SHELF LIFE OF LIQUID ORGANIC FORMULATIONS

By

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THESIS

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DECLARATION

I hereby declare that the thesis entitled **"Shelf life of liquid organic formulations"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University and Society.

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Certified that the thesis, entitled **"Shelf life of liquid organic formulations"** is a record of research work done independently by Miss. **Rameeza E. M. (2014-11-118)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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%	-	per cent
@	-	at the rate of
B: C	-	Benefit Cost ratio
Cfu	-	colony forming units
CRD	-	Completely Randomised Design
DAS	-	Days after sowing
dSm^{-1}	-	Deci Siemens per meter
EC	-	Electrical conductivity
et al	-	and others
FYM	-	Farm yard manure
i.e	-	that is
Mg ha^{-1}	-	Mega gram per hectare
MSL	-	Mean Sea Level
OC	-	Organic Carbon
PGPR	-	Plant growth promoting rhizobacteria
POPR	-	Package of practices recommendation
RBD	-	Randomized Block Design
WOP	-	Week old preparation

Introduction

1. INTRODUCTION

Organic farming became popular during the last few years among farmers due to the rising concern about environmental degradation, food safety and health issues. Presently organic agriculture is being projected as a new perspective for achieving sustainable production by restoring the native soil fertility, ecological balance and also offering pesticide residue free foods.

Use of chemical fertilizers and pesticides indiscriminately has adversely affected the soil quality and the beneficial microbial load leading to decreased productivity in intensive agriculture. Organic farming mainly relies on locally available inputs especially on-farm inputs like livestock wastes which can be effectively recycled for sustainable crop production. In order to sustain crop productivity, combined use of organic manures along with liquid organic formulation is a viable alternative (Kanwar *et al.*, 2006). This will ensure higher yield by enhancing the availability of nutrients through faster decomposition of bulky organic manures by boosting microbial activity in the soil.

Presently, the demand for eco-friendly fermented liquid organic formulations prepared from on-farm wastes such as *Panchagavyam*, *Beejamrutham* and *Jeevamrutham* has increased. Many of these formulations are rich in beneficial microflora and can act as efficient plant growth promoters (Devakumar *et al.*, 2014) which are mainly preferred by resource poor farmers.

Due to the several positive effects of foliar or soil applied liquid organic formulations on growth and productivity of crops, it has become a major thrust area of research in the field of organic agriculture. Moreover, early maturing crops like vegetables will be benefited with the foliar application of these formulations. The indiscriminate use of pesticides in vegetables is affecting the quality and safety of the produce causing health hazards in human beings. Hence the production of organic vegetables using these cost effective formulations are gaining popularity among the farmers.

The studies conducted by Krishnan (2014) and Vemaraju (2014) in cucurbits have revealed the positive effects of liquid organic formulations along with the package of practices (*ad hoc*) recommendations for organic farming of Kerala Agricultural University. Recent reports from elsewhere also proved that the foliar application of fermented liquid organic manures is capable of enhancing the microbial population and availability of essential nutrients in the soil.

Generally, only the fresh preparations of liquid organic formulations are used by the farmers as they do not have any information about the shelf life. There is dearth of scientific data to support the shelf life of these formulations without deteriorating the quality during storage. Studies on keeping quality of these formulations are also meagre. Hence, the present study on "Shelf life of liquid organic formulations" was undertaken with the following objectives.

- To study the shelf life of liquid organic formulations *viz.*, *Panchagavyam* and *Jeevamrutham*
- To analyze the chemical and biological properties of *Panchagavyam* and *Jeevamrutham*
- To study the effect of shelf life of these liquid organic formulations on growth and yield of cucumber

Review of Literature

2. REVIEW OF LITERATURE

Liquid organic formulations as foliar spray, *viz.*, *Panchagavyam*, *Jeevamrutham*, fish amino acid are gaining importance in organic agriculture due to several advantages.

The review of literature pertaining to the study on "Shelf life of liquid organic formulations" is presented below.

2.1. Liquid organic formulations and its general effects on crops

Liquid organic formulation is an organic source of plant supportive microbial consortia with nutrients mainly applied through seed treatment, foliar spray and through irrigation which is meant to enhance soil health by improving biological activity, crop productivity and sustainability of organic crop production. The commonly used liquid organic formulations are *Panchagavyam*, *Jeevamrutham*, *Beejamrutham*, vermi wash, compost tea, green leaf extract, *Dasagavyam*, seaweed extract, fish amino acid, egg amino acid, effective microorganisms (EM) solution, biodigester and biogas slurry.

In addition to nutrients, fermented liquid organic formulations contain plant growth hormones and microbial load which helps to boost the plant growth, improve metabolic activities and impart resistance to pest and diseases (Geetha and Devaraj, 2013). Organic farming mainly relies on locally available materials and on-farm resources as the nutrient source. The liquid organic formulations *viz.*, *Panchagavyam* and *Jeevamrutham* are meant to improve the soil properties without damaging the environment by utilizing the waste materials (Amareswari and Sujathamma, 2015).

The major drawback of organic manures is the slow release of nutrients which may reduce the yield and net returns from the crop. Nutrient availability can be improved by combined application of composts, green manures and crop residues along with liquid organic formulations *viz.*, *Panchagavyam*, *Jeevamrutham*, *Beejamrutham*, vermi wash, biogas slurry *etc.* Application of

these combinations should be in a synchronized way to release the nutrients in a need based manner for the crop to ensure maximum productivity (Kanwar *et al.*, 2006).Good quality food without traces of chemical substituent could be obtained by foliar application of fermented organic formulations rich in beneficial micro-organisms and could bring changes in modern agriculture (Galindo *et al.*, 2007).

Gore and Sreenivasa (2011) noticed that the combined use of liquid organic formulations can contribute significant improvement in growth and yield attributes of tomato compared to the recommended dose of fertilizers alone. According to Krishnan (2014), the foliar spray of *Panchagavyam* and fish amino acid improved the quality of organic salad cucumber by contributing better appearance and shelf life.

Vijayanand *et al.* (2014) reported that the use of Seaweed Liquid Extract (SLE) @ 1.5 per cent improved the growth and yield parameters of cluster bean. The content of photosynthetic pigments, reducing sugar, protein, ascorbic acid and nitrate reductase activity were also improved in the treated seedlings of cluster bean when compared to control plants. Foliar spray of sea weed extract of *Sargassum crassifolium* @ 20 per cent at weekly intervals significantly improved the fruit yield in tomato by 58.7 per cent and total soluble salts by 25.71 per cent and total acidity by 76.95 per cent over the control treatment (Sutharsan *et al.*, 2014). But, sea weed application at higher concentration (100%) has reduced the above parameters. Field trial conducted by Ganesh *et al.* (2015) revealed that foliar spray of seaweed extracts prepared from *Kappaphycus alvarezii* and *Gracilaria edulis* improved the growth, yield attributes and quality of produce in black gram. Among the various concentrations tried, application @ 10 per cent exhibited superior results. According to Patel *et al.* (2015), foliar application of sea weed extract along with recommended dose of fertilizers significantly improved the height of plants, number of tillers per hill, grain and straw yield of rice and the increased productivity might be due to the presence of growth regulators such as IAA, kinetin, GA and zeatin in seaweed extract. Ku *et al.* (2016) reported that foliar application of seaweed sap of *Gracilaria* and

Kappaphycus (10%) along with recommended dose of fertilizers significantly improved the growth, tuber yield, nutrient uptake and net returns in potato compared to control.

The presence of beneficial microorganisms in *Beejamrutham* enhanced the microbial activity of soil (Sreenivasa *et al.*, 2009) and the application of vermi wash enhanced the nutrient uptake by improving the soil microbial population (Gopal *et al.*, 2010). Maillard *et al.* (2015) reported that long term application of Liquid Dairy Manure (LDM) in perennial sward improved the soil organic carbon stock in the soil layer of 0-20 cm. The LDM possessed organic matter in liquid and solid phase which was directly contributing towards the soil organic carbon stock.

According to Hangarge *et al.* (2004), application of liquid organic slurry at the rate of 2 L m^{-2} along with five tonnes of vermi compost in chilli enhanced the nutrient availability in soil mainly nitrogen (353 kg ha^{-1}), phosphorus (21 kg ha^{-1}), and potassium (284 kg ha^{-1}) content. Ramasamy *et al.* (2010) conducted a field trial to compare the effects of farm yard manure, vermi compost, seaweed *(Hypnea muciformis* Lamour) extract and liquid organic manures in combination and individually in okra. Increased LAI and fruit weight were observed in vermi compost and liquid organic manures treated plants.

According to Singh (2011), the growth, yield and quality of produce in okra was significantly improved with the application of organic manures such as poultry manure, fermented oil cakes, *Panchagavyam*, fermented leaf extract and fish amino acid when compared to integrated nutrient management (INM) and she inferred that the organic manures could maintain crop productivity in okra by improving the soil fertility.

Scheuerell *et al.* (2002) noticed that the foliar application of compost tea could reduce the incidence of pests and diseases in various crops by competing with disease causing pathogens and it also could degrade the toxic pesticides. Basak *et al.* (2002) reported that complete control of *Sclerotiana sclerotiorum* in cucumber was achieved with the application of a formulation containing different

herbal plant extracts, fresh cow dung and cow urine. According to Giradi *et al.* (2003) soil application of vermi wash 30 days after transplanting and foliar application on 60th and 75th day after transplanting significantly reduced the leaf curl index and pest population in chilli.

Mohan (2008) investigated the effect of organic growth promoters in vegetable crops. He observed that the application of *Bokashi* (Effective Microorganisms solution) @ 750 and 1250 kg ha^{-1} resulted in better growth and yield in brinjal followed by *Panchagavyam* (3 and 5%) application. *Bokashi* registered highest growth and yield followed by *Amrit pani* (3 and 5%) and *Panchagavyam* in tomato. Uppar and Rayar (2014) reported that foliar sprays of liquid organic formulations like vermi wash @ 5 per cent and biodigester on mulberry plants significantly improved the leaf yield and plant growth which in turn enhanced the rearing of silk worms and cocoon production.

2.1.1. *Panchagavyam*

Panchagavyam, a vedic liquid organic formulation, is a blend of five products from cow *viz.*, dung, urine, milk, curd and ghee. Nowadays modified *Panchagavyam* is gaining popularity among the organic farmers of Kerala and Tamil Nadu (Shilaja *et al.*, 2014).

Each and every ingredient used for the preparation of *Panchagavyam* is rich in beneficial microorganisms and nutrients (Babou, 2005). Cow dung will act as a medium for the growth of beneficial micro-organisms, cow urine contributes nitrogen essential for the plant growth and milk is a source of calcium, protein, carbohydrates, fat and amino acids. *Lactobacillus* present in curd will acts as a catalyst in the digestion of organic wastes and ghee supplies calcium, vitamins and fat (Britto *et al.*, 2006).

Pathak and Ram (2013) reported that the presence of fermentative microorganisms like *Lactobacillus* and yeast is due to the ingredients such as cow milk and curd where the pH is low. Addition of substrate like jaggery will serve as the energy source. *Panchagavyam* is rich in beneficial microbes, mainly lactic

acid bacteria, photosynthetic bacteria, yeast, nitrogen fixers, actinomycetes, phosphorus solubilizers and fungi (Swaminathan *et al.*, 2007). *Panchagavyam* can be applied to crops by means of foliar spray, seed and seedling treatment, soil drenching and also along with irrigation water (Somasundaram *et al.*, 2007).

The beneficial effects of *Panchagavyam* on commercial crops were studied by Natarajan (2008) in various crops which revealed the increase in yield (22 per cent) and improved curcumin content of turmeric, 50 per cent increase in yield of cucumber, heavy tillering with advanced harvesting in paddy, improvement in the quality of flowers and continuous flowering in jasmine, improved shelf life and higher TSS in guava, induction of female flowers with regular bearing and improved quality of fruits in terms of aroma, flavour and shelf life in mango. He has also reported the general effects of *Panchagavyam* in plants *i.e.*, enhanced biological efficiency by activating the photosynthetic system, improved branching, rooting and quality of produce. It also imparted drought hardiness.

2.1.1.1 Influence of *Panchagavyam* on production of growth promoting hormones

According to Ravikumar *et al.* (2011), the foliar spray of *Panchagavyam* facilitated easy transfer of plant nutrients due to the stimuli caused by the presence of growth regulators such as IAA and GA, which in turn increased the crop production.

Vennila and Jayanthi (2008) reported that water regulation in developing fruits of okra can be controlled by the auxin present in *Panchagavyam* and it resulted in increased ascorbic acid and crude protein content.

2.1.1.2. Influence of *Panchagavyam* on crop nutrition

The highest macro, secondary and micronutrients content in leaves and pods, nutrient uptake and nutrient use efficiency in both the main and ratoon crops

of annual moringa were recorded with the treatment of poultry manure + neem cake + *Panchagavyam* (Beaulah, 2002).

An experiment conducted by Somasundaram *et al.* (2007) revealed that the application of BGS (Biogas slurry) along with foliar spray of *Panchagavyam* (500 litres ha^{-1}) applied at 15, 30, 45 and 60 DAS for maize and sunflower and at 15, 25, 40 and 50 DAS for green gram improved the nitrate reductase activity in sunflower and maize, and nitrogen uptake in all the crops.

Sangeetha and Thevanathan (2010) reported that the seedlings of *Lablab purpureus, Vigna radiata, Arachis hypogaea, Vigna mungo, Cyamopsis tetragonoloba, Cicer arietinum* raised in *Panchagavyam* amended soil registered a low C: N ratio as compared to control.

Foliar spray of *Panchagavyam* along with leaf extract of neem at branching and flowering stages improved the nutrient uptake of nitrogen and phosphorus in ground nut (Choudhary *et al.*, 2014). According to Jain *et al.* (2014), soil applied with *Panchagavyam* @ 4 per cent recorded higher content of macro and micronutrients and microbial activity when compared to vermi compost and farm yard manure applied soils.

2.1.1.2. Influence of *Panchagavyam* on growth, yield and quality attributes of crops

Field trial conducted by Muthuvel (2002) to study the effect of liquid organic formulations on growth and yield of okra revealed that application of four sprays of *Panchagavyam* @ 3 per cent and moringa leaf extract @ 25 ml $plant^{-1}$ given at fortnightly intervals recorded higher plant height and number of branches whereas *Panchagavyam* treated plants registered highest number of fruits $plant^{-1}$ and fruit yield ha^{-1}.

Field trial conducted by Kanimozhi (2003) revealed that the foliar spray of *Panchagavyam* @ 4 per cent in *Coleus forskohlii* improved the number of roots (14.99), root length (13.73), root diameter (2.49), root weight (459.35 g/plant) and root yield (12.40 kg/plot) as compared to control (5.23 kg/plot).

An experiment conducted by Rao (2006) inferred that maize and sunflower crops can be sustained in pure organic system with the use of farmyard manure or vermi compost or poultry manure along with foliar spray of *Panchagavyam* where they perform same as with recommended dose of fertilizers.

An experiment conducted to study the effect of *Panchagavyam* on the germination of okra seeds revealed that *Panchagavyam* @ 3-5 per cent can impart better germination (Balasubramanian *et al.*, 2009).

Anuja and Jayasri (2011) reported that combined application of organic manures along with liquid organic formulations improved the herbage yield and essential oil content of sweet basil and the application of farm yard manure @ 25 t ha^{-1} + biofertilizers + *Panchagavyam* @ 3 per cent was found to be superior among the treatments.

Patil *et al.* (2012) recorded an increase in dry matter accumulation in chickpea at various growth stages by the application of organic manures and foliar source such as 3 per cent *Panchagavyam*. Ravi *et al.* (2012) conducted an experiment to evaluate the effect of integrated nutrient management on growth, yield and protein quality in maize. The 75 per cent RDF (Recommended Dose of Fertilizers) along with insitu green manuring of sunhemp, application of biofertilizers like azospirillum and phosphorus solubilizing bacteria, and liquid organic formulations such as *Panchagavyam* @ 3 per cent foliar spray and soil application of *Jeevamrutham* @ 500 L ha^{-1} could save the remaining 25per cent of fertilizer dose by improving the yield. Shashikumar *et al.* (2013) found that the application of 3 per cent *Panchagavyam* along with RDF could improve the height of plants, number of branches, dry matter production and yield in black gram compared to the RDF alone.

Seed invigoration with *Panchagavyam* at different concentrations and soaking durations for bio-fuel crops revealed that soaking *Jatropha curcas* seeds for 16 hours in two per cent and *Pongamia pinnata* seeds for 8 hours in five per cent *Panchagavyam* were found to be superior in germination and seedling vigour

to control (Srimathi *et al.*, 2013). Treatment of rice seeds with bio growth regulator *viz.*, *Panchagavyam* @ 3 per cent for 16 hours significantly improved germination, growth and vigour of seedlings and storage life of treated seeds (Senthivel and Ranganathan, 2015).

Vimalendran and Wahab (2013) conducted an experiment to study the effect of foliar applied *Panchagavyam* on yield of baby corn. The highest yield was recorded by *Panchagavyam* @ 3 per cent at 15, 25, 35 and 45 DAS along with RDF and they have opined that this is due to the increased photosynthetic activity and improved root system which enabled the plants to extract nutrients and finally improved the yield attributes.

A field experiment conducted by Pradeep and Sharanappa (2014) at Bengaluru in chilli to validate the organic farming practices revealed that the application of enriched bio-digested liquid manure @ 125 kg N equivalent ha^{-1} along with three sprays of *Panchagavyam* @ 3 per cent recorded significantly higher capsaicin content (0.64%), ascorbic acid (137.3 mg/100g), total extractable colour (280.8 ASTA units), and oleoresin content (15.4%) compared to the control treatment. The effect of *Panchagavyam* spray on growth, yield and biochemical changes of okra studied by Rajesh and Jayakumar (2013) revealed that all parameters were improved with the foliar spray of 3 per cent *Panchagavyam.*

An experiment conducted by Britto and Girija (2006) to study the effect of inorganic and organic farming practices on green gram and black gram showed that the use of *Panchagavyam* @ 3 per cent as seed treatment and foliar spray along with biogas slurry improved the yield when compared to the inorganic practices.

The influence of different organic supplements on vitamin content in french bean (*Phaseolus vulgaris*) was studied by Amareswari and Sujathamma (2014a). Foliar applied *Panchagavyam* @ 3 per cent (5 sprays) along with vermi compost and straw mulch improved both riboflavin and ascorbic acid content of tender pods followed by *Jeevamrutham* @ 5 per cent applied to the soil as well as

foliar spray at 15 DAS, 30 DAS, @ 6.5 per cent at 45 DAS and 60 DAS, and @ 10 per cent at 75 DAS along with *Panchagavyam* and straw mulch.

According to Boraiah *et al.* (2015), application of *Panchagavyam* @ 3 per cent as foliar spray along with FYM recorded higher number of fruits per plant, number of branches per plant, plant height and yield in capsicum. Field trial conducted by Kumar *et al.* (2015) revealed that application of 2 per cent foliar spray of *Panchagavyam*, mulching with paddy straw (5 t ha^{-1}) and vermi compost (2 t ha^{-1}) significantly improved the growth and yield of rice fallow black gram. The effect of foliar spray of liquid organics was studied by Sivagamy (2015) where the foliar spray of *Panchagavyam* @ 3 per cent at 30 and 60 DAS of maize were found to be superior.

According to Ashiya and Tank (2015), *Panchagavyam* (3%) treated mango stones for three hours produced taller root stock with more number of leaves, higher number of lateral roots and hence *Panchagavyam* was found to be an alternative to cow dung.

2.1.1.3. Influence of *Panchagavyam* on microbial activity

Use of dried *Panchagavyam* as manure was found to be good in promoting the survival and root nodule formation in pulse crops with inoculation of *Rhizobium* (Sangeetha and Thevanathan, 2010).

The biological properties of soil after the harvest of green gram was improved with the soil application of *Panchagavyam* at 15 and 30 DAS along with the recommended dose of organic manures (Chaudhari *et al.*, 2013). The increased microbial population of *Azotobacter*, *Azospirillum*, *Rhizobium*, and PSB were also observed in the above experiment.

According to Shubha *et al.* (2014), *Panchagavyam* spray and seed treatment @ 3 per cent along with organic manures showed higher rhizosphere microbial activity followed by seed treatment with *Beejamrutham* and *Panchagavyam*.

Treatments receiving biodigested liquid manure at 125 kg N equivalent ha^{-1} along with three sprays of *Panchagavyam* @ 3 per cent significantly

improved the total microbial count of soil such as fungi (23.2×10^3 cfu/g soil), bacteria (37.0×10^6 cfu/g soil), and actinomycetes (13.2×10^3 cfu/g soil) as compared to the control treatment (Pradeep and Sharanappa, 2014).

Vajantha *et al.* (2015) reported that the soil applied *Panchagavyam* @ 15 per cent significantly improved the soil urease and dehydrogenase activity as compared to foliar application of *Panchagavyam.* Moreover, foliar application of *Panchagavyam* @ 5 per cent (4 sprays) registered higher dehydrogenase and urease activity as compared to *Panchagavyam* @ 3 per cent (3 sprays) of foliar spray in ashwagandha.

