

**Influence of different Bio-fertilizers on the growth, yield, Vitamin E,
chlorophyll and nitrogen content in two oil-seeded plants –
Arachis hypogaeae L. and *Sesamum indicum* L.**

BY

K. AISWARIYA

(17PBO002)

**Thesis submitted to the
Avinashilingam Institute for Home Science and Higher Education
for Women, Coimbatore – 641 043.**

**In Partial Fulfillment of the Requirements for the
Degree of Master of Science in Botany**

APRIL 2019

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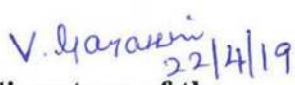
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Signature of the

Head of Department


Signature of the

Supervisor

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I. INTRODUCTION

Plants are the backbone of life on Earth and an essential resource for humans. Humans obtain many products directly or indirectly from plants (Wangchuk *et al.*, 2012; Polunin and Stainton, 1997 and Thalluri, 2016). The plant kingdom contributes immensely to human health when no synthetic medicines were available and when no concepts of surgery existed. There is therefore, need to conserve these plants associated with indigenous knowledge for human development and good health. Synthetic drugs gained popularity against green remedies because their fast-acting effects, however, people have begun to realize the benefits associated with natural remedies (Idu, 2009).

The plants produce several chemical compounds that have biological functions as well as produce defense against insects, fungi and anthophagous mammals. A minimum of 12,000 such compounds are isolated till now, which is considered to be only 10% of the total availability (Thalluri, 2016). Many plant species contain active ingredients such as alkaloids, phenols, tannins, cryogenics and terpenoids (Akinyemi *et al.*, 2018).

Plants are the source of many natural products such as essential oils, natural dyes, pigments, waxes, resins, tannins, alkaloids, amber and cork. Phytochemical is a natural bioactive compound found in plants, such as vegetables, fruits, medicinal plants, flowers, leaves and roots that work with nutrients and fibers to act as a defense system against disease or more accurately, to protect against disease. These are the reservoirs of potentially useful chemical compounds which could serve as newer leads and clues for modern drug design (Vijayalakshmi and Ravindran, 2012). The most important of these bioactive constituents of plants are alkaloids, tannins, flavonoids and phenolic compounds (Doss, 2009).

Organic farming is a method of crop and livestock production that involves much more than choosing not to use pesticides, fertilizers, genetically modified organisms, antibiotics and growth hormones. Biofertilizers are best defined as biologically active products or microbial inoculants viz., formulations containing one or more beneficial bacteria or fungal strains in easy to use and economical carrier materials which add, conserve and mobilize crop nutrients in the soil. Organic fertilizers contain organic compounds which directly or by their decay, increase soil fertility. More commonly known as microbial inoculants, are artificially multiplied cultures

of certain soil organisms that can improve soil fertility and crop productivity. In other words, Biofertilizer is a substance which contains living microorganisms which when applied to seed, plant surfaces, or soil, colonizes the rhizosphere or the interior of the plant and promotes growth by increasing the availability of primary nutrients to the host plant (Mazid *et al.*, 2011a).

Vesicular arbuscular mycorrhizal fungi belong to the class Zygomycetes, order Endogonales (Benjamin, 1979) and family Endogonaceae. Mycorrhizal Fungi are responsible in improving growth of host plant species due to increased nutrient uptake, production of growth promoting substances, tolerance to drought, salinity and synergistic interactions with other beneficial microorganisms (Sreenivasa and Bagyaraj, 1989). Mycorrhizal Fungi that grow into the root cortex of the host plant and penetrate root cells to form two kinds of specialized structures, arbuscules and vesicles. Mycorrhizal Fungi is specifically designed to reduce transplant stress while improving soil hydration and fertility. Mycorrhizal association can also enable the plant host to access nutrients in an organic form which would be unavailable otherwise (Howeler *et al.*, 1981). The soil conditions prevalent in sustainable agriculture are likely to be more favorable to AM fungi than those under conventional agriculture (Smith and Read, 1997).

Panchagavya also contain phosphate solublizing microorganisms. Phosphorus is a major essential macronutrient for biological growth and development. Panchagavya has played a significant role in providing resistance to pests and diseases, resulting in increased overall yields (Tharmaraj *et al.*, 2011 and Sumangala and Patil, 2009). Panchagavya possess the properties of fertilizers and biopesticides (Sireesha, 2013). Panchagavya has resulted in positive effect on growth and productivity of crops as reported by Somasundaram *et al.* (2007).

Azospirillum is a gram-negative, microaerophilic, non-fermentative and nitrogen-fixing bacterial genus from the family of Rhodospirillaceae. It is a free-living, plant-growth-promoting bacterium (PGPB) capable of affecting growth and yield of numerous plant species, many of agronomic and ecological significance. They are found in the soil around plant roots and root surfaces (Indu and Savithri, 2003). It also produces growth-promoting substances like Indoleacetic acid (IAA), gibberellins and promotes root proliferation (Bhaskara *et al.*, 2005 and Ananthaik, 2006). It increases the rootlet density and root branching resulting in the increased uptake of mineral and water.

The natural oils such as mustard, peanut and sesame are stable, non-drying or semi-drying oils with a low tendency to oxidize in the light. In their natural form, they contain antioxidants which prevent rancidity and reversion (development of 'off' odors). In contrast, soybean and safflower oil are drying oils while sunflower oil is semidrying oil. Thus, due to a higher percentage of PUFAs, they are prone to oxidation in the presence of light, temperature and air and metal (Sharma and Sharma, 2017).

Nuts and seeds are a rich source of Vitamin E compared to vegetables and fruits (Bauernfiend, 1980; Murphy *et al.*, 1990). Edible oil seeds play a vital role in human nutrition by providing calories and aiding in digestion of several fat soluble vitamins for example vitamin A, D, E, K (Sharma and Sharma, 2017). Seeds store TAG (Triacylglycerols), as a food reserve for germinative growth of the seedlings. They are present in small, discrete intercellular organelles called oil bodies (Yatsu and Jacks, 1972; Appelquist, 1975; Stymne and Stobart, 1987; Huang, 1992).

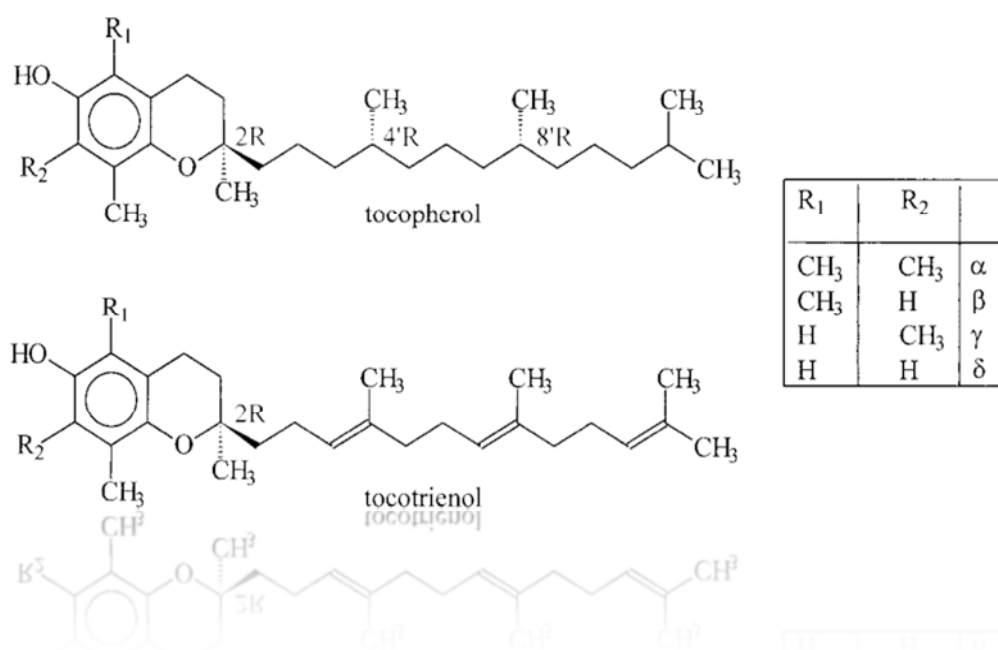
Oils and fats are one of the largest groups of organic compounds which are of great importance in the food, indispensable part of the human diet and more than 90% of global production is used as food or as ingredients in food products. Fats and other lipids contribute essential fatty acid to the diet which our body cannot synthesize. The edible oils play a significant role in diet for all people. It has been extracted through eco- friendly cold pressing technique called 'Ghani' which extract the oil from seed very slowly at low velocity and room temperature. The extracted oil is fresh, healthy, pure and nutritious with natural color, flavor and odor.

Traditional oils like Sesame, Coconut, Mustard and Groundnut oils are being used in India from long time, which may be used in cooking vegetables, deep frying and for storage purposes as pickles. Therefore, the fact is that mostly oil is treated at high temperature or stored for long period. Literature survey reveals that rancidity and reversion are found to be the major problems in the use of vegetable oils, which are caused due to tendency of unsaturated fatty acids to oxidize during thermal treatment and storage (Sharma and Sharma, 2017).

Vitamin E is a group of eight fat soluble compounds that include four tocopherols (α -T, β -T, γ -T, δ -T) and corresponding tocotrienols (α -T, β -T, γ -T, δ -T) in which α -tocopherol is the

most biologically active form (Pryor,1995). Vitamin E was discovered in 1922, isolated in 1935 and first synthesized in 1938. Since the Vitamin activity was first identified as essential for fertilized eggs to result in live births (in rats), it was given the name "tocopherol" from Greek words meaning birth and to bear or carry(Evans *et al.*, 1922 and Evans *et al.*, 1936). Vitamin E play a role as an antioxidant and, therefore, prevents and/or delays lipid oxidation, including oxidation of low density lipoprotein (Esterbauer *et al.*, 1991). Due to the antioxidant effect of Vitamin E in nuts and seeds and increasing nutritional interest in these foods, more complete data on the Vitamin E content of nuts and seeds are needed (Lee *et al.*, 1998).

Structure of VitaminE



Vitamin E is essential for normal growth and development, and deficiency leads to clinical abnormalities. Vitamin E prevents cell damage by preventing *in vivo* peroxidation and is thought to be a preventive factor for inflammation, cardiovascular disease, cancer, various neurodegenerative diseases-including Alzheimer's disease and other disease states involving oxidative stress (Huang *et al.*, 1986; Meydani *et al.*, 1990; Byers and Perry, 1992; Gey, 1993; Evans, 1994; Bowling and Bcal, 1995; Knight, 1997; Manton *et al.*, 1997; Sayrc *et al.*, 1997).

Leaf chlorophyll content, a good indicator of photosynthetic activity, mutations, stress, and nutritional state has important potential implications on crop stress and chlorosis detection,

agricultural field management, and especially for precision agriculture practices in which the healthy plants have higher range of chlorophyll content when compared to the unhealthy ones (Zarco-Tejada *et al.*, 2004). Chlorophyll is an extremely important biomolecule containing chlorin pigment found in the chloroplasts of plants. It is critical in photosynthesis as it allows plants to absorb energy from light (Anthony *et al.*, 2003). Chlorophyll molecules are specifically arranged in and around photosystems that are embedded in the thylakoid membranes of chloroplasts (Chen *et al.*, 2010). Chlorophyll content can be an indicator of the plant's condition.

Nitrogen is an essential nutrient for plant growth, development and reproduction. Despite nitrogen being one of the most abundant elements on earth, nitrogen deficiency is probably the most common nutritional problem affecting plants worldwide. Nitrogen from the atmosphere and earth's crust is not directly available to plants. Healthy plants often contain 3 to 4 percent nitrogen in their above-ground tissues. This is a much higher concentration compared to other nutrients. Nitrogen is so vital because it is a major component of chlorophyll, the compound by which plants use sunlight energy to produce sugars from water and carbon dioxide (i.e., photosynthesis). It is also a major component of amino acids, the building blocks of proteins. Nitrogen is a significant component of nucleic acids such as DNA, the genetic material that allows cells (and eventually whole plants) to grow and reproduce. Without nitrogen, there would be no life on earth.

Arachis hypogaeae L.

The peanut or ground nut (*Arachis hypogaeae L.*) is a species in the legume or bean family (Fabaceae). It is a major, significant, commercial oil seeded crop in India (Guha and Chandrasekhar, 2001). It is commonly called as poor man's nut (Bankole *et al.*, 2005 and Varghese, 2014). The only nut that grows on ground is the groundnut, often called as "The King of Oilseeds", and is the important inexpensive source of protein, fat, minerals and Vitamins in the diets of rural populations, especially children (Stansell *et al.*, 1976; Nageswara Rao *et al.*, 1989). Legumes play an important role in human nutrition since these are rich sources of protein, calories, certain minerals and vitamins (Deshpande, 1992). Peanut is an annual spreading, branched herb, stem 30 – 50 cm long. Unripe fruit is lactagogue. Groundnut is resistant to water stress conditions but drought conditions have adverse effects on the pod yield and seed grade (Stansell *et al.*, 1976; Nageswara Rao *et al.*, 1989). Groundnut is called a self-fertilizing crop,

nevertheless, it is very exhaustive crop compared to other legumes because a very little portion of the plant residue is left in the soil after harvest (Varade and Urkude, 1982).

Arachis hypogaeae L. has been used in Vietnamese folk remedies for the treatment of various diseases such as loose cough, arthritis, constipation, recuperation after illness, etc. Groundnuts are a good source of oil and fat ranging from 36 to 54% (Asibuo *et al.*, 2008). Among the fat, the unsaturated fatty acids content is higher compared to saturated fatty acids. Groundnut seed contains 30% essential nutrients and phytonutrients, 44 to 56% oil and 22 to 30% protein on a dry seed basis and is a rich source of minerals (P, Ca, Mg and K) and Vitamins (E, K and B group) (Savage and Keenan, 1994). Groundnut provides considerable amount of mineral elements to supplement the dietary requirements of humans and farm animals (Asibuo *et al.*, 2008). Groundnuts are one of those plant foods that are a dietary source of phytochemicals (Govindaraj and Jain, 2011). Array of nutrients and phytochemicals play an important role in mechanism responsible for its putative health benefits (Prabasheela *et al.*, 2015).

Chemical constituents of ground nut are moisture, protein, lipids, crude fibre, reducing sugars, disaccharide sugars, starch and pentosans, oil contains glycerides of palmitin, olein, hypogaeic, lignoceric, linolic and arachidonic acids. It is also highly rich in Vitamin E, nicotinic acid and riboflavin (Prajapati *et al.*, 2003).

Peanuts contain important components for human nutrition. Peanuts high nutritional content is attributed to the presence of biologically active compounds such as, tocopherols, flavonoids, phytosterols, resveratrol, as well as, to their relatively high level of protein and their easy oil digestibility (Venkatachalam and Sathe, 2006).

Vesicular Arbuscular Mycorrhiza (VAM) forms mutualistic symbiosis with the host plant and has a positive effect in the absorption of nutrients, plant health and soil fertility, so it gives a positive effect on plant growth (Ramasamy *et al.*, 2011). The main role of VAM is to increase the available soil P and hence P uptake increases by macro symbiont (Toljander, 2006). Mate and Saindandshiv (2018) have undertaken a study to evaluate the role of VAM fungi in the growth of groundnut crop plants.

Panchagavya is one of the most important and beneficial manure. It induces large leaves and enhances high level of photosynthesis. In ground nut, it influences high level of nodulation and it increases height of the plant. It increases the sugar content and aroma of the fruit.

Azospirillum is a free-living, microaerophilic, heterophilic, diazotropic bacteria. It is actively involved in heterotrophic nitrogen fixation in several plants. It is also called as plant-growth-promoting bacterium (PGPB), capable of affecting growth and yield of numerous plant species, many of agronomic and ecological significance. It increases the yield and is the growth promoting bacteria, which induces early fruiting in groundnut.

Peanuts is an excellent source of vitamin E. Peanuts contain approximately 50% oil composed of 81% of unsaturated fatty acids of which about 39% is polyunsaturated (USDA, Nutrient Data Bank, 2002). Recent reports (Kris-Etherton *et al.*, 1999; Hu *et al.*, 2001) indicated that replacing saturated fat with unsaturated fat is more effective in lowering risk of congenital heart disease than simply reducing total fat consumption. One ounce of peanuts provides 25% of daily need of vitamin E. Oil extraction yields (%) by pressing was 35.9 ± 0.02 for raw and 36.8 ± 1.77 for roasted peanuts (Chun, 2002). Tocopherol contents of the raw and roasted peanut oils could be prepared by hydraulic pressing. The levels of tocopherols in pressed peanut oil significantly decreased by roasting at all temperatures (Lee *et al.*, 1998).

