VALIDATION OF LIQUID ORGANIC MANURES AND THEIR EFFECT ON CROP PRODUCTIVITY

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(2015-11-019)

THESIS

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DECLARATION

I, Dhanalakshmi V. N. (2015-11-019) hereby declare that the thesis entitled **"Validation of liquid organic manures and their effect on crop productivity"** is a bonafide record of research work done by me during the course of research and the thesis has not been previously formed the basis for the award to me any degree, diploma, fellowship or other similar title, of any other University or Society.

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Certified that the thesis entitled **"Validation of liquid organic manures and their effect on crop productivity"** is a record of research work done independently by **Ms. Dhanalakshmi V. N. (2015-11-019)** under my guidance and supervision and that it has not been previously formed the basis for the award of any degree, diploma, associateship or fellowship to her.

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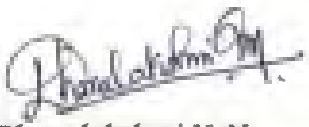

Dhanalakshmi V. N.

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%	-	per cent
@	-	at the rate of
B: C	-	Benefit Cost ratio
cfu	-	colony forming unit
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(s) old preparation

Introduction

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1. INTRODUCTION

The major factors that lead to the growing interest in alternate forms of agriculture are increasing consciousness about environment conservation as well as health hazards associated with agrochemicals and consumers' preference to safe and hazard free food.

Organic farming practices are gaining importance nowadays in terms of soil health, fertility, sustainable productivity and food safety.

Organic farming works to increase sustainability, biodiversity and to encourage good soil and air quality. This is maintained by the use of natural growing practices, avoidance of harmful chemicals, and continued practice of crop rotation and other natural farming methods.

Liquid organic manures are used in conventional as well as organic farming. Liquid manures are helpful to overcome temporary nutrient shortages. It also helps farmers to boost the growth of plants as chemical fertilizers do. These organic liquid manures play a key role in promoting growth and providing immunity to the plant system. Beneficial microorganisms like fungi, bacteria, actinomycetes and yeast were detected in organic liquid manures.

It has been claimed that liquid organic manures when applied as foliar spray can act as a tonic for plants. It contains enormous number of microorganisms that recycle organic matter, enhance the activity of soil life. These microorganisms act on soil material and make soil nutrients more available to plants. Vennila and Jayanthi (2008) found that *Panchagavya* spray (2 per cent) along with recommended dose of fertilizers (100 per cent) increased the growth and yield attributing characters, fruit yield and quality of okra. The beneficial effects of liquid organic formulations on cucurbits have been reported by Krishnan (2014), Vemaraju (2014) and Rameeza (2016).

Farmers are well aware about the use of liquid organic manures such as *Panchagavya*, *Beejamrutha*, *Jeevamrutha* and fish jaggery extract in organic

farming. Foliar spray of fish jaggery extract and egg extract is reported to be promising to improve the nutrient status of soil and crop productivity. Balraj et al. (2014) found that fish jaggery extract decreased soil pH, enhanced exchangeable cation levels, organic matter and the essential plant nutrients, N, P and K. Foliar spray of Gunapaselam at different concentrations (5, 10 and 15 per cent) had a significant effect on the growth and yield of okra. Gunapaselam 10 per cent spray showed the highest plant height, shoot length, length and diameter of internodes and number of leaves (Srikumaran et al., 2017).

Although many farmers are getting better yield using organic liquid manures, scientific validation has not been carried out so far. There is lack of adequate research findings regarding various characteristics including shelf life of liquid organic formulations and their effect on soil health, crop growth, and yield. Hence, the present study on "Validation of liquid organic manures and their effect on crop productivity" was conducted taking okra as test crop with two commonly used liquid organic manures, fish jaggery extract and egg extract. The following were the objectives:

1. To study the characteristics of fish jaggery extract and egg extract
2. To study the effect of fish jaggery extract and egg extract on soil health and crop productivity

Review of literature

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2. REVIEW OF LITERATURE

Liquid organic manures such as *Panchagavya*, *Jeevamrutha*, Amritapani, EM solution, fish jaggery extract and egg extract are widely used by the farmers presently to supplement the nutrient requirement of the crop and also to control some pests and diseases.

Limited information is available regarding the effect of fish jaggery extract and egg extract on crop productivity. Hence, an attempt has been made to review the available information on various liquid organic manures used by farmers.

2.1. LIQUID ORGANIC MANURES AND ITS GENERAL EFFECTS ON CROPS

Liquid organic manures are the fermented products used in organic agriculture as plant growth enhancing substances. They include *Panchagavya*, *Jeevamrutha*, seaweed extract, compost tea, fish jaggery extract etc. which are prepared with the materials available with farmers. They are also believed to contain beneficial microflora, which support and stimulate plant growth and thereby help in getting better yield.

Combination of vermicompost and vermiwash had significant influence on plant growth parameters, biochemical characteristics of soil, soil micronutrients, physical and chemical properties of the soil (Ansari and Sukhraj, 2010).

Gore and Sreenivasa (2011) reported that fermented liquid organic manures contain plant growth promoting substances (IAA, GA), beneficial microbial load, vitamins, essential amino acids and macro and micro nutrients that help in improving plant growth, metabolic activities and resistance to pests and diseases.

2.1.1. Influence of liquid organic manures on production of growth promoting hormones

Kumar *et al.* (2011) reported that there was an increase in the production of growth regulators due to the stimuli created by the presence of IAA and GA in

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Panchagavya and the easy transfer of nutrients through foliar spray. According to Vennila and Jayanthi (2008), water regulation in the developing okra fruits was controlled by the auxin present in vermiwash and *Panchagavya*, which resulted in high crude protein content, Barletts Index and ascorbic acid content.

In soybean, the treatment with *Beejamrutha* improved seed germination, seed vigour and seedling length by the production of IAA and GA by the beneficial microorganisms present in it (Sreenivasa *et al.*, 2009).