2.1.1.4. Influence of *Panchagavyam* in controlling pests and diseases

Mishra (2002) reported that soil drenching with *Panchagavyam* @ 10 per cent had successfully controlled the bacterial wilt of tomato. Selvaraj (2003) also observed that foliar spray of *Panchagavyam* in potato reduced thepopulation of cut worms, which in turn resulted in higher yield. An attempt to study the acaricidal activity of indigenous organic materials in controlling *Tetranychus urticae* by Chandrasekharaiah *et al.* (2012) revealed that the treatment of modified *Panchagavyam* @ 2.5 per cent and *Dasagavyam* @ 10 per cent moderately caused the larval and adult mortality. Mallinath and Biradar (2015) reported improved population of natural enemies such as spiders and coccinellid beetles by the application of *Panchagavyam* @ 2 per cent which in turn controlled the thrips population in onion.

Machenahalli *et al* (2003) reported the disease suppressing activity of *Panchagavyam* @ 5-10 per cent against *Pseudoperonospora cubensis,* the causal agent of downy mildew of *Cucumis sativus. Panchagavyam* was investigated invitro for the suppression of *Curvularia lunata* causing grain discoloration in rice and it revealed that the seed treatment with *Panchagavyam* inhibited mycelia and spore germination of the pathogen and the treatment further improved the seed germination and vigour index (Sumangala and Patil, 2009).

The ingredients of *Panchagavyam* such as milk is known for its antiviral and fungicidal effect (Balasubramanian *et al.*, 2009), cow dung and cow urine possess the insecticidal activity (Shailaja *et al.*, 2014).

Ravichandran *et al.* (2011) reported that 3 per cent spray of *Panchagavyam* applied at 15 days interval in potato and soaking of seed tubers prior to storage significantly reduced the loss in weight of seed tubers and spoilage upon storage.

Vallimayil and Sekar (2012) investigated the antiviral activity of *Panchagavyam* in sunhemp as systemic host and cluster bean as assay host at different time intervals. *Panchagavyam* @ 3 per cent as seed treatment and foliar spray showed higher yield and lesser SSMV (Southern Sunhemp Mosaic Virus) activity over control treatment in sunhemp. Higher viral inhibition rate was also registered in the *Panchagavyam* sprayed plants of cluster bean.

Radha and Rao (2014) identified bacterial isolates from *Panchagavyam* like *Bacillus safensis* and *Bacillus cereus* which were antagonistic to plant pathogen *Rhizoctonia bataticola*. According to Sarkar *et al.* (2014), application of *Panchagavyam* @ 3 per cent as foliar spray in tomato, chilli and cowpea induced the production of polyphenol oxidase, a defense related enzyme which could have triggered the immune system of plant to acquire resistance against diseases.

2.1.2. *Jeevamrutham*

Jeevamrutham is an enriched consortium of soil microorganisms prepared from farm wastes such as cattle dung and urine along with other ingredients like jaggery, pulse flour, fertile soil and water (Kabse *et al*, 2009). Ravikumar *et al.* (2011) reported that the addition of jaggery and pulse flour with continuous stirring while preparing *Jeevamrutham* will help in faster multiplication of nitrogen fixing bacteria.

Jeevamrutham has to be applied once in 15 days @ 50-200 litres $acre^{-1}$ during vegetative stage, flowering stage and grain filling stage and can also be applied alone or along with irrigation water (Ramprasad *et al.*, 2009).

Analysis of nutrient composition of *Jeevamrutham* by Sreenivasa *et al.*, (2011) has revealed the presence of nitrogen (0.077 - 0.1 per cent), phosphorous (0.016 - 0.017 per cent), potassium (0.012- 0.019 per cent), iron (29.7 – 282 ppm), zinc (1.27- 4.29 ppm), copper (0.38 – 1.58 ppm) and manganese (1.8 -10.7 ppm).

Devakumar *et al.* (2014) noticed higher colony forming units of bacteria, N-fixers, fungi and actinomycetes in *Jeevamrutham* which revealed that the formulation is a rich consortia of naturally occurring soil microbes. He also observed that *Jeevamrutham* would give better result if it is used within 9-12 days after preparation.

2.1.2.1 Influence of *Jeevamrutham* on crop nutrition

The soil application of *Jeevamrutham* significantly increased the availability of phosphorus in soil as compared to the RDF revealing its effect in solubilising the phosphorus in soil pool (Ninan *et al.*, 2013). This could be due to the increased activity of PSB present in *Jeevamrutham* which is capable of releasing phosphate ions.

2.1.2.2. Influence of *Jeevamrutham* on growth, yield and quality of crops

Kesarwani (2010) reported that the millable cane and ethanol yield from sweet sorghum was improved with the use of *Jeevamrutham* (soil application) along with 100 per cent recommended nitrogen through compost than the use of compost alone.

According to Ravikumar *et al.* (2011) application of *Jeevamrutham* along with biodigester improved the yield in groundnut and it could be due to the addition of calcium and presence of nitrogen fixing bacteria.

Channagoudra (2012) reported that integrated application of compost and vermi compost equivalent to RDF, gliricidia green leaf manure along with surface application of *Jeevamrutham* @ 500 L ha^{-1} registered significantly higher number of bolls, mean boll weight, yield and total dry matter production in cotton.

A field trial was conducted by Ninan *et al.* (2013)at the Regional Agricultural Research Station, Kumarakom *viz.*, seed treatment with *Beejamrutham* + soil application of *Jeevamrutham* prepared from vechur and cross bred @ 500 L ha^{-1} each at 10, 40 and 70 DAS with and without straw mulch in njavara rice. This increased the chlorophyll content over the recommended dose of fertilizers in njavara rice plants since *Jeevamrutham* is rich in photosynthetic bacteria.

A field trial conducted by Vemaraju (2014) in College of Horticulture, Vellanikkara revealed that the treatment receiving *Jeevamrutham* was found to be superior in terms of number of fruits $plant^{-1}$, weight of fruits $plant^{-1}$, yield ha^{-1} and dry matter production in organic oriental pickling melon. An experiment conducted by Amareswari and Sujathamma (2014b) revealed that rice production (Variety Hamsa) using *Jeevamrutham* is commercially viable since it gave better grain yield, net returns and benefit-cost ratio as compared to chemical farming.

Soil application of *Jeevamrutham* @ 1000 L ha^{-1} contributed significant higher yield in french bean (Basavaraj *et al.*, 2015). Murali *et al.* (2015) studied the effect of different concentrations of *Jeevamrutham* (0, 500, 1000 and 1500 L ha^{-1}) and FYM (100, 150 and 200 per cent N) on growth and yield of organic field bean (*Dolichos lablab* L.). Higher dose of *Jeevamrutham* and FYM significantly increased the seed yield while the lowest yield was recorded without *Jeevamrutham* application.

2.1.2.3. Influence of *Jeevamrutham* on microbial activity

According to Gore and Sreenivasa (2011), *Jeevamrutham* will promote biological activity in soil and as a result the nutrient availability to the crop will be improved. They have also enumerated microbes present in *Jeevamrutham* namely fungi (13.40×10^3 cfu ml^{-1}), bacteria (19.70×10^5 cfu ml^{-1}), actinomycetes (3.50×10^3 cfu ml^{-1}), nitrogen fixers (4.60×10^2 cfu ml^{-1}) and phosphate solubilisers (4.20×10^2 cfu ml^{-1}).

2.1.2.4. Influence of *Jeevamrutham* in controlling pests and diseases

An experiment conducted by Mallinath and Biradar (2015) to assess the bioefficacy of organics and inorganics in controlling the population of onion thrips (*Thrips tabacci*) revealed the possibility of using *Jeevamrutham* for the management of the pests. Application of *Jeevamrutham* @ 2 per cent was equally effective to the inorganic treatments in managing thrips population. Sujatha *et al.* (2015) reported that the application of compost prepared using weeds and *Jeevamrutham* improved the resistance against fungal and bacterial pathogens in field.

2.1.3. Shelf life of liquid organic formulations

Natarajan (1999) observed that fortified or modified *Panchagavyam* solution can be kept for 6 months without any deterioration in its quality, when stirred twice daily in clock wise direction. He also reported that the macro and micro nutrients, growth hormones and micro organisms got increased and it made *Panchagavyam* a nutrient rich manure. Natarajan (2003) reported a significant increase in TVC (Total Viable Count) of *Panchagavyam* during different storage periods. According to Purohit and Gehlot (2006), *Panchagavyam* solution can be kept for six months without any deterioration in its quality. However, Natarajan (2008) experienced the problem of solidification of *Panchagavyam* due to high temperature during longer period of storage. Kumar *et al.* (2011) reported that the quality of *Panchagavyam* will be improved on storage up to six months. The modified *Panchagavyam* prepared using cow urine collected 24 hours earlier, cow dung, boiled and cooled cow milk, curd, ghee, banana, tender coconut water and jaggery had a shelf life of 3 months (Suresh *et al.*, 2013).

Rao *et al* (2015) studied the shelf life and microbial population of fermented liquid organic formulations which showed a progressive increase in the microbial count of *Panchagavyam* from 31st day onwards. The microbial

population (cfu/ml) recorded on 45th day was as follows: fungi (17 x 10^4), bacteria (32.67 x 10^6), actinomycetes (9.67 x 10^3), PSM (4 x 10^2) and nitrogen fixers (8 x 10^3). Shelf life of the liquid organic formulations was further improved by the use of desi cow ingredients than that of Holstein-Friesian cow. He also opined that *Jeevamrutham* and *Beejamrutham* could be used on eighth and first day after preparation respectively to obtain maximum benefits.

Kabse *et al.* (2009) found that the nutrient status of *Jeevamrutham* decreased during storage and hence *Jeevamrutham* should be used within 5 days after 48 hours of incubation. A significant increase in the microbial count was noticed in *Jeevamrutham* and *Panchagavyam* during different storage periods (0, 5 and 7 days). As the days of storage increased, microbial count *viz.*, Total Viable Count (TVC) of *Pseudomonas aeruginosa*, *Lactobacilli*, nitrogen fixing bacteria and *Bacillus* were increased. Highest microbial count was observed on 7th day of storage. Microbial analysis of 7 month old samples of *Jeevamrutham* and *Panchagavyam* also showed the presence of viable microbes (Babu, 2011).

The possibility of keeping vermi wash up to two months without any reduction in nutrient content was reported by Murali and Neelanarayanan (2011). According to Pillai (2012), the liquid extracts of composite manures prepared from groundnut cake, neem cake and poultry manure could be stored without any nutrient reduction for 60 days both under open and refrigerated condition with pH adjustment, PGPR addition and autoclaving.

Devakumar *et al.* (2014) conducted laboratory analysis of *Beejamrutham* and *Jeevamrutham*. Higher count of fungi, bacteria, actinomycetes, phosphorus solubilizers, and nitrogen fixers were recorded in *Jeevamrutham* between 9-12 days after preparation and gradual reduction of microbes was noticed 20 days after preparation. Higher colony forming units in *Beejamrutham* were observed on the day of preparation while a decline was noticed thereafter with a minimum population on seventh day after preparation.

Materials and Methods

3. MATERIALS AND METHODS

The present investigation entitled "Shelf life of liquid organic formulations" was carried out at the College of Horticulture, Kerala Agricultural University, Vellanikkara, Thrissur during 2015 - 2016. The main objective of the project was to study the shelf life of liquid organic formulations by analyzing the chemical and biological properties and to study the effect on growth and yield of cucumber (*Cucumis sativus* L.). The investigation was carried out with two experiments.

3.1. Experiment I

Influence of ageing on quality of liquid organic formulations

3.1.1. Experimental site

The experiment was conducted in the Agronomy Laboratory, College of Horticulture, Vellanikkara.

3.1.2. Time of experiment

The experiment was conducted from 31st January to 8th August, 2015.

3.1.3. Methods

Jeevamrutham and *Panchagavyam* were stored in plastic vessels covered with muslin cloth in open condition for different periods and the quality analysis was done.

Technical programme

Design: CRD

Treatments: 11

Replications: 3

Treatments

S_1 – Fresh preparation (*Jeevamrutham* on third day and *Panchagavyam* on twenty second day)

S_2 – 1 week old preparation

S_3 – 2 weeks old preparation

S_4 – 4 weeks old preparation

S_5 – 6 weeks old preparation

S_6 – 8 weeks old preparation

S_7 – 10 weeks old preparation

S_8 – 12 weeks old preparation

S_9 – 16 weeks old preparation

S_{10} – 20 weeks old preparation

S_{11} – 24 weeks old preparation

Methods of preparation of *Jeevamrutham* and *Panchagavyam* are as follows.

Jeevamrutham

Jeevamrutham was prepared by mixing 500g cow dung, 500 ml cow urine, 100g green gram (soaked overnight and ground), 25g undisturbed soil, 100 ml coconut water and ten litres of water thoroughly and kept for 3 days. Stirring was done twice a day in clock wise direction.

Panchagavyam

For preparing *Panchagavyam* 2.5 kg cow dung and 500g ghee were mixed in a clean container thoroughly and stirring was done twice a day. After three days, one and a half litres of cow urine and ten litres of water were added and

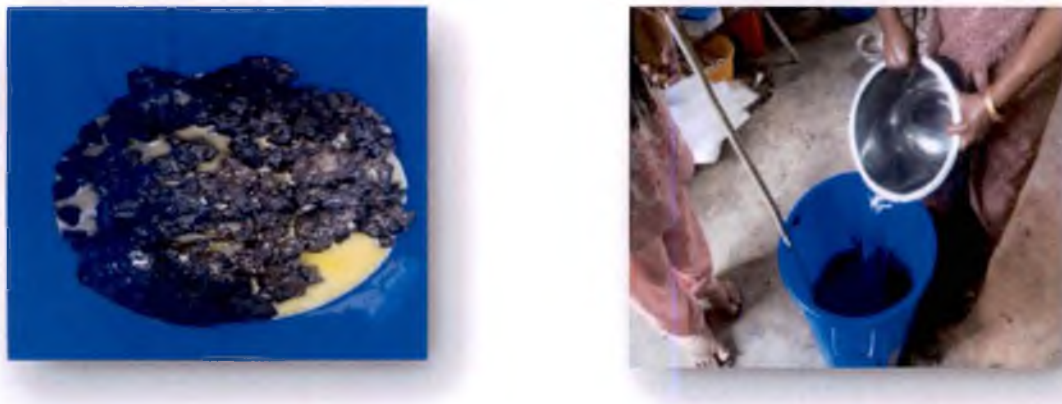


Plate 1. Preparation of *Panchagavyam*

Plate 2. Preparation of *Jeevamrutham*

Plate 3. Storage of liquid organic formulations

were kept for 15 days with regular mixing both in the morning and evening hours. After 15 days, one litre each of cow milk and curd, 500g jaggery, two litres of coconut water and eight numbers of well ripened palayankodan banana were also added and mixed well and kept it for six more days.

3.1.4. Observations

Colour

The change in the colour of liquid organic formulations during different storage periods was visually evaluated.

Odour

Sensory evaluation was done to assess the change in odour of liquid organic formulations during storage.

Mould growth

The surface growth of the mould in liquid organic formulations was visually observed and noted.

pH

The pH of the liquid organic formulations was recorded by using 1: 2.5 suspension ratio pH meter method (Jackson, 1958).

EC

The electrical conductivity of the liquid organic formulations was measured by using conductometric method (Jackson, 1958).

Nutrient content

The total content of macro nutrients (N, P and K), secondary nutrients (Ca, Mg and S) and micro nutrients (Fe, Mn, Zn and Cu) were analyzed using standard analytical methods given in Appendix I.

Organic Carbon

The percentage of organic carbon content in liquid organic formulations was analyzed using Walkley and Black method (Jackson, 1973).

Microbial population

The total microbial count (bacteria, fungi, actinomycetes and *Escherichia coli*) of the liquid organic formulations were enumerated during different storage periods. The method followed for the isolation and enumeration was serial dilution and plate count technique with appropriate medium (Agarwal and Hasija, 1986). Enumeration of microbial population was carried out on Hi-media of Nutrient agar for bacteria at 10^6 dilution, Martin's Rose Bengal Agar for fungi at 10^4 dilution, Kenknight's and Munair's Agar for actinomycetes at 10^5 dilution and Eeosine Methylene Blue Agar for *E. Coli* at 10^1 to 10^7 dilution and the plates were incubated at 28 ± 2 °C.

Maggot population

The presence of maggots was visually observed.

3.2. Experiment II

Influence of shelf life of *Jeevamrutham* and *Panchagavyam* on growth and yield of cucumber

3.2.1. Experimental site

The experiment was conducted at Agronomy Farm of College of Horticulture, Vellanikkara. Geographically, the site is situated at 10° 31' N latitude and 76 °13' E longitude and at an altitude of 40.30 m above MSL.

3.2.2. Soil

The soil of the experimental site was sandy clay loam in texture and belonged to the order ultisol. The physico-chemical properties of the soil are given in Appendix II.

3.2.3. Climate

The meteorological data during the period of study is furnished in Appendix III.

3.2.4. Season of the experiment

The experiment was conducted from January to April, 2016.

3.2.5. Methods

Crop and variety

The variety Pusa Uday of cucumber (*Cucumis sativus* L.) was used for the study. The fruits are medium-sized and striped, light green in colour, tender with soft skin, and are non-hairy and non-prickled.

Technical programme

Design : RBD

Treatments : 7

Replications: 4

Spacing : 2 m x 1.5 m

Plot size : 4 m x 3 m

Treatments

T_1 &T_2 - Best of *Jeevamrutham* of Expt. I @ 100% (Weekly spray)

T_3 & T_4- Best of *Panchagavyam* of Expt. I @ 3% (Weekly spray)

T_5 - Water spray (Weekly spray)

T_6 - Commercial organic formulation (Microzyme @ 0.5%) (Weekly spray)

T_7 - POP Recommendations, KAU

Cultural operations

The experimental site was ploughed using disc plough and cultivator. Pits (60 cm diameter and 30 cm depth) were taken at a spacing of 2 m X 1.5 m on levelled field. Seeds were sown on fifth February, 2016 (4 seeds/pit). All the management practices (except in T_7) were done as per the package of practices recommendations (*ad hoc*) for organic farming: Crops (KAU, 2009). A basal dose of FYM @ 20t ha^{-1} along with fertilizers (35:25:25 kg ha^{-1} NPK) were applied in T_7 whereas poultry manure @ 4t ha^{-1} was applied in the remaining treatments. Seeds except for T_7 (soaked in water only) were soaked overnight in *Pseudomonas fluorescence* (1%) and PGPR I (1%). Gap filling and thinning were done to secure a uniform stand of the crop (3plants/pit). 35 kg ha^{-1} nitrogen was applied in two splits for T_7 while coir pith compost @ 8t ha^{-1} along with PGPR I (1%) was given twice at winding and flowering stages in the remaining treatments.

Cow dung slurry application was done at fortnightly intervals from flowering. Irrigation was given daily during early growing period and it was extended later to once in three to four days interval. Weeding was done as and when required. Liquid organic formulations were applied as foliar spray at weekly intervals from 20 DAS as per the technical programme.

Plate 4. Field operations

Field preparation

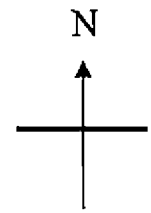
Manuring

Sowing

Mulching

Plate 5. Spraying of liquid organic formulations at different growth stages

The layout plan of Experiment II is presented in Figure 1.



T_2	T_6	T_1	T_3	T_7	T_4	T_5	R_1
T_1	T_5	T_6	T_4	T_2	T_3	T_7	R_2
T_7	T_4	T_5	T_2	T_3	T_1	T_6	R_3
T_3	T_7	T_6	T_1	T_4	T_5	T_2	R_4

Fig.1. Layout plan

T_1 - 12 weeks old *Jeevamrutham*@ 100% (Weekly spray)

T_2 - 20 weeks old *Jeevamrutham* @ 100% (Weekly spray)

T_3 - 24 weeks old *Panchagavyam* @ 3% (Weekly spray)

T_4 - 12 weeks old *Panchagavyam* @ 3% (Weekly spray)

T_5 - Water spray (Weekly spray)

T_6 - Commercial organic formulation (Microzyme @ 0.5%) (Weekly spray)

T_7 - POP Recommendations, KAU

Plate 6. Field view

3.2.6. Observations

Nine plants from three pits were selected from each treatment for taking various observations. The following parameters were recorded and the average was worked out for further analysis.

Soil characteristics

Soil characters such as pH, EC, organic carbon, available NPK and total microbial count (Bacteria, fungi & actinomycetes) were estimated before and after the experiment using appropriate methods given in Appendix II & IV. Soil samples collected separately from each experimental plot were air dried and processed before analysis.

Biometric observations

Height of plants

The length of vines in cm was recorded from the base to the tip of plant at 30 DAS and 60 DAS.

Number of leaves per plant

The number of leaves/plant was counted at 30 DAS and 60 DAS.

Days to first flowering

The number of days taken to first flowering was counted from the date of sowing to the opening of first female flower.

Days to first harvest

The number of days from sowing to the date of first harvest of the fruits was noted.

Number of harvests

The total number of harvests was recorded.

Plate 7. Different growth stages of crop

Germination

15 DAS

30 DAS

Flowering

Fruiting

50 DAS

Duration of the crop

The number of days taken from sowing to the last harvest of the crop was recorded.

Yield and yield attributes

Number of fruits per plant

The total number of fruits produced per plant at the time of each harvest was noted and the average was worked out.