Peanut consists of higher energy source like proteins, vitamin, minerals, nutrients and antioxidant. It helps to lower bad cholesterol level and increases good cholesterol level which in turn lowers the risk of heart disease as it contains mono-unsaturated fatty acid. The polyphenolic anti-oxidants are seen in the groundnut in higher concentration. It reduces the risk of stomach cancer.

***Sesamum indicum* L.**

Sesame (*Sesamum indicum*) commonly referred to as ben seed, is a flowering plant in the genus *Sesamum* and belongs to the family Pedaliaceae. It is described as the “queen of oilseeds” because of its high oil, protein, calcium and phosphorus (Prasad, 2002; Misari and Iwo, 2000). It

is an erect glandular pubescent, annual herb branching from the base, growing up to a height of 95cms. Fruits (capsules) are 2-5 cm long and 0.5-2 cm in diameter, quadrangular, oblong, compressed, capsules deeply 4 grooved, dehiscent to half way down. Seeds are many, flat, ovate, obovoid, compressed, black or white (Sani *et al.*, 2013; Putnam *et al.*, 2003). It is widely naturalized in tropical regions around the world and is cultivated for its edible seeds, which grow in pods.

Sesame seed is one of the oldest oilseed crops known, domesticated well over 3000 years ago (Ram *et al.*, 1990). Roots and leaves are emollient and a decoction of them forms a good hair-wash which will promote hair growth and will blacken them. The leaves are used to treat cholera, diarrhea, dysentery, headache, malignant tumors and respiratory ailments (Burkill, 1997 and Namiki, 2007).

Chemical constituents

Sesamum seeds are fairly rich in thiamine and niacin. The principle protein is a globulin. Seeds contain a fixed oil and leaves contain a gummy matter. From this flavonoid, glucoside and pedalin are isolated.

Bio-fertilizer (microbial inoculants) and organic amendments are cheap nutrient source that could serve as alternative to chemical fertilizers and improve crop production in low-input agriculture. Application of organic amendments, increases soil organic carbon and stimulate microbial activity which provides N and P to soil. Soil microorganisms on the other hand play a vital role in their ability to provide and recycle nutrient for plant growth (Weil and Magdoff, 2004). Their population and activities may not only reflect the quality of soil, but also reflect soil environmental conditions (Leungvutiviroj *et al.*, 2010). Biofertilizer help in increasing crop productivity by way of increased BNF, increased availability or uptake of nutrients through solubilization or increased absorption, stimulation of plant growth through hormonal action or antibiosis, or by decomposition of organic residues (Mohammadi and Sohrabi, 2012).

Vesicular Arbuscular Mycorrhiza (VAM) is the most abundant kind of mycorrhiza described as 'a universal plant symbioses'. Lack of host specificity is even more characteristic of

this symbiosis than other types known. Vesicular Arbuscular Mycorrhiza (VAM) is a potential biofertilizer (Sullia, 1991). Mycorrhizal fungi are specifically designed to reduce transplant stress while improving soil hydration and fertility. Mycorrhizal association can also enable the plant host to access nutrients in an organic form which would be unavailable otherwise. Compared to normal plant roots, mycorrhizal structures can take up phosphorus from lower concentration effectively (Howeler *et al.*, 1981). Mycorrhizal association is responsible for up to 80% of the total phosphorus uptake by plants (Marschner and Dell, 1994). Mycorrhizal association can also enable the plant host to access nutrients in an organic form which would be unavailable otherwise.

Azospirillum is found to be very effective in increasing 10- 15% yield of cereal crops and fixing N₂ up to 20-40 Kg N/ha (Youssef and Eissa, 2014). Positive growth response of inoculated plants could be due to provision of nutrients especially nitrogen and growth promoting hormones by *Azospirillum* and enhanced uptake of phosphorus and other nutrients due to mycorrhizal colonization (Zaidi *et al.*, 2004).

Panchagavya means "mixture of five products (cow dung, cow urine, milk, ghee and curd) of cow. Of these, the three direct constituents are cow dung, urine and milk; and the two derived products are curd and ghee. The consequences of panchagavya application are superior growth, yield and quality of crops. It provides major macronutrients, essential micro nutrients, many vitamins, required amino acids, growth promoting substances and beneficial microorganisms for plant well growth (Vimalendran and Wahab, 2013).

Sesame seeds contain many phytochemically important compounds like flavonoids, phenolic acids, alkaloids, tannins, saponins, steroids, terpenoids and minerals like calcium, iron, magnesium, manganese, copper, zinc and phosphorus. Sesame has compounds like sesamin, sesaminol, gamma tocopherol, cephalin and lecithin. These compounds impart many of the pharmacological activities like antioxidant, antibacterial, cardiogenic, antidiabetic, hypocholesterolemic, antitumor, antiulcer, antiinflammatory and analgesic to sesame (Anilkumar *et al.*, 2010).

The seed which is very rich in oil, vitamins, minerals and proteins could be processed and utilized in various ways in different parts of the world e.g. the seed meal and extracted edible oil for livestock feeding, domestic cooking, salad oil, manufacture of margarine, soaps, paints, cosmetics, perfume, pharmaceuticals and insecticides (Doker *et al.*, 2010 and Bedigion, 2006). Crushed leaves of sesame are considered suitable for soup making, health treatments, beautification and rejuvenation (Morris, 2002).

The main objective of the present study is

- i) To analyze the germination percentage, growth and yield of the two test crops
- ii) To calculate the Vitamin E, Chlorophyll and Nitrogen content of the two test crops

II. REVIEW OF LITERATURE

The literature available on the uses of Panchagavya, *Azospirillum* and VAM on the growth parameters and production of vitamin E content in the two oil-seeded crops relevant to the current investigation has been reviewed and presented in this chapter.

Olaleye *et al.* (2018) revealed that sesame seed oil is rich in Fatty acid ester, alkyl alcohol, hydrocarbon, alkaloids and fragrance. These possess antimicrobial, antifungal, antioxidant, anti-inflammatory, hypocholesterolemic, antiarthritic, anticoronary and antiandrogenic activities.

Awadalla and Abbas (2017) from their study have shown that the application of bio fertilizer to Peanut (*Arachis hypogaea* L.) increases the oil content, yield and its chemical components.

Saha *et al.* (2016a, b) have suggested that the conservation agriculture practice is the need of current agriculture situation and a global force of safe ecology promoted the biofertilizer use with fast pace.

The Organic manures are very important, as it contains both major and minor elements necessary for plant growth, and improve the physical, chemical and biological properties of soil (Selvam and Sivakumar, 2014).

Yang *et al.* (2013) have obtained a remarkable increase in leaf quality, yield parameters, soluble sugar content, and thus an economic benefit, in *Stevia rebaudiana*, a perennial herb which is an excellent source of sugar, under organic cultivation compared to traditional inorganic fertilization. Nile and Park (2013) have reported that ground kernel, cake and groundnut grits show relatively high O/L ratio, with good antioxidant activity.

Geetha *et al.* (2013) in their review have stated that peanuts consist of 30 essential nutrients and they are a good source of niacin, foliate, fiber, magnesium, vitamin E, manganese, phosphorus and a wide variety of chemical constituents such as acids, proteins, minerals, carbohydrates and fats. The antioxidant activity of the ground nut has been reported by Shad *et al.* (2012).

Momoh *et al.* (2012) have reported that in Nigeria, the leaves and roots of sesame plant are used for treating migraine, hypertension, ulcer, constipation, chicken pox and pile.

Mohammadi and Sohrabi (2012) has reported that biofertilizers help in increasing crop productivity by way of increased BNF, increased availability or uptake of nutrients through solubilization or increased absorption stimulation of plant growth through hormonal action or antibiosis, or by decomposition of organic residues.

The results obtained by Haruna and Abimiku indicated (2012) that yield and yield attributes of sesame were significantly increased by the application of poultry manure, cow and sheep manure.

Mohammadi *et al.* (2011) have reported that application of biofertilizers have a significant effect on nutrient uptake of chickpea.

Habibi *et al.* (2011) have strongly suggested that the use of biofertilizers (combined strains) plus half a dose of organic and chemical fertilizers could have resulted in the greatest grain yield and oil yield in medicinal pumpkin.

Gaur (2010) have stated that the biofertilizer is a substance that contains living microorganisms which, when applied to seed, plant surface, or soil, colonizes the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant.

Veena *et al.* (2009) and Shankarappa *et al.* (2012) have shown that biofertilizers are attributed to the production of various growth promoting hormones such as IAA, Gibberellic acid and cytokinins by the beneficial microorganisms.

Rokhzadi *et al.* (2008) have reported that biofertilizers are products containing living cells of different types of microorganisms which when, applied to seed, plant surface or soil, colonize the rhizosphere or the interior of the plant and promotes growth by converting nutritionally important elements (nitrogen, phosphorus) from unavailable to available form through biological process such as nitrogen fixation and solubilization of rock phosphate.

Aseri *et al.* (2008) reported that the biofertilizers improve plant growth, fruit yield, nutrition, metabolism and rhizosphere enzyme activities of Pomegranate (*Punica granatum* L.).

To improve the level of soil carbon for sustenance of soil quality and future agricultural productivity, the only option is to improve the use of Biofertilizers (Ramesh, 2008). El-yazeid *et*

al.(2007) have reported that the beneficial microorganisms in biofertilizers accelerate and improve plant growth and protect plants from pests and diseases.

Khan *et al.*(2007)havestated that biofertilizers, based on plant growth microorganisms, particularly phosphate –solubilizing microorganisms in place of inorganic fertilizers, could also be used in nematode disease management.

According to Chen *et al.* (2006) nutrients must be available in sufficient and balanced quantities for optimum plant growth. Biofertilizers is cost-effective, environment-friendly, more proficient, productive, and easily accessible to marginal and small farmers over chemical fertilizers(Mahajan *et al.*, 2003b).

According to Kannaiyan (2002), the value of nitrogen fixing legumes in improving the yield of legumes and other crops could be achieved by the application of Biofertilizers.

Ghosh and Mohiuddin (2000) havereported that the use of Biofertilizers has resulted in significant increase in sesame plant height and yield components such as number of capsules/plant, number of seeds/capsule, 1000-seed weight and seed yield/plant over that of control.

Vaiyapuri *et al.* (2004) evaluated the effect of sulphur levels and different organic amendments on the growth and yield of sesame and reported that application of 45 kg ha⁻¹ of sulphur and 10t ha⁻¹ of poultry manure could give the maximum plant height, leaf area index, number of branches per plant, total dry matter, number of capsules per plant, capsule weight per plant, number of seeds per capsules, 1000-seed weight and seed yield per hectare.

Sharma *et al.* (2014) have reported that defined inoculation with Rhizobium, PSB and VAM in *Arachis hypogaeae* L. significantly increased the N and P concentrationand their uptake, protein and oil content in kernel and oil yield.

According to Abiala *et al.* (2013), mycorrhizal biofertilizers are produced in large scale mainly for supplying plant nutrients, reducing the toxic effect of contaminants in soil, controlling the pest and disease of root, and improving soil moisture and soil fertility.

Enteshari and Hajbagheri (2011) have reported an increase in the growth rate in VAM treated plants of *Ocimum basilicum* L. in which the VAM acts as a growth regulator and it influences growth even at stress conditions.

Azospirillum is a heterotrophic bacteria that is associative in nature. In addition to their nitrogen fixing ability of about 20-40 kg/ha, they also produce growth regulating substances (Mahdi *et al.*, 2010). The fungi that are probably most abundant in agricultural soils are Arbuscular Mycorrhizal (AM) fungi. They account for 5-50% of the biomass of the soil microbes (Olssoet *et al.*, 1999). Apart from this, the AM fungi also increases the uptake and efficiency of micronutrients like Zn, Cu, Fe, etc, by secreting the enzymes, organic acids which makes the fixed macro and micronutrients mobile and as such are available for the plant. David *et al.* (2008) reported that inoculation of plants with Arbuscular Mycorrhizal [AM] fungi has the potential to increase or maintain the yield and allow reduced fertilizer and pesticide application.

Gupta (2004) suggested that VAM stimulate plant growth by physiological effects or by reducing the severity of diseases caused by the soil pathogens.

According to Devi and Reddy (2002), Mycorrhizal and *Rhizobium* inoculation resulted in significant increase in the phenolic acid content of groundnut plants as compared to uninoculated plants. *Rhizobium* has the diverse ability to fix atmospheric N in symbiotic association with legumes and certain non-legumes like *Parasponia* (Saikia and Jain, 2007).

The study done by Gayathri *et al.* (2015) have shown that the panchagavya increases the yield and the growth of the vegetable crops without any side effects. The application of panchagavya has influenced a better photosynthetic activity, more extensive root system and better yield in baby corn (Vimalendrant and Wahab, 2013).

Sireesha (2013) have stated that panchagavya possess the properties of fertilizers and bio pesticides. Panchagavya contains growth regulatory substances that help in the development of integrated pest management (IPM) such as IAA, GA, Cytokinin, essential plant and organic farming nutrients and effective microorganisms (Vallimayil and Sekar, 2012).

According to Tharmarajet *et al.* (2011) and Sumangala and Patil (2009), Panchagavya has played a significant role in providing resistance to pests and diseases, resulting in increased overall yields mostly in fruits and vegetables. Sangeetha and Thevanathan (2010) have reported that the panchagavya is an organic manure and it helps to improve the crops in organic agriculture.

Naik and Sreenivasa (2009) have found that Panchagavya contains bacteria producing plant growth promoting substances as well as bacteria having biological deterrent activities.

Somasundaram *et al.* (2007) have reported that the panchagavya has resulted in positive effect on growth and productivity of crops. Natarajan (2002) have reported that pachagavya contain growth regulatory substances such as IAA, GA, Cytokinins and essential plant nutrients.

Microorganisms such as *Azospirillum* fix atmospheric nitrogen to be taken up by plants. *Pseudomonas fluorescens* control the soil borne pathogens. Mycorrhizae form symbiotic association with plant and supply unavailable phosphorus to plants (Gurumurthy *et al.*, 2014).

The positive growth response was observed in *Sesamum indicum* L. by the supply of nutrients especially nitrogen and growth promoting hormones by *Azospirillum* and enhanced uptake of phosphorus and other nutrients due to mycorrhizal colonization (Ezhil and Ramakrishnan, 2010; Sridevi and Ramakrishnan, 2010; Zaidi *et al.*, 2004)

The *Azospirillum* form associative symbiosis with many plants particularly with those having the C₄-dicarboxylic pathway of photosynthesis (Hatch and Slack pathway), because they grow and fix nitrogen on salts of organic acids such as malic and aspartic acid (Arun, 2007).

Kennedy *et al.* (2004) have stated that the *Azospirillum* enhances the yield of the rice plant when the roots of rice seedlings are suspended in 2% of *Azospirillum* inoculants. Studies carried out by Prabasheela *et al.* (2015) have revealed the presence flavonoids, tannins, terpenoids, saponins, steroids, alkaloids in the phytochemical screening of ethanolic extracts of *Arachis hypogaeae*.

Studies by Vijay *et al.* (2015) have shown the presence of terpenoids, tannins, cardiac glycosides and saponifiable lipids in the aqueous extracts of Black Sesame seeds.

According to Comfort *et al.* (2015), the methanol extract of *S. indicum*, showed the presence of secondary metabolites tannins, steroids, saponins, phenol, alkaloids, terpenoid, carbohydrates, cardiac glycosides and resins.

Ogwuche *et al.* (2015) found that the white species of the *Sesamum indicum* contains carbohydrates, reducing sugars, cardiac glycosides, saponins, steroids, triterpenes, flavonoids, and tannins.

Sharma *et al.* (2014) have showed promising antimicrobial and antioxidant activity in methanol extract than aqueous extract of *Sesamum indicum*.

The qualitative phytochemical analysis done by Sani *et al.* (2013) in the *Sesamum indicum* L. extract have indicated the presence of anthraquinones, tannins, alkaloids, flavonoids, saponins, phenols, terpenoids and steroids.

A study carried out by Marka *et al.* (2013) on the analysis of the leaf, stem, root and seed extracts of the *A. hypogaeae* showed the presence of phytochemicals such as alkaloids, glycosides, tannins, flavonoids, sterols, fats, oils, phenols, lignins, quinones and saponins.

The preliminary qualitative phytochemical analysis of different extracts of *Sesamum indicum* L. studied by Somwanshi *et al.* (2018) have revealed the presence of different bioactive constituents, including alkaloids, flavonoids, glycosides, tannins, phenols, anthraquinones and carbohydrates.

