0.092
T1V3	4.131 ± 0.070
T2V1	4.864 ± 0.170
T2V2	4.528 ± 0.137
T2V3	3.961 ± 0.128
T3V1	4.088 ± 0.146
T3V2	3.530 ± 0.06
T3V3	3.097 ± 0.150

T1V1:- 30% Root extract

T1V2:- 60% Root extract

T1V3:- 100% Root extract

T2V1:- 30% New leaf extract

T2V2:- 60% New leaf extract

T2V3:- 100% New leaf extract

T3V1:- 30% Abscission extract

T3V2:- 60%Abscession extract

T3V3:- 100% Abscission extract

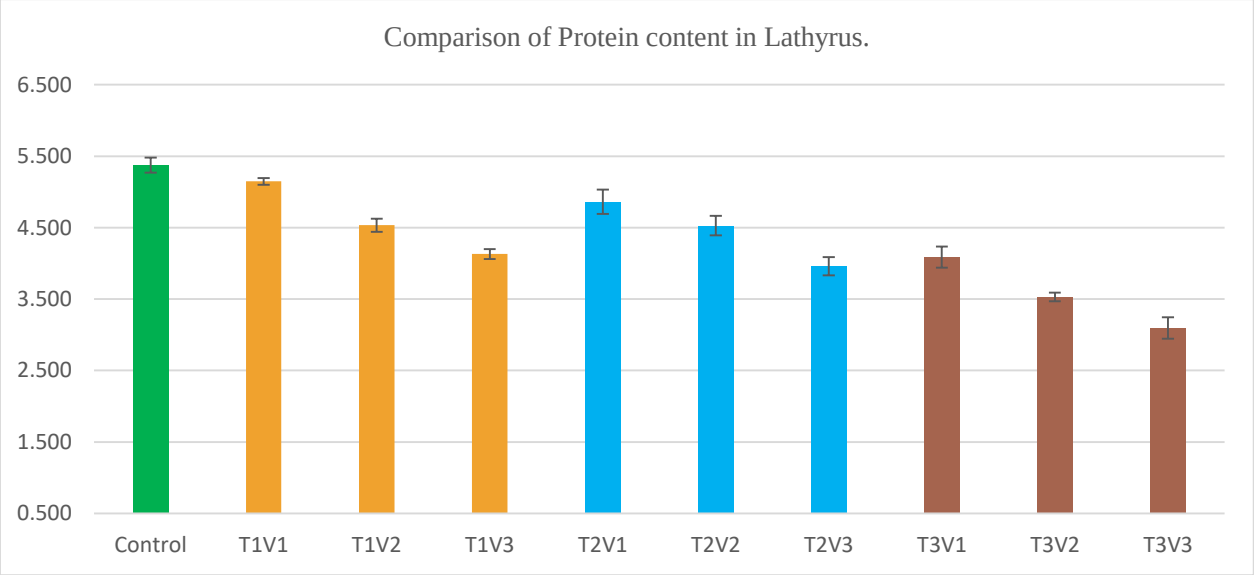

Fig. 21. Comparison of Protein content in Lathyrus under various *Eucalyptus* extracts.

5.5.2. Protein Estimation in Chickpea:

Table 18. Total protein content in leaves of Chickpea:

Treatment	Chlorophyll content () Mean ± S.D
Control	5.420 ± 0.298
T1V1	4.757 ± 0.102
T1V2	4.290 ± 0.06
T1V3	3.710 ± 0.310
T2V1	4.57 ± 0.150
T2V2	3.85 ± 0.230
T2V3	3.157 ± 0.110
T3V1	4.270 ± 0.14
T3V2	4.157 ± 1.189
T3V3	3.130 ± 0.22