Volume of fruits per plant

Volume of fruits (cm^3) from each observation plant was found by using water displacement method.

Weight of fruits per plant

The weight of fruits from all the treatments was recorded and the average was worked out.

Yield per hectare

Fruits harvested separately from each plot periodically were weighed and the total yield for each treatment was worked out.

Incidence of pests and diseases

The incidence of pests and diseases was observed visually and recorded.

B: C Ratio

The ratio of benefit to the cost was worked out as per the formula given below.

$$BCR = \frac{\text{Gross return}}{\text{Cost of cultivation}}$$

3.2.7. Statistical analysis

Data pertaining to different observations were tabulated and subjected to statistical analysis by applying the technique of analysis of variance using the WASP 2.0 package and the significance among the treatments was estimated by Duncan's Multiple Range Test (DMRT) at 5 per cent level of probability (Gomez and Gomez, 1984).

Statistically analysed data of the first experiment were further subjected to a method of decision making as proposed by Arunachalam and Bandyopadhyay (1984) to select the treatments for second experiment.

Results

4. RESULTS

The results pertaining to the study on "Shelf life of liquid organic formulations" are furnished below.

4.1. Experiment I

Influence of ageing on quality of liquid organic formulations

4.1.1. Colour

The colour of freshly prepared *Panchagavyam* was yellowish green and it became dark green from the second week onwards. As the storage period progressed, the preparation became darker in colour without much significant change.

Fresh preparation of *Jeevamrutham* was moderate green in colour. No colour change was noticed one (S_2) and two (S_3) weeks after preparation. The colour became darker afterwards till the end of storage period.

4.1.2. Odour

Panchagavyam and *Jeevamrutham* possess mild odour due to fermentation of ingredients. Fresh preparation of *Panchagavyam* possessed a fruity smell. The change in odour was noticed from the second week onwards and was constant up to 6^{th} week (S_5). Foul odour was observed from eighth week onwards and progressed up to the end of storage.

Jeevamrutham exhibited mild foul odour for fresh preparation itself and became strong from second week onwards. The odour of the preparation became stronger by 16^{th} week (S_9) and was constant till the end of the storage period.

4.1.3. Mould growth

There was no mould growth in fresh preparation of *Panchagavyam* whereas it was first observed one week after preparation and the growth

progressed up to 8th week (S_6). Mould growth was observed both on the surface and also on the sides of the storage vessel. From 10th week onwards (S_7), the decrease in mould growth was observed and was completely absent in S_{10} and S_{11} (20 and 24 WOP respectively).

There was no appearance of mould in *Jeevamrutham* during the entire storage period.

4.1.4. pH

The pH of *Panchagavyam* and *Jeevamrutham* during different storage periods is furnished in Table 1. Fresh preparation of *Panchagavyam* was found to be highly acidic with a pH value of 3.51. The data shows that there is an increasing trend in the pH due to storage. The highest pH (5.63) was noticed in the treatment S_9 (16 WOP), followed by S_8 (12 WOP) and S_{11} (24 WOP) which were on par.

Freshly prepared *Jeevamrutham* was acidic with a pH of 5.69. The significant increase in pH was evident due to storage and the preparation became highly alkaline while progressing to the end of storage period. A high pH of 9.77 was noticed in the treatment S_{10} (20 WOP) followed by S_{11} (8.16).

4.1.5. EC

The electrical conductivity of liquid organic formulations of different storage periods furnished in Table 2 showed a significant influence of ageing. The EC of freshly prepared *Panchagavyam* was 0.14 dS m^{-1}. The highest EC of 6.00 dS m^{-1} was recorded in the treatment S_{11} (24 WOP) of *Panchagavyam*.

An EC of 0.23 dS m^{-1} was noticed for fresh preparation of *Jeevamrutham*. A general trend of gradual increase in EC due to ageing was noticed and the value was 2.22 dS m^{-1} at the end of storage period.

4.1.6. Organic carbon

The organic carbon content of liquid organic formulations is given in Table 3. In *Panchagavyam*, there was no significant difference in organic carbon content due to different storage periods and the values ranged from 2.66 to 2.94%.

The highest organic carbon content of 0.76% was found in *Jeevamrutham* one week after preparation followed by the treatments S_1 (Fresh) and S_{10} (20 WOP) with 0.57 and 0.36% respectively. The lowest value of 0.15% was recorded in S_{11} (24 WOP). In general, the organic carbon content was decreased due to ageing.

Table 1. pH of liquid organic formulations during storage

Treatments	pH	
	Panchagavyam	***Jeevamrutham***
S_1 - Fresh	3.51^{de}	5.69^{g}
S_2 - 1 WOP	3.83^{d}	6.16^{f}
S_3 - 2 WOP	3.29^{e}	6.24^{f}
S_4 - 4 WOP	3.56^{de}	7.30^{e}
S_5 - 6 WOP	3.86^{d}	7.78^{d}
S_6 - 8 WOP	4.25^{c}	7.96^{bcd}
S_7 -10 WOP	4.58^{c}	7.22^{e}
S_8 - 12 WOP	5.15^{b}	7.80^{cd}
S_9 - 16 WOP	5.63^{a}	8.07^{bc}
S_{10} -20 WOP	4.46^{c}	9.77^{a}
S_{11} -24 WOP	5.13^{b}	8.16^{b}

WOP – Weeks Old Preparation

Table 2. EC of liquid organic formulations during storage

Treatments	EC (dS m^{-1})	
	Panchagavyam	*Jeevamrutham*
S_1 - Fresh	0.14^{g}	0.23^{e}
S_2 - 1 WOP	1.85^{f}	0.72^{d}
S_3 - 2 WOP	2.17^{f}	1.26^{c}
S_4 - 4 WOP	3.93^{de}	1.47^{b}
S_5 - 6 WOP	1.99^{f}	1.15^{c}
S_6 - 8 WOP	3.81^{de}	1.58^{b}
S_7 -10 WOP	4.44^{cd}	1.51^{b}
S_8 - 12 WOP	3.45^{e}	1.50^{b}
S_9 - 16 WOP	5.52^{ab}	2.05^{a}
S_{10} -20 WOP	4.88^{bc}	2.25^{a}
S_{11} -24 WOP	6.00^{a}	2.22^{a}

WOP – Weeks Old Preparation

Table 3. Organic carbon content of liquid organic formulations during storage

Treatments	Organic Carbon (%)	
	Panchagavyam	***Jeevamrutham***
S_1 - Fresh	2.73^{a}	0.57^{b}
S_2 – 1 WOP	2.78^{a}	0.76^{a}
S_3 – 2 WOP	2.81^{a}	0.28^{cd}
S_4 - 4 WOP	2.80^{a}	0.32^{cd}
S_5 - 6 WOP	2.94^{a}	0.09^{f}
S_6 - 8 WOP	2.66^{a}	0.23^{dc}
S_7 -10 WOP	2.65^{a}	0.30^{cd}
S_8 - 12 WOP	2.76^{a}	0.27^{cd}
S_9 - 16 WOP	2.73^{a}	0.31^{cd}
S_{10} -20 WOP	2.66^{a}	0.36^{c}
S_{11} -24 WOP	2.70^{a}	0.15^{ef}

WOP – Weeks Old Preparation

4.1.7. Nutrient content

4.1.7.1. Macro nutrients

The results presented in Table 4 show that the different storage periods had influenced the nitrogen content of *Panchagavyam*. Among the treatments, 20 WOP of *Panchagavyam* recorded the highest nitrogen content of 0.21% while S_9 (16 WOP) and S_4 (4 WOP) recorded the lowest value (0.11%). The nitrogen content of *Jeevamrutham* estimated at different storage periods revealed that there is no significant variation due to ageing. Nitrogen content of *Jeevamrutham* was in the range of 0.3 to 0.8%.

The phosphorus content of both *Panchagavyam* and *Jeevamrutham* estimated at different storage intervals (Table 5) showed significant difference due to ageing. A high P content of 0.25% was recorded in the treatments S_4 and S_5 of *Panchagavyam* which were on par. The lowest P content (0.05%) was noticed in S_7 (10 WOP) of *Panchagavyam*. In the case of *Jeevamrutham*, the treatments S_1 to S_5 were found to be on par. In general the P content decreased with increase in storage periods.

The potassium content of both liquid organic formulations also varied with different treatments (Table 6). In *Panchagavyam* it ranged from 0.14% to 0.22% whereas the values for *Jeevamrutham* were 0.05% to 0.11%. In general, K content was slightly increased with increase in storage time.

The calcium content in *Panchagavyam* was found to be significant. The treatment S_{11} (24WOP) recorded the highest value of 702.10 ppm while the lowest content was noticed in fresh preparation with 220.80 ppm (Table 7). In general, the calcium content of *Panchagavyam* was increased with the increase in storage intervals. Traces of calcium was detected in many treatments of *Jeevamrutham* except in S_1 (Fresh), S_3 (2 WOP) and S_{11} (24 WOP).

The data on magnesium content present in both the liquid organic formulations are furnished in Table 8. The results revealed that the Mg content in

Panchagavyam varied with different storage periods and 10 WOP recorded with a high content of 103.10 ppm. The lowest Mg content of 95.33 ppm was observed in S_4 (4 WOP) of *Panchagavyam*. There was no significant variation in the magnesium content of *Jeevamrutham* due to various treatments and the value was in the range of 50.33 to 62.83 ppm.

The sulphur content of both *Panchagavyam* and *Jeevamrutham* at different storage intervals (Table 9) revealed significant variation due to ageing. The S content of *Panchagavyam* was increased with increase in storage time compared to the fresh preparation. The highest S content in *Jeevamrutham* was recorded during 20th and 8th week (280.11 ppm) followed by fresh and 24 WOP while the lowest content (81.62 ppm) was recorded in S_3 (2 WOP).

4.1.7.2. Micronutrients

The data on iron content of both the liquid organic formulations presented in Table 10 revealed the significant variation due to treatments. In general, Fe content of *Panchagavyam* was increased by the end of storage period (101.23 ppm) compared to the fresh preparation (57.00 ppm). In the case of *Jeevamrutham*, 4 WOP recorded the highest Fe content (104.16 ppm) whereas S_2 recorded the lowest content (49.00 ppm).

Presence of zinc and manganese were detected in both liquid organic formulations. Zinc content of 5 ppm and manganese content of 3.30 ppm was recorded in 24 WOP and fresh preparation of *Panchagavyam* respectively whereas 7.50 ppm of zinc and 26.90 ppm of manganese were detected in four and six WOP of *Jeevamrutham* respectively (Table 11). Copper was not detected in any of the treatments.

Table 4. Nitrogen content of liquid organic formulations during storage

Treatments	Nitrogen (%)	
	Panchagavyam	*Jeevamrutham*
S_1 - Fresh	0.16^{bc}	0.06^{a}
S_2 – 1 WOP	0.14^{bcde}	0.08^{a}
S_3 – 2 WOP	0.14^{bcde}	0.06^{a}
S_4 - 4 WOP	0.11^{de}	0.05^{a}
S_5 - 6 WOP	0.10^{e}	0.04^{a}
S_6 - 8 WOP	0.12^{cde}	0.04^{a}
S_7 -10 WOP	0.15^{bcd}	0.04^{a}
S_8 - 12 WOP	0.17^{ab}	0.03^{a}
S_9 - 16 WOP	0.11^{de}	0.04^{a}
S_{10} -20 WOP	0.21^{a}	0.04^{a}
S_{11} -24 WOP	0.14^{bcde}	0.05^{a}

WOP – Weeks Old Preparation

Table 5. Phosphorus content of liquid organic formulations during storage

Treatments	Phosphorus (%)	
	Panchagavyam	*Jeevamrutham*
S_1 - Fresh	0.23^{ab}	0.23^{a}
S_2 - 1 WOP	0.23^{ab}	0.22^{a}
S_3 - 2 WOP	0.19^{b}	0.21^{a}
S_4 - 4 WOP	0.25^{a}	0.26^{a}
S_5 - 6 WOP	0.25^{a}	0.25^{a}
S_6 - 8 WOP	0.11^{cd}	0.09^{b}
S_7 -10 WOP	0.05^{e}	0.03^{c}
S_8 - 12 WOP	0.07^{de}	0.03^{c}
S_9 - 16 WOP	0.12^{c}	0.04^{c}
S_{10} -20 WOP	0.07^{de}	0.04^{c}
S_{11} -24 WOP	0.08^{cde}	0.05^{bc}

WOP – Weeks Old Preparation

Table 6. Potassium content of liquid organic formulations during storage

Treatments	Potassium (%)	
	Panchagavyam	*Jeevamrutham*
S_1 - Fresh	0.16^{cd}	0.06^{fg}
S_2 - 1 WOP	0.16^{cd}	0.05^{g}
S_3 - 2 WOP	0.16^{cd}	0.06^{efg}
S_4 - 4 WOP	0.14^{d}	0.06^{efg}
S_5 - 6 WOP	0.18^{bc}	0.07^{def}
S_6 - 8 WOP	0.18^{bc}	0.08^{cd}
S_7 -10 WOP	0.22^{a}	0.08^{cde}
S_8 - 12 WOP	0.21^{ab}	0.09^{bc}
S_9 - 16 WOP	0.21^{ab}	0.11^{ab}
S_{10} -20 WOP	0.21^{ab}	0.10^{ab}
S_{11} -24 WOP	0.21^{ab}	0.11^{a}

WOP – Weeks Old Preparation

Table 7. Calcium content of liquid organic formulations during storage

Treatments	Calcium (ppm)	
	Panchagavyam	***Jeevamrutham****
S_1 - Fresh	220.80^{d}	66.4
S_2 - 1 WOP	239.46^{d}	Traces
S_3 - 2 WOP	286.66^{d}	24.1
S_4 - 4 WOP	237.23^{d}	Traces
S_5 - 6 WOP	341.03^{cd}	Traces
S_6 - 8 WOP	306.96^{d}	Traces
S_7 -10 WOP	420.86^{bcd}	Traces
S_8 - 12 WOP	598.96^{ab}	Traces
S_9 - 16 WOP	534.26^{abc}	Traces
S_{10} -20 WOP	587.50^{ab}	Traces
S_{11} -24 WOP	702.10^{a}	35.56

*Not analyzed statistically

WOP – Weeks Old Preparation

Table 8. Magnesium content of liquid organic formulations during storage

Treatments	Magnesium (%)	
	Panchagavyam	***Jeevamrutham***
S_1 - Fresh	99.86^{abcd}	58.76^{a}
S_2 - 1 WOP	98.40^{cde}	50.33^{a}
S_3 – 2 WOP	98.50^{bcde}	58.80^{a}
S_4 - 4 WOP	95.33^{e}	55.60^{a}
S_5 - 6 WOP	99.56^{abcd}	56.06^{a}
S_6 - 8 WOP	101.20^{abcd}	59.60^{a}
S_7 -10 WOP	103.10^{a}	59.46^{a}
S_8 - 12 WOP	100.93^{abcd}	60.86^{a}
S_9 - 16 WOP	102.00^{abc}	57.03^{a}
S_{10} -20 WOP	97.66^{de}	62.36^{a}
S_{11} -24 WOP	102.23^{ab}	62.83^{a}

WOP – Weeks Old Preparation

Table 9. Sulphur content of liquid organic formulations during storage

Treatments	Sulphur (ppm)	
	Panchagavyam	***Jeevamrutham***
S_1 - Fresh	166.95^{d}	226.31^{ab}
S_2 -1 WOP	879.30^{abc}	96.46^{de}
S_3 - 2 WOP	599.18^{bcd}	81.62^{e}
S_4 - 4 WOP	536.11^{cd}	100.17^{cde}
S_5 - 6 WOP	999.88^{ab}	135.53^{bcde}
S_6 - 8 WOP	884.86^{abc}	280.11^{a}
S_7 -10 WOP	1079.64^{a}	207.76^{abc}
S_8 - 12 WOP	1049.96^{ab}	198.49^{abcd}
S_9 - 16 WOP	892.28^{abc}	183.64^{abcde}
S_{10} -20 WOP	1051.82^{ab}	280.11^{a}
S_{11} -24 WOP	979.47^{abc}	222.60^{ab}

WOP – Weeks Old Preparation

Table 10. Iron content of liquid organic formulations during storage

Treatments	Iron (ppm)	
	Panchagavyam	***Jeevamrutham***
S_1 - Fresh	57.00^{e}	53.56^{ef}
S_2 -1 WOP	75.80^{cde}	49.00^{f}
S_3 - 2 WOP	83.86^{bcde}	55.73^{def}
S_4 - 4 WOP	165.83^{a}	104.16^{a}
S_5 - 6 WOP	85.20^{bcde}	66.00^{cdef}
S_6 - 8 WOP	118.43^{b}	74.90^{bcde}
S_7 -10 WOP	106.66^{bc}	80.36^{bc}
S_8 - 12 WOP	109.13^{bc}	77.76^{bcd}
S_9 - 16 WOP	109.50^{bc}	68.50^{cdef}
S_{10} -20 WOP	67.63^{de}	92.43^{ab}
S_{11} -24 WOP	101.23^{bcd}	71.16^{bcdef}

WOP – Weeks Old Preparation

Table 11. Zinc and Manganese content of liquid organic formulations during storage*

Treatments	Zn (ppm)	Mn (ppm)	Zn (ppm)	Mn (ppm)
	Panchagavyam		*Jeevamrutham*	
S_1 - Fresh	3.30	3.30	5.20	9.80
S_2 -1 WOP	Traces	1.26	Traces	6.43
S_3 - 2 WOP	2.40	Traces	2.90	4.93
S_4 - 4 WOP	Traces	Traces	7.50	4.35
S_5 - 6 WOP	Traces	Traces	Traces	26.90
S_6 - 8 WOP	Traces	0.20	2.90	Traces
S_7 -10 WOP	Traces	Traces	0.40	Traces
S_8 - 12 WOP	2.65	Traces	Traces	Traces
S_9 - 16 WOP	Traces	Traces	Traces	Traces
S_{10} -20 WOP	Traces	Traces	Traces	Traces
S_{11} -24 WOP	5.00	Traces	Traces	1.70

*Not analyzed statistically

WOP – Weeks Old Preparation

4.1.8. Microbial population

The data regarding the total microbial population in *Panchagavyam* and *Jeevamrutham* showed that there was significant variation among the treatments during different storage periods. There was a pronounced increase in microbial population during ageing.

The highest population of 66.00 x 10^4 cfu ml^{-1} of fungi was observed in S_{10} followed by 28.33 x 10^4 cfu ml^{-1} in S_{11} for *Panchagavyam* (Table 12). The lowest population was observed in S_1, S_2 and S_3 of *Panchagavyam* which were on par. The 24 WOP of *Jeevamrutham* recorded the highest fungal population of 44.00 x 10^4 cfu ml^{-1} followed by 10 WOP (23.66 x 10^4 cfu ml^{-1}).

The treatment, 12 WOP of *Panchagavyam* recorded the highest count of bacteria (385.00 x 10^6 cfu ml^{-1}) followed by fresh preparation (300.00 x 10^6 cfu ml^{-1}) and 20 WOP (288.00 x 10^4 cfu ml^{-1}). The lowest population was noticed in S_2 which was on par with S_3 and S_4 of *Panchagavyam*. The highest population of bacteria was noticed in 16 WOP (665.00 x 10^6 cfu ml^{-1}) followed by 20 WOP (576.66 x 10^6 cfu ml^{-1}) of *Jeevamrutham* which were on par (Table 13). The lowest population was observed in S_7 which was on par with S_2 and S_3 of *Jeevamrutham*.

The results in Table 14 showed that the highest population (250.33 x 10^5 cfu ml^{-1}) of actinomycetes was recorded in 12 WOP of *Panchagavyam*. The treatment, 12 WOP of *Jeevamrutham* had the highest population of actinomycetes (288.00 x 10^5 cfu ml^{-1}). There were no actinomycetes observed in fresh preparation of both the liquid organic formulations.

All the treatments of *Panchagavyam* were free of *Escherichia coli* whereas in some of the treatments of *Jeevamrutham*, *E. coli* was detected. The presence of *E. coli* in *Jeevamrutham* was to the tune of 10^7 cfu ml^{-1} (Fresh preparation), 100 cfu ml^{-1} (12 WOP) and 40 cfu ml^{-1} (16 WOP). However, total coliforms were present in *Panchagavyam* and *Jeevamrutham* during the entire period of storage.