Preliminary phytochemical analysis and antimicrobial evaluation by Mythily and Revathi (2017) using aqueous, petroleum ether, chloroform and ethanol extracts of *Arachis hypogaeae* L. revealed the presence of alkaloid glycoside, fixed oils and fats, tannin, saponins& phenols and it possessed antimicrobial activity against the bacteria and fungi.

Phytochemical analysis of ethanolic extract of leaf of sesame carried out by Vani *et al.* (2016) showed the presence of saponins, flavonoids, alkaloids, steroids, carbohydrates and phenolic compounds.

Peanut's high nutritional content is attributed to the presence of biologically active compounds such as, tocopherols, flavonoids, phytosterols, resveratrol, as well as relatively high level of protein and their easy oil digestibility (Venkatachalam and Sathe, 2006).

Shakeriet *al.* (2015) showed the ability of N-fixing bacteria to increase the beneficial fatty acids and also an increase in the level of Vitamin E in different traits of sesame.

According to Bedigion (2011), sesame (Til) seed and oil have been in use as a food and healing oil for hundreds of years. It is a good source of protein (22%) and fatty oil (54%).

Sesame oil is a source of vitamin E which is an anti-oxidant. The uses of sesame and olive oils as natural antioxidants and its claim of having potential to lower cholesterol levels

have been reported by several workers like Fazel *et al.*(2008); Rajaei *et al.* (2008) and Borchani *et al.*(2010).

Falade *et al.* (2008) stated that tocopherols are one of the major compound that is present in groundnut.

Tuberoso *et al.* (2007) have compared the oil content of groundnut with the other major oilseeds and showed that the ground nut has high oil content than other crops.

According to Damyanova *et al.* (2002), *Sesamum indicum* ranks second with regard to nutritional value after olive oil. The oil contains palmitic acid (2.47%), stearic acid (4.75%), oleic acid (46.26%), linoleic acid (38.85%) and linolenic acid (0.36%) as major fatty acids.

According to Babajide and Fagbola (2014), the inoculation of microorganisms and biofertilizers increase the level of nitrogen in the *Sesamum indicum* plant.

El-Azouni *et al.* (2008) revealed that bacterial–mycorrhizal–legume symbiosis increase nodule number, nitrogenase activity, total pigments, carbohydrate, protein and lipid content. Also, the nitrogen, phosphorus and potassium (NPK) uptake were significantly increased due to the single or dual inoculation with VA mycorrhizae and/or *Bradyrhizobium*.

Nitrogen is the most dynamic nutrient element and becomes the first limiting nutrient as land use intensifies and photosynthetic rate and leaf surface area increase with increase in nitrogen levels (Tiessen *et al.*, 2003; Lafond *et al.*, 2003 and Akanbi *et al.*, 2005).

III. MATERIALS AND METHODS

The plants taken for the present study were *Arachis hypogaeae* L. belonging to the family Fabaceae and *Sesamum indicum* L. belonging to the family Pedaliaceae. Growth studies were carried out under different treatments of biofertilizers namely Vesicular Arbuscular Mycorrhiza, Panchagavya and *Azospirillum* during different stages of growth of the plants.

Collection of the seeds

Seeds of *Arachis hypogaeae* L. and *Sesamum indicum* L. were obtained from Tamil Nadu Agricultural University, Coimbatore.

Collection of biofertilizers

The bio-fertilizers such as VAM, Panchagavya and *Azospirillum* were collected from TNAU, Coimbatore.

Arachis hypogaeae L.



Plate 1: Habit of *Arachis hypogaeae* L.

Scientific classification

Binomial name: *Arachis hypogaeae* L.

Kingdom: Plantae

Class: Dicotyledonae

Sub Class: Polypetalae

Series: Calyciflorae

Order :Leguminosae

Family :Fabaceae

Genus :*Arachis*

Species :*hypogaeae*

Geographical source

The center of origin of groundnut is north-eastern Nigeria and northern Cameroon. It is found in the wild from central Nigeria eastwards to southern Sudan and is now cultivated throughout tropical Africa and to a lesser extent in tropical parts of the America, Asia and Australia. Its use as a pulse in West Africa was recorded by Arabic travelers in the 14th Century. Its importance declined after the introduction of groundnut from the New World tropics (Geetha *et al.*, 2013).

Vernacular Name (Prajapati *et al.*, 2003)

Tamil: Nillakadalai

English: Ground nut, pea nut, monkey nut

Hindi: Mung-phali

Sanskrit: Bhucanakah, mandapi

Taxonomic description

Habit

Low annual herb; usually cultivated for its beneficial fruits, used in several ways.

Root

Tap root and branched; lateral branches are fewer near the surface of earth; root hairs usually absent; bacterial nodules present.

Stem

The central axis of the stem is erect. On the basis of the branching the plants can be subdivided into two groups (i) prostrate type (ii) bush type. The stem is cylindrical, hairy, short internodes, becomes somewhat angular and hollow as it becomes older.

Leaves

Pinnately compound, stipulate, usually the stipules are one inch long, linear and fused half of their length to the petiole; Petiolate, petiole long, slender, with a distinct swelling (pulvinus); leaflets four, arranged in two opposite and equal pairs, 1 to 2 ½ inches long, hairy, entire, obovate to obtuse, netveined, pubescent.

Inflorescence

Flowers arranged in either solitary or in groups of three in leaf axis. Mostly the flowers develop towards the base of the plant and sometimes buried in the soil.

Flowers

Pedicellate (small pedicels), pedicel usually hairy, zygomorphic, irregular, hypogynous, bisexual, complete, papilionaceous.

Calyx

5 sepals, gamosepalous, the sepals unite to form a calyx tube approximately one inch long; the free lobes are short and irregular.

Corolla

5 petals, free, one standard, two wings and two keels united, united Keels form a beak-like structure; the corolla is inserted on the rim of the calyx tube, yellow, papilionaceous.

Androecium

10 stamens, monadelphous, filaments fused about two-thirds of their length. Sometimes only nine stamens are sterile and their filaments are fused with the filaments of the neighbouring stamens. In the remaining eight, fertile stamens four have bi-celled, elongated anthers and dehisce by longitudinal silts while the remaining four have rounded and elongated anther.

Gynoecium

Monocarpellary, ovary sessile, unilocular, marginal placentation, 1 to 5 ovules, the ovary wall is constricted between each ovule; style curved and hairy, stigma simple and terminal.

Fruit

Oblong, large, indehiscent, ridged (due to these ridges the surface of the pod becomes somewhat reticulate). It consists of 1 to 3 seeds, constrictions present between the seeds.

Seeds

Elongated cylindrical or elongated and ovoid, short, beaked, rounded or diagonally flattened. The embryo is covered by a thin papery, reddish seed coat.

Medicinal uses

Parts used: seeds and oil

Peanut is an enrich source containing fats, vitamins, minerals and dietary fibre with high calorific value and also rich in phytochemicals (Jennette, 2003), antinutrients, allergens and toxins which limit their frequent use as food supplements for long time (Fleischer *et al.*, 2003 and Fasoyiro *et al.*, 2006). The seeds are sweet, oleaginous, aphrodisiac, galactagogue, constipating and tonic and are useful in agalactia, diarrhoea and general debility. The oil is sweet, purgative and emollient and is used in nephropathy and dislocated joints (Prajapati *et al.*, 2003). Groundnut seed contains 44 to 56% oil and 22 to 30% protein on a dry seed basis and is a rich source of minerals (P, Ca, Mg and K) and Vitamins (E, K and B group) (Savange and Keenan, 1994). It provides considerable amount of mineral elements to supplement the dietary requirements of humans and farm animals (Asibuo *et al.*, 2008).

Groundnuts are one of those plant foods that are a dietary source of phytochemicals (Govindaraj and Jain, 2011). It is reported that the antioxidant constituents of plant materials provide protection from coronary heart disease and cancer and protect the body from damage caused by free radical induced oxidative stress (Shad *et al.*, 2009).

***Sesamum indicum* L.**



Plate 2: Habit of *Sesamum indicum* L.

Scientific classification

Binomial name: *Sesamum indicum* L.

Kingdom: Plantae

Class: Dicotyledonae

Sub Class: Gamopetalae

Series: Bicarpellatae

Order :Personales

Family :Pedalineae

Genus :*Sesamum*

Species :*indicum*

Vernacular name(Prajapati *et al.*, 2003)

Tamil: Ellu, eellu-cceti

English: Sesamum, gingelly

Hindi: Til, kan

Sanskrit:Tilah

Taxonomic description

Habit

Annual herb 1 to 2 feet high, cultivated

Root

Tap root and branched

Stem

Erect, pubescent, profusely branched from the base, angular

Leaves

Oblong or ovate, 3 to 5 inches, lower leaves opposite, lobed, with serrated margins, upper leaves alternate, narrow, oblong, the upper surface glabrous, the lower surface pubescent

Inflorescence

Cymose, solitary axillary

Flower

Pedicellate (small pedicels), hermaphrodite, zygomorphic, hypogynous, complete and ebracteate

Calyx

Sepals 5 (small in size about $\frac{1}{4}$ inch long), gamosepalous, sepals lanceolate, acute, hairy, aestivation imbricate or valvate

Corolla

5 petals, gamopetalous, 2 lipped, pinkish in colour with yellow markings, each petal about $1\frac{1}{2}$ inches long, corolla 5-lobed, the upper lip consists of two equal sized lobes while the lower lip includes three petals out of which the central one is largest, corolla tubular-ventricose with subgibbous throat which is hairy outside.

Androecium

4 stamens, didynamous, epipetalous. Instead of fifth stamen, usually a staminode is present, anthers 2-celled (ditheous) sagittate, introse and dehisce by longitudinal slit.

Gynoecium

2 carpels (Bicarpellary), syncarpous, ovary superior, bilocular (four locules formed due to false septation), placentation axile, style filiform, stigma 2 and lobed.

Fruit

Loculicidal capsule, one inch long, erect, hispid, beak short, valves separating half way down

Seeds

Small and many, smooth, albuminous with straight embryo, black and white

Medicinal uses

Parts Used: Roots, Leaves, Seeds, oil

Roots and leaves are emollient and a decoction of them forms a good hair-wash which will promote hair growth and will blacken them. The leaves are useful in dysentery, cholera, vitiated conditions of kapha, nephropathy, uropathy, ophthalmopathy and dermatopathy. The seeds are sweet, astringent, bitter, acrid, emollient, thermogenic, aphrodisiac, laxative, galactagogue, digestive, hair-restorer and tonic. They are useful in haemorrhoids, ulcer, burns, dysentery and vitiated conditions of vata, strangury, dermatopathy, migraine, alopecia, ophthalmopathy and obesity.

In medicated oils, sesame oil forms a fat soluble medium. The oil is bitter, astringent, sweet, thermogenic, digestive, anthelmintic, constipating and emollient, and is good for ophthalmopathy, burning sensation of legs, gonorrhoea, otalgia, cephalgia, obesity and emaciation. Externally, it is used for dryness of the skin and leucoderma.

It is an important part of Ayurvedic, Chinese and Tibetan traditional medicinal systems (Reshma *et al.*, 2012). Sesame oil has many pharmaceutical uses like oleaginous vehicle for drugs, solvent for intramuscular injections etc. (Anilkumar *et al.*, 2010). It is also used to treat teeth, bone and lung problems (Patil *et al.*, 2008; Anilkumar *et al.*, 2010).

The oil is used as an antidote for Bhallatak toxicity (Raut, 2006). In Nigeria and many other tropical areas, the leaves of *Sesamum radiatum* are used for the treatment of catarrh, eye pain, bruises and erupted skin lesions (Shittu *et al.*, 2009).

The seed oil is mildly laxative, emollient and demulcent and the refined oil is rich in antioxidant components like lignans, which are responsible for greater shelf-life, flavor and taste (Raghavan *et al.*, 2010). The seeds have desirable physiological effects including antioxidant activity, blood pressure and serum lipid lowering potential as proven in experimental

animals and humans (Shirato-Yasumoto *et al.*, 2001). Sesamum oil is also useful in the industrial preparations of perfumery, cosmetics and in pharmaceuticals as a vehicle for drug delivery, insecticides, paints and varnishes (Chakraborty *et al.*, 2008).

Methods

Pot Culture Experiment

The seeds obtained from TNAU, Coimbatore were soaked in different organic fertilizers overnight. Later, the seeds were sown in pots (30cm×30cm×30cm sized pots) containing red soil and sandy soil in the ratio 1:1. The treated pots were maintained in triplicates. The effect of different organic fertilizers on the growth and yield parameters of *Arachis hypogaea* L. and *Sesamum indicum* L. were assessed. A preliminary phytochemical screening was also carried out for both the plants. The growth, Vitamin E, Chlorophyll and Nitrogen content was estimated in both the plants. Neem extract was sprayed at intervals to control the growth of insects.

The different organic fertilizer treatments given were:

T₀-Control

T₁- Vesicular Arbuscular Mycorrhiza

T₂-Panchagavya

T₃-*Azospirillum*

T₄- VAM + Panchagavya + *Azospirillum*

Growth Parameters

Plant samples were uprooted carefully on the 30th day, 45th day, 60th day and 75th day and the following growth parameters were measured and recorded for all the treatments.

1. Root length (cm)
2. Shoot length (cm)
3. Number of leaves
4. Fresh weight (gm)
5. Dry weight (gm)

Root Length

The plants were taken from control pot and other treatment pots and washed to get rid off adhering soil particles. Then, the length of the roots were measured with the help of a scale from root collar point to root tip and expressed in centimeter. Ten seedlings were

randomly selected from each treatment and their root length was measured using cm scale and recorded as cm/seedling.

Shoot Length

The shoot length of the plants was measured with the help of scale from the shoot collar point to shoot apex and expressed in centimeter. Ten seedlings were randomly selected from each treatment and their shoot length was measured using cm scale and recorded as cm/seedling. Three readings were taken for statistical analysis.

Number of leaves

The number of leaves present in the uprooted plants were calculated.

Fresh Weight

Fresh weight of the plants was measured with the help of an electronic digital balance and expressed in grams.

Dry weight

The collected plant materials were kept in hot air oven at 55°C for 24 hours. Then, the dry weight of the plants was measured using an electronic digital balance and expressed in grams.

Yield parameters

Number of fruits

The number of fruits obtained on the 60th day and 75th day were calculated for *Arachis hypogaea* L. and for *Sesamum indicum* L., the study was carried out up to 75th day only because, the plant started losing its vigour after that period.

Plant Nutrient Analyzer

Description

Plant nutrient analyzer (PX- 152) shows three parameters namely chlorophyll, nitrogen content and leaf temperature at the same time. These parameters are important for a plant. They are important basis for plant fertilization and irrigation. It is mostly used to analyze the effectiveness of the fertilizers to the plant.

Procedure

The fresh plant sample was taken on the 30th day of growth and the leaves were washed. The plant nutrient analyzer was clipped to the centre of the leaf. The upper part of the nutrient analyzer was pressed for few seconds. Then the level of chlorophyll, nitrogen and humidity of the plant leaf was calculated. Three readings were taken for statistical analysis.

Number of Nodules

Nodules were formed in the roots of the groundnut plants and the number of nodules formed were calculated on the 30th, 45th, 60th and 75th day.

STATISTICAL ANALYSIS

The data obtained from various biometric observations were subjected to statistical analysis as per the procedure of Panse and Sukhatme (1978).

Vitamin E

Vitamin E is an essential constituent in our daily diet. In plants vitamin E contribute a major role in maintaining stress. Vitamin E analysis was carried out based on the method of Devries and Silvera (2002).

Vitamin E was estimated for the seeds of groundnut and sesame. It was also estimated for the leaf sample on the 30th day.

Preliminary phytochemical screening procedure

The preliminary phytochemical analysis of various primary and secondary plant metabolites were carried out using the method of Harborne (1984).

Preparation of plant extract

The leaves of both the plants taken for the present study were collected, cleaned and air dried under shade for almost three weeks. After drying, the leaves were then blended using a household electric blender. This fine powder (Plate 3 and 4) was analysed for phytochemical constituents present in it. The plant sample was soaked in ethanol and methanol for overnight extraction and filtered through Whatman No.1. filter paper. Qualitative tests were conducted on these extracts.

Test for Alkaloids

Mayer's test

To 1ml of extract, 2ml of Conc. HCl was added. Then, a few drops of Mayer's reagent was added. Green colour or white precipitate indicates the presence of alkaloids.

Test for Tannins

To 1ml of extract, 2ml of 0.1% Ferric chloride was added. Brownish green or blue black colouration indicates the presence of tannins.

Test for Flavonoids

To 1ml of extract, 1ml of neutral ferric chloride was added. The formation of brown colour confirmed the presence of flavonoids.

Test for Quinones

A small amount of the extract was treated with Conc. HCl and observed for the formation of yellow precipitate.