T1V1:- 30% Root extract

T1V2:- 60% Root extract

T1V3:- 100% Root extract

T2V1:- 30% New leaf extract

T2V2:- 60% New leaf extract

T2V3:- 100% New leaf extract

T3V1:- 30% Abscission extract

T3V2:- 60%Abscession extract

T3V3:- 100% Abscission extract

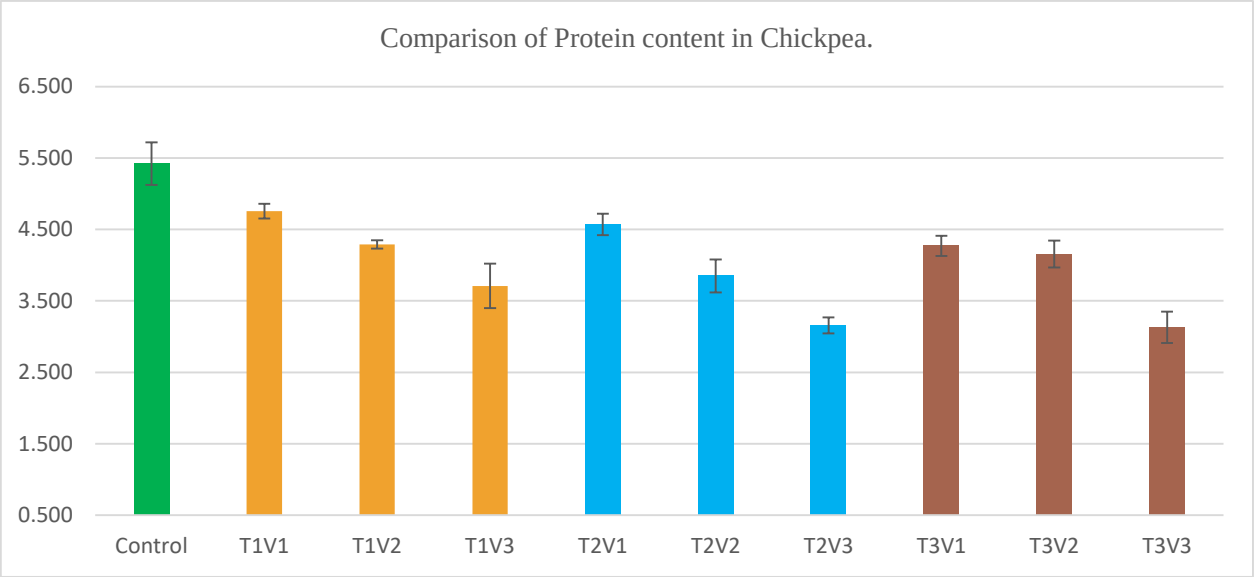

Fig. 22. Comparison of Protein content in Chickpea under various *Eucalyptus* extracts.

5.5.3. Protein Estimation in Groundnut:

Table 19. Total protein content in leaves of Groundnut:

Treatment	Chlorophyll content () Mean ± S.D
Control	5.990 ± 0.177
T1V1	5.513 ± 0.189
T1V2	5.103 ± 0.030
T1V3	4.697 ± 0.030
T2V1	5.223 ± 0.151
T2V2	4.660 ± 0.045
T2V3	3.950 ± 0.210
T3V1	4.407 ± 0.032
T3V2	3.773 ± 0.150
T3V3	2.967 ± 0.293