Table 12. Population of total fungi in liquid organic formulations

Treatments	Fungi ($x10^4$ cfu ml^{-1})	
	Panchagavyam	*Jeevamrutham*
S_1 - Fresh	1.33^{g} (4.10)*	1.33^{e} (4.10)
S_2 - 1 WOP	1.33^{g} (4.10)	1.33^{e} (4.10)
S_3 - 2 WOP	1.66^{g} (4.20)	3.00^{e} (4.47)
S_4 - 4 WOP	10.00^{f} (4.99)	7.66^{de} (4.83)
S_5 - 6 WOP	18.00^{cde} (5.25)	17.33^{bc} (5.23)
S_6 - 8 WOP	12.33^{ef} (5.08)	9.66^{cde} (4.97)
S_7 -10 WOP	13.66^{def} (5.12)	23.66^{b} (5.36)
S_8 - 12 WOP	22.33^{c} (5.34)	15.66^{bcd} (5.15)
S_9 - 16 WOP	19.00^{cd} (5.27)	2.667^{e} (4.40)
S_{10} -20 WOP	66.00^{a} (5.81)	1.33^{e} (4.10)
S_{11} -24 WOP	28.33^{b} (5.45)	44.00^{a} (5.62)

*Log transformed value is given in paranthesis

WOP – Weeks Old Preparation

Table 13. Population of total bacteria in liquid organic formulations

Treatments	Bacteria ($x10^6$ cfu ml^{-1})	
	Panchagavyam	*Jeevamrutham*
S_1 - Fresh	300.00[ab] (8.47)*	243.33[bcd] (8.38)
S_2 - 1 WOP	8.76[e] (6.94)	85.66[e] (7.91)
S_3 - 2 WOP	10.33[e] (6.85)	70.66[e] (7.82)
S_4 - 4 WOP	23.66[e] (7.36)	154.66[cde] (8.16)
S_5 - 6 WOP	145.00[cd] (8.04)	266.66[bc] (8.42)
S_6 - 8 WOP	242.66[b] (8.35)	218.00[cd] (8.28)
S_7 -10 WOP	125.33[d] (8.09)	55.33[e] (7.73)
S_8 - 12 WOP	385.00[a] (8.57)	360.00[b] (8.55)
S_9 - 16 WOP	231.66[bc] (8.36)	665.00[a] (8.81)
S_{10} -20 WOP	288.00[ab] (8.45)	576.66[a] (8.75)
S_{11} -24 WOP	272.00[b] (8.43)	123.33[de] (8.07)

*Log transformed value is given in paranthesis

WOP – Weeks Old Preparation

Table 14. Population of total actinomycetes in liquid organic formulations

Treatments	Actinomycetes ($x10^5$cfu ml^{-1})	
	Panchagavyam	*Jeevamrutham*
S_1 - Fresh	0.00 [f] (0.00)*	0.00 [e] (0.00)
S_2 - 1 WOP	106.00 [bc] (7.02)	102.00 [c] (6.98)
S_3 - 2 WOP	63.00 [cd] (6.76)	105.33 [c] (7.01)
S_4 - 4 WOP	45.33 [de] (6.64)	110.67 [c] (7.04)
S_5 - 6 WOP	36.33 [def] (6.45)	72.66 [cd] (6.86)
S_6 - 8 WOP	18.33 [ef] (6.26)	84.66 [cd] (6.91)
S_7 -10 WOP	140.00 [b] (7.12)	78.00 [cd] (6.89)
S_8 - 12 WOP	250.33 [a] (7.39)	288.00 [a] (7.45)
S_9 - 16 WOP	76.66 [cd] (6.88)	186.66 [b] (7.22)
S_{10} -20 WOP	51.33 [de] (6.68)	92.66 [c] (6.96)
S_{11} -24 WOP	37.33 [def] (6.54)	32.66 [de] (6.49)

*Log transformed value is given in paranthesis

WOP – Weeks Old Preparation

4.1.9. Maggot population

No maggots were observed in *Panchagavyam* up to ten weeks of storage. However, maggots were observed in 12 WOP and were innumerable at the end of storage period. It was observed that hatched small and big flies were present in the storage vessel after 20 weeks of storage. No maggots were observed in *Jeevamrutham* during the entire period of storage.

Statistically analysed data of all parameters were further subjected to a method of decision making for a number of dependent parameters as proposed by Arunachalam and Bandyopadhyay (1984). Scoring was done separately for both *Panchagavyam* and *Jeevamrutham* and the treatments receiving lowest score were selected. The ranking order is given in Table 15. Based on the scoring, S_{11} (24 WOP) and S_8 (12 WOP) of *Panchagavyam* and S_8 (12 WOP) and S_{10} (20 WOP) of *Jeevamrutham* were selected as the best treatments for second experiment.

Table 15. Rank of treatments after scoring

Treatments	*Panchagavyam*	*Jeevamrutham*
S_1 - Fresh	10	11
S_2 - 1 WOP	8	10
S_3 - 2 WOP	11	9
S_4 - 4 WOP	9	6
S_5 - 6 WOP	7	8
S_6 - 8 WOP	6	4
S_7 -10 WOP	5	7
S_8 - 12 WOP	**2**	**1**
S_9 - 16 WOP	3	5
S_{10} -20 WOP	4	**2**
S_{11} -24 WOP	**1**	3

WOP – Weeks Old Preparation

4.2. Experiment II

Influence of shelf life of *Jeevamrutham* and *Panchagavyam* on growth and yield of cucumber

Based on the results of experiment I (Influence of ageing on quality of liquid organic formulations), four treatments were selected for conducting the second experiment. The treatments include S_8 (12 WOP) and S_{10} (20 WOP) of *Jeevamrutham* and S_{11} (24 WOP) and S_8 (12 WOP) of *Panchagavyam* as T_1, T_2, T_3, and T_4 respectively.

4.2.1. Soil Analysis

4.2.1.1. pH

Soil was analysed before and after the experiment (Table 16). The initial pH of the soil was 5.11. The pH of the soil after cropping significantly varied among the different treatments. The highest pH of 5.87 was recorded in the treatment receiving commercial organic formulation *viz.* Microzyme (T_6) followed by T_5 (water spray) with a value of 5.60. The lowest pH was recorded by T_1 receiving 12 weeks old *Jeevamrutham* (5.17).

4.2.1.2. EC

The initial EC of the soil from the experimental site was 0.11 dS m^{-1}. The different treatments significantly influenced the EC of soil after the experiment (Table 16). The treatment (T_5) receiving *ad hoc* organic POP with water spray recorded the highest EC of 0.64 dS m^{-1} followed by T_3 (24 weeks old *Panchagavyam*). The lowest value of 0.36 dS m^{-1} was recorded by T_7 (POPR) which was on par with T_4 (12 weeks old *Panchagavyam*).

4.2.1.3. Organic Carbon

The organic carbon content of soil after the field experiment was significantly influenced by different treatments (Table 16). The initial organic carbon content of the soil was 1.11%. The highest value (1.69%) was recorded by

the treatment (T_1) receiving 12 weeks old *Jeevamrutham* spray followed by T_3 (24 weeks old *Panchagavyam*), T_2 (20 weeks old *Jeevamrutham*) and T_4 (12 weeks old *Panchagavyam*) which were on par. The lowest value was recorded by T_7 (1.08%).

4.2.1.4. Available Nitrogen

The initial value of available nitrogen content in the soil was 184.80 kg ha^{-1}. The data furnished in Table 17 shows that the treatments significantly influenced the available nitrogen content in soil after the experiment. The treatment T_2 (20 weeks old *Jeevamrutham*) recorded the highest nitrogen content of 245.70 kg ha^{-1} followed by T_3 (24 weeks old *Panchagavyam*) and the lowest with a value of 201.60 kg ha^{-1} was recorded by T_7 (POPR).

4.2.1.5. Available Phosphorus

The available phosphorus content of the soil analysed before and after the experiment revealed the significant difference among the treatments (Table 17). The highest content of available phosphorus was recorded in T_4 (12 weeks old *Panchagavyam*) with a value of 25 kg ha^{-1} followed by 22.81 kg ha^{-1} in T_2 (20 weeks old *Jeevamrutham*).The lowest content was observed in T_7 (POPR) being 17.90 kg ha^{-1}. The initial value was 15.43 kg ha^{-1}.

4.2.1.6. Available Potassium

The data given in Table 17 clearly shows the significant variation in available potassium content after cropping due to different treatments. T_2 (20 weeks old *Jeevamrutham*) recorded the highest K content of343.02 kg ha^{-1} followed by T_3 (24 weeks old *Panchagavyam*) with 339.77 kg ha^{-1}. The lowest value was observed in T_7 (POPR) and T_6 (Microzyme) with 254.58 and 267.81 kg ha^{-1} respectively which were on par. The initial value was 234.13 kg ha^{-1}.

4.2.1.7. Total microbial count

The total microbial population in soil before and after the experiment is given in Table 18. The treatments varied significantly. The initial population of fungi, bacteria and actinomycetes were 1.66 x 10^4, 30 x 10^6 and 6 x 10^5 cfu g^{-1} of soil respectively.

The treatment (T_2)receiving 20 week old *Jeevamrutham* spray recorded the highest population of fungi (6.25 x 10^4 cfu g^{-1} of soil) followed by all other treatments which were on par. The highest population of bacteria (110.83x 10^6 cfu g^{-1}) was observed in T_2 (20 weeks old *Jeevamrutham*) followed by T_1 (12 weeks old *Jeevamrutham*), T_3 (24 weeks old *Panchagavyam*), T_4 (12 weeks old *Panchagavyam*) with values of 99.83, 98.75 and 89.50 x 10^6 cfu g^{-1} of soil respectively, whereas the lowest colony forming units of 34 x 10^6 cfu g^{-1} were recorded by T_7 (POPR).

The highest population of actinomycetes (26.83 x 10^5 cfu g^{-1}) was noticed in T_2 (20 weeks old *Jeevamrutham*) followed by the treatment receiving 12 weeks old *Jeevamrutham* spray (18x 10^5 cfu g^{-1}) and 24 weeks old *Panchagavyam* spray (16.41 x 10^5 cfu g^{-1}), which were on par. The lowest population was recorded by the treatments T_7 (POPR) and T_5 (Water spray) with values of 7.33 and 8.58 x 10^5 cfu g^{-1} respectively, which were on par.

Table 16. pH, EC and organic carbon of soil as influenced by treatments

Treatments	pH	EC (dS m^{-1})	Organic Carbon (%)
T_1 - 12 weeks old *Jeevamrutham* (100%)	5.18^{e}	0.39^{cd}	1.69^{a}
T_2 - 20 weeks old *Jeevamrutham* (100%)	5.39^{cd}	0.46^{bcd}	1.41^{b}
T_3- 24 weeks old *Panchagavyam* (3%)	5.33^{d}	0.56^{ab}	1.44^{b}
T_4- 12 weeks old *Panchagavyam* (3%)	5.42^{cd}	0.35^{d}	1.38^{b}
T_5 - Water spray	5.60^{b}	0.64^{a}	1.56^{ab}
T_6 - Commercial organic formulation (Microzyme @ 0.5%)	5.87^{a}	0.49^{bc}	1.51^{ab}
T_7 - POPR, KAU	5.50^{bc}	0.36^{d}	1.08^{c}
Initial value	**5.11**	**0.109**	**1.11**

Table 17. Available nutrient content of soil as influenced by treatments

Treatments	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})
T_1 - 12 weeks old *Jeevamrutham* (100%)	217.35^{cd}	22.00^{b}	284.89^{bcd}
T_2 - 20 weeks old *Jeevamrutham* (100%)	245.70^{a}	22.81^{ab}	343.02^{a}
T_3 - 24 weeks old *Panchagavyam* (3%)	239.40^{ab}	21.77^{b}	339.77^{ab}
T_4 - 12 weeks old *Panchagavyam* (3%)	223.65^{bc}	25.00^{a}	326.67^{abc}
T_5 - Water spray	217.35^{cd}	18.80^{cd}	281.76^{cd}
T_6 - Commercial organic formulation (Microzyme @ 0.5%)	218.40^{cd}	20.96^{bc}	267.81^{d}
T_7 - POPR, KAU	201.60^{d}	17.90^{d}	254.58^{d}
Initial value	**184.80**	**15.43**	**234.13**

Table 18. Total microbial population in soil as influenced by treatments*

Treatments	Fungi ($x 10^4$ cfu g^{-1})	Bacteria ($x 10^6$ cfu g^{-1})	Actinomycetes ($x 10^5$ cfu g^{-1})
T_1- 12 weeks old *Jeevamrutham* (100%)	4.16^{b} (4.60)	99.83^{ab} (7.99)	18.00^{b} (6.23)
T_2 - 20 weeks old *Jeevamrutham* (100%)	6.25^{a} (4.79)	110.83^{a} (8.04)	26.83^{a} (6.42)
T_3 - 24 weeks old *Panchagavyam* (3%)	4.58^{b} (4.66)	98.75^{b} (7.99)	16.41^{b} (6.21)
T_4 - 12 weeks old *Panchagavyam* (3%)	3.33^{b} (4.51)	89.50^{b} (7.94)	14.50^{bc} (6.15)
T_5 - Water spray	3.25^{b} (4.50)	43.66^{cd} (7.63)	8.58^{d} (5.93)
T_6 - Commercial organic formulation (Microzyme @ 0.5%)	3.33^{b} (4.51)	53.33^{c} (7.72)	9.58^{cd} (5.98)
T_7 - POPR, KAU	3.00^{b} (4.41)	34.00^{d} (7.51)	7.33^{d} (5.84)
Initial value	**1.66**	**30**	6

*Log transformed value is given in parenthesis

4.2.2. Biometric observations

4.2.2.1. Length of vine

Length of cucumber vine recorded at 30 and 60 DAS presented in Table 19 revealed the significant influence on vine length by different treatments at 30 DAS. The highest vine length was observed in T_2 (20 weeks old *Jeevamrutham*) and T_5 (Water spray) at 30 DAS which were on par (48.95 cm) whereas the lowest vine length of 41.65 cm was recorded in T_7 (POPR). However, there was no significant influence of treatments on length of vine at 60 DAS and slightly highest vine length of 121.91 cm was observed in T_1.

4.2.2.2. Number of leaves per plant

Treatments showed significant influence on number of leaves of cucumber at 30 and 60 DAS (Table 19). At 30 DAS, the highest number of leaves (23.7) were recorded by T_5 (Water spray) followed by T_6 (Microzyme) and T_2 (20 weeks old *Jeevamrutham*) which were on par with values of 20.61 and 20.55 respectively. At 60 DAS, the highest number of leaves was produced by the treatment receiving POPR (83.18) followed by treatment receiving Microzyme spray (80.58).

4.2.2.3. Days to first flowering

There was no significant variation in the days taken for first female cucumber flower opening due to different treatments (Table 20) though the POPR treated plants took two more days to flower.

4.2.2.4. Days to first harvest

Days taken for first harvest of tender fruits of cucumber are furnished in Table 20. The different treatments did not influence the days taken to first harvest.

4.2.2.5. Number of harvests

There was no significant difference in the number of harvests among the various treatments (Table 20). Harvesting could be done 9 times in T_6 and T_1 whereas in all other treatments the number of harvests was only 8.

4.2.2.6. Duration of the crop

The data regarding the duration of crop given in Table 20 showed that there was no significant influence among treatments. The crop was maintained in the field up to 67- 68 DAS.

4.2.3. Yield and yield attributes

4.2.3.1. Number of fruits per plant

The number of fruits per plant obtained from plots of different treatments showed significant influence among the treatments (Table 21). The highest number of fruits was obtained from the treatment receiving 20 weeks old *Jeevamrutham* (11.08) followed by 12 weeks old *Jeevamrutham* (10.04). The lowest number of fruits was obtained in T_7 (POPR) which was on par with T_5 (Water spray).

4.2.3.2. Volume of fruits per plant

The data on volume of fruits per plant given in Table 21 revealed the significant influence of different treatments. T_2 (20 weeks old *Jeevamrutham*) registered the highest volume of fruits (3320.68 cm^3) followed by 12 weeks old *Jeevamrutham* (3040.61 cm^3). The lowest volume of 2571.60 cm^3 was recorded by the treatment receiving water spray.

4.2.3.3. Weight of fruits per plant

Per plant fruit yield of cucumber was significantly influenced by the treatments (Table 21). T_2 (20 weeks old *Jeevamrutham*) recorded the highest weight of fruits (3.32 kg $plant^{-1}$) followed by T_1 (12 weeks old *Jeevamrutham*)

with 3.01 kg plant^{-1}. The lowest fruit weight of 2.48 and 2.50kg plant^{-1} respectively was noticed in T_7 (POPR) and T_5 (Water spray), which was on par.

4.2.3.4. Yield per hectare

Table 21 revealed the influence of treatments on the yield of cucumber per hectare. The highest yield of 28.92 Mg ha^{-1} was obtained in T_2 receiving 20 weeks old *Jeevamrutham* spray followed by 26.19 Mg ha^{-1} in T_1 (12 weeks old *Jeevamrutham*) whereas the lowest yield was recorded in T_7 and T_5.

Table 19. Length of vine and number of leaves of cucumber as influenced by treatments

Treatments	Length of vine (cm)		Number of leaves per plant	
	30 DAS	60 DAS	30 DAS	60 DAS
T_1- 12 weeks old *Jeevamrutham* (100%)	47.33^{ab}	121.9^{a}	19.97^{b}	76.83^{abc}
T_2 - 20 weeks old *Jeevamrutham* (100%)	48.95^{a}	113.28^{a}	20.55^{ab}	77.37^{abc}
T_3 - 24 weeks old *Panchagavyam* (3%)	43.82^{bc}	108.81^{a}	17.40^{bc}	70.60^{c}
T_4 - 12 weeks old *Panchagavyam* (3%)	46.11^{abc}	112.83^{a}	18.14^{bc}	70.63^{c}
T_5 - Water spray	48.59^{a}	112.49^{a}	23.70^{a}	74.49^{bc}
T_6 - Commercial organic formulation (Microzyme @ 0.5%)	46.13^{abc}	110.73^{a}	20.61^{ab}	80.58^{ab}
T_7 - POPR, KAU	41.65^{c}	111.07^{a}	16.03^{c}	83.18^{a}

Table 20. Days taken for first flowering, harvest, number of harvests and duration of the crop as influenced by treatments

Treatments	Days to first flowering	Days to first harvest	Number of harvests	Duration of the crop
T_1- 12 weeks old *Jeevamrutham* (100%)	31.25[a]	40.50[a]	9.00[a]	68.00[a]
T_2 - 20 weeks old *Jeevamrutham* (100%)	31.50[a]	40.75[a]	8.25[a]	67.25[a]
T_3 - 24 weeks old *Panchagavyam* (3%)	31.50[a]	40.75[a]	8.25[a]	67.25[a]
T_4 - 12 week old *Panchagavyam* (3%)	32.00[a]	41.00[a]	8.25[a]	67.00[a]
T_5 - Water spray	31.50[a]	40.25[a]	8.25[a]	66.50[a]
T_6 - Commercial organic formulation (Microzyme @ 0.5%)	31.50[a]	40.50[a]	9.00[a]	68.00[a]
T_7 - POPR, KAU	33.50[a]	42.25[a]	8.00[a]	67.50[a]

Table 21. Yield and yield attributes of cucumber as influenced by treatments

Treatments	Number of fruits plant^{-1}	Volume of fruits plant^{-1} (cm^3)	Weight of fruits plant^{-1} (kg)	Yield (Mg ha^{-1})
T_1- 12 weeks old *Jeevamrutham* (100%)	10.04^{ab}	3040.61^{ab}	3.01^{ab}	26.19^{ab}
T_2- 20 weeks old *Jeevamrutham* (100%)	11.08^{a}	3320.68^{a}	3.32^{a}	28.92^{a}
T_3 - 24 weeks old *Panchagavyam* (3%)	9.00^{bc}	2759.40^{bc}	2.70^{bc}	23.49^{bc}
T_4 - 12 weeks old *Panchagavyam* (3%)	9.32^{bc}	2945.59^{abc}	2.80^{bc}	24.33^{bc}
T_5 - Water spray	8.35^{c}	2571.60^{c}	2.50^{c}	21.78^{c}
T_6 - Commercial organic formulation (Microzyme @ 0.5%)	8.78^{bc}	2888.48^{abc}	2.64^{bc}	22.92^{bc}
T_7 - POPR, KAU	8.27^{c}	2643.16^{bc}	2.48^{c}	21.58^{c}

4.2.4. Incidence of pests and diseases

Severe attack of pests and diseases was not observed during the period of crop growth. However, all plots were uniformly attacked by *Diaphania indica*. Very low population of pumpkin beetle, fruit fly and leaf minor were also observed in the field. Neem soap and Beauveria @ 1% was sprayed for the control of the pests and PGPR mix II (2%) was sprayed as a preventive measure for diseases.

4.2.5. B: C Ratio

The data on economic analysis given in Table 22 revealed that all the treatments were economically viable. The different treatments contributed significant variation in benefit to cost ratio. Among the treatments, T_2 (20 weeks old *Jeevamrutham*) was found to be superior with respect to gross return, net return and with a B: C ratio of 3.05 followed by T_7 (POPR).The lowest net income (Rs. 3, 79, 203 ha^{-1}) and B: C ratio (2.38) was registered in T_5.

Table 22. Total cost of cultivation, gross returns, net returns and B: C ratio as influenced by treatments

Treatments	Total cost of cultivation (Rs.)	Gross returns (Rs.)	Net returns (Rs.)	B: C ratio
T_1- 12 weeks old *Jeevamrutham* (100%)	284246.97	785730	501483.02	2.76
T_2 - 20 weeks old *Jeevamrutham* (100%)	284246.97	867570	583323.02	3.05
T_3 - 24 weeks old *Panchagavyam* (3%)	282322.97	704700	422377.02	2.49
T_4 - 12 weeks old *Panchagavyam* (3%)	282322.97	729750	447427.02	2.58
T_5 - Water spray	274196.97	653400	379203.02	2.38
T_6 - Commercial organic formulation (Microzyme @ 0.5%)	284007.00	687660	403653.00	2.42
T_7 - POPR, KAU	226306.40	647640	421333.70	2.86

Discussion

5. DISCUSSION

An investigation entitled "Shelf life of liquid organic formulations" was conducted during 2015-2016 at the College of Horticulture, Vellanikkara, Thrissur. The results pertaining to the study are discussed below.