Test for Phlobatannins

To 1ml of extract, few drops of 1% aqueous hydrochloric acid was added. A red precipitate formed indicates the presence of phlobatannins.

Test for Phenol

To 1ml of extract, 5ml of Folinicalteau reagent and 4ml of sodium carbonate was added. Appearance of blue colour showed the presence of phenol.

Test for Carbohydrates

- a) To 1ml of extract, 5ml of Benedict's reagent was added and boiled for 5 minutes. Bluish green colour indicated the presence of carbohydrates.
- b) Purple colour is seen with the addition of few drops of Molisch' reagent and Conc. H_2SO_4 .



Plate 3: Dry powder of *Arachishypogeeae* L.



Plate 4: Dry powder of *Sesamum indicum* L.

Test for Amino acids

To 1ml of filtrate, few drops of 0.2% ninhydrin was added and heated for 5 minutes. Formation of blue colour indicated the presence of aminoacid.

Test for Steroids

To 1ml of the filtrate, 10ml of chloroform and 10ml of sulphuric acid was added slowly by the sides of the test tube. Upper layer turning red and the sulphuric acid layer turning yellow with green fluorescent indicates the presence of steroids.

Test for Terpenoids

To 1ml of filtrate, 2ml of chloroform was added and few drops of concentrated sulphuric acid was added carefully. An interface with a reddish brown colouration is formed showing the presence of terpenoids.

Test for fats and oil

To 1 ml of extract, a few drops of Sudan III solution was added. A shining orange colour showed the presence of fixed oil and fat.

IV. RESULTS AND DISCUSSION

The study conducted in the two oil-seeded crops namely *Arachis hypogaeae* L. and *Sesamum indicum* L. showed the following results.

Arachis hypogaeae L.

Growth Parameters

Germination

Germination studies were carried out in *Arachis hypogaeae* L. by soaking the seeds over night in different organic fertilizers namely VAM, Panchagavya, *Azospirillum* and mixture of the three fertilizers. Control was maintained without any fertilizer. The study showed maximum germination in T₄ ie., VAM + Panchagavya + *Azospirillum* (Table 1; Plate 5).

Shoot Length

The shoot length of the groundnut plants at different stages of growth were measured and tabulated (Table 2; Fig. 1). The growth was measured upto 75 days.

On the 30th day, the shoot length was more in T₃ ie., plants treated with *Azospirillum* (15.07 ± 1.01 cm). On the 45th, 60th and 75th day, the shoot length was higher in plants treated with the mixture of organic fertilizers (T₄) and the values were found to be 28.93 ± 0.31 cm, 28.17 ± 0.38 cm and 45.03 ± 0.15 cm respectively (Plate 6 to 9).

Root Length

The growth parameters of the groundnut plants in control and other organic fertilizer treated plants were measured and tabulated (Table 3; Fig. 2). The root length on the 30th day and 45th day was more in T₄ and values were 7.07 ± 1.01 cm and 11.53 ± 0.25 cm respectively. On the 60th day, the root length was higher in T₁ (11.83 ± 0.76 cm) and on the 75th day, it was more in T₄ (15.20 ± 0.20 cm).

Various types of material can be used as carrier for seed or soil inoculation. The properties of a good carrier material for seed inoculation are inexpensive and available in adequate amounts (Mohammadi and Soharbi, 2012). Nitrogen is one of the major important

Table 1: Germination percentage of *Arachis hypogaeae* L.

Treatments	Percentage
T ₀	60
T ₁	40
T ₂	70
T ₃	80
T ₄	90



T₀

T₁

T₂



T₃

T₄

Plate 5: *Arachis hypogaeae* L. seeds sown in Petriplates for germination

Table 2: Shoot length (cm) of *Arachis hypogaeae* L. at different stages of growth

Treatments	30 th day	45 th day	60 th day	75 th day
T₀	15.03 ± 0.95	20.50 ± 0.50	23.67 ± 0.58	37.23 ± 0.25
T₁	14.33 ± 1.53	19.50 ± 0.50	25.93± 0.31	33.30 ± 0.26
T₂	12.57 ± 0.60	21.00 ± 1.00	27.17± 0.76	33.23 ± 0.25
T₃	15.07 ± 1.01	22.83 ± 0.29	24.87± 0.81	35.33±0.25
T₄	12.17 ± 1.04	28.93 ± 0.31	28.17± 0.38	45.03±0.15
SEd	0.8715	0.4728	0.4908	0.2715
CD(P<0.05)	1.9419	1.0535	1.0936	0.6052

Values are given as mean ± SD from 3 samples in each group

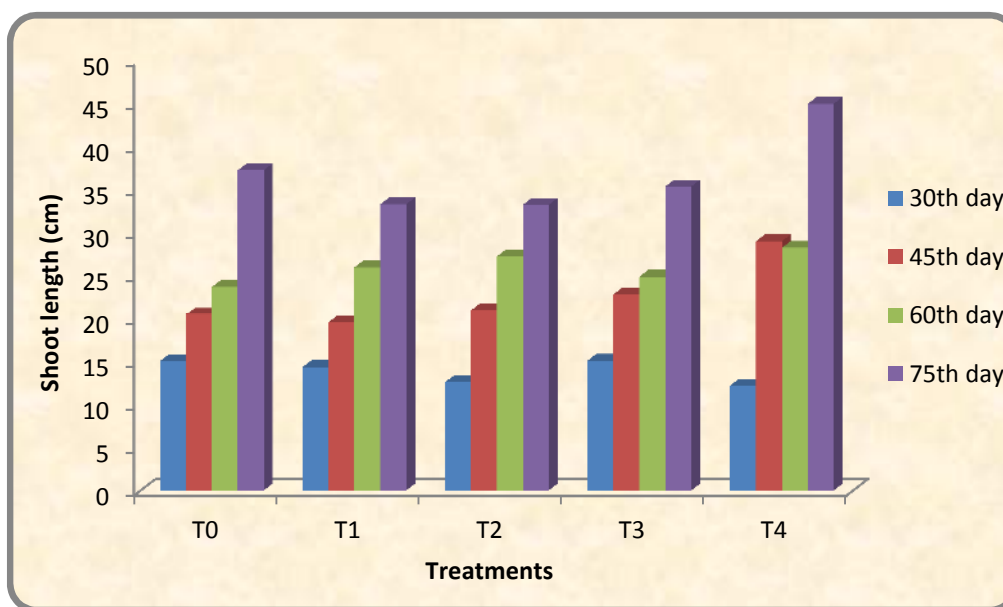


Fig. 1: Shoot length (cm) of *Arachis hypogaeae* L. at different stages of growth

T₀ – Control

T₁– VAM

T₂–Panchagavya

T₃–*Azospirillum*

T₄– VAM + Panchagavya + *Azospirillum*



Plate 6: Growth of *Arachis hypogaeae* L. on the 30th day



Plate 7: Growth of *Arachis hypogaeae* L. on the 45th day



Plate 8: Growth of *Arachis hypogaeae* L. on the 60th day



Plate 9: Growth of *Arachis hypogaeae* L. on the 75th day

Table 3: Root length (cm) of *Arachis hypogaeae* L. at different stages of growth

Treatments	30 th day	45 th day	60 th day	75 th day
T ₀	5.00 ± 1.00	4.93 ± 0.40	6.53 ± 0.50	4.43 ± 0.21
T ₁	5.00 ± 1.00	7.13 ± 0.31	11.83 ± 0.76	10.20 ± 0.20
T ₂	7.00 ± 1.00	9.50 ± 0.50	9.43 ± 0.40	13.40 ± 0.53
T ₃	4.00 ± 1.00	5.17 ± 0.76	9.47 ± 0.06	10.43 ± 0.51
T ₄	7.07 ± 1.01	11.53 ± 0.25	7.40 ± 0.26	15.20 ± 0.20
SEd	0.8176	0.3921	0.3783	0.2981
CD(P<0.05)	1.8217	0.8738	0.8429	0.6643

Values are given as mean ± SD from 3 samples in each group

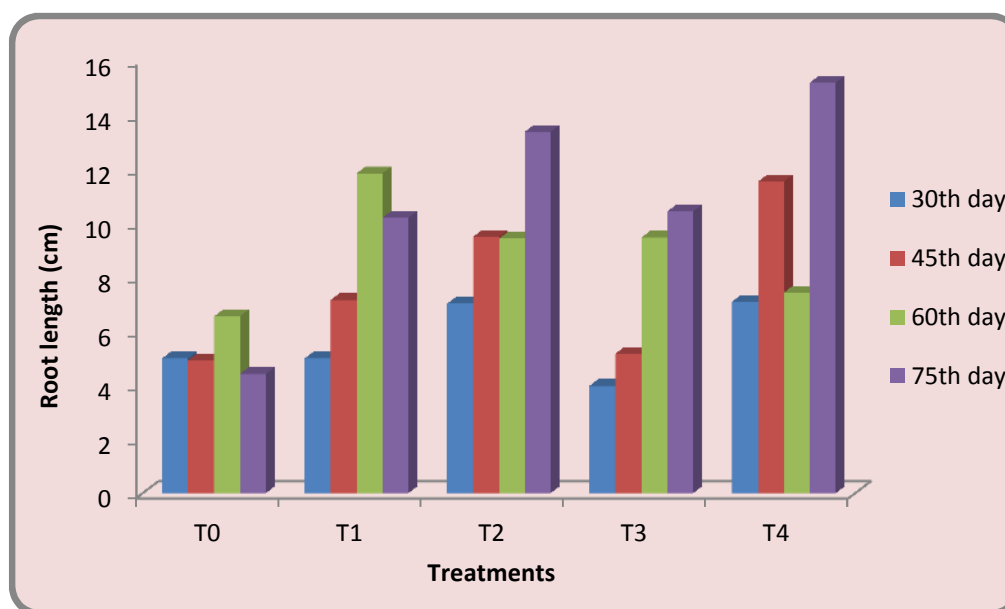


Fig. 2: Root length (cm) of *Arachis hypogaeae* L. at different stages of growth

T₀ – Control

T₁– VAM

T₂–Panchagavya

T₃–*Azospirillum*

T₄– VAM + Panchagavya + *Azospirillum*

nutrient very much essential for crop growth. Atmosphere contains about 80% of nitrogen volume in free state.

Earlier studies by Aseri *et al.* (2008) have shown a significant increase in nutrient uptake by pomegranate upon inoculation with various beneficial microorganisms. Their studies have also shown that, dual inoculation could lead to a maximum uptake of N, P, K, Ca and Mg and micronutrients in pomegranate seedlings. Their results showed a significant enhancement in plant height, plant canopy, pruned plant material and fruit with a maximum increase in dual inoculation treatment.

Fresh Weight

The fresh weight of the groundnut plants grown under control and different organic fertilizers were calculated and tabulated (Table 4; Fig.3). On the 30th and 75th day, the fresh weight were more in plants treated with *Azospirillum* and the values obtained were 9.68 ± 0.73 g and 43.70 ± 0.85 g respectively. On the 45th day and 60th day, the fresh weight calculated were found to be higher in plants treated with the combination of fertilizers ie., VAM + Panchagavya + *Azospirillum* and the readings were observed to be 15.53 ± 0.55 g and 33.60 ± 0.20 g respectively.

Dry Weight

The dry weight of the uprooted groundnut plants treated with different organic organic fertilizers were measured after the plants in Hot air oven and tabulated (Table 5; Fig. 4). The dry weight correlated with the fresh weight of the plants and it was observed to be more in T₃ on the 30th day (0.91 ± 0.25 g) and 75th day (8.25 ± 1.01 g). On the 45th day and 60th day, the dry weight of the plants were found to be more in T₄ and the values were 3.13 ± 0.03 g and 5.01 ± 0.19 g respectively.

Table 4: Fresh weight (g) of *Arachis hypogaeae* L. at different stages of growth

Treatments	30 th day	45 th day	60 th day	75 th day
T ₀	3.23 ± 1.07	7.54 ± 0.19	24.47 ± 0.15	22.33±0.49
T ₁	5.58 ± 0.52	10.54 ± 0.29	24.43 ± 0.15	32.27±0.81
T ₂	3.50 ± 0.56	6.57 ± 0.21	20.30 ± 0.26	34.00±1.05
T ₃	9.68 ± 0.73	12.60 ± 0.26	30.47 ± 0.84	43.70±0.85
T ₄	4.63 ± 0.40	15.53 ± 0.55	33.60 ± 0.20	22.57±0.67
SEd	0.5692	0.2677	0.3386	0.6512
CD(P<0.05)	1.2682	0.5965	0.7545	1.4509

Values are given as mean ± SD from 3 samples in each group

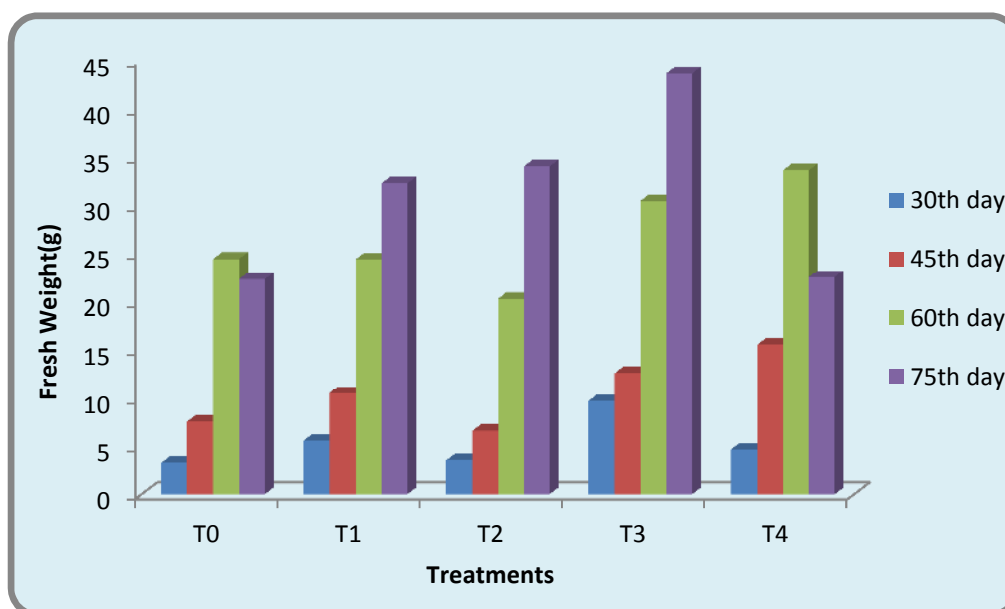


Fig. 3: Fresh weight (g) of *Arachis hypogaeae* L. at different stages of growth

T₀ – Control

T₁– VAM

T₂–Panchagavya

T₃–*Azospirillum*

T₄– VAM + Panchagavya + *Azospirillum*

Table 5: Dry weight (g) of *Arachis hypogaeae* L. at different stages of growth

Treatments	30 th day	45 th day	60 th day	75 th day
T ₀	0.23 ± 0.10	1.43 ± 0.60	2.68 ± 0.38	3.56±0.41
T ₁	0.41 ± 0.17	2.03 ± 0.06	4.05 ± 0.09	5.50±0.66
T ₂	0.59 ± 0.07	0.94 ± 0.29	4.01 ± 0.13	7.29±0.61
T ₃	0.91 ± 0.25	2.30 ±0.52	2.45 ± 0.43	8.25±1.01
T ₄	0.31 ± 0.15	3.13 ±0.03	5.01 ± 0.19	4.76±0.85
SEd	0.1326	0.3089	0.2295	0.6005
CD(P<0.05)	0.2954	0.6882	0.514	1.3381

Values are given as mean ± SD from 3 samples in each group

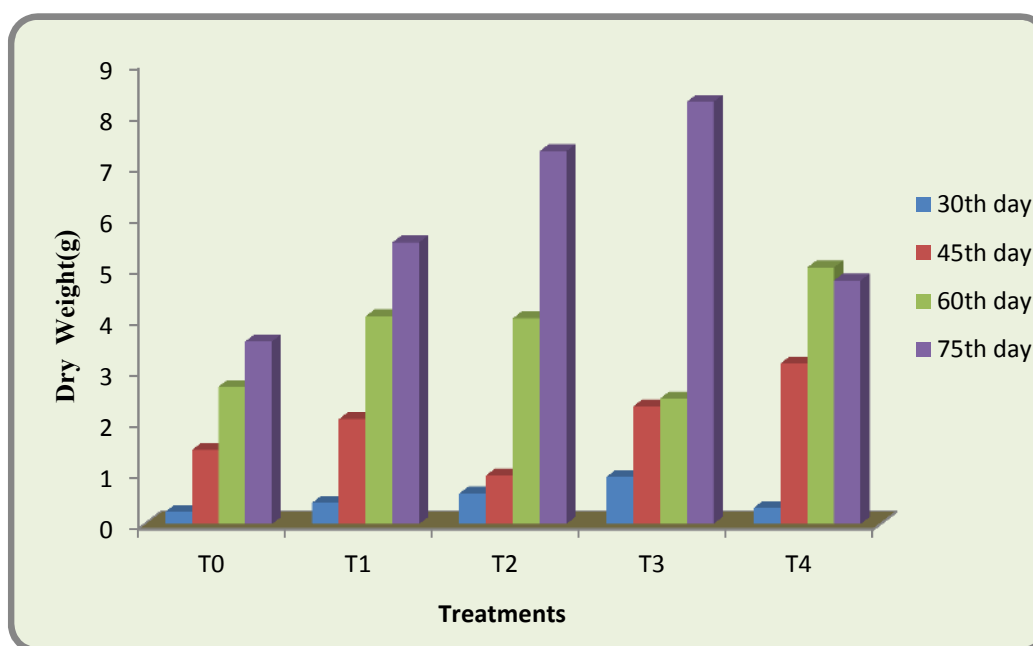


Fig. 4: Dry weight (g) of *Arachis hypogaeae* L. at different stages of growth

T₀ – Control

T₁– VAM

T₂–Panchagavya

T₃–*Azospirillum*

T₄– VAM + Panchagavya + *Azospirillum*

Number of Leaves

The number of leaves present in the test crop during different days of growth was counted and tabulated (Table 6; Fig. 5). The number of leaves were found to be more in T₃ on the 30th day (10.67 ± 0.58), 45th day (14.67 ± 0.56) and 75th day (28.00 ± 1.00). On the 60th day, the number of leaves was more in T₄ (24.67 ± 0.58).