Zhang *et al.* (2014) successfully detected and quantified cytokinins present in vermicompost tea, which in turn enhanced the plant growth and development.

A study conducted by Patel *et al.* (2015) revealed that the treatment with seaweed sap along with recommended dose of fertilizers in rice increased the plant height and number of tillers/hill. This positive effect was due to the presence of growth regulators *viz.*, IAA, zeatin, GA and kinetin.

According to Xu (2001), maize plant growth was stimulated by the application of effective microorganism (EM) solution, which contain phytohormones such as auxins and other growth regulators.

Seed treatment of tomato seeds with *Panchagavya* and *Jeevamrutha* enhanced the germination by two folds over control because of the presence of gibberellic acid. Presence of auxins, nucleotides, readily utilizable amino acids, sugars and acids contributed rapid development of shoot, flowers and fruits in tomato plants (Ukale *et al.*, 2016).

2.1.2. Influence of liquid organic manures on crop nutrition

Sundararasu and Jeyasankar (2014) reported that application of vermiwash in brinjal elevated the levels of total soil macro (N, P, K and C) and micronutrients (Fe, Cu, Mg and Zn).

In potato tubers and haulm, the seaweed sap sprays significantly influenced the NPK uptake. The nutrient uptake also increased with increase in

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doses of seaweed sap. Applying 10 per cent *Gracilaria* sap spray + RDF showed the highest uptake of N by tuber and haulm (Dwivedi *et al.*, 2016).

Pramanick *et al.* (2014) found that application of seaweed extract at higher concentrations increased the N, P and K uptake by grains in rice significantly. The treatments receiving 15 per cent *Kappaphycus* sap + RDF and 15 per cent *Gracilaria* sap + RDF and 10 per cent *Kappaphycus* sap + RDF resulted in the highest N and P uptake by grains.

According to Hatti *et al.* (2010) significant increase in the growth and yield of *Vigna mungo*, *Vigna radiata* and *Sesamum indicum* was obtained with vermiwash due to the presence of macro and micro nutrients and organic carbon.

2.1.3. Influence of liquid organic manures on growth, yield, and quality attributes of crops

Several workers reported the effects of liquid organic manures on the growth, yield and quality attributes after their experimentation in various crops such as vegetables, mango, rice groundnut, maize and black gram.

Seedlings of pulses *Vigna radiata, Vigna mungo, Arachis hypogaea, Cyamopsis tetragonoloba, Lablab purpureus, Cicer arietinum* and cereal, *Oryza sativa* var. *ponni* showed an increase in the number of lateral roots, number of leaves, leaf area, nodule formation by *Rhizobium* and a decrease in chlorophyll a/b and C/N ratio by the amendment of soil with *Panchagavya* (1:100 *Panchagavya*: soil). By using seaweed based *Panchagavya* at the same concentration, the effect was further enhanced (Sangeetha and Thevanathan, 2010).

Mohan (2008) conducted a study in brinjal (*Solanum melonogena)* and tomato *(Lycopersicon esculentum*) to compare the effects of *Panchagavya*, Amritpani and Bokashi (made using Effective Microorganisms (EM) technology). Lower glycol alkaloid content and higher yield were found in bokashi treated crops, followed by *Panchagavya*. The study also revealed that the most cost-effective growth promoter was *Panchagavya* followed by Amritpani and Bokashi. According to Sundararasu and Jeyasankar (2014), application of vermiwash

improved the parameters like plant height, number of leaves, number of flowers, flowering and fruiting ratio and fruits per plant in brinjal.

Latique *et al.* (2013) reported that application of lower concentrations of *Fucus spiralis* and *Ulva rigida* extracts (25 per cent) improved the vegetative growth, shoot length and root length in bean plant (*Phaseolus vulgaris* c. v. paulista). Vijayanand *et al.* (2014) noticed that *Sargassum wightii* liquid extract at low concentration (1.5 per cent) showed increase in growth and yield parameters and biochemical characteristics of cluster bean. Application of FYM, *Panchagavya* and *Jeevamrutha* improved the growth and yield of French bean. Application of manures resulted in better availability of nutrients, increased the beneficial microbes and growth promoting substances (Kumbar *et al.*, 2015).

Ashiya and Tank (2015) observed that stones of mango treated with 3 per cent *Panchâgavya* for 3 hours showed more number of lateral roots per rootstock and maximum dry weight. This treatment was on par with GA3 100 ppm for 10 minutes and cow dung for 24 hours.

According to Srimathi *et al.* (2013), the highest invigoration effect was obtained with *Panchagavya* at 2 and 5 per cent fortification of *Jatropha curcas* and *Pongamia pinnata* seeds for 16 and 8 hours respectively after soaking.

Iwaishi (2001) noticed that inoculation with effective microorganism in rice resulted in increased kernel enlargement, ear number, length and kernel number, glutinousness and the total quality index of glutinous rice varieties. It was also found that EM inoculated brown rice yielded more than the standard fertilizer rate.

Vennila and Jayanthi (2008) found that *Panchagavya* spray @ 2 per cent along with recommended dose of fertilizers (100 per cent) increased the growth and yield attributing characters, fruit yield and quality in okra. According to Rajesh and Jayakumar (2013), foliar spray of 3 per cent *Panchagavya* in *Abelmoschus esculentus* (L.) Moench resulted in an increase in the morphological parameters such as plant height, number of leaves, fresh weight and dry weight. It

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was also observed that biochemical contents and photosynthetic pigments also increased with the *Panchagavya* spray. According to Elumalai *et al.* (2013), foliar application of vermiwash 15 per cent increased the plant height, number of leaves, length and diameter of the internode, root length, fresh and dry weight of okra. The highest yield attributing characters and yield with highest economic returns in okra was recorded with 3 to 4 sprays of vermiwash at 30 DAS at weekly intervals with recommended dose of N, P and K fertilizers or vermicompost @ 5 t ha^{-1} Leaves could directly absorb vermiwash, which contributed humic acid and effective micro organisms and thereby promoted the yield (Latha *et al.*, 2014).