5.1. Experiment I

Influence of ageing on quality of liquid organic formulations

5.1.1. Influence of ageing on physico-chemical properties of liquid organic formulations

The colour of the fresh preparation of *Panchagavyam* was yellowish green and that of *Jeevamrutham* was moderate green. As the storage period progressed, both the preparations became darker in colour. The liquid organic formulations undergo fermentation. Hence the fresh preparation of these formulations itself possessed a mild odour due to the fermentation of ingredients. The strong foul odour was noticed in the case of both the formulations upon storage. Microbial and biochemical changes happening in these formulations during storage are the reasons of changes in colour and odour. Production of volatile fatty acids, volatile amines, methane *etc.* during fermentation of carbohydrate, proteins and lipids (Harison and McAllan, 1980) present in ingredients of liquid organic formulation might have induced the change in odour during storage.

The fresh preparation of *Panchagavyam* was free from surface mould growth whereas it was noticed after one week upto 8^{th} week. No mould growth was observed in *Jeevamrutham* during the entire storage period. Higher quantity of undecomposed solid portion in *Panchagavyam* compared to *Jeevamrutham* might be the reason.

No maggots were observed initially in *Panchagavyam* whereas it was appeared in later periods of storage from 12 weeks onwards. The presence of maggots was not observed in *Jeevamrutham* during the entire period of storage.

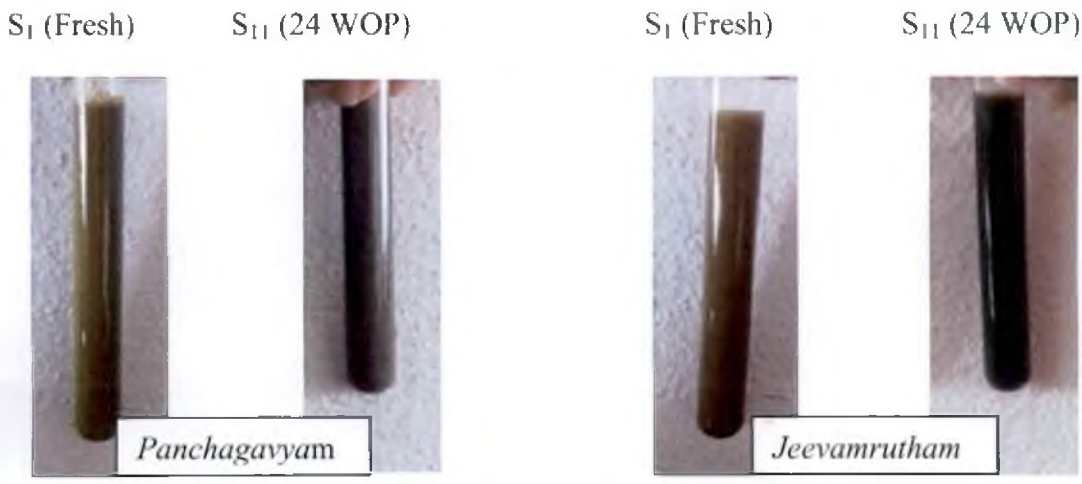


Plate 8. Change in colour of liquid organic formulations during storage

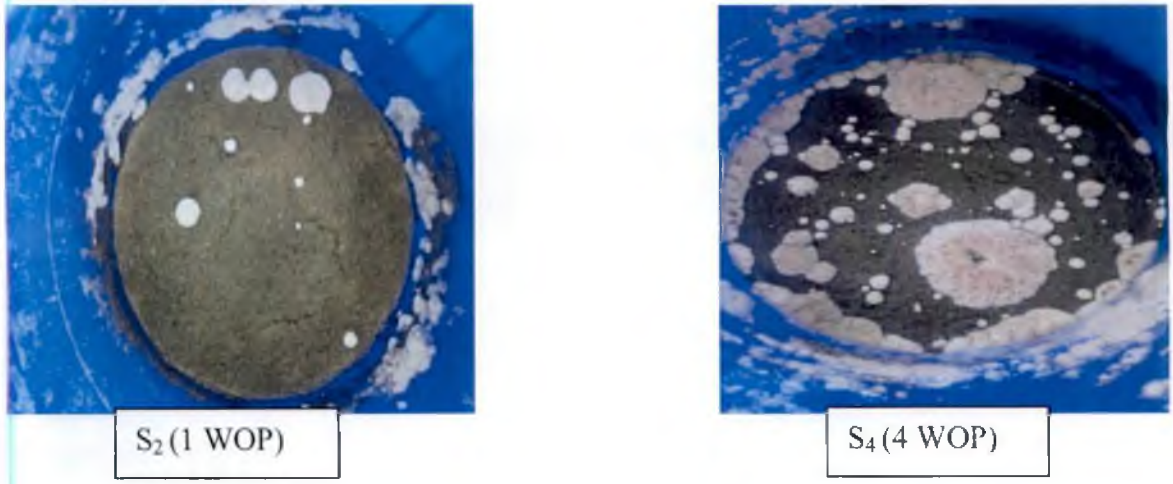
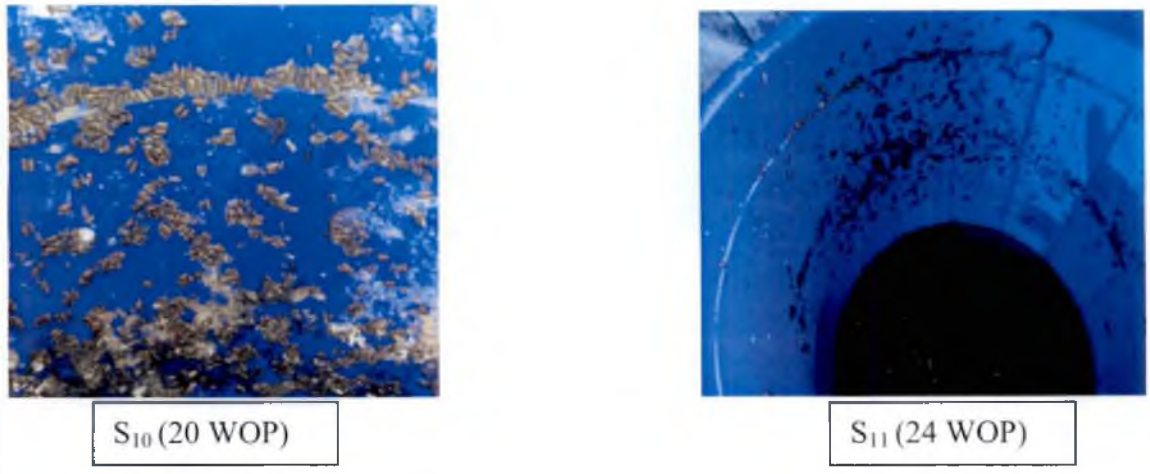


Plate 9. Presence of mould growth and maggots in *Panchagavyam*



The pH of both liquid organic formulations was significantly influenced by ageing which is evident from Fig 2. The fresh preparation of *Panchagavyam* was highly acidic with a pH of 3.51 and the data showed an increasing trend in pH during the storage period. *Lactobacillus* and yeast present in milk products initiated the fermentation of *Panchagavyam* and produced organic acids which might have contributed the low pH (Pathak and Ram, 2013). The freshly prepared *Jeevamrutham* was acidic in nature with a pH of 5.63. Devakumar *et al.* (2014) observed an acidic pH of 4.92 in fresh preparation of *Jeevamrutham.* The preparation became highly alkaline while progressing to the end of storage period. The highest pH of 9.77 was noticed in S_{10} (20 WOP). Fermentation of lactic acid in *Panchagavyam* and alcohol production in *Jeevamrutham* (production of methanol, propanol, butanol and ethanol as the fermentation by-products) contributed towards the increase in pH of liquid organic formulations during storage (Natarajan, 2008).

The EC of the *Panchagavyam* and *Jeevamrutham* was significantly increased due to ageing (Fig. 3). The fresh preparation of *Panchagavyam* and *Jeevamrutham* recorded the least value of 0.14 and 0.23 dS m^{-1} respectively. The highest EC of 6.00 and 2.25 dS m^{-1} was observed in S_{11} (24 WOP) of *Panchagavyam* and S_{10} (20 WOP) of *Jeevamrutham* respectively. A high EC of 8.2 dS m^{-1} in *Panchagavyam* during storage was reported by Natarajan (2008) and the increase in EC of liquid organic formulations during storage might be due to the increase in soluble salts in these formulations. The organic carbon content of *Panchagavyam* was stable during different storage periods and the value was in the range of 2.66 to 2.94%. In general, the organic carbon content of *Jeevamrutham* decreased due to ageing. Utilization of carbon in liquid organic formulations by microbes as the energy source might have reduced the organic carbon content during storage.

The results of the study showed the significant influence of ageing on macro nutrients content of *Panchagavyam* (Fig. 4; Fig. 5; Fig. 6). Among the treatments, 20 WOP of *Panchagavyam* recorded the highest nitrogen content of

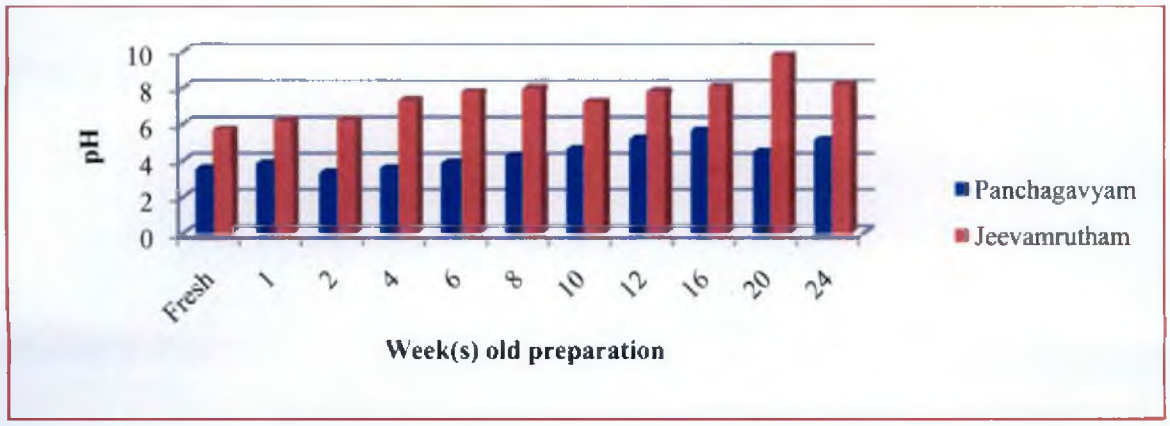


Fig.2. pH of liquid organic formulations as influenced by storage

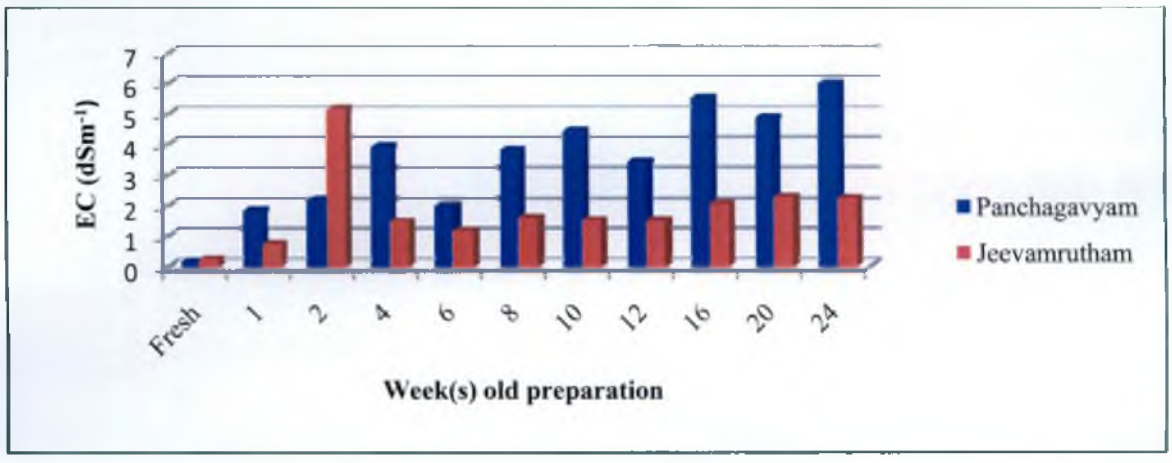


Fig.3. EC of liquid organic formulations as influenced by storage

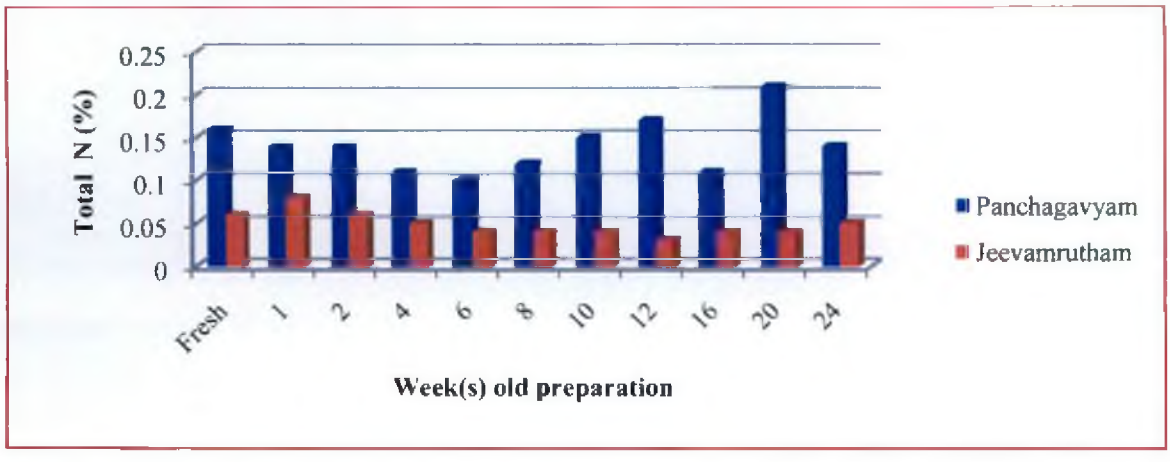


Fig. 4. Total N content of liquid organic formulations as influenced by storage

0.21%. There was no significant variation in nitrogen content of *Jeevamutham* due to ageing and was in the range of 0.3 to 0.8%. The poor status of N in both liquid organic formulations than its ingredients may be due to the volatile loss during fermentation and subsequent biochemical reactions. In general, the P content of liquid organic formulations decreased during storage while the K content was slightly increased with increase in storage intervals. The decrease in P content during the storage of liquid organic formulations was reported by Pillai (2012).

The secondary nutrients detected in the liquid organic formulations were significantly influenced by different storage periods (Fig. 7; Fig. 8; Fig. 9). The Ca content of *Panchagavyam* increased due to ageing. The significant amount of Ca in *Panchagavyam* was contributed by the milk products used for its preparation. Calcium was detected in *Jeevamrutham* during storage and the highest content was recorded in S_1 (66.4 ppm). Significantly higher Mg content (103.10 ppm) was recorded in 10 WOP of *Panchagavyam*. There was no significant variation in the magnesium content of *Jeevamrutham* due to ageing and the value was in the range of 50.33 to 62.83 ppm. In general, the Mg content was slightly improved due to ageing. The sulphur content of both liquid organic formulations was significantly influenced by ageing. Compared to the fresh preparation, S content of *Panchagavyam* increased with storage. The highest S content (1079.64 ppm) was noticed in S_7 (10 WOP) of *Panchagavyam*. The highest S content in *Jeevamrutham* was recorded during 20th and 8th week (280.11 ppm) while the lowest content (81.62 ppm) was recorded in S_3 (2 WOP). The increased nutrient content of liquid organic formulations during storage might be due to the increased release of these nutrients from organically bound form through microbial decomposition.

A few micronutrients (Fe, Mn and Zn) were detected in both the liquid organic formulations. The content of these nutrients was significantly influenced by different storage intervals (Fig. 10). In general, Fe content of *Panchagavyam* was increased due to ageing (101.23 ppm) compared to the fresh preparation