Girth of the Stem

The girth of the groundnut plants also showed variations due to organic fertilizer treatments. The girth of the stem was measured on the 45th day, 60th day and 75th day and tabulated (Table 7; Fig. 6). The girth was more in T₄ on the 45th day (1.77 ± 0.15 cm) and 60th day (2.10 ± 0.36 cm). On the 75th day of growth, the girth was more in T₁ (1.77 ± 0.06 cm).

Yield Parameter

Number of Pods

The number of pods produced by the groundnut was calculated to analyze the yield parameter. The number of pods was more in the plants treated with *Azospirillum* on the 60th day (8.33 ± 0.58) as well as 75th day (18.67 ± 0.58). The values were tabulated (Table 8; Fig. 7)

Most of the leguminous crop plants have symbiotic relationship with root nodule rhizobacteria called *Rhizobia* (Singh *et al.*, 2016). Soil fertility status and soil microclimate also affect the rate of interaction, nodulation as well as amount of N fixation.

Studies carried out by Mounika *et al.* (2018) on the influence of Biofertilizers and micronutrients on seed yield, essential oil and oleoresins of coriander have inferred that the combination of seed inoculation with *Azospirillum* + Phosphate solubilizing bacteria and foliar application of ZnSO₄ at 5% showed a beneficial effect on the yield and yield attributing parameters of coriander.

Kumar *et al.* (2011) have studied the growth and development of black gram under foliar application of panchagavya as an organic source of nutrient and proved that the foliar spray at different intervals recorded significantly higher growth and yield of black gram than NPK and untreated control.

Table 6: Number of leaves in *Arachis hypogaeae* L. at different stages of growth

Treatments	30 th day	45 th day	60 th day	75 th day
T ₀	6.67 ± 0.59	8.67 ± 0.58	17.00 ± 1.00	23.33±0.51
T ₁	10.33 ± 0.56	9.00 ± 0.00	23.33 ± 0.50	26.33±0.56
T ₂	5.67 ± 0.48	6.67 ± 0.52	18.67 ± 0.58	25.33±0.58
T ₃	10.67 ± 0.58	14.67 ± 0.56	20.67 ± 0.56	28.00±1.00
T ₄	6.67 ± 0.53	10.33 ± 0.54	24.67 ± 0.58	15.00±1.01
SEd	0.4714	0.4216	0.5578	0.6325
CD(P<0.05)	1.0504	0.9395	1.2428	1.4092

Values are given as mean ± SD from 3 samples in each group

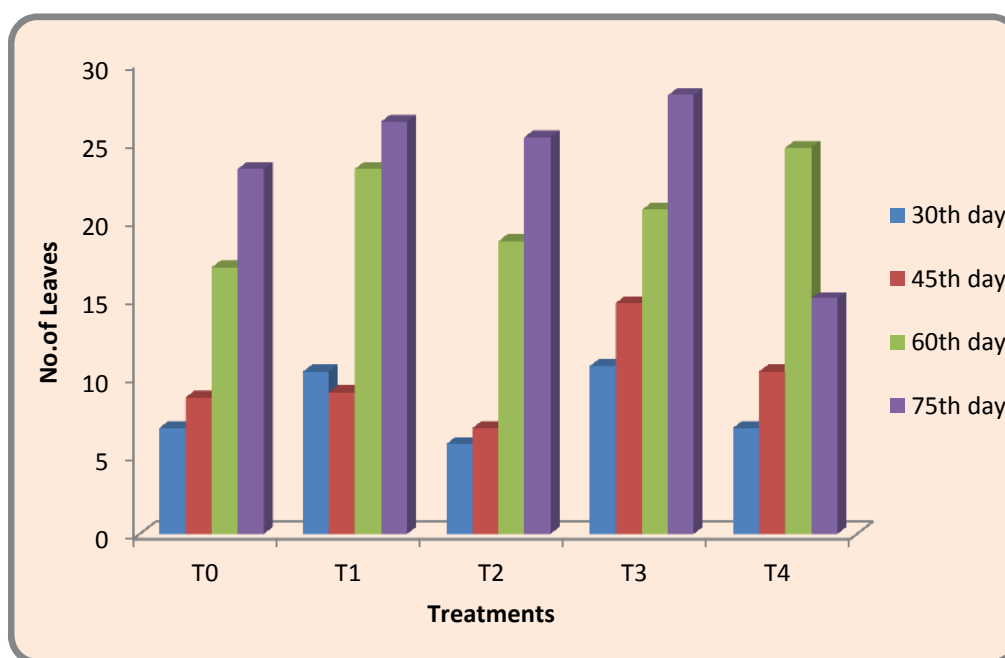


Fig. 5: Number of leaves in *Arachis hypogaeae* L. at different stages of growth

T₀ – Control

T₁– VAM

T₂–Panchagavya

T₃–*Azospirillum*

T₄– VAM + Panchagavya + *Azospirillum*

Table 7: Girth (cm) of the stem of *Arachis hypogaeae* L. at different stages of growth

Treatments	45 th day	60 th day	75 th day
T ₀	1.17±0.15	1.43 ± 0.21	0.97±0.15
T ₁	1.48±0.21	1.57 ± 0.06	1.77±0.06
T ₂	1.00±0.10	1.43 ± 0.12	1.40±0.10
T ₃	1.17±0.15	1.83 ± 0.06	1.20±0.12
T ₄	1.77±0.15	2.10 ± 0.36	1.13±0.12
SEd	0.1700	0.1606	0.0816
CD(P<0.05)	0.3787	0.3577	0.1819

Values are given as mean ± SD from 3 samples in each group

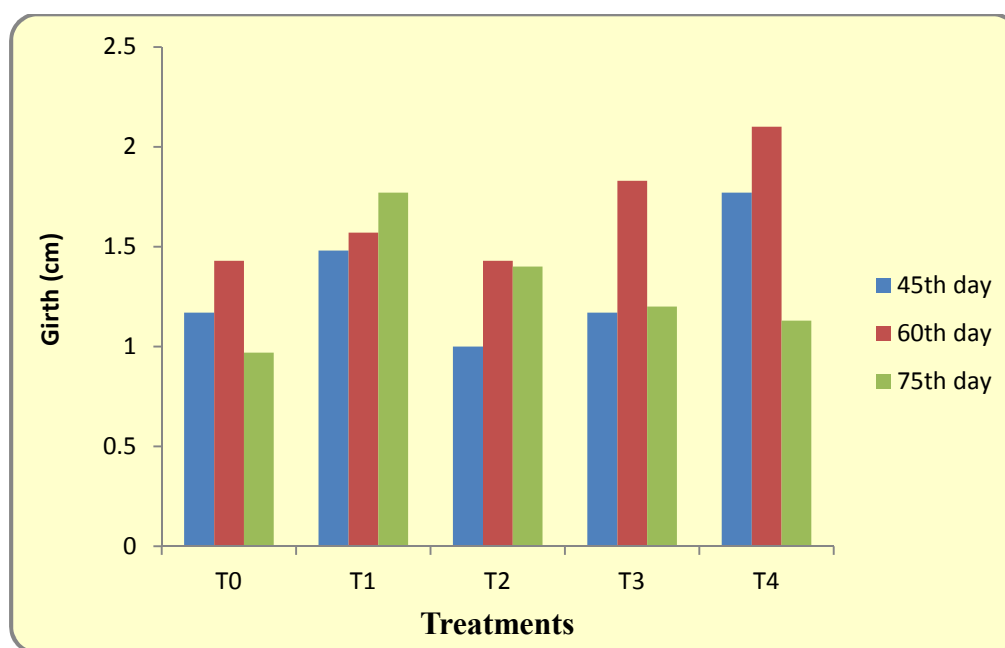


Fig. 6: Girth (cm) of the stem of *Arachis hypogaeae* L. at different stages of growth

T₀ – Control

T₁– VAM

T₂–Panchagavya

T₃–*Azospirillum*

T₄– VAM + Panchagavya + *Azospirillum*

Table 8: Number of pods in *Arachis hypogaeae* L. at different days

Treatments	60 th day	75 th day
T ₀	5.67 ± 0.58	7.33±0.58
T ₁	8.00 ± 1.00	7.00±0.00
T ₂	2.67 ± 0.58	7.67±0.58
T ₃	8.33 ± 0.58	18.67±0.58
T ₄	8.33 ± 0.58	14.67±0.58
SEd	0.5578	0.4216
CD(P<0.05)	1.2428	0.9395

Values are given as mean ± SD from 3 samples in each group

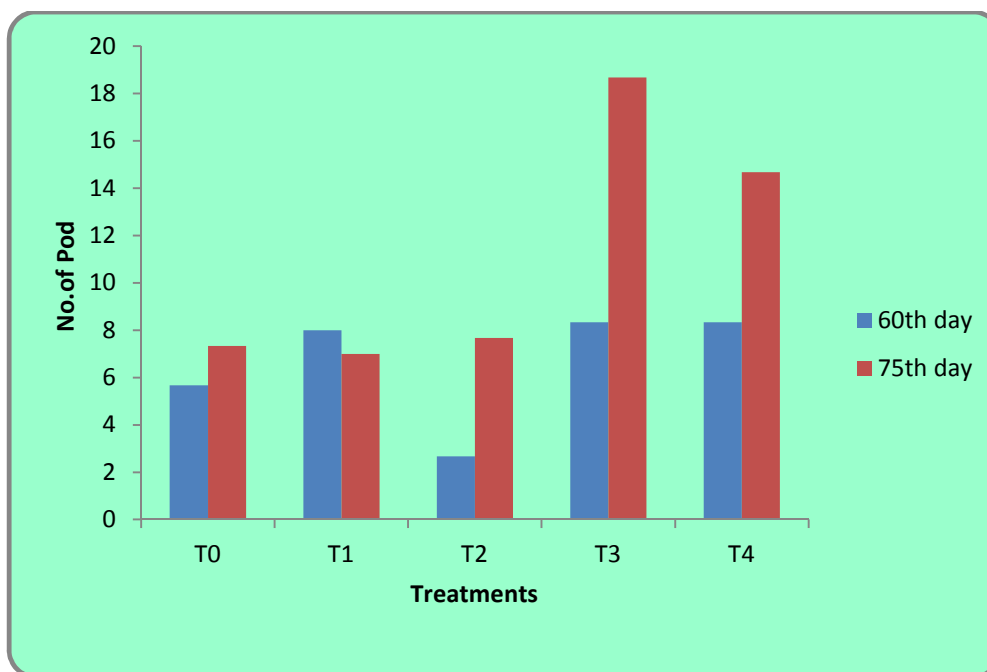


Fig. 7: Number of pods in *Arachis hypogaeae* L. at different days

T₀ – Control

T₁– VAM

T₂–Panchagavya

T₃–*Azospirillum*

T₄– VAM + Panchagavya + *Azospirillum*

Earlier studies by Sangeetha and Thevanathan (2010) have shown that panchagavya, a vedic formulation increases the productivity and disease resistance in plants when amended with seaweed extract.

Rao *et al.* (2015) have carried out a study on comparative yield analysis of chilli by application of vermicompost and panchagavya and showed enhancement in the growth parameter of chilli plant.

The inoculation of consortia of three Biofertilizers; *Azospirillum*, *Pseudomonas fluorescens* and VAM was efficient in increasing the growth of Cashew graft under nursery conditions (Shankarrappa *et al.*, 2017).

Studies by Shete *et al.* (2018) have shown that foliar spray of Biofertilizers significantly increased the growth and nutrient uptake of Kharif Groundnut. The present result on the increase in growth parameters of groundnut due to use of Biofertilizers is on par with the earlier studies.

***Sesamum indicum* L.**

Growth parameters

Germination

The viable seeds of *Sesamum indicum* L. were soaked overnight in different organic fertilizers and the germination percentage was calculated and tabulated (Table 9; Plate 10).

The germination percentage was more (93%) in seeds treated with mixture of organic fertilizers viz., VAM + Panchagavya + *Azospirillum*.

Shoot Length

The growth parameters measured in terms of shoot length showed more length in T₃ (23.83 ± 0.76 cm) on the 30th day (Table 10; Fig. 8). On the 45th day and 75th day, the shoot length was observed to be more in T₁ and the values were 36.23 ± 0.25 cm and 50.73 ± 1.17 cm respectively. On the 60th day of the growth, the shoot length was more in T₄ (46.00 ± 2.18 cm) (Plate 11 to 14).

Table 9: Germination percentage of *Sesamum indicum* L.

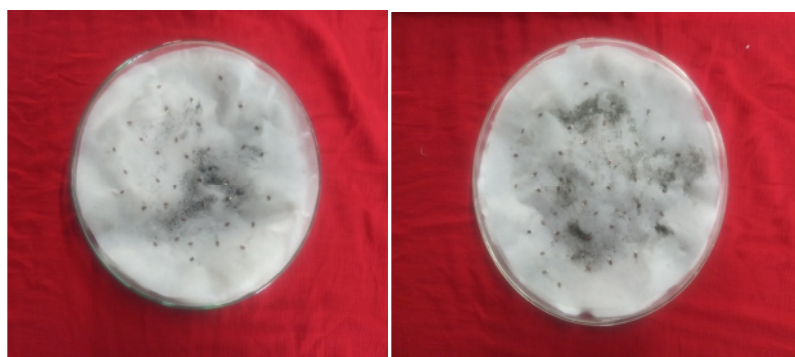
Treatments	Percentage
T₀	89
T₁	87
T₂	89
T₃	89
T₄	93



T₀

T₁

T₂



T₃

T₄

Plate 10: *Sesamum indicum* L. seeds sown in Petriplates for germination

Table 10: Shoot length (cm) of *Sesamum indicum* L. at different stages of growth

Treatments	30 th day	45 th day	60 th day	75 th day
T₀	14.07 ± 0.90	25.40 ± 0.53	36.03 ± 3.85	38.12±0.32
T₁	22.00 ± 1.00	36.23 ± 0.25	44.93 ± 1.10	50.73±1.17
T₂	18.67 ± 0.58	28.50 ± 0.50	34.90 ± 0.36	47.90±0.36
T₃	23.83 ± 0.76	24.50 ± 0.50	44.20 ± 0.35	44.37±0.32
T₄	21.00 ± 1.00	34.17 ± 0.29	46.00 ± 2.18	48.10±0.10
SEd	0.7052	0.3515	1.6757	0.4789
CD(P<0.05)	1.5713	0.7832	3.7338	1.0670

Values are given as mean ± SD from 3 samples in each group

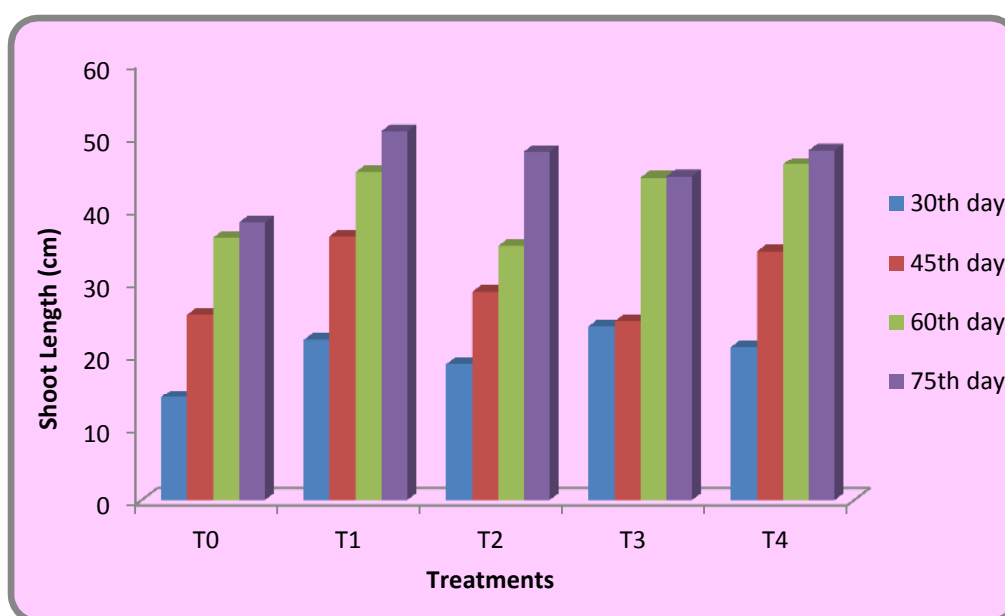


Fig. 8: Shoot length (cm) of *Sesamum indicum* L. at different stages of growth

T₀ – Control

T₁– VAM

T₂–Panchagavya

T₃–*Azospirillum*

T₄– T₄– VAM + Panchagavya + *Azospirillum*



Plate 11: Growth of *Sesamum indicum* L. on the 30th day



Plate 12: Growth of *Sesamum indicum* L. on the 45th day



Plate 13: Growth of *Sesamum indicum* L. on the 60th day



Plate 14: Growth of *Sesamum indicum* L. on the 75th day

Root Length

The root length of *Sesamum* at different stages of the growth was measured and tabulated (Table 11; Fig. 9). The root length was more in T₄ on the 30th day and 45th day and the value observed was 6.43 ± 0.40 cm. On the 60th day, control plant showed a higher root length of 5.73 ± 0.646 cm. On the 75th day of growth, the root length was higher in T₁ (6.47 ± 0.25 cm).