In groundnut, foliar application of *Panchagavya* + neem leaf extract resulted in increased chlorophyll content, root nodule weight, nutrient content and uptake, LAI, yield attributes, harvest index and yield (Kumawat *et al.*, 2009). According to Poorni *et al.* (2013), application of 6 per cent vermiwash in *Arachis hypogaea* resulted in increased physical parameters like root length, shoot length, number of leaves, biomass and chemical parameters in ground nut. Choudhary *et al.* (2014) found that at branching and flowering stages of ground nut, application of foliar spray of *Panchagavya* + neem leaf extract resulted in an increase in number of nodules, nutrient uptake, yield parameters, yield and quality of ground nut.

Spraying of vermiwash in tomato showed a significant increase in shoot length and number of leaves per plant. Vermiwash alone as well as in combination with vermicompost applied to the plants resulted in an increase in shoot length of 19.72±0.30 cm and 19.61±0.18 cm respectively as compared to the control (17.92±0.21 cm) (Samadhiya *et al.*, 2013). In tomato plants, foliar application of 20 per cent seaweed (*Sargasssum crassifolium*) extract increased the fruit number, shoot dry weight, root dry weight, fruit yield per hectare, total soluble solids and total acidity (Sutharsan *et al.*, 2014).

Abou-El-Hassan *et al.* (2014) reported that the use of 100 per cent and 125 per cent compost with the addition of plant growth promoting rhizobacteria or

compost tea had a positive effect on vegetative growth, nutritional content and yield of cucumber plants. The highest length of vine, number of leaves, number, weight and volume of fruits and yield in cucumber were reported with the application of 20 weeks old *Jeevamrutham* (Rameeza, 2016).

Ansari (2008) reported the positive effect of vermiwash on two crops *viz*., onion and spinach. The yield of onion and spinach was significantly higher in plots treated with vermiwash 10 per cent and 5 per cent respectively. In the case of average weight of onion bulbs, the highest value was in plots amended with vermicompost and 5 per cent vermiwash.

Four sprays of three per cent *Panchagavya* at 15, 25, 35 and 45 days after sowing along with entire dose of recommended fertilizers (100 per cent) showed higher yield attributes, yield and economics in baby corn (Vimalendran and Wahab, 2013).

Chandrakala (2008) noticed that the combined application of *Panchagavya*, *Jeevamrutha* and *Beejamrutha* significantly improved the growth, yield and quality of chilli. According to Gopakkali and Sharanappa (2014), available N, P and K, organic carbon and microbial population in soil were enhanced with enriched biodigested liquid manure (EBDLM) at 125 kg N equivalent/ha + 3 sprays of *Panchagavya* (3 per cent). Higher yield attributes, yield, biochemical parameters were also obtained for chilli in this experiment.

Study conducted by Uppar and Rayar (2014) in mulberry revealed that application of vermiwash @ 5 per cent significantly increased the leaf number, plant growth and biochemical constituents (chlorophyll, total sugar, crude protein content), which stimulated silkworm growth, cocoon and silk traits.

Hatti *et al.* (2010) observed that application of vermiwash in *Vigna mungo*, *Vigna radiata* and *Sesamum indicum* resulted in an increase in growth, root length, shoot length, number of leaves, flowers, biomass and induced early flowering. According to Kumar *et al.* (2011), foliar spray of 3 per cent *Panchagavya* at 15^{th}, 25^{th}, 35^{th} and 45^{th} days of interval in black gram resulted in

higher yield attributes, such as number of pods per plant, number of seeds per pod, test weight, growth and yield. Jaybhaye and Bhalerao (2015) found that seed germination and growth of seedling was more in green gram (*Vigna radiata* L.) and black gram (*Vigna mungo* L.) at lower concentration of vermiwash (10 per cent) compared to 20 and 30 per cent, and as the concentration of vermiwash increased the germination percentage also increased.

2.1.4. Influence of liquid organic manures on microbial activity

Naturally occurring beneficial microorganisms, predominantly bacteria, yeast, actinomycetes and certain fungi were reported in organic liquid manures by Sreenivasa *et al.* (2009).

The highest population of total bacteria (22×10^9 cfu ml^{-1}), actinomycetes (60×10^4 cfu ml^{-1}), phosphate solubilizers (103×10^6 cfu ml^{-1}), fluorescent pseudomonas (151×10^5 cfu ml^{-1}), nitrifiers (5.4×10^6 cfu ml^{-1}) was observed in *Panchagavya*. The dehydrogenase activity (6.61 µg g^{-1} h^{-1}) and microbial biomass carbon (89.6 µg g^{-1}) were also higher in *Panchagavya* when compared to vermicompost and FYM (Amalraj *et al.*, 2013).

Devakumar *et al.* (2014) noticed higher colony forming units on the day of preparation of *Beejamrutha* and between 9^{th} and 12^{th} day after preparation of *Jeevamrutha*. He opined that *Jeevamrutha* is an enriched consortia of native soil microorganisms, which contain higher number of bacteria, N-fixers and fungi.

According to Zambare *et al.* (2008), vermiwash contains nitrogen-fixing bacteria like *Azotobacter* sp., *Agrobacterium* sp. and *Rhizobium* sp. and some phosphate solublizing bacteria.

Rameeza (2016) observed the highest microbial population (bacteria, fungi and actinomycetes) in soil in the treatment receiving 20 weeks old *Jeevamrutha*m (100 per cent) in cucumber.