T1V1:- 30% Root extract

T1V2:- 60% Root extract

T1V3:- 100% Root extract

T2V1:- 30% New leaf extract

T2V2:- 60% New leaf extract

T2V3:- 100% New leaf extract

T3V1:- 30% Abscission extract

T3V2:- 60%Abscession extract

T3V3:- 100% Abscission extract

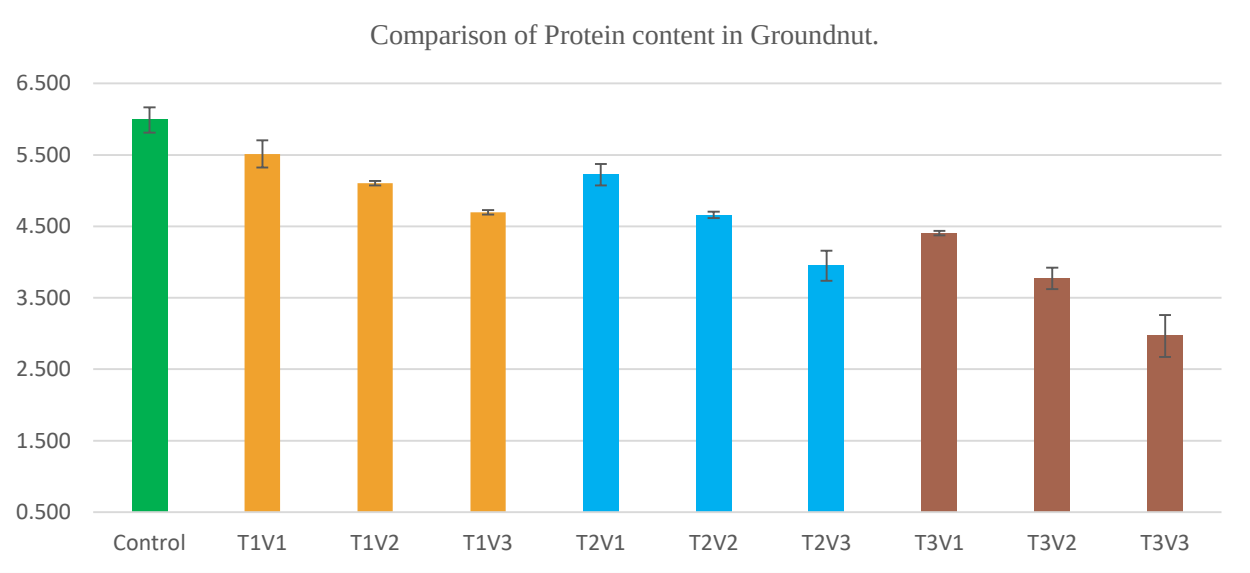

Fig. 23. Comparison of Protein content in Groundnut under various *Eucalyptus* extracts

5.5.4. Protein Estimation in Sesame:

Table 20. Total protein content in leaves of Sesame:

Treatment	Chlorophyll content () Mean ± S.D
Control	5.663 ± 0.160
T1V1	5.003 ± 0.280
T1V2	4.457 ± 0.205
T1V3	3.693 ± 0.130
T2V1	4.377 ± 0.040
T2V2	3.570 ± 0.1
T2V3	2.713 ± 0.100
T3V1	3.827 ± 0.075
T3V2	3.050 ± 0.147
T3V3	2.433 ± 0.211