Singh *et al.* (2018) have carried out studies on the use of panchagavya for the sustainable production of vegetable crops. Panchagavya could be used as an organic growth- promoter for small and marginal vegetable growers (Boomathi *et al.*, 2006).

Shekh *et al.* (2018) have proved that foliar spraying of panchagavya and seaweed extract is as good as soil application of FYM.

Studies carried out by Gayathri *et al.* (2015) on the use of different concentration of panchagavya on the vegetable crops have shown that 8% concentration could bring about change in the growth of plants.

Earlier Nahar *et al.* (2008) have shown an increase in growth and yield of sesame in response to N fertilizer application. A significant increase in all the investigated morphological characters was obtained as an effect of biofertilizer in sesame plants (Boghdady *et al.*, 2012).

Fresh Weight

The growth parameter in terms of fresh weight of the plant was measured by uprooting the whole plant and tabulated (Table 12; Fig. 10). The fresh weight was found to be more in T₃ on the 30th day and 60th day and the values were 1.78 ± 0.20 g and 5.34 ± 0.55 g respectively. On the 45th day, the fresh weight of the plant was found to be more in plants treated with the mixture of organic fertilizers (3.56 ± 0.40 g). On the 75th day, the fresh weight was observed to be more in T₁ (8.07 ± 0.15 g).

Dry Weight

The uprooted *Sesamum* plants from control pot and organic fertilizer treated pots, after measuring the fresh weight was kept in Hot air oven for calculating the dry weight. The dry weight was calculated and tabulated (Table 13; Fig.11). The dry weight was more in T₃ ($0.90 \pm$

Table 11: Root length (cm) of *Sesamum indicum* L. at different stages of growth

Treatments	30 th day	45 th day	60 th day	75 th day
T₀	2.83 ± 0.29	4.37 ± 0.32	5.73±0.646	3.03±0.15
T₁	3.17 ± 0.86	6.17 ± 0.35	5.03±0.15	6.47±0.25
T₂	3.50 ± 0.50	4.43 ± 0.21	4.97±0.35	3.03±0.15
T₃	4.43 ± 0.40	4.83 ± 0.29	3.93±0.31	4.43±0.21
T₄	6.43 ± 0.40	6.43 ± 0.40	4.40±0.10	5.10±0.26
SEd	0.4326	0.2625	0.2974	0.1726
CD(P<0.05)	0.9638	0.5848	0.6626	0.3845

Values are given as mean ± SD from 3 samples in each group

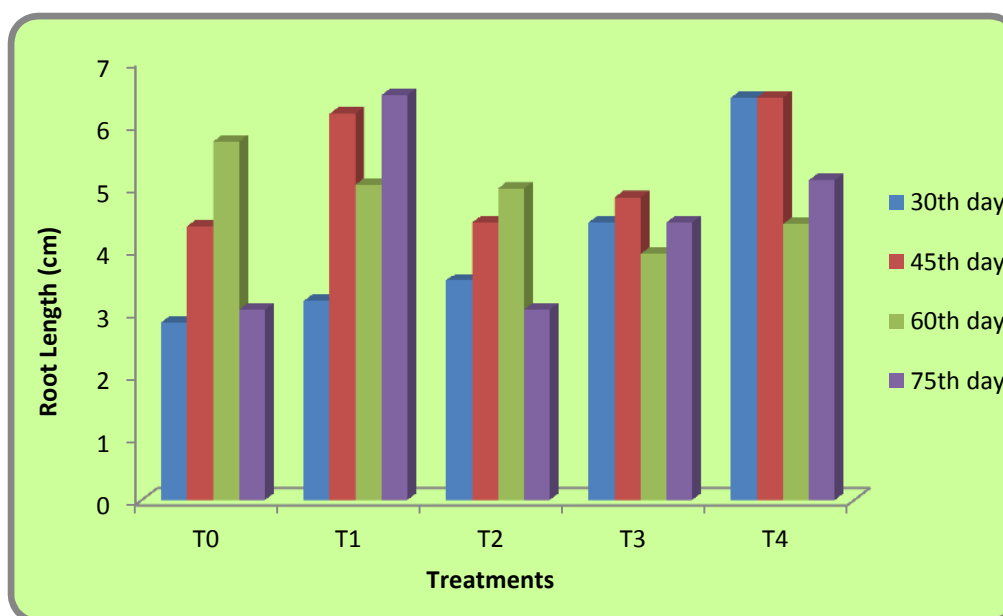


Fig. 9: Root length (cm) of *Sesamum indicum* L. at different stages of growth

T₀ – Control

T₁– VAM

T₂–Panchagavya

T₃–*Azospirillum*

T₄– VAM + Panchagavya + *Azospirillum*

Table 12: Fresh weight (g) of *Sesamum indicum* L. at different stages of growth

Treatments	30 th day	45 th day	60 th day	75 th day
T ₀	0.71 ± 0.28	1.65±0.17	4.33 ± 0.15	5.50 ± 0.10
T ₁	1.30 ± 0.29	2.76±0.12	3.57 ± 0.21	8.07 ± 0.15
T ₂	1.66 ± 0.38	1.35±0.17	3.03 ± 0.04	4.43±0.15
T ₃	1.78 ± 0.20	2.57±0.29	5.34 ± 0.55	3.10±0.30
T ₄	1.48 ± 0.18	3.56±0.40	5.03 ± 0.15	5.40±0.10
SEd	0.2241	0.2055	0.2293	0.6618
CD(P<0.05)	0.4993	0.4578	0.5108	1.4746

Values are given as mean ± SD from 3 samples in each group

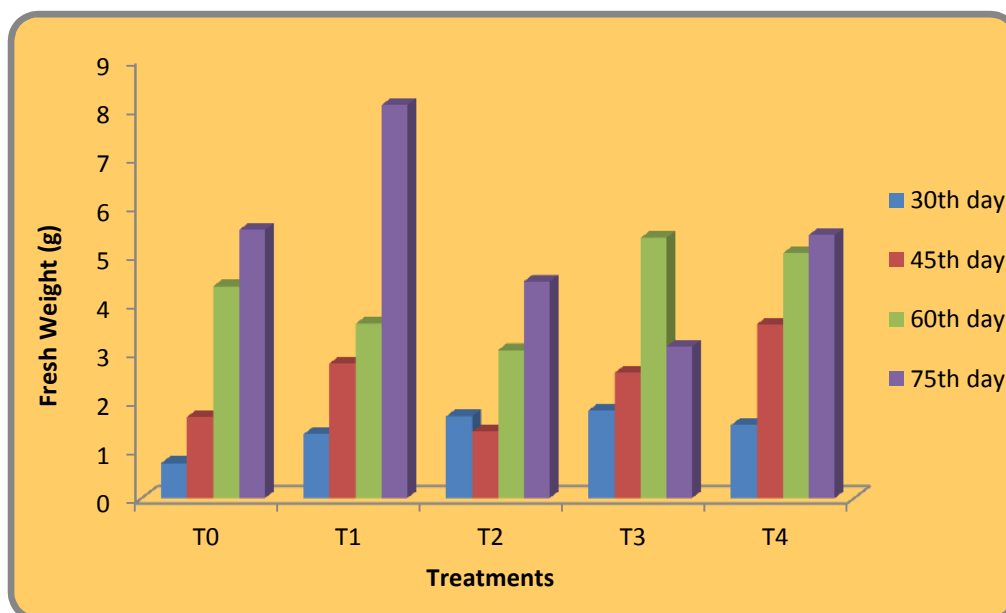


Fig. 10: Fresh weight (g) of *Sesamum indicum* L. at different stages of growth

T₀ – Control

T₁– VAM

T₂–Panchagavya

T₃–*Azospirillum*

T₄– VAM + Panchagavya + *Azospirillum*

Table 13: Dry weight (g) of *Sesamum indicum* L. at different stages of growth

Treatments	30 th day	45 th day	60 th day	75 th day
T ₀	0.09 ± 0.01	0.13±0.15	0.21 ± 0.04	0.45±0.18
T ₁	0.58 ± 0.34	0.17±0.04	0.66 ± 0.12	1.05±0.17
T ₂	0.25 ± 0.12	0.94±0.52	0.66 ± 0.12	0.80±0.13
T ₃	0.90 ± 0.31	1.18±1.06	0.44 ± 0.18	0.42±0.16
T ₄	0.19 ± 0.06	1.74±1.26	1.07 ± 0.06	0.74±0.11
SEd	0.1759	0.6334	0.0927	0.1230
CD(P<0.05)	0.3920	1.4114	0.2066	0.2740

Values are given as mean ± SD from 3 samples in each group

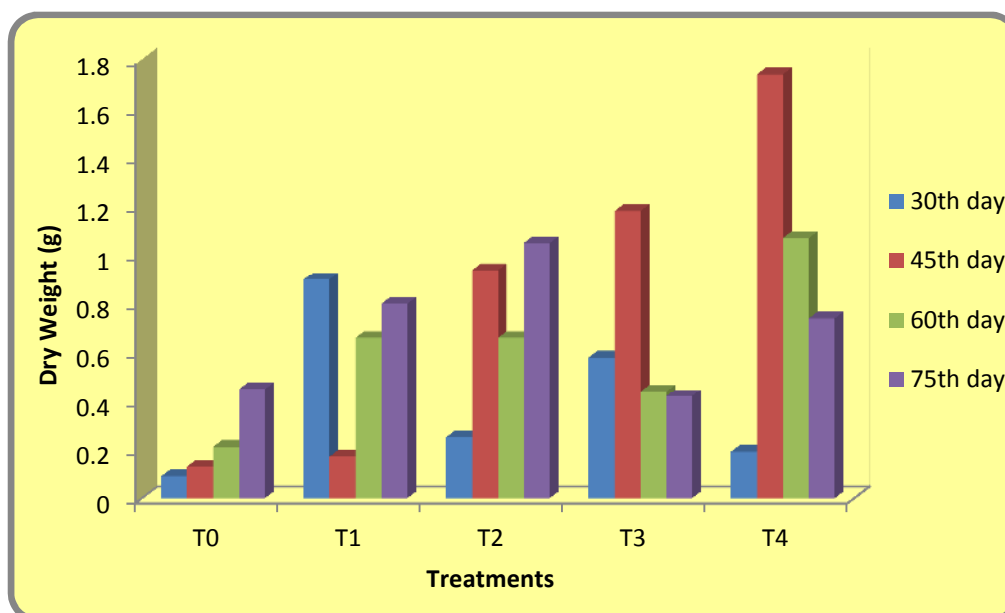


Fig. 11: Dry weight (g) of *Sesamum indicum* L. at different stages of growth

T₀ – Control

T₁– VAM

T₂–Panchagavya

T₃–*Azospirillum*

T₄– VAM + Panchagavya + *Azospirillum*

0.31 g) on the 30th day of growth. On the 45th day and 60th, the dry weight was higher in T₄ and the values were 1.74 ± 1.26 g and 1.07 ± 0.06 g respectively. On the 75th day, the dry weight was found to be more in T₁ (1.05 ± 0.17 g).

Number of Leaves

The number of leaves of *Sesamum* during different days of growth was measured and tabulated (Table 14; Fig.12). The leaf number was more in T₃ on the 30th day (10.33 ± 0.58) and 45th day (14.00 ± 1.73). On the 60th day, the number of leaves was found to be more in T₄ (16.33 ± 1.53). On the 75th day, control plants showed more number of leaves (21.33 ± 0.58).

Girth of the Stem

The girth of the stem was measured on the 45th, 60th and 75th day and tabulated (Table 15; Fig. 13). The girth was found to be more on all the days in T₄ ie., plants treated with VAM + Panchagavya + *Azospirillum*).

Yield Parameter

Number of Fruits

The yield of *Sesamum* was calculated by counting the number of fruits formed and tabulated (Table 16; Fig. 14). The fruits started forming on the 60th day. On the 60th day, control plant showed more fruit formation (5.33 ± 0.58). On the 75th day, the number of fruit was more in control as well as plants treated with VAM (8.67 ± 0.58).

Chlorophyll and Nitrogen content of *Arachis hypogae* L. and *Sesamum indicum* L.

The chlorophyll content and nitrogen content was measured at random on the 30th day in the leaves of control plants and organic fertilizer treated plants using Plant Nutrient Analyzer and tabulated (Table 17; Fig. 15 and Table 18; Fig. 16).

The chlorophyll content seemed to be more in the plants treated with mixture of organic fertilizers in both the plants. The values observed were 45.53 ± 4.82 (SPAD) for *Arachis* and 55.90 ± 10.81 (SPAD) for *Sesamum*.