2.1.5. Influence of liquid organic manures in controlling pests and diseases

Vallimayil and Sekar (2012) reported that the treatment with *Panchagavya* on southern sunhemp mosaic virus infected plants resulted in lesser viral intensity and better growth than the control. A study conducted by Jandaik and Sharma (2016) revealed that *Panchagavya* showed antifungal activity against three pathogens *viz.*, *Fusarium oxysporium*, *Rhizoctonia solani* and *Sclerotium rolfsii.*

According to Reddy *et al.* (1996), an organic formulation, Maha panchagavya (MPG) was highly effective in controlling tomato wilt. Maha panchagavya was also reported to be effective in suppressing the panama wilt of banana caused by *Fusarium oxysporum* f. sp. *cubense* (Jahagirdhar *et al.*, 2001). Sugha (2005) conducted an *in vitro* study on the effectiveness of Maha panchagavya against five soil borne pathogens *i.e.*, *Rhizoctonia solani, Scierotium rolfsii, Fusarium solani, Scierotinia scierotiorum*, *Phytophthora colocasiae* and found that it was highly toxic to the pathogens. It was very effective in controlling damping-off in the nursery bed of cauliflower seedlings.

Kumar *et al.* (2010) observed the effectiveness of Maha panchagavya in inhibiting the growth of pathogen, *Pythium aphanidermatum*. In the nursery beds of tomato, soil application of 10 per cent Maha panchagavya resulted in 48.27 per cent disease control and enhanced the seedling stand. Maximum increase in seedling height and complete control of damping-off resulted from a combination of Maha panchagavya, neem cake and neem leaf extract.

Bahadur *et al.* (2007) reported that foliar spray of two strains of plant growth promoting rhizobacteria (PGPR), *viz.*, *Pseudomonas fluorescens* (Pf4) and *P. aeruginosa* (Pag) reduced the conidial germination of powdery mildew pathogen *Erysiphe pisi* on pea (*Pisum sativum*).

George *et al.* (2007) recorded lower mite and thrips population by application of vermicompost (2.5 t ha^{-1}) with six sprays of vermiwash (1:1) in chilli.

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Aphid population in mustard could be effectively reduced without any harm on coccinellid predators using neem (leaf and kernel extract) + cow urine combination (Gupta, 2005).

Rakesh *et al.* (2013) reported that cow urine extracts of selected plants (*Elaegnus kologa, Artocarpus lakoocha*, *Hemidesmus indicus, Croton roxburghii* and *Maesa indica*) could inhibit the rhizome rot pathogens in ginger.

Mallinath and Biradar (2015) recorded lower thrips population in onion when treated with vermiwash (1: 5) and *Jeevamrutha* @ 2 per cent, which were on par with insecticide treatment.

Foliar spray of *Panchagavya* (5 per cent) + fermented cow urine (5 per cent) at 15 days interval on bell pepper resulted in maximum 87.02 per cent control of *Phytophthora* blight followed by anthracnose (85.22 per cent). Drenching with the solution gave the maximum control on soil borne diseases *viz.*, stem rot, fusarium wilt and root rot (Ashlesha and Paul, 2014).

Kumar *et al.* (2015) reported that application of 7 per cent diluted *Panchagavya* in teak (*Tectona grandis*) controlled teak defoliators, skeletonizers, ground hopper and mealy bug effectively. After the treatment, there was an increase in the population of predatory spider, *Oxyopes* spp.

Vermiwash and cow urine at 50 per cent concentration in brinjal reduced the incidence of shoot and fruit borer (*Leucinodes orbonalis* Guen.) and sucking pests (leaf hopper, *Amrasca biguttula biguttula* (Ishida); whitefly, *Bemisia tabaci* Genn.; aphid, *Aphis gossypii* Glover) in brinjal (Karkar *et al.*, 2014).

Garima and Ram (2006) found that in soybean, application of lower concentration of cow urine (15, 10 and 5 per cent) significantly reduced Girdle beetle (*Obereopsis brevis*) infestation. Higher concentrations of cow urine (75 and 100 per cent) lowered the infestation of stem fly (*Melanagromyza sozae*) and stem tunnelling was reduced in almost all concentrations of cow urine.

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2.2. EGG EXTRACT

There is limited information on the use of egg extract and its effects on soil health and crop productivity. Alagesan *et al.* (2009) noticed that application of egg lime mix with *Panchagavya* (40: 40) in tomato increased the plant height, leaf area and number, chlorophyll content, fruit number and weight compared to the lower concentrations and control.

2.3. FISH JAGGERY EXTRACT

Vemaraju (2014) observed that application of fish amino acid as foliar spray resulted in maximum length of vine and highest number of leaves at 45 DAS, early flowering and harvest and maximum shelf life in oriental pickling melon. The highest score for appearance, colour, flavour, texture, odour and taste for the fruits was obtained in the study.

Murray and Anderson (2004) reported that the application of fish emulsion increased the seedling growth and dry weight of tomato and pepper transplants.

Foliar spray of fish jaggery extract induced early flowering *i.e.* at 27 DAS as against 47 DAS in absolute control and early harvesting of cucumber fruits. It produced quality fruits with a maximum shelf life of nine days (Krishnan, 2014).

According to Weinert *et al.* (2014) incorporation of fish amino acid in soil increased nitrogen availability and improved the crop yield. Abbasi *et al.* (2003) reported that foliar sprays of fish emulsion (0.5 per cent) reduced the severity of bacterial spot of tomato and bell pepper when they were inoculated with *Xanthomonas campestris* pv. *vesicatoria*.

Application of fish soluble resulted in higher growth and yield compared to control in tomato (Aung and Flick, 1980). Abbasi *et al.* (2006) reported that 0.5 per cent fish emulsion controlled soil borne diseases of eggplant such as verticillium wilt [*Verticillium dahliae* and *V.albo-atrum*] and 1 per cent fish emulsion controlled potato scab [*Streptomyces* spp.] in potato. In the green house,

soil amendment with 1 per cent fish emulsion increased the fresh and dry weight of brinjal and also increased the number and yield of scab free tubers.