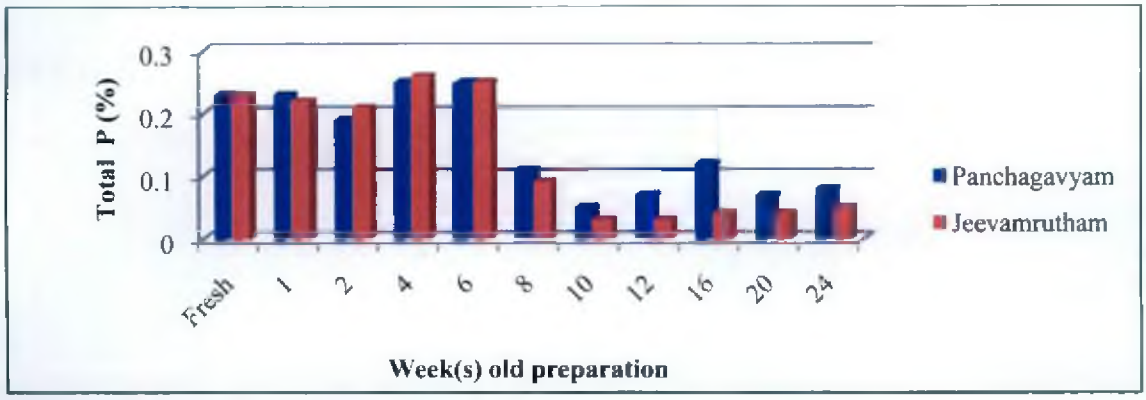


Fig.5. Total P content of liquid organic formulations as influenced by storage

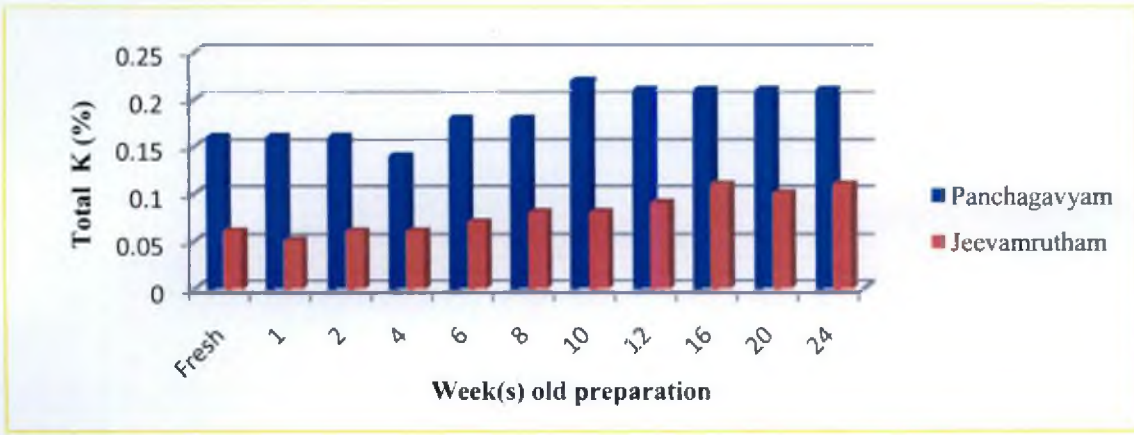


Fig.6.Total K content of liquid organic formulations as influenced by storage

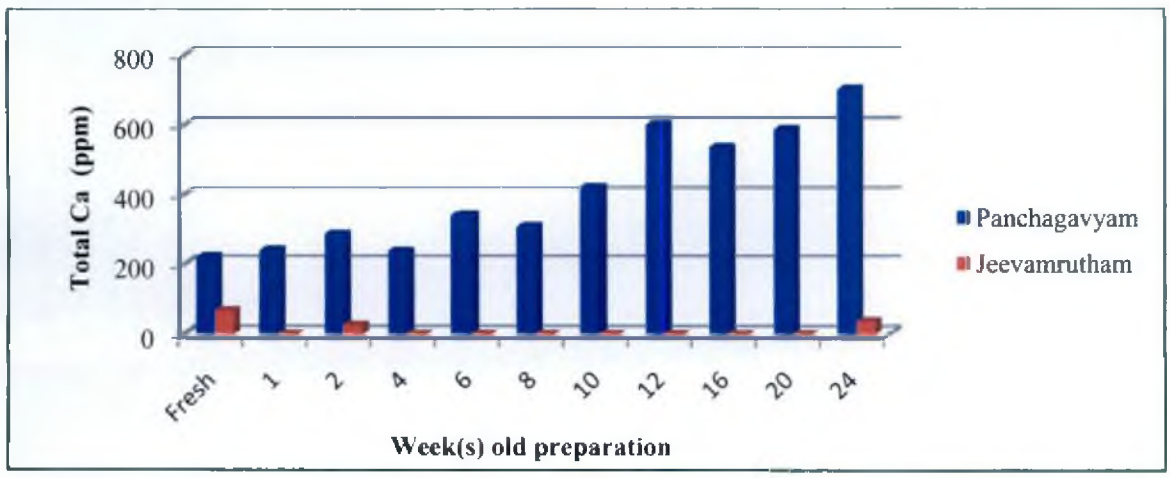


Fig.7. Total Ca content of liquid organic formulations as influenced by storage

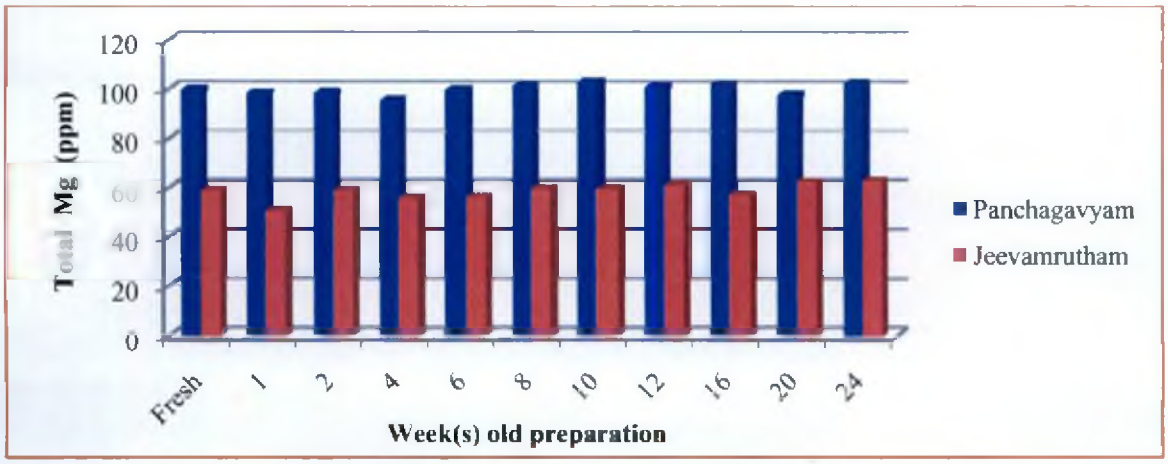


Fig.8. Total Mg content of liquid organic formulations as influenced by storage

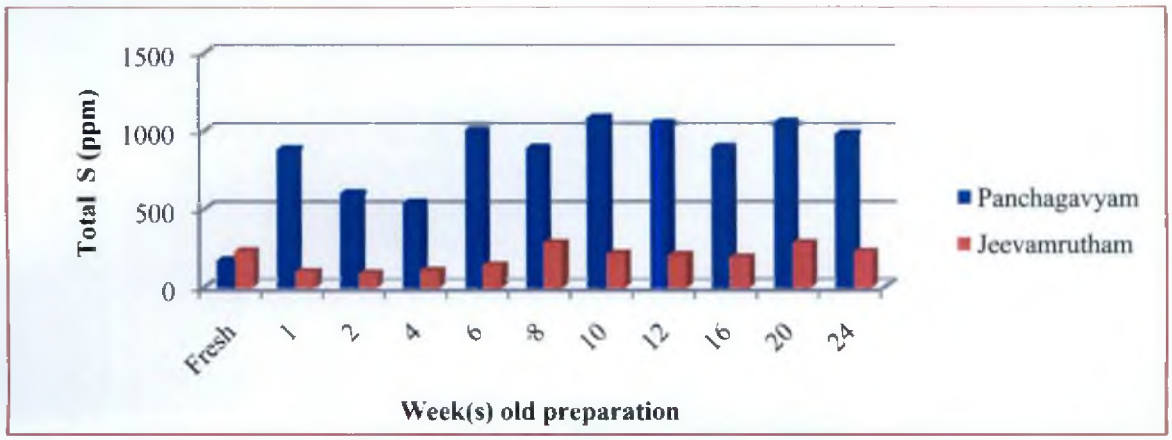


Fig.9. Total S content of liquid organic formulations as influenced by storage

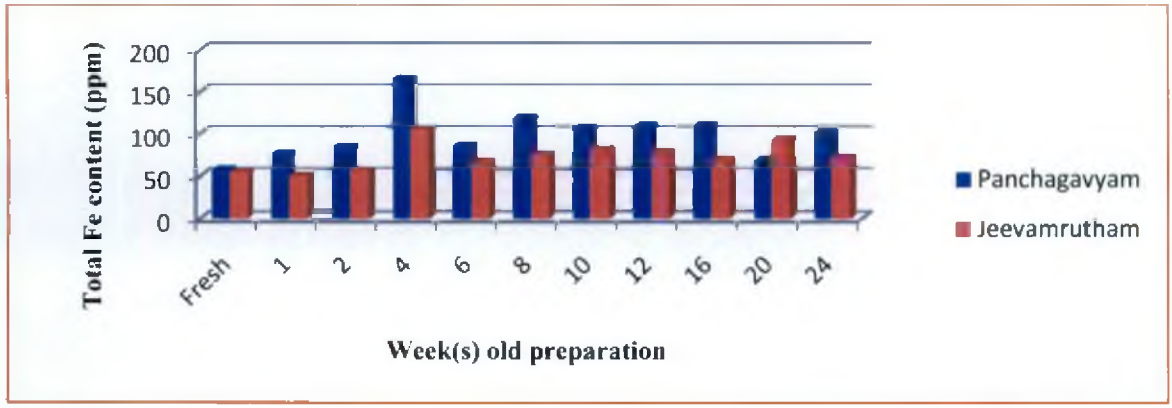


Fig.10. Total Fe content of liquid organic formulations as influenced by storage

(57.00 ppm). Four weeks old *Jeevamrutham* recorded the highest Fe content (104.16 ppm). Presence of zinc and manganese were detected in both liquid organic formulations during storage. The value was in the range of 2.40 - 5.00 ppm of Zn, 0.20 - 3.30 ppm of Mn in *Panchagavyam* and 0.40 - 7.50 ppm of Zn, 1.70 - 26.90 ppm of Mn in *Jeevamrutham*. Copper was not detected in any of the formulation during the entire storage period.

The chemical properties of the liquid organic formulations are subjected to changes according to the ingredients used. The quality of cow dung, cow urine, milk *etc.* may vary depending on the breeds of cow and the feed given to them. The changes occurring due to fermentation and subsequent reactions may be responsible for the changes in the observed parameters.

5.1.2. Influence of ageing on biological properties of liquid organic formulations

The total microbial population *viz.*, fungi, bacteria and actinomycetes were significantly influenced by different storage periods. There was a pronounced increase in microbial population during ageing which is clearly evident from Fig. 11; Fig. 12and Fig. 13. The treatment S_{10} (20 WOP) recorded the highest population of 66.00 x 10^4 cfu ml^{-1} of fungi followed by 28.33 x 10^4cfu ml^{-1} in S_{11} (24 WOP) of *Panchagavyam*. The 24 WOP of *Jeevamrutham* recorded the highest fungal population of 44.00 x 10^4 cfu ml^{-1} followed by 10 WOP (23.66 x 10^4 cfu ml^{-1}). In general, the population of fungi in liquid organic formulations increased with storage intervals compared to the fresh preparation. The change in count and species of microbes in *Panchagavyam* and *Jeevamrutham* may be due to the difference in composition of ingredients and method of preparation.

The 12 WOP of *Panchagavyam* recorded the highest count of bacteria (385.00 x 10^6 cfu ml^{-1}) followed by fresh preparation (300.00 x 10^6 cfu ml^{-1}). The lowest population was noticed in S_2 (1 WOP) which was on par with S_3 (2 WOP) and S_4 (4 WOP) of *Panchagavyam*. The highest population of bacteria was noticed in 16 WOP (665.00 x 10^6 cfu ml^{-1}) followed by 20 WOP (576.66 x 10^6

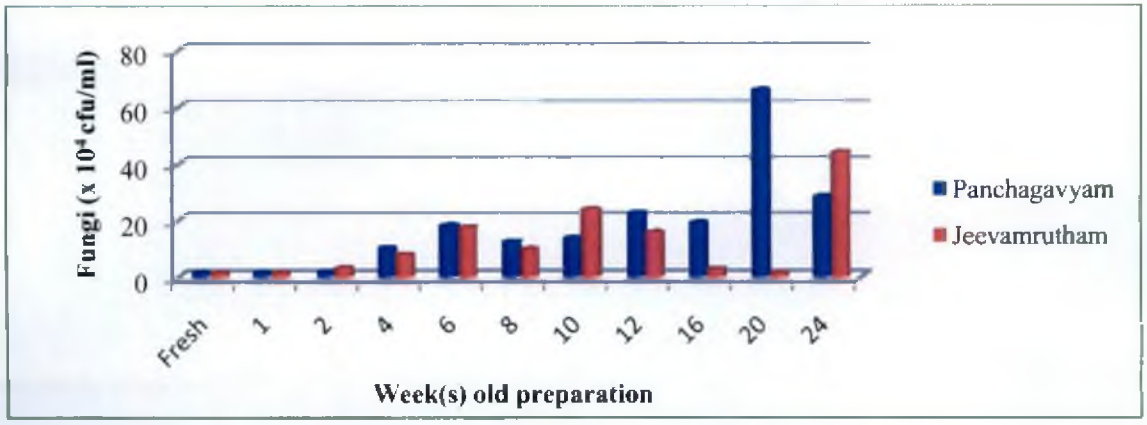


Fig.11. Population of total fungi of liquid organic formulations as influenced by storage

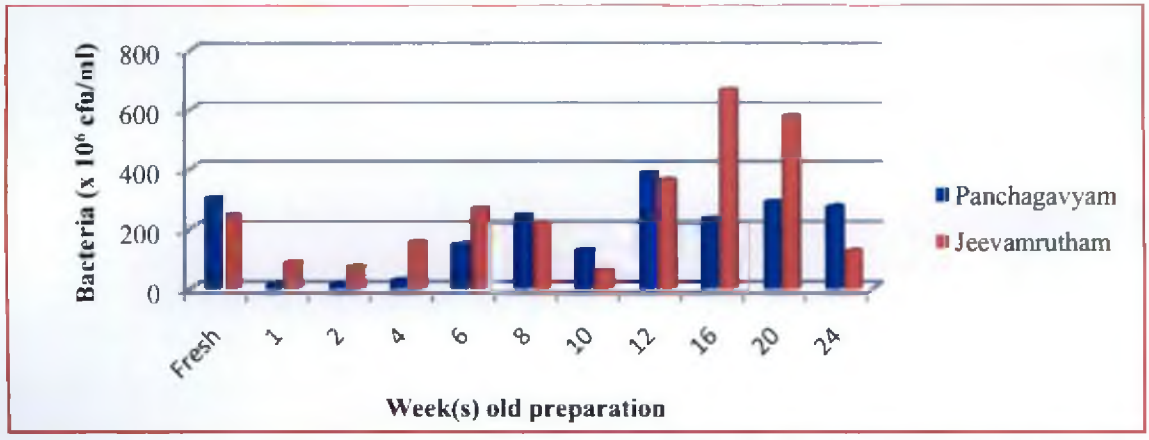


Fig.12. Population of total bacteria of liquid organic formulations as influenced by storage

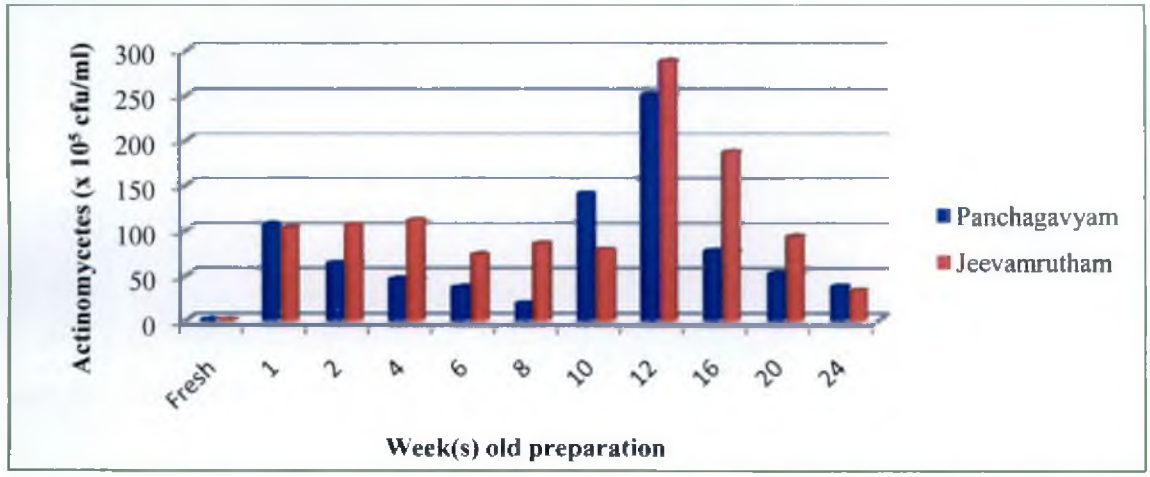


Fig.13. Population of total actinomycetes of liquid organic formulations as influenced by storage

cfu ml^{-1}) of *Jeevamrutham* which were on par. The result indicates that the higher population of bacteria was maintained at the end of storage periods. Babu (2012) observed significant growth of viable microbes in 7 months old *Panchagavyam* and *Jeevamrutham* and also reported the uncountable rate of *Bacillus* in these preparations. There are reports of increase in total viable count of *Panchagavyam* (Natarajan, 2003) and *Jeevamrutham* (Devakumar, 2009) during different storage intervals.

The results showed that the highest population (250.33 x 10^5cfu ml^{-1}) of actinomycetes was recorded in 12 WOP of *Panchagavyam.* The 12 WOP of *Jeevamrutham* had the highest population of actinomycetes (288.00 x 10^5 cfu ml^{-1}). There were no actinomycetes observed in fresh preparation of both the liquid organic formulations. Radha and Rao (2014) also reported that the actinomycetes were absent in freshly prepared *Panchagavyam.* The actinomycetes population of liquid organic formulations gradually increased during the middle period of storage and further the population was decreased.

All the treatments of *Panchagavyam* were free from *Escherichia coli* whereas in some of the treatments of *Jeevamrutham, E. coli* was detected. However, total coliforms were detected in both the liquid organic formulations during the entire storage periods. According to shailaja *et al.* (2014) *Panchagavyam* was free from coliforms like *Staphylococci* and *Streptococci.*

Swaminathan *et al.* (2007) reported that *Panchagavyam* is rich in beneficial micro organisms like lactic acid and photosynthetic bacteria, PSB, actinomycetes, N fixers, yeast and fungi. Devakumar *et al.* (2014) also observed higher colony forming units of bacteria, actinomycetes, fungi and nitrogen fixers in *Jeevamrutham.* The higher microbial population of these liquid organic formulations made them as a potent source to maintain soil fertility and to enhance nutrient availability by helping in fast decomposition of bulky organic manures.

Plate 10. Total microbial population in liquid organic formulations

(a) *Panchagavyam* (b) *Jeevamrutham*

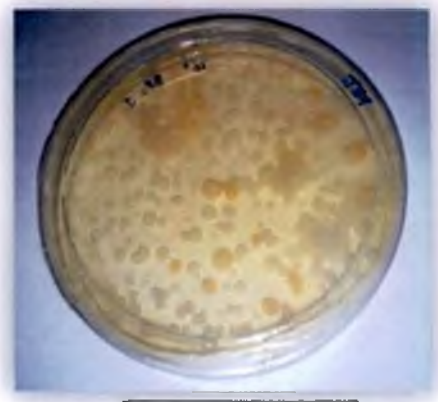
S_{10} (20 WOP)

Fungi

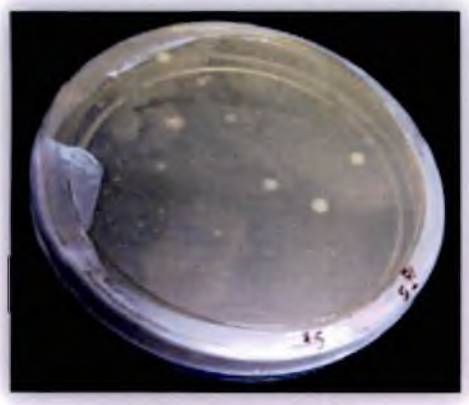
S_{11} (24 WOP)

S_8 (12 WOP)

Bacteria

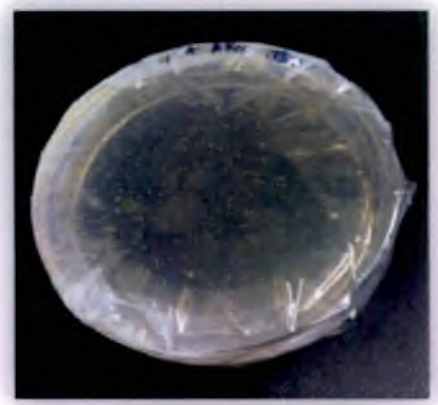


S_9 (16 WOP)



S_8 (12 WOP)

Actinomycetes



S_8 (12 WOP)

5.2. Experiment II

Influence of shelf life of *Jeevamrutham* and *Panchagavyam* on growth and yield of cucumber

5.2.1. Soil characters

The study revealed that the soil characteristics like pH, EC, organic carbon, available nutrients and total microbial population were significantly influenced by different treatments. Soil of the experimental plot was acidic with a pH of 5.11 and the pH increased after cropping due to different treatments. The treatment receiving commercial organic formulation of sea weed extract (Microzyme) @ 0.5% recorded the highest pH (5.87) after the experiment, which was followed by application of organic *ad hoc* POP with water spray (T_5). The increase in pH might be due to the application of organic manures. Among the treatments receiving liquid organic formulations, 12 weeks old *Panchagavyam* @ 3% recorded the highest pH.

The EC of the soil after the experiment was slightly increased with the application of all treatments compared to the initial value. Among the treatments, T_5 recorded the higher value followed by 24 weeks old *Panchagavyam* @ 3%. The organic carbon content was significantly improved with each treatment receiving organic management practices (Fig. 14). The initial organic carbon content was 1.11%. After the harvest of the crop, the organic carbon status in T_7 (POPR) was reduced. The highest organic carbon content (1.69%) was recorded in the treatment receiving 12 weeks old *Jeevamrutham* @ 100%. The increase in organic carbon content can be attributed to the application of poultry manure, coir pith compost and drenching of cow dung slurry along with liquid organic formulations. The result revealed the influence of shelf life of liquid organic formulations in improving the organic carbon status of soil. Maillard *et al.* (2015) also reported that the application of liquid dairy manure improved the organic carbon status of soil in the plough layer.

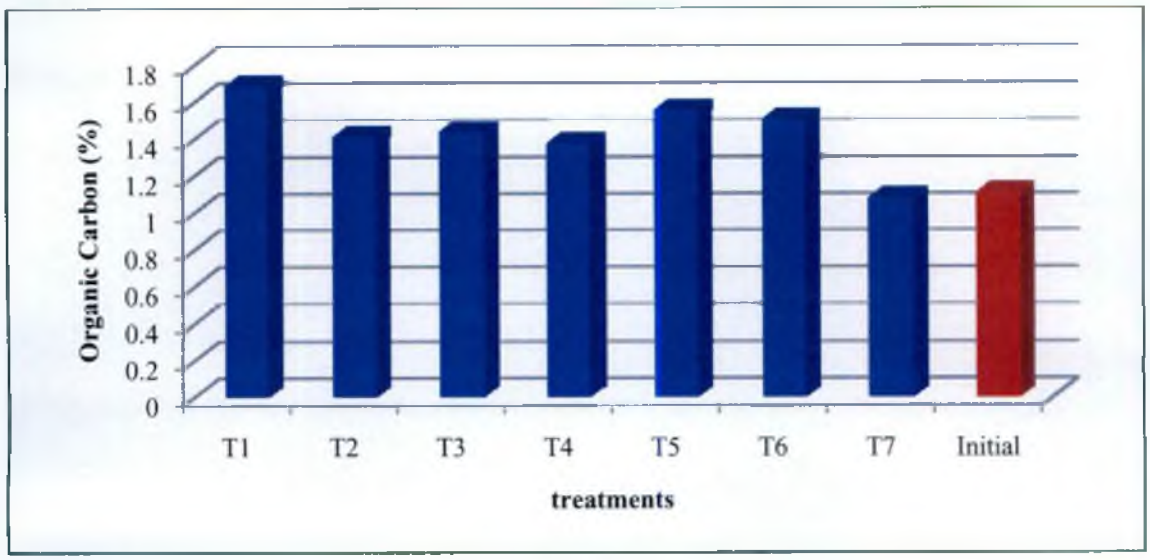


Fig14. Influence of different treatments on organic carbon content of soil

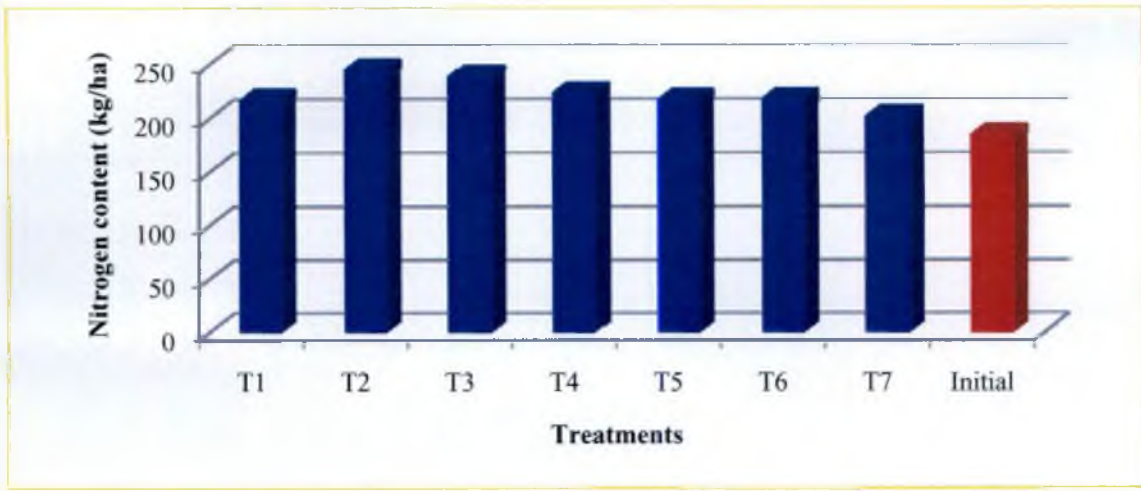


Fig.15. Influence of different treatments on available N content of soil

T_1 - 12 weeks old *Jeevamrutham*

T_2 - 20 weeks old *Jeevamrutham*

T_3 - 24 weeks old *Panchagavyam*

T_4 -12 weeks old *Panchagavyam*

T_5 - Water spray

T_6 - Commercial organic formulation (Microzyme)

T_7 – POP Recommendations, KAU

The available nutrient content (NPK) of soil has significantly improved with various treatments from the initial nutrient status (Fig. 15; Fig. 16; Fig. 17). The highest available N content of 245.70 kg ha^{-1} was registered in T_2 (20 week old *Jeevamrutham* @ 100%) followed by 24 weeks old *Panchagavyam* @ 3%. The increase in availability of N might be due to the presence of microbial load in the fermented organic formulations which improved the dehydrogenase and urease activity and increased the release of nitrogen through mineralisation. The availability of N might have increased by the presence of nitrogen fixers in *Jeevamrutham* and *Panchagavyam*, which helped to improve the soil fertility (Vadakatu and Paterson, 2006). Foliar application of 12 weeks old *Panchagavyam* @ 3% recorded the highest content of available P (25.00 kg ha^{-1}) followed by 20 weeks old *Jeevamrutham* @ 100%. The increased P availability might be due to the improved activity of PSB in releasing phosphate ions from the soil pool (Ninan *et al.* 2013). The maximum content (343.02 kg ha^{-1}) of available K was noticed in 20 weeks old *Jeevamrutham* @ 100% (T_2) followed by 24 weeks old *Panchagavyam* @ 3% (T_3). Vemaraju (2015) also reported the improved availability of major nutrients with the application liquid organic formulations. The availability of all the nutrients was low in the treatment receiving POPR (Package of Practices Recommendations) compared to all other treatments.