T1V1:- 30% Root extract

T1V2:- 60% Root extract

T1V3:- 100% Root extract

T2V1:- 30% New leaf extract

T2V2:- 60% New leaf extract

T2V3:- 100% New leaf extract

T3V1:- 30% Abscission extract

T3V2:- 60%Abscession extract

T3V3:- 100% Abscission extract

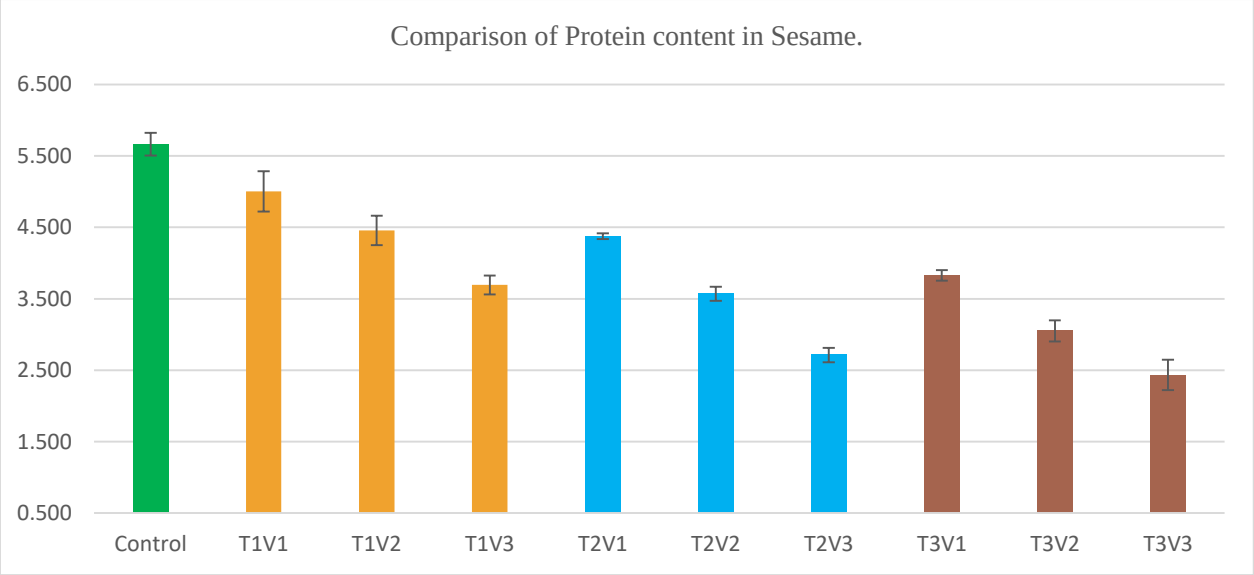

Fig. 24. Comparison of Protein content in Sesame under various *Eucalyptus* extracts

5.8 Root Cell Abnormality:

Root cell abnormalities observed under microscopic field just after germination by cutting the root tip. In case of control condition several mitotic phases were observed under microscope but in stressed condition chromosomes found as abnormal.

In some crop like Lathyrus clearly shows abnormalities as compared to control plants while other crops like groundnut, Chickpea and sesame doesn't showed clear visible of abnormalities under allelochemicals because of the hardiness and high thickness of its root. Every protocol is followed but the end result was not quite appreciable in testing of chromosomal abnormalities.