Table 14: Number of leaves in *Sesamum indicum* L. at different stages of growth

Treatments	30 th day	45 th day	60 th day	75 th day
T ₀	5.67 ± 0.58	9.67±0.58	11.00 ± 1.00	21.33±0.58
T ₁	8.33 ± 0.58	10.00±0.00	14.67 ± 0.58	12.00±1.00
T ₂	7.67 ± 0.58	9.33±0.58	12.00 ± 1.00	8.67±0.58
T ₃	10.33 ± 0.58	14.00±1.73	13.67 ± 0.58	7.67±0.58
T ₄	7.67 ± 0.58	11.00±1.00	16.33 ± 1.53	14.67±0.58
SEd	0.4714	0.7888	0.8165	0.5578
CD(P<0.05)	1.0504	1.7576	1.8193	1.2428

Values are given as mean ± SD from 3 samples in each group

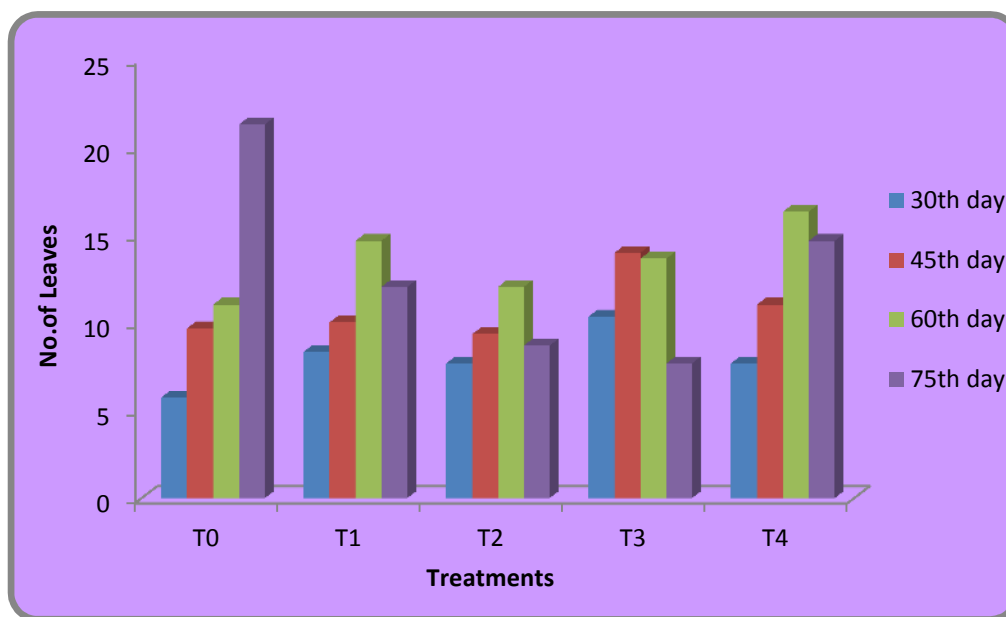


Fig. 12: Number of leaves in *Sesamum indicum* L. at different stages of growth

T₀ – Control

T₁– VAM

T₂–Panchagavya

T₃–*Azospirillum*

T₄– VAM + Panchagavya + *Azospirillum*

Table 15: Girth (cm) of the stem of *Sesamum indicum* L. at different stages of growth

Treatments	45 th day	60 th day	75 th day
T ₀	1.17±0.15	1.43 ± 0.21	0.95±0.06
T ₁	1.48±0.21	1.57 ± 0.06	1.17±0.06
T ₂	1.00±0.10	1.43 ± 0.12	1.00±0.10
T ₃	1.17±0.15	1.83 ± 0.06	0.70±0.20
T ₄	1.77±0.15	2.10 ±0.36	1.27±0.06
SEd	0.1700	0.1606	0.0894
CD(P<0.05)	0.3787	0.3577	0.1993

Values are given as mean ± SD from 3 samples in each group

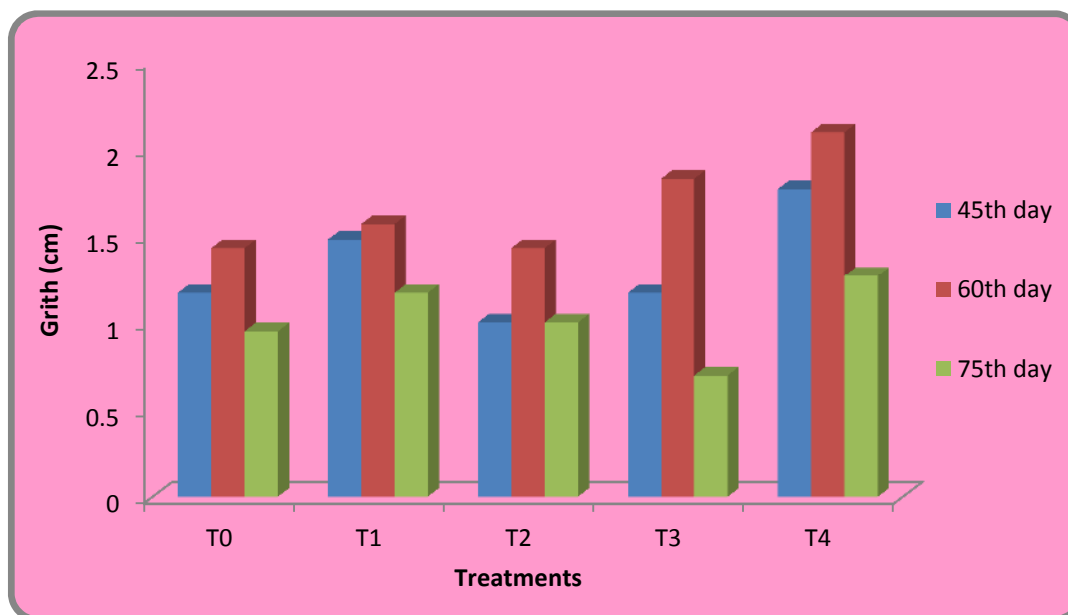


Fig. 13: Girth (cm) of the stem of *Sesamum indicum* L. at different stages of growth

T₀ – Control

T₁– VAM

T₂–Panchagavya

T₃–*Azospirillum*

T₄– VAM + Panchagavya + *Azospirillum*

Table 16: Number of Fruits of *Sesamum indicum* L. at different days

Treatments	60 th day	75 th day
T₀	5.33 ±0.58	8.67±0.58
T₁	4.00 ±0.00	8.67±0.58
T₂	4.33 ±0.58	6.33±0.58
T₃	4.67 ±0.58	6.67±0.58
T₄	2.33 ±0.58	5.33±0.58
SEd	0.4216	0.4714
CD(P<0.05)	0.9395	1.0504

Values are given as mean ± SD from 3 samples in each group

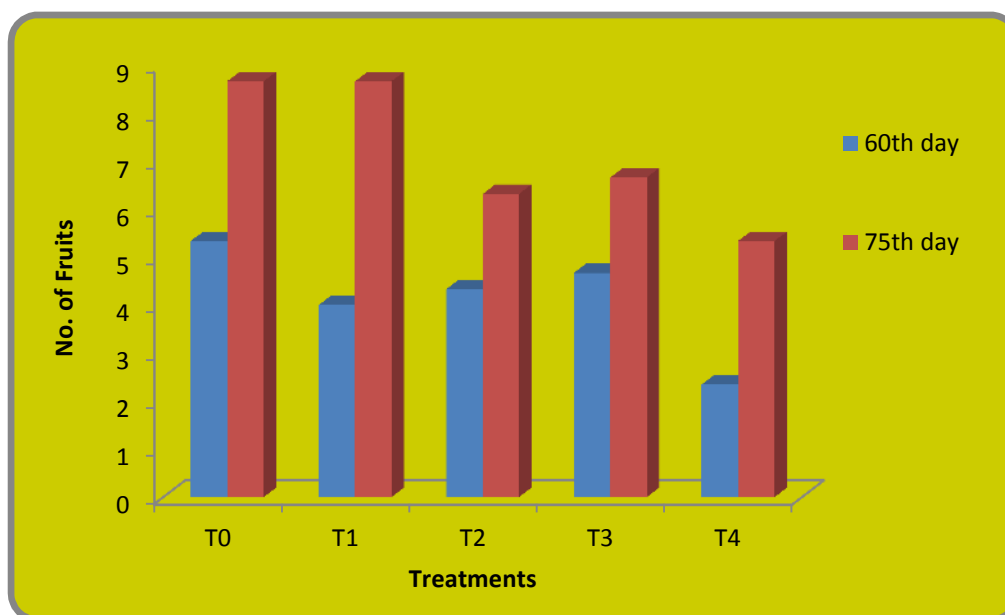


Fig. 14: Number of Fruits of *Sesamum indicum* L. at different days

T₀ – Control

T₁– VAM

T₂–Panchagavya

T₃–*Azospirillum*

T₄– VAM + Panchagavya + *Azospirillum*

Table 17: Chlorophyll (SPAD) content of *Arachis hypogaeae* L. and *Sesamum indicum* L. on the 30th day

Treatments	<i>Arachis hypogaeae</i>	<i>Sesamum indicum</i>
T ₀	35.53 ± 0.85	44.73±9.55
T ₁	44.27 ±5.34	53.13±5.60
T ₂	45.17 ± 5.73	46.10±2.65
T ₃	43.50 ± 2.42	49.50±4.77
T ₄	45.53 ± 4.82	55.90±10.81
SEd	3.4870	5.9926
CD(P<0.05)	7.7695	13.3525

Values are given as mean ± SD from 3 samples in each group

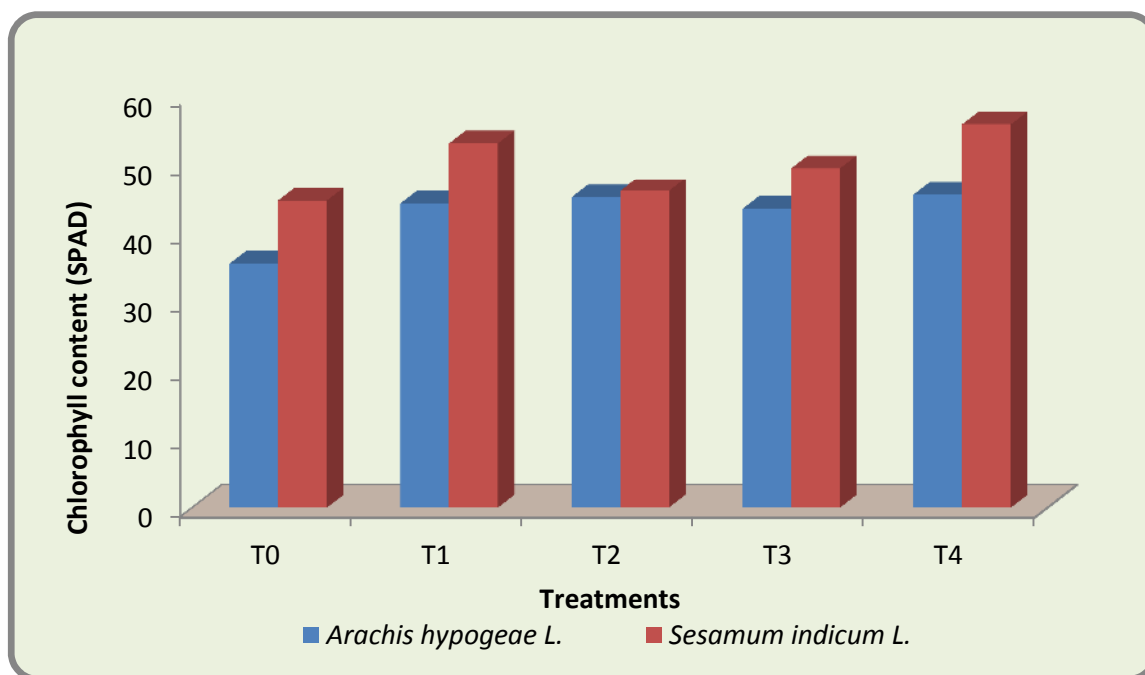


Fig. 15: Chlorophyll (SPAD) content of *Arachis hypogaeae* L. and *Sesamum indicum* L. on the 30th day

T₀ – Control

T₁– VAM

T₂–Panchagavya

T₃–*Azospirillum*

T₄– T₄– VAM + Panchagavya + *Azospirillum*

Table 18: Nitrogen (mg/g) content of *Arachis hypogaeae* L. and *Sesamum indicum* L. on the 30th day

Treatments	<i>Arachis hypogaeae</i>	<i>Sesamum indicum</i>
T ₀	13.90 ±0.30	11.83±9.11
T ₁	16.67 ±1.70	19.47±1.82
T ₂	16.97 ±1.83	17.23±0.85
T ₃	16.43 ±0.76	18.33±1.50
T ₄	17.03 ±1.53	20.37±3.42
SEd	1.1126	3.6696
CD(P<0.05)	2.4789	8.1765

Values are given as mean ± SD from 3 samples in each group

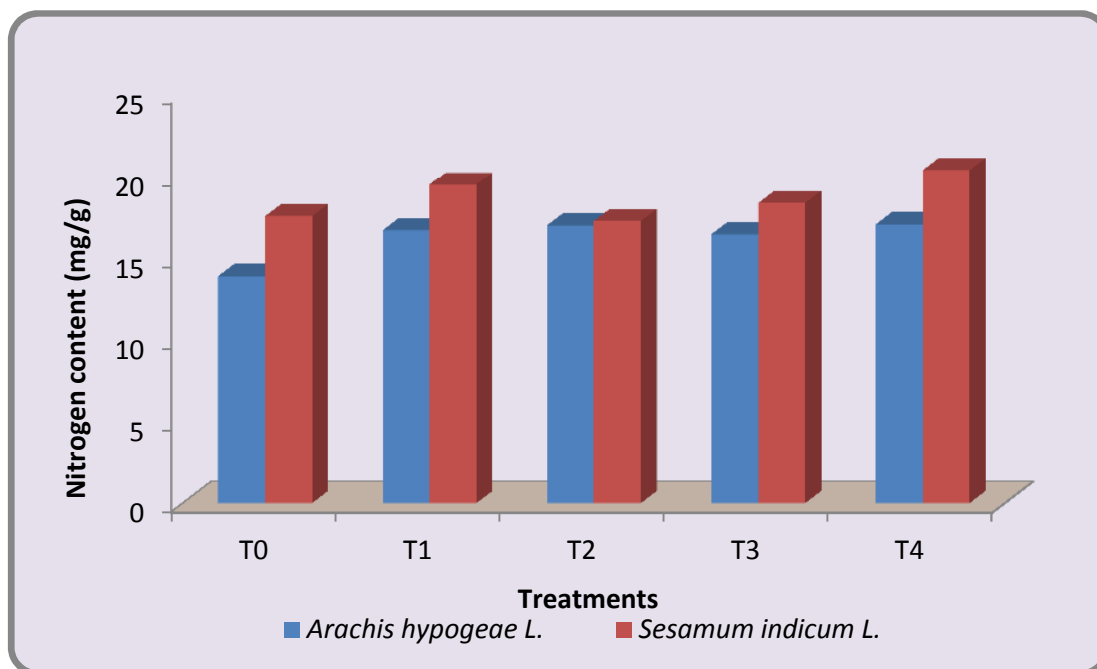


Fig. 16: Nitrogen (mg/g) content of *Arachis hypogaeae* L. and *Sesamum indicum* L. on the 30th day

T₀ – Control

T₁– VAM

T₂–Panchagavya

T₃–*Azospirillum*

T₄– VAM+Panchagavya+*Azospirillum*

Similarly, the nitrogen content was also more in plants treated with VAM + Panchagavya + *Azospirillum* and the values observed were 17.03 ± 1.53 mg/g for *Arachis* and 20.37 ± 3.42 mg/g for *Sesamum*.

Sesamum seemed to contain more chlorophyll and nitrogen content.

Nodulation in *Arachis hypogaeae* L.

The number of nodules formed in *Arachis* was calculated on the 30th, 45th, 60th and 75th day. Since, *Arachis* is a leguminous crop, it forms symbiotic association with the soil bacteria and forms root nodules. These nodules help the plant to fix the atmospheric nitrogen. The nodules formed were calculated and tabulated (Table 19; Fig. 17).

The root nodules started forming on the 30th day of growth itself. In plants treated with *Azospirillum*, more nodules were formed on the 30th day and 45th day and the values were 23.00 ± 2.65 and 26.00 ± 2.00 . On the 60th day and 75th day, the nodule formation was very high in plants treated with panchagavya. This shows that the plant could utilize the available nutrient source and grow well when treated with panchagavya in the later stages.

Vitamin E in Seeds and Leaves

The groundnut as well as sesame seeds contain Vitamin E in it. So, an attempt was made to estimate the Vitamin E content in the seeds obtained from control plant and plants treated with various organic fertilizers and tabulated (Table 20; Fig. 18).

In seeds of control plant of groundnut, the Vitamin E content was more (4.0 mg/dl). Among the various treatments, the Vitamin E content was found to be more in seeds obtained from groundnut plants treated with *Azospirillum* (3.6 mg/dl).

In case of the sesame seeds, more Vitamin E content was observed in the plants treated with VAM fungus (1.8 mg/dl). Second higher reading was observed in T₄ (1.7 mg/dl).

The 30th day leaf of groundnut and sesame was taken randomly to check the Vitamin E content. The harvested seeds were sown in different pots. While comparing the two oil-seeded crops, Vitamin E content was more in the leaves of sesame (2.8 mg/dl) than the groundnut (2.4 mg/dl) on the 30th day (Table 21; Fig. 19).