Foliar spray of fish amino acid in leafy vegetables resulted in good taste and higher yield (Pline- Brown and Davis, 2007).

Fish emulsion, when used as the nutrient source for the growth of bacteria and actinomycetes, promoted the growth of radish in a study conducted by El-Tarabily *et al.* (2003). Foliar spraying and soil drenching of fish amino acid (5%) controlled stem rot caused by *Pythium* in vegetable cowpea (Anees and Gokulapalan, 2014).

Application of Gunapaselam (liquid fermented fish waste) in brinjal, affected the soil as well as plant parameters. It decreased the soil pH, increased the organic matter, N, P and K, leaf area, plant height and stem diameter. Study on the anatomy of the stem revealed that the thickness of phloem and xylem conducting tissues were increased in Gunapaselam applied plants (Balraj *et al.*, 2014). Vincent *et al.* (2014) isolated and characterized the microorganisms present in the fermented fish waste (Gunapaselam) and reported the presence of ammonifiers, nitrifiers and phosphate solubilizers in the solution.

Hepsibha and Geetha (2017a) conducted an *in vitro* study on the germination of green gram at varying levels of Gunapaselam. It was found that, higher concentration of Gunapaselam (1:25) was toxic, but at higher dilutions (1:50, 75 and 100) it increased the growth attributes like leaf, shoot and root formation, pigments and protein content in the plant. According to Srikumaran *et al.* (2017), foliar spray of Gunapaselam at different concentrations (5, 10 and 15%) had a significant effect on the growth and yield of okra. Gunapaselam 10% spray showed the highest plant height, shoot length, length and diameter of internodes and number of leaves. Application of Gunapaselam in green gram improved the soil parameters like organic carbon, macro (N, P and K) and micro (Fe, Mn, Zn etc.) nutrients and increased the plant height and number of nodules

per plant. It was also noticed that, the Gunapaselam applied soil had the highest population of rhizobacteria and *Rhizobium* (Hepsibha and Geetha, 2017b).

Liquid organic manures are widely used in organic farming to supply the nutrients as well as to prevent the attack of pests and diseases. Though liquid formulations like *Panchagavya, Jeevamrutha*, fish jaggery extract and egg extract are widely used by the farmers, there is lack of scientific validation. There is dearth of research findings regarding the effect of fish jaggery extract and egg extract. Hence the study regarding other liquid organic manures was reviewed in this chapter with the available research data.

Materials & Methods

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3. MATERIALS AND METHODS

The present study entitled "Validation of liquid organic manures and their effect on crop productivity" was carried out at the College of Horticulture, Kerala Agricultural University, Vellanikkara, Thrissur during 2016-2017. The work was carried out as two experiments. The methods employed and the materials used for this study are briefly mentioned in this chapter.

3.1. Experiment I

Influence of shelf life on the quality of fish jaggery extract and egg extract

Fish jaggery extract

Fish jaggery extract was prepared by mixing 1 kg sardine fish and 1 kg jaggery in an airtight container. Fish was cut into pieces and powdered jaggery was put in alternate layers and kept for 21 days.

Egg extract

For egg extract preparation, 10 eggs (with shell) were taken in an airtight container and lime juice was poured to cover the eggs. It was kept for 10 days and then 250 g jaggery (powdered) was added and kept for 10 more days.

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 during April - October, 2016.

3.1.3. Methods

Fish jaggery extract and egg extract were stored in air tight plastic containers for different periods and the quality analysis was done.

Technical programme

Design : CRD

Treatment : 11

Replications : 3

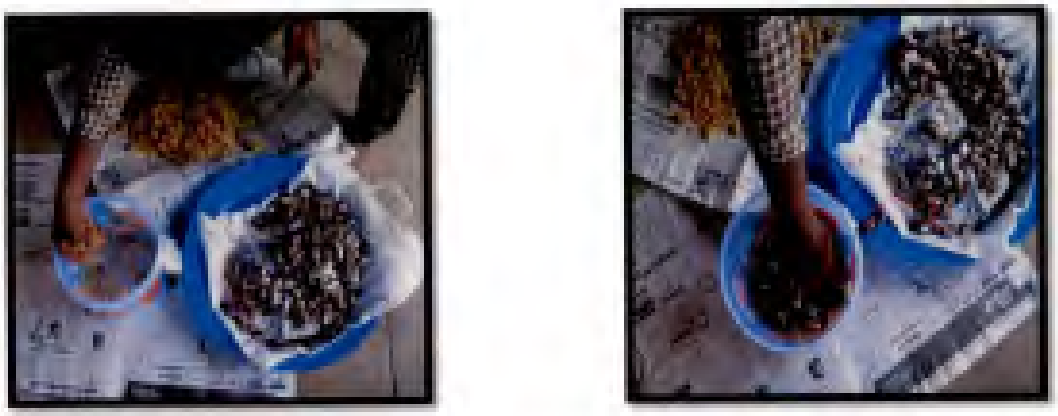

Plate 1. Preparation of fish jaggery extract

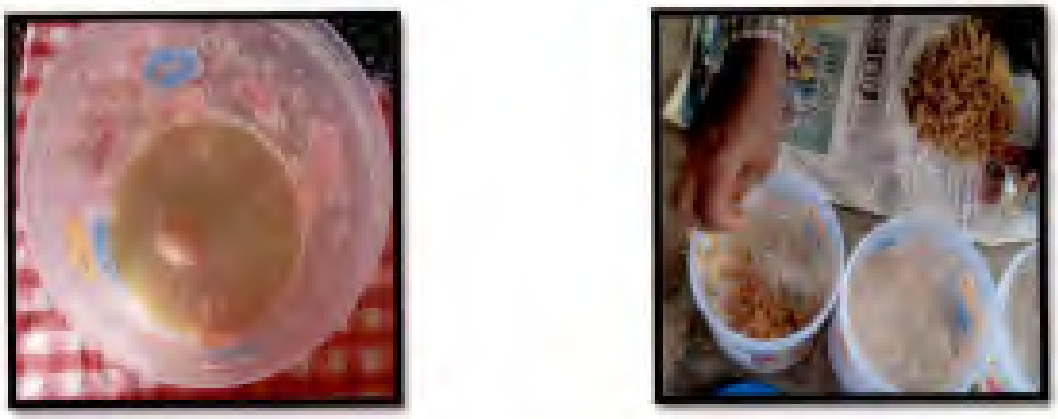

Plate 2. Preparation of egg extract

Plate 3. Storage of liquid organic manures

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Treatments

T_1 - Fresh preparation (21 days old)