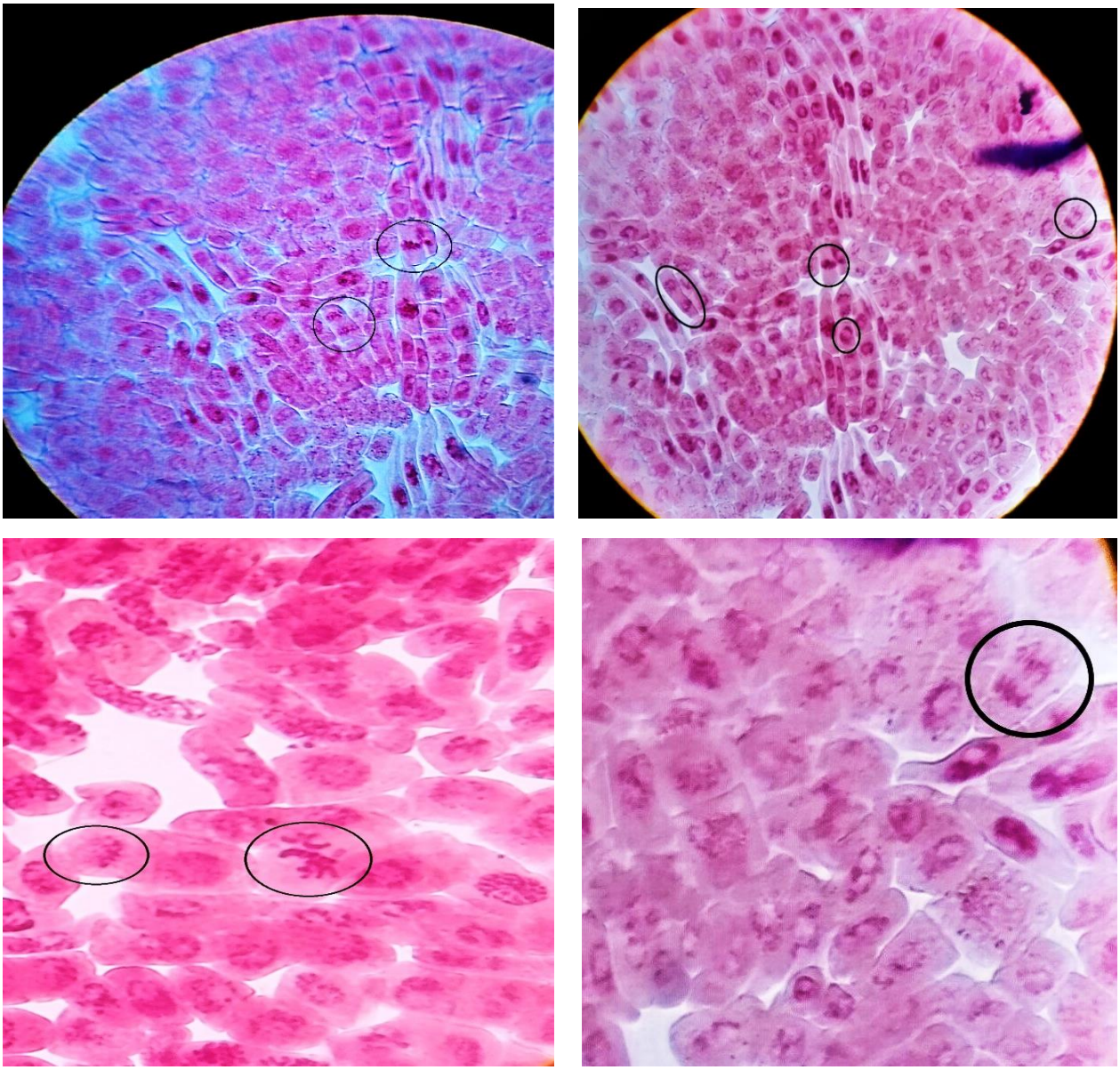

Fig. 25. Chromosomal abberation in Root cells under *eucalyptus* extracts.

Chapter 6: Discussion

6. Discussion:

In this study 4 crops were used i.e., Grass Pea, the botanical name of Grass Pea is *Lathyrus Sativus*, Chromosome no. 2n=14, Leguminosae family; Chickpea the botanical name is *Cicer arietinum,* Chromosome no. 2n=14, Leguminosae family; Groundnut, the botanical name is *Arachis hypogaea,* Chromosome no. 2n=40, Leguminosae family; Sesame, the botanical name is *Sesamum indicum,* Chromosome no. 2n=26, Pedaliaceae family. The study entitled "Comparative study on impact of eucalyptus allelopathy on different sensitive and resistant crop plants". It was found that though *Eucalyptus* have a huge allelopathic effect, a suitable data sheet of specific effect of its allelochemicals on plant basis more specifically on legume crops was not clear. As legumes are well-known for their ability to withstand abiotic stress, it can be a potent group to experiment the anti-allelopathic property against allelochemicals of *Eucalyptus* which is totally unrevealed in this field.

Here tried to find out the difference of morphological, physiological and biochemical changes between stressed and normal plants.

Pawlowski *et al*., 2012 noticed that volatile eucalyptol can decreased germination rate. By observing the germination rate, it was seen that every crop is getting too much effected by Eucalyptus allelopathy and the Abscission leaf are affecting the most in compared to root and new leaf extract. Groundnut and Chickpea is showing highest germination than other plants in every type of treatments individually.

In case of Root Length / Shoot Length stressed plant's root or shoots are more swelled and have more divisions than control, control plants roots and shoots are straight but in case of stressed those root and shoots are not that straight and they have difference in color, which supported the comments given by Bakkali *et al*., 2008.

According to Wang *et al*., 2014, the impact of allelochemicals on plants photosynthesis mainly involve inhibition or damaged to synthesis machinery and acceleration of the decomposition of photosynthetic pigments. In this present study, Chlorophyll content all 4 crops having high chlorophyll content in control condition compared to stress condition. But in overall comparison groundnut is having much more relaxation in stressed condition also, which supports the given commands.