Table 19: Number of nodules in *Arachis hypogaeae L.* at different stages of growth

Treatments	30 th Day	45 th Day	60 th Day	75 th Day
T ₀	1.67 ± 1.15	6.67±2.08	53.33±4.93	93.33±6.51
T ₁	7.67 ±1.53	12.00±2.65	77.67±3.06	102.33±5.86
T ₂	16.67 ±3.06	18.67±3.06	98.00±3.00	156.00±9.54
T ₃	23.00 ±2.65	26.00±2.00	49.67±4.04	82.00±7.00
T ₄	15.00 ±2.65	25.00±3.61	51.67±3.06	89.33±3.21
SEd	1.8974	2.2410	3.0185	5.5015
CD(P<0.05)	4.2276	4.9934	6.7256	12.2582

Values are given as mean ± SD from 3 samples in each group

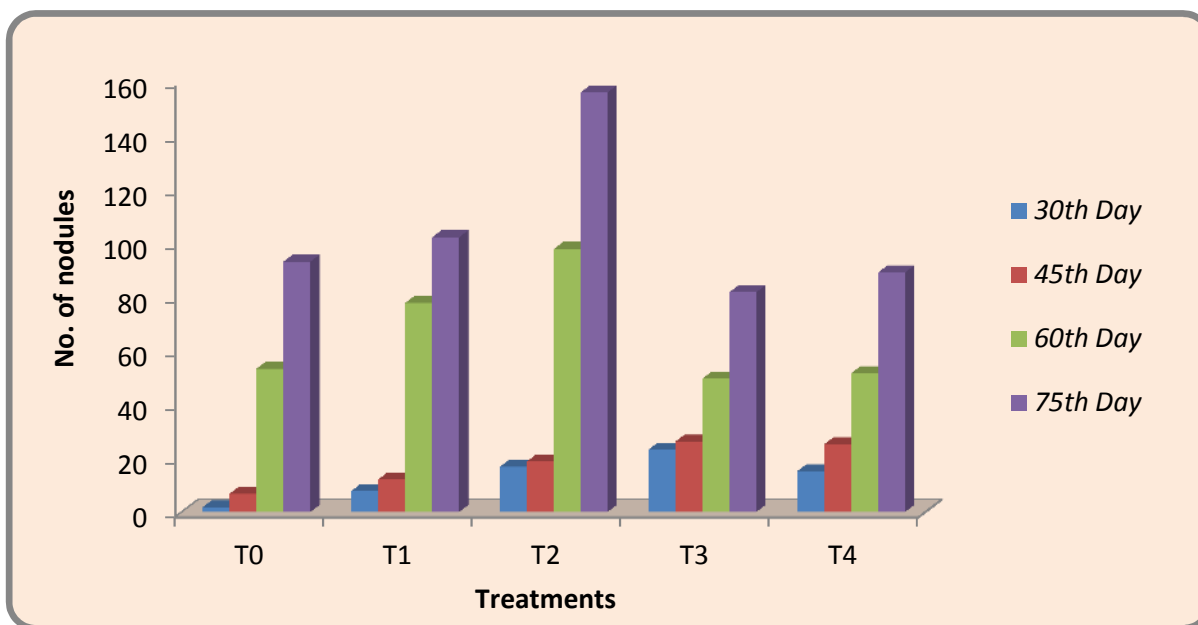


Fig. 17: Number of nodules in *Arachis hypogaeae L.* at different stages of growth

T₀ – Control

T₁– VAM

T₂–Panchagavya

T₃–*Azospirillum*

T₄– VAM + Panchagavya + *Azospirillum*

Table 20: Vitamin E content (mg/dl) in the seeds of *Arachis hypogaea* L. and *Sesamum indicum* L.

Treatments	<i>Arachis hypogaea</i> L. (mg/dl)	<i>Sesamum indicum</i> L. (mg/dl)
T ₀	4.0	1.5
T ₁	3.0	1.8
T ₂	3.1	1.0
T ₃	3.6	1.2
T ₄	3.3	1.7

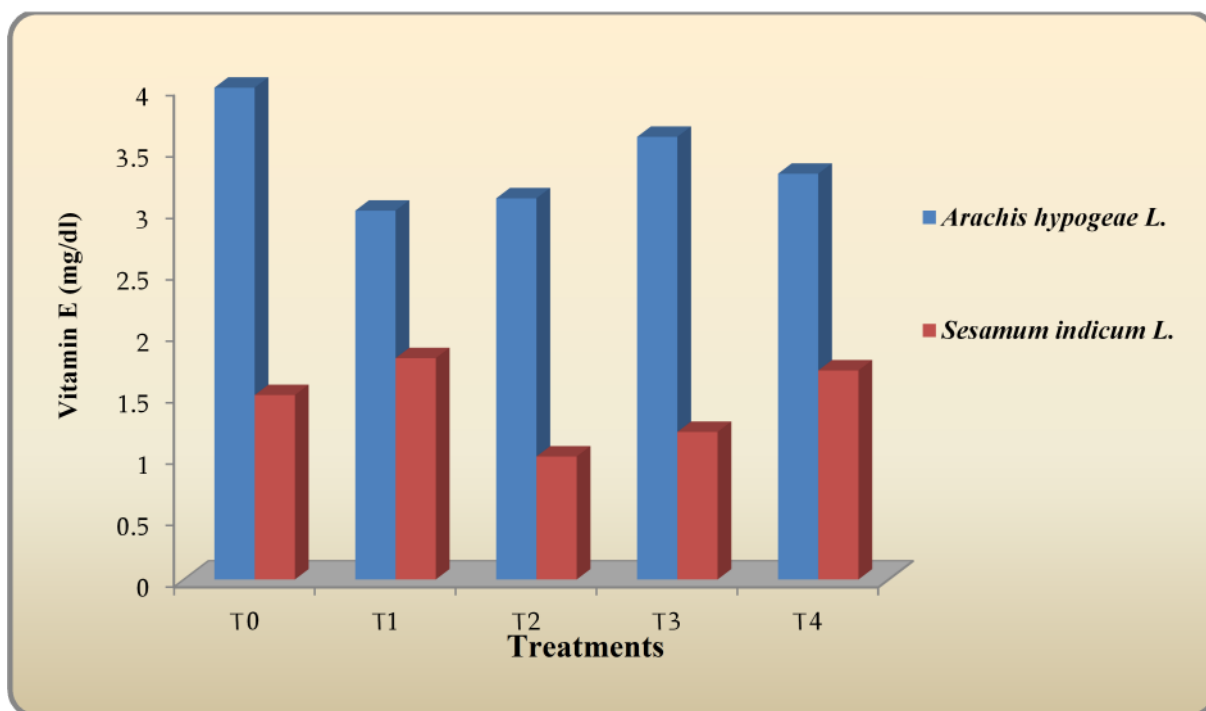


Fig. 18: Vitamin E content (mg/dl) in the seeds of *Arachis hypogaea* L. and *Sesamum indicum* L.

T₀ – Control

T₁– VAM

T₂–Panchagavya

T₃–*Azospirillum*

T₄– VAM + Panchagavya + *Azospirillum*

Studies by Gharib *et al.* (2008) on the effect of compost and bio-fertilizers on the growth, yield and essential oil of sweet Marjoram plant have shown an increase in oil percentage and yield per plant as a result of aqueous extract of compost at low level + Biofertilizers.

Naturally occurring Vitamin E are synthesized by photosynthetic organisms and functions as antioxidants (Hunter and Cahoon, 2007). The tocopherols (Vitamin E) are lipophilic antioxidants synthesized by all the plants and are particularly abundant in seeds (Satler *et al.*, 2004).

Now-a-days, Biofertilizers have emerged as a highly potent alternative to chemical fertilizers due to their eco-friendly, easy to apply, non-toxic and cost effective nature (Mazid and Khan, 2014).

Groundnut seeds are a rich source of protein, sugars and oil. Earlier studies by Shad *et al.* (2009) have proved its higher calorific score as compared to most of the other legumes.

Preliminary phytochemical screening of *Arachis hypogaea* L. and *Sesamum indicum* L.

Preliminary phytochemical screening using the ethanol and methanol extracts of the dried leaf powder of *Arachis hypogaea* L. and *Sesamum indicum* L. were done and tabulated (Table 22).

In groundnut, the ethanol and methanol extract showed the presence of alkaloid, quinones, carbohydrate, steroids, terpenoids and fats and oils. Apart from the above phytochemicals, tannin was present in methanol extract and ethanol extract, showed the presence of flavonoids.

In sesame, both ethanol and methanol extracts showed the presence of similar phytochemical compounds such as alkaloid, quinones, carbohydrate, steroids, terpenoids and fats and oils.

Preliminary phytochemical screening of *Arachis hypogaea* by Marka *et al.* (2013) have shown that legumes are nutritious and contain some phytochemicals such as alkaloids, glycosides, tannins, flavonoids, sterols, fats, phenols, lignins, quinones and saponins.

Table 21: Vitamin E content (mg/dl) in the leaf of *Arachis hypogaea* L. and *Sesamum indicum* L.

No of days	<i>Arachis hypogaea</i> L.	<i>Sesamum indicum</i> L.
30 th day	2.4	2.8

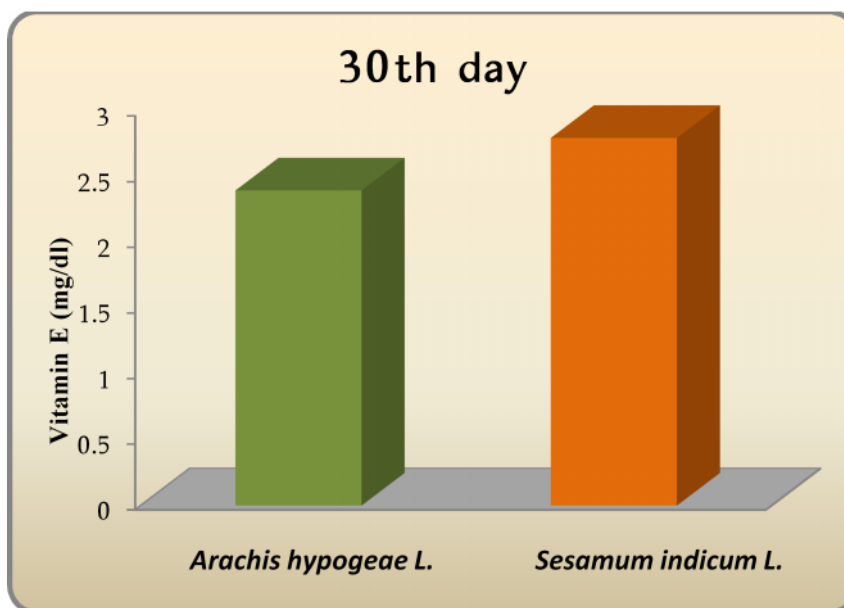


Fig. 19: Vitamin E content (mg/dl) in the leaf of *Arachis hypogaea* L. and *Sesamum indicum* L.

Table 22: Phytochemical screening of two different leaf extracts of *Arachis hypogaeae* L. and *Sesamum indicum* L.

	<i>Arachis hypogaeae</i> L.		<i>Sesamum indicum</i> L.	
	Ethanol	Methanol	Ethanol	Methanol
Alkaloid	+	+	+	+
Tannin	–	+	–	–
Flavonoids	+	–	–	–
Quinones	+	+	+	+
Phlobatannins	–	–	–	–
Phenol	–	–	–	–
Carbohydrate	+	+	+	+
Amino acid	–	–	–	–
Steroids	+	+	+	+
Terpinoids	+	+	+	+
Fats and oils	+	+	+	+

Arachis hypogaea L. is a very important nut used for various diseases such as loose cough, arthritis, constipation, recuperation after illness, etc. Preliminary phytochemical screening done by Mythily and Revathi (2017) on the aqueous, petroleum ether, chloroform and ethanol extracts of *Arachis hypogaea* L. revealed the presence of alkaloids, glycosides, fixed oils and fats, tannin, saponins and phenols. Maximum constituents were found in petroleum ether extracts.

Earlier Mbagwu *et al.* (2011) have carried out phytochemical screening and quantitative estimation of four edible legumes and showed that legumes are nutritious and contain some phytochemicals such as alkaloids, flavonoids, saponin, tannin and phenols.

Earlier studies by Prabasheela *et al.* (2015) on the phytochemical screening of *Arachis hypogaea* have revealed the presence of tannin, saponin, phlobatannin, flavonoid, terpenoid and cardiac glycoside. Quinone was absent. Fats and oils are one of the large group of organic compounds that are of great importance in the food (Sharma and Sharma, 2017).

Lee *et al.* (1998) have carried out different extraction procedure and found the direct solvent extraction method to be the best method for the determination of tocopherol in peanuts.

Mate and Saindanshiv (2018) carried out a pot culture experiment using sterile potassium deficient soil to study the application of VAM fungi to increase the groundnut production and found that the combination of all VAM fungi increased the yield significantly.

Babajide and Fagbola (2014) have shown that inoculation of *Azospirillum* may be beneficial for improved biological nitrogen fixation and also for the performance of non-leguminous plants like sesame.

V. SUMMARY AND CONCLUSION

Bio-fertilizers are important components of integrated nutrient management in crop production and mostly used in every part of the Indian territory, these fertilizers play a key role in crop productivity and sustain ability of soil and also protecting the environment. These area renewable source of plant nutrients in sustainable agricultural systems. Application of bio-fertilizers results in increased mineral and water uptake, root development, vegetative growth and yield of the crop. They are eco- friendly, non-toxic, easy to use and cost effective that improves the soil fertility and crop productivity.

The use of inorganic chemical fertilizers has led to soil and water pollution and affected the population and diversity of beneficial microorganisms in soil. This results in the crops more prone to attack by insect pest and drastic decline in crop yield. Biofertilizers are low-cost and environment-friendly plant nutrients and enhances the soil quality.

Biofertilizers help in increasing the crop productivity by way of increased BNF, increased availability or uptake of nutrients through solubilisation or increased absorption, stimulation of plant growth through hormonal action or antibiosis, or by decomposition of organic residues.

Panchagavya application is one of the traditional, eco-friendly and low cost technique to enhance the better seed in vigation and promote the successful large scale afforestation in tree species. Panchagavya is an organic formulation made from cow goods. Consequences of panchagavya application are superior growth, yield and quality of crops. Panchagavya could be used by farmers, since it has no side effects and also increases the fertility of the soil.

In the present study, two oil-seeded crops namely *Arachis hypogae* L. and *Sesamum indicum* L. were taken and growth, yield, chlorophyll and nitrogen content were estimated. In the leguminous crop, the nodules formed were also estimated.

The Vitamin E content was estimated in seeds of both the crops and in the leaves of both the oil-seeded plants. Preliminary phytochemical screening was carried out.

In *Arachis*, the germination percentage was higher when the mixture of fertilizers was used. The shoot length, root length, fresh weight and dry weight were found to be maximum in either VAM treated plants or the plants treated with the mixture of fertilizers.

The yield was more in *Azospirillum* treated plants. In case of nodules, in the early stages of growth, more nodules were formed in the *Azospirillum* treated plants. In later stages, Panchagavya treated plants showed more nodule formation.

In *Sesamum*, higher germination percentage was observed in seeds soaked in the mixture of bio-fertilizers. The shoot length, fresh weight and dry weight were found to be more in T₁ on the 75th day. The number of fruits formed was higher in VAM treated plants on the 75th day.

The Vitamin E content in the seeds were found to be higher in *Azospirillum* treated plants in groundnut and VAM fungus treated plants in sesame. The 30th day leaf was also analysed for the Vitamin E content and it was found to be more in sesame than groundnut leaves.

The preliminary phytochemical screening using ethanol and methanol extracts in groundnut leaf powder showed the presence of alkaloid, quinones, steroids, carbohydrate, terpenoids and fats & oils.

In sesame, both ethanol and methanol extracts showed the presence of alkaloid, quinones, carbohydrate, steroids, terpenoids and fats & oils.

CONCLUSION

Bio-fertilizers are eco-friendly as well as cost effective. Their use leads to soil enrichment and the quality of the soil improves with time. They do not show immediate results, but the results shown over a period of time are spectacular. They harness the atmospheric nitrogen and make it available to the plants and also increase the phosphorus content of the soil by solubilizing and releasing the available phosphorus. The yield and yield component has increased significantly. Microbial flora of soil plays an important role in soil health. The microbes present in the environment around the roots influence the plant growth and crop yield.

The microorganisms in Bio-fertilizers restore the soils natural nutrient cycle and build soil organic matter. The increased amount of chlorophyll content in leaves treated with organic fertilizers indicates the photosynthetic efficiency of the plants.

Mycorrhiza is a symbiotic relationship between Arbuscular Mycorrhizal fungi (AMF) and roots of majority of vascular plants. The use of *Azospirillum*, Panchagavya and VAM fungi improves the growth potential of the crop plants. It also increases the yield and maintenance of soil health for sustainable agriculture. However, quantitative understanding of the ecological factors that control the performance of biological N₂ fixation systems of the bacterium in crop fields is essential for promotion and successful adoption of the bio-fertilizer production technology.

On the basis of the results obtained and the discussion made so far, it may be concluded that application of the organic fertilizer or bio-fertilizer is the most effective way for higher growth and yield of the crop plants studied. Hence, the use of and management of natural resource in sustainable agriculture, the microbial fertilizers hold vast potential for future. The conclusion is based on only pot culture experiments. Further studies in the field are required to strongly support the current investigation.

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