T_2 - 1 week old preparation

T_3 - 2 weeks old preparation

T_4 - 4 weeks old preparation

T_5 -6 weeks old preparation

T_6 - 8 weeks old preparation

T_7 - 10 weeks old preparation

T_8 - 12 weeks old preparation

T_9 - 16 weeks old preparation

T_{10} -20 weeks old preparation

T_{11} -24 weeks old preparation

3.1.4. Observations

Colour

Visual evaluation of change in the colour of liquid organic manures was done during different storage periods.

Odour

The change in the odour of liquid organic manures during different storage periods were done by sensory evaluation.

Mould growth

Visual observation of surface mould growth in liquid organic manures was done.

pH

The pH of the liquid organic manures was estimated by using 1: 2.5 ratio Beckman glass electrode method (Jackson, 1958).

Electrical conductivity

Conductometric method (Jackson, 1958) was used to measure the electrical conductivity of the liquid organic manures.

Nutrient content

The two liquid organic manures were analysed to find out the total macro (N, P and K), secondary (Ca, Mg and S) and micro nutrients (Fe, Mn, Zn and Cu) using standard analytical methods as furnished in Table 1.

Table 1. Analytical method used for the chemical characterisation of liquid organic manures

Sl. No.	Estimated characters	Method used	References
1	Total N	Microkjeldahl 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	Diacid 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	Chesnin and Yein, 1951
7	Total Micronutrients	Diacid method using Atomic Absorption Spectrophotometer	Jackson, 1958

Organic carbon

Loss on ignition, which is an index of organic matter contained in the manure was done to find out the organic carbon content in liquid organic manures (Ball, 1964).

Protein content

Protein content in the fresh preparation and best treatments was analyzed using Lowry's method (Lowry *et al.*, 1951).

Amino acid content

Amino acid content in fresh preparation and best treatments was analysed using paper chromatography.

Microbial population

The total microbial population (bacteria, fungi, actinomycetes and *Escherichia coli*) of the liquid organic manures during different storage periods were enumerated. Serial dilution and plate count technique with appropriate medium (Agarwal and Hasija, 1986) was adopted for the enumeration. The media used were nutrient agar for bacteria (10^{-2}), potato dextrose agar for fungi (10^{-3}), Kenknight and Munaier's agar for actinomycetes (10^{-3}) and eosine methylene blue agar for *E. coli* (10^{2}) and the plates were incubated at 28 ± 2^{0} C.

Maggot population

Visual observation of the presence of maggots was done.

3.2. Experiment II

Effect of fish jaggery extract and egg extract on the growth and yield of okra

3.2.1. Experimental site

The experiment was conducted at Plant Protection and Nursery Management Unit (PPNMU), Kerala Agricultural University, Vellanikkara. The site is situated at 10°31' N latitude, and 76°13'E longitude and at an altitude of 40.3 m above MSL.

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3.2.2. Soil

Soil of the experimental area is classified as sandy clay loam (taxonomical order: Ultisol). The physico-chemical properties of the soil are furnished in Table 2.

Table 2. Physico-chemical properties of the soil

Particulars	Content	Method used
Physical properties		
Particle size composition		Robinson international pipette method (Piper, 1966)
Coarse sand (%)	31.90	
Fine sand (%)	27.30	
Silt (%)	18.64	
Clay (%)	22.16	
Chemical properties		
pH	6.18	1:2.5 soil water suspension – pH meter (Jackson, 1958)
Organic carbon (%)	0.84	Walkley and Black method (Jackson, 1958)
Available N (kg ha^{-1})	188.16	Alkaline permanganate method (Subbiah and Asijah, 1956)
Available P (kg ha^{-1})	28.61	Ascorbic acid reduced molybdo phosphoric blue colour method (Watnabe and Olsen, 1965)
Available K (kg ha^{-1})	446.09	Neutral normal ammonium acetate extractant flamephotometry (Jackson, 1958)

3.2.3. Climate

The meteorological data during the period of investigation is given in Appendix I.

3.2.4. Season of the experiment

The field trial on 'Validation of liquid organic manures and their effect on crop productivity' was conducted during January to April, 2017.

3.2.5. Crop and variety

Okra (Variety : Arka Anamika) was used for the field experiment. The plants are tall and well branched with green stem having purple shade. Long pods are green in colour. Green colour fruits, 110 days duration and yellow vein mosaic virus resistance are the uniqueness of the variety.

3.2.6. METHODS

Technical programme

Design : RBD

Treatments : 10

Replications : 3

Spacing : 60 cm × 30 cm

Plot size : 3.6 m × 3 m

Treatments

The best two treatments of fish jaggery extract and egg extract were selected based on the shelf life study (Experiment I). Both soil and foliar application were compared with water spray and standard POPR, KAU. Soil application was done at 20 DAS and foliar spray at fortnightly intervals (5 sprays).