Zhou *et al*., 2010 finds that allelochemicals exert different effects on the synthesis, functions, contents and activities of various proteins. This experiment showed similar trends. Amount of protein is more in controlled crops as compare to stress condition in case of all 4 crops. Leaves are treated for estimation of proteins and the values are justified as per previous studies.

The root cell abnormalities estimated just after germination by cutting the root tip. In case of control condition several mitotic phases were observed under microscope but in stressed condition chromosomal disseminates were found. In some crop like lathyrus clearly shows abnormalities as compared to control plants while other crops like groundnut, Chickpea and sesame didn't showed clear visible of abnormalities under allelochemicals because of the hardiness and high thickness of its root. Every protocol is followed but the end result was not quite appreciable in testing of chromosomal abnormalities.

While the root extract of Eucalyptus did not exert significant effects on the crops, it was observed that the abscission leaf extract hindered the growth and development of the crops, resulting in compromised plant Vigor compared to the controlled plants. Notably, groundnut exhibited some level of resistance to the allelopathic effects, displaying similar growth patterns as the controlled plants.

Chapter 7: Conclusions

7. Conclusion:

The conducted study aimed to investigate the allelopathic effects of Eucalyptus on Lathyrus, chickpea, groundnut, and sesame crops by evaluating various parameters including germination rate, chlorophyll content, protein content, and root length. The results of the study revealed intriguing findings regarding the impact of Eucalyptus allelopathy on these crops. While the root extract of Eucalyptus did not exert significant effects on the crops, it was observed that the abscission leaf extract hindered the growth and development of the crops, resulting in compromised plant Vigor compared to the controlled plants. Notably, groundnut exhibited some level of resistance to the allelopathic effects, displaying similar growth patterns as the controlled plants. On the other hand, Lathyrus was found to be particularly susceptible, experiencing severe negative impacts on its growth.

The findings of this study have important implications for agricultural practices and land-use planning. Farmers and agricultural stakeholders should consider the potential allelopathic effects of Eucalyptus when considering crop rotations and selecting suitable companion crops. The detrimental effects observed in Lathyrus highlight the need for careful consideration when cultivating this crop in proximity to Eucalyptus stands. Such considerations are crucial to prevent or minimize the negative consequences on crop yield and overall agricultural productivity.

The results obtained in this study provide valuable insights into the allelopathic interactions between Eucalyptus and the tested crops. By demonstrating that the abscission leaf extract plays a prominent role in hindering crop growth and development, this study highlights the importance of understanding the chemical composition and mechanisms of action of allelopathic compounds. Further research should be conducted to isolate and identify the specific allelochemicals present in the abscission leaf extract, as this knowledge will facilitate a more comprehensive understanding of the allelopathic effects and aid in the development of targeted management strategies.

Investigating the mechanisms by which these allelochemicals interfere with crop growth and development should be a key focus of future studies. Understanding the physiological and biochemical processes affected by the allelopathic compounds will enable the development of crop varieties with enhanced resistance to allelopathic interference. By unravelling the intricate mechanisms involved, researchers can develop innovative approaches to mitigate the negative effects of Eucalyptus allelopathy on susceptible crops.

Furthermore, exploring the crop-specific responses to Eucalyptus allelopathy is essential. Different crops may exhibit varying levels of sensitivity or resistance to allelopathic interference, and understanding these variations will inform crop selection decisions and assist in designing sustainable crop rotations. By identifying crop species or varieties that are less susceptible to Eucalyptus allelopathy, farmers can optimize their agricultural practices and maximize overall crop productivity.

In addition to crop-specific responses, future research should also focus on evaluating the impact of Eucalyptus allelopathy on soil health, microbial communities, and biodiversity. The long-term ecological implications of these allelopathic interactions are significant and should not be overlooked. Assessing the effects on soil properties, nutrient cycling, and the overall ecosystem will provide a holistic understanding of the consequences of Eucalyptus allelopathy. This knowledge will be invaluable for sustainable land-use planning, biodiversity conservation, and maintaining the long-term productivity of agricultural systems.