Organic management practices have improved the population and activity of micro organisms in soil. Combined application of organic manures *viz.*, poultry manure, coir pith compost with drenching of cow dung slurry in the treatments T_1 to T_6 has made the favourable conditions for the growth and multiplication of beneficial microbes in the soil. The influence of ageing of liquid organic formulations on microbial population *viz.*, fungi, bacteria and actinomycetes is evident from the results (Fig. 18). The initial microbial count for fungi, bacteria and actinomycetes was 1.66 x 10^4, 30 x10^6 and 6 x 10^5 cfu g^{-1} of soil respectively. The treatment receiving 20 weeks old *Jeevamrutham* @ 100% registered the highest population of fungi (6.25 x 10^4 cfu g^{-1}), bacteria (110.83 x 10^6 cfu g^{-1}) and

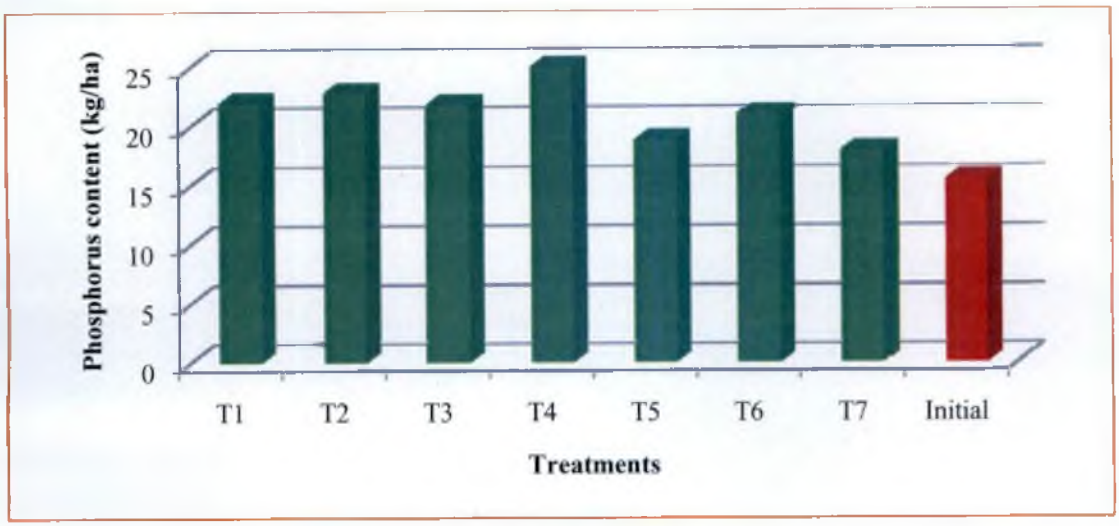


Fig.16. Influence of different treatments on available P content of soil

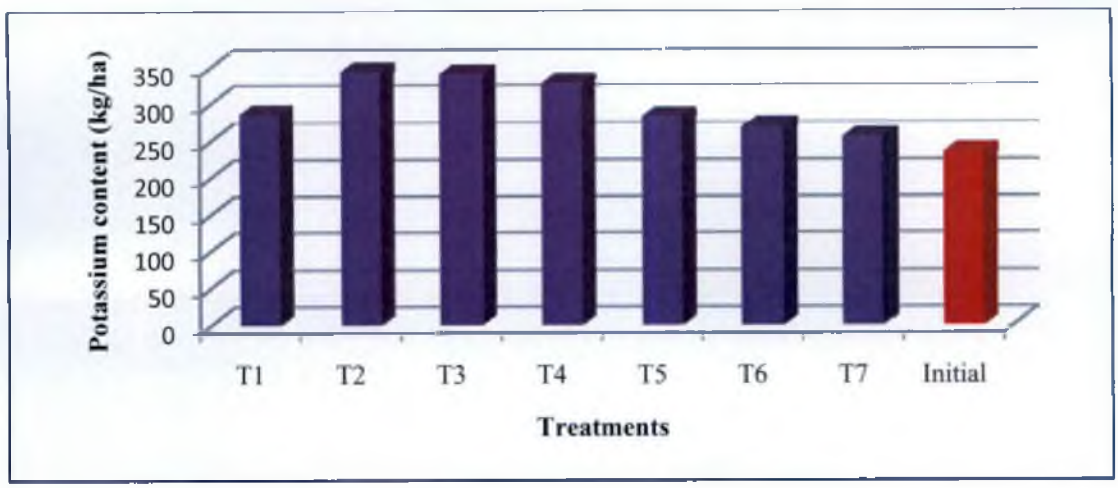


Fig.17. Influence of different treatments on available K content of soil

T_1 - 12 weeks old *Jeevamrutham*

T_2 - 20 weeks old *Jeevamrutham*

T_3 - 24 weeks old *Panchagavyam*

T_4 - 12 weeks old *Panchagavyam*

T_5 - Water spray

T_6 - Commercial organic formulation (Microzyme)

T_7 - POP Recommendations, KAU

actinomycetes (26.83 x 10^5 cfu g^{-1}) followed by 12 weeks old *Jeevamrutham* @ 100% and 24 weeks old *Panchagavyam* @ 3%. The population of fungi, bacteria and actinomycetes were observed least in the treatment receiving inorganic fertilizers. Similarly, the higher microbial count in *Jeevamrutham* was observed by Devakumar *et al.* (2011) and the foliar application of *Panchagavyam* improved the rhizosphere microbial activity (Shubha *et al.*, 2014).

The significantly increased population of micro organisms with the foliar spray of aged *Panchagavyam* and *Jeevamrutham* could be due to the improved quality of these formulations upon storage. The enhanced microbial activity due to the application of *Jeevamrutham* could improve the nutrient availability to crop (Gore and Sreenivasa, 2011) as also evident from the results of the present study. Sharanappa and pradeep (2014) reported that application of *Panchagavyam* @ 3% along with other organics significantly improved the total microbial count in soil.

5.2.2. Growth attributes

Growth and development of cucumber was initially influenced by different treatments. The treatment receiving 20 weeks old *Jeevamrutham* @100% registered significantly highest vine length of 48.95 cm which was on par with T_5 followed by 12 weeks old *Jeevamrutham* @ 100% (47.33 cm) at 30 DAS. Even though the vine length at 60 DAS was not significant, T_1 recorded highest vine length of 121.91 cm. The production of leaves was significantly influenced by different treatments. The highest number of leaves per plant at 30 DAS was recorded in T_5 followed by T_2 and T_6 which were on par. T_7 recorded the highest number of leaves at 60 DAS followed by T_6. The results indicate that the application of liquid organic formulations improved the growth and development during the early stage of the crop (Fig. 19; Fig. 20).

There was no significant difference in days to first flowering and fruiting, number of harvests and duration of the crop. Still, comparatively late flowering and fruiting was observed in the treatment receiving inorganic fertilizer.

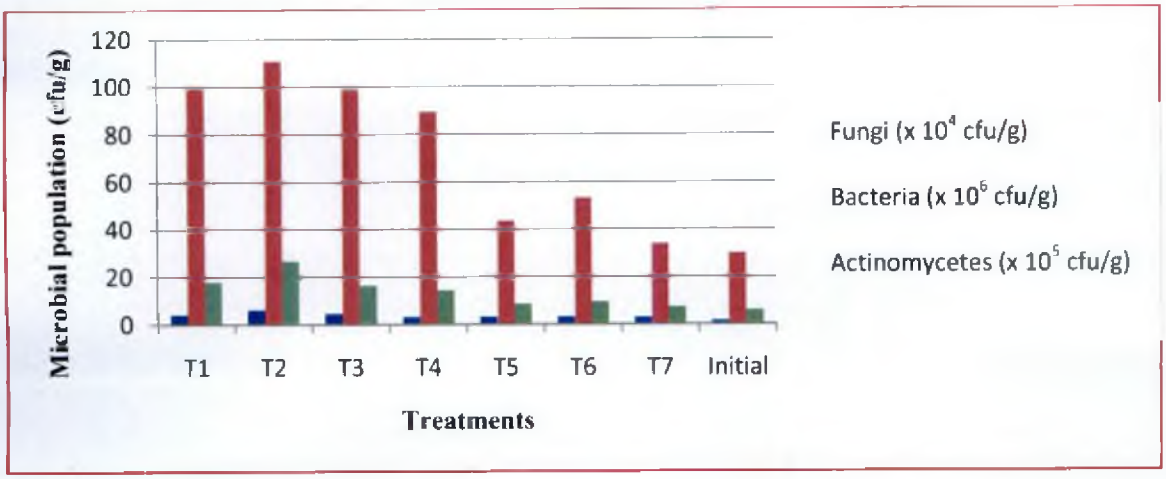


Fig.18. Influence of different treatments on total microbial population in soil

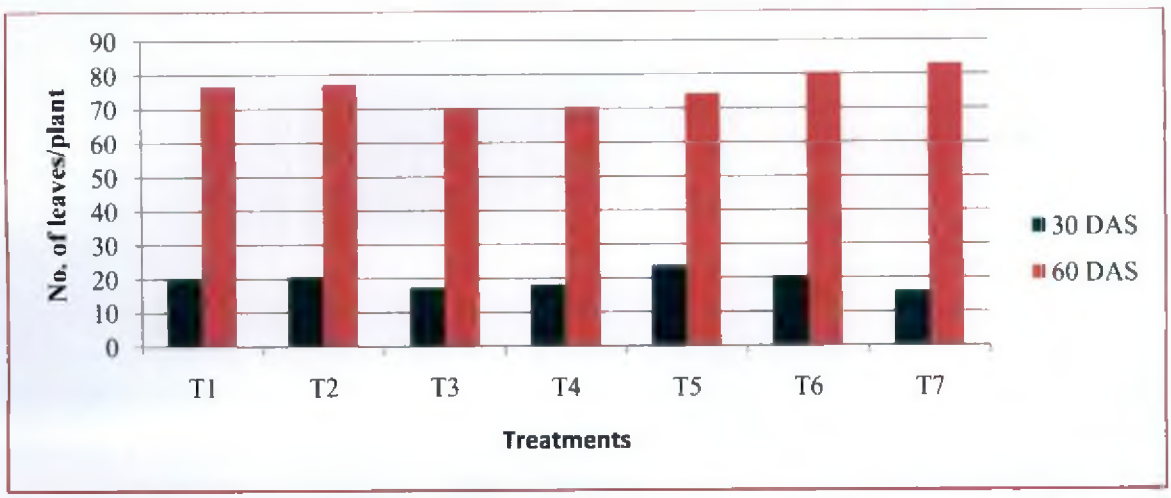


Fig.19. Number of leaves per plant as influence by different treatments

T_1 - 12weeks old *Jeevamrutham*

T_2 - 20weeks old *Jeevamrutham*

T_3 - 24 weeks old *Panchagavyam*

T_4 -12 weeks old *Panchagavyam*

T_5 - Water spray

T_6 - Commercial organic formulation (Microzyme)

T_7 - POP Recommendations, KAU

5.2.3. Yield and yield attributes

The yield and its attributes like number, volume and weight of fruits per plant were significantly influenced by different treatments (Fig. 21, Fig. 22; Fig. 23). The treatment (T_2) receiving 20 weeks old *Jeevamrutham* @ 100% foliar spray recorded maximum number of fruits per plant (11.08) followed by 12 weeks old *Jeevamrutham* @ 100% (10.04). The increase in number of fruits could be attributed to the growth regulators and hormones present in the liquid organic formulations which might have improved the physiological activities leading to better fruit production in cucumber. Basavaraj *et al.* (2015) also reported significant higher yield in French bean with *Jeevamrutham* application.

The highest volume of fruits was also recorded in T_2 (3320.68 cm^3) followed by T_1 (3040.61 cm^3) and the lowest volume was recorded in T_5 (*ad hoc* organic POP with water spray). Similarly the highest volume of fruits was obtained in oriental pickling melon (Vemaraju, 2014) and chilli (Chandrakala, 2008) with *Jeevamrutham* application.

The foliar application of 20 weeks old *Jeevamrutham* @ 100% (T_2) recorded highest weight of fruits (3.32 kg $plant^{-1}$) followed by T_1 (3.01 kg $plant^{-1}$) whereas the lowest weight of fruits was observed in T_7 and T_5 which were on par. Improvement in yield and yield attributes with combined use of organic manures along with *Jeevamrutham* in cotton was reported by Channagoudra (2012).

The yield of cucumber (*Cucumis sativus* L.) was significantly influenced by shelf life of liquid organic formulations and other treatments as evident from the Fig. 24. Application of 20 weeks old *Jeevamrutham* @ 100% (T_2) recorded the highest yield of 28.92 Mg ha^{-1} followed by 12 weeks old *Jeevamrutham* @100% (T_1). The lowest yield was observed with T_7 (21.58 Mg ha^{-1}) and T_5 (21.78 Mg ha^{-1}) which were on par. The yield enhancement with the application of *Jeevamrutham* was also reported in ground nut (Ravikumar *et al.*, 2011) and field bean (Murali *et al.*, 2015). The per cent increase in yield in T_2 over organic *ad hoc* POPR with water spray was 32.78 and 34.01% increase over POPR.

Plate 11. Crop at harvest

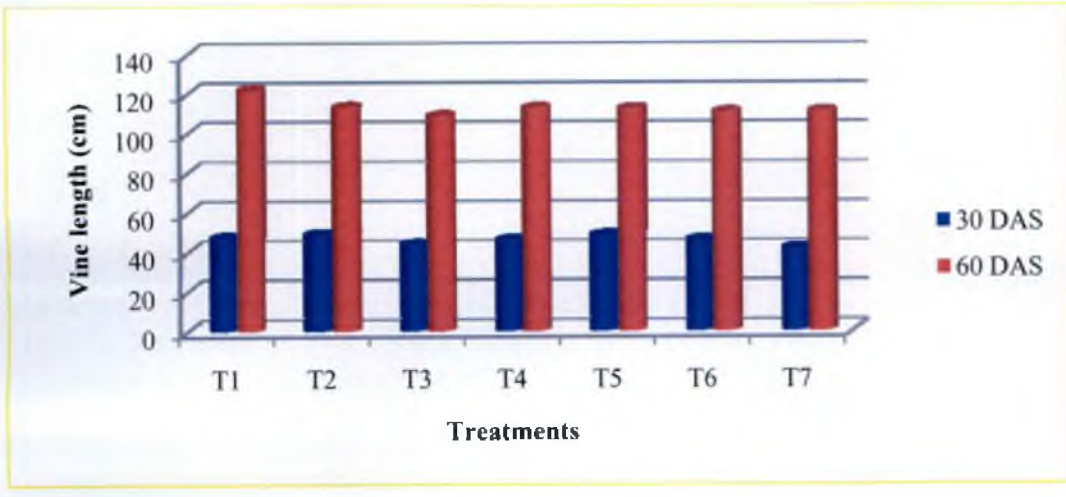


Fig. 20. Vine length of cucumber as influence by different treatments

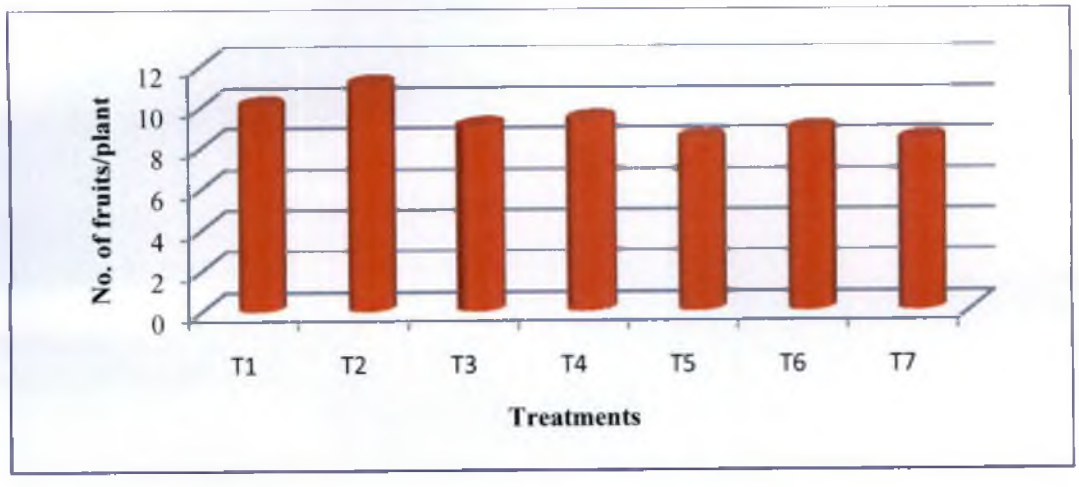


Fig. 21. Number of fruits per plant as influence by different treatments

T_1 - 12 WOP of *Jeevamrutham*

T_2 - 20 WOP of *Jeevamrutham*

T_3 - 24 WOP of *Panchagavyam*

T_4 - 12 WOP of *Panchagavyam*

T_5 - Water spray

T_6 - Commercial organic formulation (Microzyme)

T_7 - POP Recommendations, KAU

The enhanced microbial activity and nutrient availability with the application of liquid organic formulations along with organic manures might have improved the yield and yield attributes in cucumber. Application of liquid organic formulations as foliar spray also helped to overcome the heat stress during cropping which in turn improved the yield by nurturing the crop. Organic management of pests have increased the number of pollinators in the field which in turn has contributed towards increase in yield. A good response with foliar application of aged liquid organic formulation is evident in the present study. The results reveal the capacity of these fermented liquid dairy formulations in improving the yield even after a long period of storage.

5.2.4. Incidence of pests and diseases

No severe attack of pests and diseases was observed during the period of cropping. However, attack of *Diaphania indica* was noticed uniformly in all the plots. Very low population of pumpkin beetle, fruit fly and aphids were also observed in the field. Neem soap and Beauveria @ 1% was sprayed for controlling the pests and PGPR mix II (1%) was sprayed as a preventive measure against disease. The lower incidence of pests could be attributed to the insecticidal property of cow dung and cow urine (Shilaja *et al.*, 2014) which are the components of *Panchagavyam* and *Jeevamrutham*. Babu (2011) isolated *Pseudomonas aeruginosa* from *Jeevamrutham* and *Panchagavyam* which is capable of P solubilisation, synthesizing pathogenesis related proteins, siderophore and antibiotics and auxins.

Organic management practices helped to improve the multiplication of natural enemies and parasites which in turn controlled the pests. It is evident that replacing the chemical pesticides from the field could bring natural balance which would contribute to safest control measures. Also, these might have induced the production of defence related enzymes, which impart resistance against diseases (Sarkar *et al.*, 2014).