T_1: 2 weeks old fish jaggery extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_2: 4 weeks old fish jaggery extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_3: 2 weeks old fish jaggery extract @ 0.2% (Foliar spray at fortnightly intervals)

T_4: 4 weeks old fish jaggery extract @ 0.2% (Foliar spray at fortnightly intervals)

T_5:4 weeks old egg extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_6: 6 weeks old egg extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_7: 4 weeks old egg extract @ 0.2% (Foliar spray at fortnightly intervals)

T_8: 6 weeks old egg extract @ 0.2% (Foliar spray at fortnightly intervals)

T_9: Water spray

T_{10}: Raising crop adopting Package of Practices Recommendations, KAU

Cultural operations

The experimental site was initially ploughed using a cultivator. After levelling the field, furrows of 30 cm width were taken at a spacing of 60 cm.

Seeds were soaked in a solution containing both *Pseudomonas* sp. (1 %) and cow dung (10 %) for 6 hours. Dibbling was done with pre- soaked okra seeds uniformly in the furrows at a spacing of 30 cm. To secure a uniform stand of the crop, gap filling was done at 10 DAS using the seedlings raised in the protrays.

All the management practices (except in T_{10}) were done as per the Package of Practices Recommendations (*Ad hoc*) for organic farming: Crops (KAU, 2009). Lime was applied uniformly to all the plots one week before sowing @ 500 kg ha^{-1}. Cowdung @ 10 t ha^{-1}along with fertilizers (55:35:70 kg ha^{-1} NPK) was applied in T_{10} as the basal dose. In the remaining treatments, poultry manure @ 6 t $ha^{-1}$and coir pith compost @ 9 t ha^{-1}were applied.

Nitrogen (55 kg ha^{-1}) was applied for T_{10}, whereas neem cake @ 400 kg ha^{-1}, groundnut cake @ 400 kg ha^{-1} and bone meal @ 150 kg ha^{-1} were applied as top dressing 30 DAS in the remaining treatments. Soil application of fresh cowdung slurry @ 1 kg per 10 litres of water was done at fortnightly intervals.

Irrigation was given daily in the growing season, and later it was extended to once in two days towards the end. Weeding was done as and when required uniformly to all the treatments.

Liquid organic formulations were applied as per the technical programme (as soil application at 20 DAS and foliar spray at fortnightly intervals from 20 DAS)

Plate 4. Field operations

Field preparation

Manuring

Sowing

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The layout plan of Experiment II is given in Fig. 1.

T_8	T_1	T_5	T_7	T_{10}	R_1
T_4	T_9	T_2	T_3	T_6	
T_1	T_8	T_7	T_{10}	T_5	R_2
T_2	T_4	T_6	T_9	T_3	
T_3	T_8	T_{10}	T_5	T_1	R_3
T_7	T_6	T_2	T_9	T_4	

Fig.1. Layout plan of experimental field

T_1: 2 weeks old fish jaggery extract @ 10% (Soil application at 20 DAS @1L/plant)

T_2: 4 weeks old fish jaggery extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_3: 2 weeks old fish jaggery extract @ 0.2% (Foliar spray at fortnightly intervals)

T_4: 4 weeks old fish jaggery extract @ 0.2% (Foliar spray at fortnightly intervals)

T_5:4 weeks old egg extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_6: 6 weeks old egg extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_7: 4 weeks old egg extract @ 0.2% (Foliar spray at fortnightly intervals)

T_8: 6 weeks old egg extract @ 0.2% (Foliar spray at fortnightly intervals)

T_9: Water spray

T_{10}: Raising crop adopting Package of Practices Recommendations, KAU

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

Plate 6. General view of experimental field

3.2.7. Observations on soil

Soil pH, EC, organic carbon, available N, P, K and total microbial count (bacteria, fungi and actinomycetes) were determined before and after the experiment. From each experimental plot, soil samples were collected before and after the experiment. Samples were shade dried and sieved before analysis. For the estimation of macro nutrients, soil was passed through 2 mm sieve and for organic carbon 0.5 mm sieve was used. The analysis was conducted using appropriate methods given in Table 2 and 3.

Table 3. Media used for enumeration of microorganisms in soil

Sl. No.	Microbes	Dilution for plating	Medium used	References
1	Bacteria	10^{-4}	Nutrient agar Soil extract agar	Agarwal and Hasija, 1986
2	Fungi	10^{-3}	Martin's Rose Bengal agar Potato dextrose agar	
3	Actinomycetes	10^{-4}	Kenknight and Munaier's agar	

3.2.8. Biometric observations

Five plants from each plot were selected at random and labelled. Biometric observations of these plants at 30 and 60 DAS were recorded and the average was worked out.

Plant height (cm)

Plant height was measured from the base of the plant to the tip of the growing point at 30 DAS and 60 DAS.

Number of leaves per plant

At 30 DAS and 60 DAS, the total number of green leaves produced was recorded in each plot.

Days to 1st flowering

Number of days taken to 1st flowering from the date of sowing was noted.

Days to 1st harvest

Number of days to 1st harvest of green fruits from the date of sowing was recorded.

Number of harvests

Total number of harvests from each plot was recorded.

Duration of the crop

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

Total dry matter production (t ha^{-1})

Three plants were uprooted from each plot and oven dried at 80^0 C. Weight of the biomass produced was recorded and expressed on per hectare basis.

3.2.9. Observations on yield and yield attributes

Number of fruits per plant

Total number of fruits produced per plant was noted and the mean was determined.

Plate 7. Different growth stages of crop

Germination

10 DAS

30 DAS

Flowering

Fruiting

60 DAS

Weight of fruits per plant (g)

The weight of fruits produced per plant from each plot was recorded and the mean was calculated.

Number of seeds per pod

The number of seeds produced per pod was counted and the mean was calculated.

Yield per hectare (t ha^{-1})

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

Seed weight (g)

Hundred seed weight of each treatment was found out.

Shelf life (days)

Ten fruits of okra were harvested and kept in ambient conditions for checking the shelf life of fruits. When the fruits started shrivelling, the observations were taken.