In conclusion, the study findings have shed light on the allelopathic effects of Eucalyptus on Lathyrus, chickpea, groundnut, and sesame crops. However, further research is necessary to unravel the underlying mechanisms, identify specific allelochemicals, and develop effective management strategies. Understanding the complexities of allelopathic interactions will assist farmers and agricultural stakeholders in making informed decisions to maximize crop productivity and sustainably manage their agricultural systems. By addressing the research gaps outlined in this study, knowledge can be enhanced of Eucalyptus allelopathy and its implications for crop production, ecological sustainability, and agricultural management.

Chapter 8: Future Scope

8. Future Scope:

The present study lays the groundwork for extensive future research on Eucalyptus allelopathy and its implications for crop production. Several avenues of investigation can be explored to expand understanding of this complex phenomenon and its potential applications. The following areas offer promising directions for future studies:

Allelochemical identification and characterization: Further research should focus on isolating, identifying, and characterizing the specific allelochemicals present in the abscission leaf extract of Eucalyptus. This in-depth analysis will enable a more precise understanding of the chemical interactions between Eucalyptus and the affected crops. Techniques such as chromatography, mass spectrometry, and nuclear magnetic resonance can be employed to identify the allelochemical compounds. Additionally, quantifying the concentration of these compounds under varying environmental conditions can provide insights into their production dynamics.

Mechanisms of action: Investigating the mechanisms by which the allelochemicals hinder the growth and development of crops is crucial for gaining a deeper understanding of the physiological and biochemical processes affected. This knowledge will aid in the development of targeted management strategies. Future studies should focus on unraveling the molecular mechanisms behind the allelopathic interactions, such as the disruption of key enzymes, signaling pathways, or physiological processes in the affected crops. Techniques such as transcriptomics, proteomics, and metabolomics can be employed to elucidate the molecular changes induced by allelopathic compounds.

Crop-specific responses: Understanding the varying responses of different crops to Eucalyptus allelopathy is essential for crop selection and management decisions. Future research should delve into the specific sensitivities and resistance mechanisms of various crop species and varieties. By identifying and characterizing crop traits associated with resistance to allelopathic interference, such as specific detoxification mechanisms or physiological adaptations, breeders can develop crop varieties with enhanced resilience to Eucalyptus allelopathy. This will contribute to sustainable crop production and minimize yield losses in areas where Eucalyptus cultivation coexists with susceptible crops.

Agronomic practices and management strategies: Exploring agronomic practices that may mitigate the negative effects of Eucalyptus allelopathy is of great practical significance. Future research should investigate techniques such as adjusting planting distances, utilizing intercropping or mixed cropping systems, employing crop rotations or allelopathy-resistant crop varieties, and incorporating organic amendments to ameliorate the allelopathic effects. These approaches have

the potential to minimize the allelopathic impact on crop growth and development, enhance resource utilization, and promote sustainable agricultural systems in Eucalyptus-growing regions.

Ecological implications: Assessing the long-term ecological impacts of Eucalyptus allelopathy on soil health, microbial communities, and biodiversity is crucial for understanding the broader consequences of this phenomenon. Future studies should investigate changes in soil properties, nutrient cycling dynamics, and microbial community composition and function in the presence of Eucalyptus. Evaluating the effects on above-ground and below-ground biodiversity, including plant species diversity, insect communities, and soil-dwelling organisms, will provide a comprehensive understanding of the ecosystem-level consequences. This knowledge will support informed land-use planning decisions and promote sustainable land management practices in Eucalyptus-growing regions.

While the present study has provided valuable insights into the allelopathic effects of Eucalyptus on Lathyrus, chickpea, groundnut, and sesame crops, further research is warranted to address the identified research gaps. Future studies should focus on allelochemical identification, elucidation of mechanisms of action, understanding crop-specific responses, exploring agronomic practices and management strategies, assessing ecological implications, and developing modeling tools. Advancing knowledge in these areas will empower farmers, researchers, and land managers to make informed decisions, develop sustainable agricultural systems, and effectively manage the allelopathic interactions between Eucalyptus and neighboring crops.

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