Larva of *Diphania indica* parasitised by braconids

Plate 12. Presence of natural enemies in the field

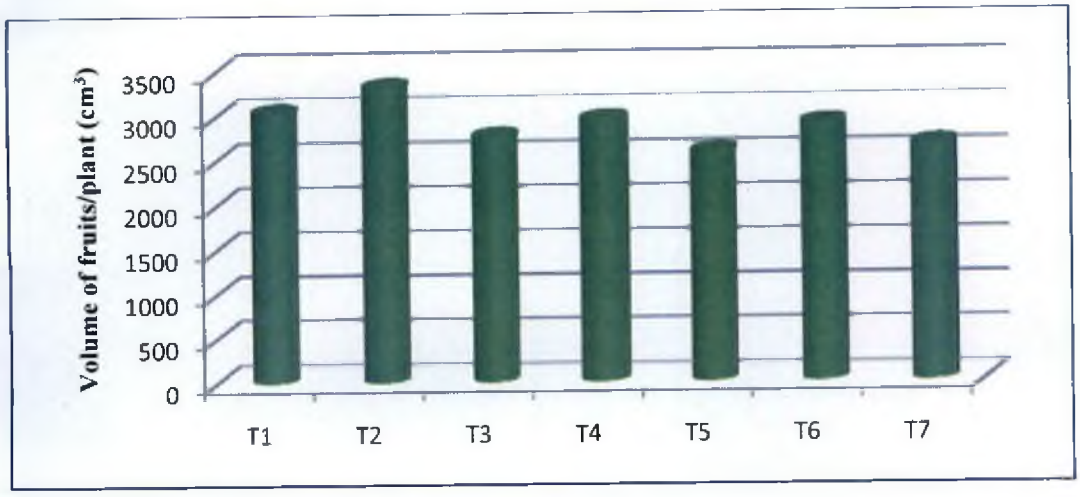


Fig. 22. Volume of fruits per plant as influence by different treatments

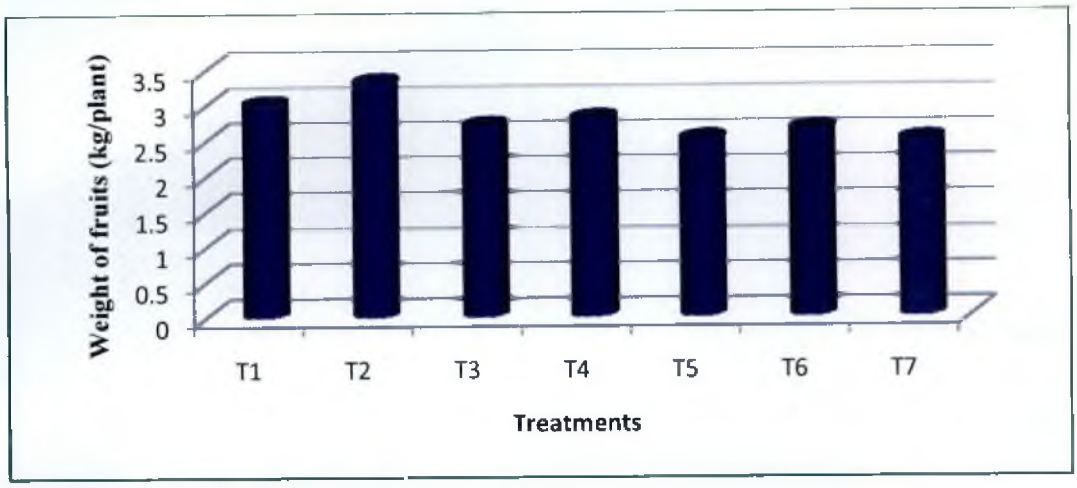


Fig. 23. Weight of fruits per plant as influence by different treatments

T_1 - 12 weeks old *Jeevamrutham*

T_2 - 20 weeks old *Jeevamrutham*

T_3 - 24 weeks old *Panchagavyam*

T_4 - 12 weeks old *Panchagavyam*

T_5 - Water spray

T_6 - Commercial organic formulation (Microzyme)

T_7 - POP Recommendations, KAU

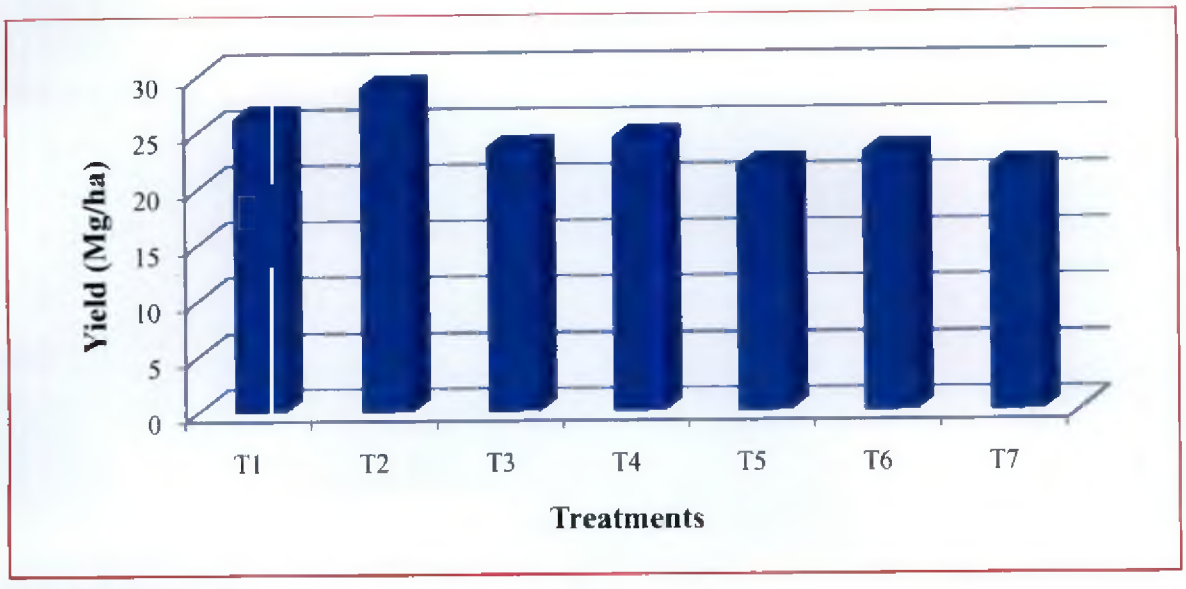


Fig. 24. Yield as influence by different treatments

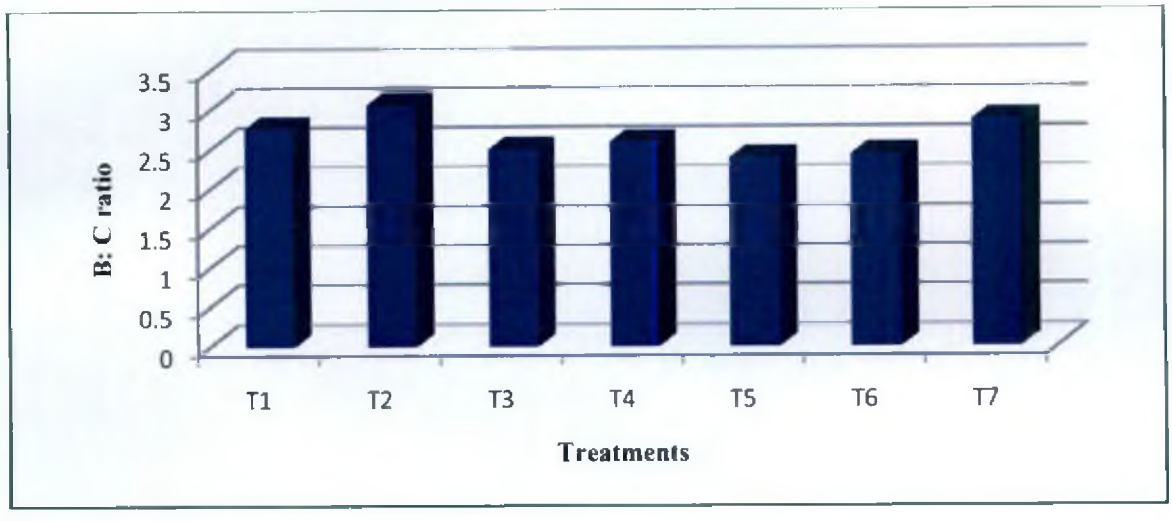


Fig. 25. Influence of different treatments on B: C ratio

T_1 – 12 weeks old *Jeevamrutham*

T_2 – 20 weeks old *Jeevamrutham*

T_3 - 24 weeks old *Panchagavyam*

T_4 -12 weeks old *Panchagavyam*

T_5 - Water spray

T_6 - Commercial organic formulation (Microzyme)

T_7 - POP Recommendations, KAU

5.2.5. Economic analysis

The economic analysis revealed significant variation in benefit to cost ratio due to different treatments. The treatment receiving 20 weeks old *Jeevamrutham* @ 100% (T_2) was found to be significantly superior to other treatments in terms of gross return, net return and B:C ratio while the present POPR recorded the B: C ratio of 2.86. All the treatments were found to be profitable (Fig. 25). The increased yield due to the application of liquid organic formulations contributed towards the higher B: C ratio. The present recommendation is to apply fresh preparation of *Panchagavyam* and *Jeevamrutham*. It necessitates the continuous preparation of these formulations which will be a labour consuming process. Hence, the storage of these preparations without affecting the quality will help to reduce the labour charge which in turn will be economic to the farmers.

CONCLUSION

The study on "Shelf life of liquid organic formulations" revealed the possibility of keeping the liquid organic formulations *viz.*, *Panchagavyam* and *Jeevamrutham* upto 6 months without quality deterioration. It was observed that *Panchagavyam* can be kept up to 6 months whereas *Jeevamrutham* up to 5 months This will help to reduce the labour cost. Application of poultry manure @ 4t ha^{-1} and coir pith compost @ 8t ha^{-1} and cow dung slurry at fortnightly intervals have improved the soil health by enhancing the physical, chemical and biological properties.

In combination with organic manures, continuous use of liquid organic formulations can address rising challenges of organic agriculture in sustaining soil and crop productivity. Foliar spray of *Panchagavyam* and *Jeevamrutham* proved to promote the yield of cucumber.

Organic management practices have contributed to better benefit to cost ratio. If we consider the premium price of the organic cucumber, the net return can be increased further. Moreover, the benefits obtained through organic farming are uncountable in terms of ecological and environmental safety and also ensures nutritious safe food to human being. For ensuring better income through organic agriculture, the cost effective inputs like fermented liquid formulations prepared mainly from on -farm wastes are an alternative.

Future line of work

1. To be repeated for confirmation of the results

2. The microbes present in the liquid organic formulations must be identified to know the benefits of these microbes

Summary

6. SUMMARY

The present study on "Shelf life of liquid organic formulations" was carried out in College of Horticulture, Kerala Agricultural University, Vellanikkara, Thrissur during 2015-2016. Two liquid organic formulations *viz.*, *Panchagavyam* and *Jeevamrutham* were selected for the experiment. The cucumber variety Pusa Uday was used in confirmatory field trial. The summary of salient findings is presented below.

Experiment I

Influence of ageing on quality of liquid organic formulations

- As the storage period progressed, *Panchagavyam* and *Jeevamrutham* became darker in colour with foul odour.
- Surface mould growth and maggots were observed in *Panchagavyam* upon storage and were absent in *Jeevamrutham* during the entire storage period.
- In general, pH of both the formulations *viz.*, *Panchagavyam* (3.29 -5.63) and *Jeevamrutham* (5.69 - 9.77) increased from the acidic range during the storage period and *Jeevamrutham* became alkaline at the end of storage.
- The EC of both the formulations increased due to ageing.
- In general, the organic carbon content of *Jeevamrutham* (0.09 – 0.76%) decreased due to ageing and no change was observed in *Panchagavyam* (2.65-2.94%).
- 20 weeks old *Panchagavyam* recorded the highest nitrogen content of 0.21% and there was no significant variation in nitrogen content of *Jeevamutham* due to ageing.
- P content of liquid organic formulations decreased and K content slightly increased with increase in storage intervals.
- The Ca, Mg and S content of *Panchagavyam* increased due to ageing.

- In *Jeevamrutham*, Ca was detected during storage. Mg content was slightly increased while S content increased further due to ageing.
- In general Fe content increased during storage, Zn and Mn were also detected and copper was not detected in any of the treatments of both *Panchagavyam* and *Jeevamrutham*.
- There was a pronounced increase in microbial population during ageing.
- *Panchagavyam* was free of *Escherichia coli* whereas it was detected in some of the treatments of *Jeevamrutham*.

Experiment II

Influence of shelf life of *Jeevamrutham* and *Panchagavyam* on growth and yield of cucumber

- The organic carbon content of soil in the plots receiving *ad hoc* organic POPR and liquid organic formulations was improved and the highest content of 1.69% observed in the plots receiving 12 weeks old *Jeevamrutham* @ 100%.
- The highest available N was recorded with treatment receiving 20 weeks old *Jeevamrutham* @ 100% (245.70 kg ha^{-1}). 12 weeks old *Panchagavyam*@ 3% recorded the highest available P (25.00 kg ha^{-1}) while 20 weeks old *Jeevamrutham* @ 100% had the highest available K content (343.02 kg ha^{-1}).
- The treatment receiving 20 weeks old *Jeevamrutham* @ 100% recorded the highest microbial population of fungi (6.25 x 10^4 cfu g^{-1} of soil), bacteria (110.83x10^6 cfu g^{-1} of soil) and actinomycetes (26.83 x 10^5 cfu g^{-1} of soil). Population of micro organisms were least in the treatment receiving POPR.
- The highest vine length was observed in the treatment receiving 20 weeks old *Jeevamrutham*.
- The treatments receiving water spray, commercial organic formulation and 20 weeks old *Jeevamrutham* had the highest number of leaves.

- Harvesting could be done 9 times in the treatment receiving commercial organic formulation and in 12 weeks old *Jeevamrutham* whereas in all other treatments the number of harvests was only 8.
- The highest number, volume and weight of fruits were obtained from the treatment receiving 20 weeks old *Jeevamrutham* followed by 12 weeks old *Jeevamrutham*.
- The highest yield of 28.92 Mg ha^{-1} was obtained in treatment receiving 20 weeks old *Jeevamrutham* spray followed by 26.19 Mg ha^{-1} in 12 weeks old *Jeevamrutham*.
- The increase in yield in treatment receiving 20 weeks old *Jeevamrutham* over organic *ad hoc* POPR was 32.78%.
- Pests and diseases incidence was low due to the organic management practices and also the presence of natural enemies and pollinators in the field.
- The treatment receiving 20 weeks old *Jeevamrutham* secured the highest B: C ratio of 3.05 followed by POPR (2.86).

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Appendices

Appendix I. Analytical method used for the chemical characterisation of liquid organic formulations

Sl No.	Estimated characters	Method used	Reference
1	Total N	Microkjeldhal method	Jackson,1958
2	Total P	Vanadomolybdo phosphoric yellow colour method	Bray and Kurtz,1945
3	Total K	Flame photometer method	Jackson,1958
4	Total Ca	Di acid method using Atomic absorption Spectrophotometer	Jackson, 1958
5	Total Mg	Diacid method using Atomic absorption Spectrophotometer	Jackson, 1958
6	Total S	Turbidimetric method using Spectrophotometer	Chesninand Yein, 1951
7	Total Micronutrients	Diacid method using Atomic absorption Spectrophotometer	Jackson, 1958

Appendix II. Physico-chemical properties of the soil

Particulars	Content	Method used
Physical properties		
1.Particle size composition Coarse sand (%) Fine sand (%) Silt (%) Clay (%)	 31.90 27.30 18.64 22.16	Robinson international pipette method (Piper, 1966)
Chemical properties		
pH	5.11	1: 2.5 soil water suspension- pH meter (Jackson, 1958)
EC	0.11	Conductometric method (Jackson, 1958)
Organic carbon	1.11	Walkley and Black method (Jackson, 1958)
Available N	184.80	Alkalinepermanganate method (Subbiah and Asijah, 1956)
Available P	15.43	Ascorbic acid reduced molybdo phosphoric blue colour method (Watnabe and Olsen, 1965)
Available K	234.13	Neutral normal ammonium acetate extractant flamephotometry (Jackson,1958)

Appendix III. Meteorological data during the crop growing period

Standard week	Max. Temperature (°C)	Min. Temperature (°C)	Mean RH (%)	Mean sun shine hrs	Rain fall (mm)	Rainy days (Mean)	Evaporation (cm)
5	34.5	22.1	49	8.2	0.0	0.0	5.8
6	34.9	22.2	61	7.5	11.4	1	4.4
7	35.1	24.1	58	8.6	0.0	0.0	4.9
8	36.2	24.6	63	8.9	0.0	0.0	5.3
9	36.0	24.8	54	8.2	0.0	0.0	5.7
10	36.7	25	61	8.2	0.0	0.0	4.7
11	36.1	25	70	7.8	23.6	2	4.6
12	35.8	27.3	74	7.4	2.2	0.0	4.3
13	36.8	25.5	70	8.5	0.0	0.0	4.5
14	36.4	25.8	69	8.9	0.0	0.0	4.8
15	35.0	26.3	74	7.0	0.0	0.0	4.0
16	35.9	26.4	71	6.7	0.0	0.0	4.6

Appendix IV. Media used for the enumeration of microorganisms in soil

Sl. No.	Microbes	Dilution for plating	Medium used	Reference
1	Bacteria	10^6	Nutrient Agar	Agarwal and Hasija,1986
2	Fungi	10^4	Martin's Rose Bengal Agar	
3	Actinomycetes	10^5	Kenknight's and Munair's Agar	

SHELF LIFE OF LIQUID ORGANIC FORMULATIONS

By

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ABSTRACT OF THE THESIS

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ABSTRACT

The study entitled "Shelf life of liquid organic formulations" was carried out in the Department of Agronomy, College of Horticulture, Vellanikkara during 2015 - 2016. The objectives were to find out the shelf life of liquid organic formulations by analyzing the chemical and biological properties, and the effect of duration of storage of these formulations on growth and yield of cucumber variety. There were two experiments *viz.*, influence of ageing on quality of liquid organic formulations and influence of shelf life of *Jeevamrutham* and *Panchagavyam* on growth and yield of cucumber variety Pusa Uday. The first experiment consisted of 11 treatments where *Panchagavyam* and *Jeevamrutham* were stored for 1, 2, 4, 6, 8, 10, 12, 16, 20 and 24 weeks. The fresh preparations as well as the stored formulations were analyzed for various parameters.

The fresh preparation of *Panchagavyam* was light green with fruity smell whereas that of *Jeevamrutham* was moderate green with mild foul odour and became darker green and brownish green respectively with foul odour at the end of storage. The surface mould growth and maggots were observed in *Panchagavyam* only.

An increasing trend in pH and EC of *Panchagavyam* and *Jeevamrutham* was noticed during the period of storage. Among the treatments, 20 weeks old preparation of *Panchagavyam* recorded the highest nitrogen content of 0.21 per cent. There was no significant variation in nitrogen content *of Jeevamrutham* on storage and was in the range of 0.3 to 0.8 per cent. In general, P content of liquid organic formulations decreased while K content slightly increased during storage. Mg and S content was slightly improved due to ageing. The micronutrients Fe, Mn and Zn were detected in both the liquid organic formulations.

The total microbial population *viz.*, fungi, bacteria and actinomycetes were significantly influenced by the storage period. The highest fungal population was noticed in 20 weeks old *Panchagavyam* and 24 weeks old *Jeevamrutham.*

Bacterial count was the highest in 12 weeks old *Panchagavyam* and 16 weeks old *Jeevamrutham*. The highest population of actinomycetes was observed in 12 weeks old *Panchagavyam* and *Jeevamrutham*. All the treatments of *Panchagavyam* were free from *Escherichia coli* whereas it was detected in some of the treatments of *Jeevamrutham*,

The field experiment consisted of 7 treatments including four best treatments selected based on the results of first experiment (12 and 20 weeks old *Jeevamrutham* and 24 and 20 weeks old *Panchagavyam*), water spray, commercial organic formulation and package of practices recommendations, KAU. Organic manures were applied in cucumber plots as per the package of practices recommendations (*ad hoc*) for organic farming: Crops in all the treatments except T_7. Weekly foliar spray of liquid organic formulations was started 20 DAS. The biometric observations were recorded at 30 and 60 DAS.

The available nutrient content (NPK) and total microbial population of soil were significantly improved with the application of liquid organic formulations. The treatment receiving 20 weeks old *Jeevamrutham* registered the highest available soil N (245.02 kg ha^{-1}) and K (343.02 kg ha^{-1}). The highest population of fungi (6.25 x 10^4cfu g^{-1}), bacteria (110.83 x10^6cfu g^{-1}) and actinomycetes (26.83 x10^5cfu g^{-1}) was also detected in soil receiving 20 weeks old *Jeevamrutham*. Application of *Jeevamrutham* contributed the highest number of fruits per plant (11.08), volume of fruits per plant (3320.68 cm^3), weight of fruits (3.32 kg $plant^{-1}$) and yield (28.92 Mg ha^{-1}) resulting in maximum gross return, net return and B: C ratio (3.05).

The results of the present investigation revealed the possibility of storing *panchagavyam* up to six months and *Jeevamrutham* up to five months without quality deterioration. Foliar spray of *Panchagavyam* and *Jeevamrutham* has proved to promote the yield of cucumber.