3.2.10. Incidence of pests and diseases

Pests and disease incidence in the field was observed visually and noted.

3.2.11. B: C Ratio

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

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

3.2.12. Statistical analysis

Data relating to different observations were compiled, tabulated and subjected to statistical analysis by applying the technique of analysis of variance

using the statistical package WASP 2.0 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).

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

Results

4. RESULTS

The results of the study on 'Validation of liquid organic manures and their effect on crop productivity' are presented below after statistical analysis.

4.1. Experiment I

Influence of shelf life on the quality of fish jaggery extract and egg extract

4.1.1. Colour

Freshly prepared fish jaggery extract was light brown in colour and it changed to dark brown from the sixth week of storage onwards till the end.

Colour of the fresh preparation of egg extract was cream and became light yellow from the second week of storage onwards. The colour became dark yellow as the storage period progressed.

4.1.2. Odour

Fish jaggery extract had a fruity smell up to the storage period of ten weeks and changed to mild foul smell up to sixteen weeks and to stronger foul smell later.

Egg extract gave mild rotten lemon smell up to 12^{th} week after preparation and later the smell became stronger.

4.1.3. Mould growth

Mould growth was noticed in the fresh preparation and afterwards it reduced.

No mould growth could be observed in the case of egg extract throughout the storage period.

4.1.4. pH

The pH during different storage periods of fish jaggery extract and egg extract are given in Table 4. Both the manures were highly acidic and there was no significant variation among the treatments. Fresh preparation of fish jaggery

extract had a pH of 3.27. During storage, pH was found to be stable with a range of 3.05-3.33.

The fresh preparation of egg extract had a pH of 2.89 and the range was 2.89-4.88.

4.1.5. Electrical Conductivity

The electrical conductivity at different storage periods of fish jaggery extract and egg extract is presented in Table 4. There was no significant difference due to storage in EC. The fresh preparation of fish jaggery extract had an EC of 0.12 dS m^{-1}. The range of EC was 0.12-0.14 dS m^{-1}.

Fresh preparation of egg extract had an EC of 0.06 dS m^{-1}. At the end of storage period, the manure showed a value of 0.08 dS m^{-1}.

4.1.6. Organic carbon

The organic carbon content of fish jaggery extract and egg extract are presented in Table 5. The fresh preparation of fish jaggery extract showed the lowest organic carbon content (41.79 per cent). The highest value of 55.03 per cent was observed in 12 weeks old preparation, which was on par with 16 weeks old preparation (54.59 %).

In egg extract, there was no significant difference in organic carbon content among the treatments. The values ranged from 56.56 to 57.03 per cent.

Table 4. pH and EC of liquid organic manures during storage

Treatments		pH		EC (dS m^{-1})	
		Fish jaggery extract	Egg extract	Fish jaggery extract	Egg extract
T_1	Fresh	3.27[a]	2.89[a]	0.12[a]	0.06[a]
T_2	1 WOP	3.11[a]	3.14[a]	0.14[a]	0.07[a]
T_3	2 WOP	3.05[a]	3.46[a]	0.14[a]	0.07[a]
T_4	4 WOP	3.30[a]	4.60[a]	0.13[a]	0.06[a]
T_5	6 WOP	3.22[a]	4.56[a]	0.13[a]	0.06[a]
T_6	8 WOP	3.33[a]	4.83[a]	0.12[a]	0.06[a]
T_7	10 WOP	3.24[a]	4.77[a]	0.12[a]	0.06[a]
T_8	12 WOP	3.20[a]	4.70[a]	0.12[a]	0.05[a]
T_9	16 WOP	3.29[a]	4.88[a]	0.13[a]	0.06[a]
T_{10}	20 WOP	3.16[a]	4.68[a]	0.13[a]	0.07[a]
T_{11}	24 WOP	3.16[a]	3.61[a]	0.12[a]	0.08[a]

- In a column, means followed by common letters do not differ significantly at 5% level in DMRT
- WOP – Weeks Old Preparation

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Table 5. Organic carbon content of liquid organic manures during storage

Treatments		Organic carbon (%)	
		Fish jaggery extract	Egg extract
T_1	Fresh	41.79[d]	57.24[a]
T_2	1 WOP	41.91[d]	57.03[a]
T_3	2 WOP	42.73[d]	56.56[a]
T_4	4 WOP	52.85[b]	57.04[a]
T_5	6 WOP	51.80[b]	57.24[a]
T_6	8 WOP	52.39[b]	57.16[a]
T_7	10 WOP	52.78[b]	56.88[a]
T_8	12 WOP	55.03[a]	57.05[a]
T_9	16 WOP	54.59[a]	56.73[a]
T_{10}	20 WOP	50.26[c]	57.03[a]
T_{11}	24 WOP	49.84[c]	56.86[a]

- In a column, means followed by common letters do not differ significantly at 5% level in DMRT
- WOP – Weeks Old Preparation

4.1.7. Nutrient content

4.1.7.1. Macronutrients

The data pertaining to total nitrogen, phosphorus and potassium content of liquid organic manures are furnished in Table 6. There was no significant variation in the content due to storage of liquid organic manures. The values of N ranged from 0.81-1.46 per cent in fish jaggery extract and 0.57-0.68 per cent in egg extract. In fish jaggery extract, the P content varied from 860-990 ppm and in egg extract 110-140 ppm. The range of K was 0.50-0.69 per cent in fish jaggery extract and 0.23-0.30 per cent in egg extract.

Table 7 shows the contents of secondary nutrients in fish jaggery extract and egg extract during storage. Different treatments did not impart significant effect on calcium, magnesium and sulphur contents. In the case of fish jaggery extract, the range of Ca, Mg and S were 1161-1290 ppm, 129-134 ppm and 1090-1150 ppm respectively. In egg extract, the corresponding values were 1139-1367 ppm, 117-126 ppm and 560-690 ppm.

4.1.7.2. Micronutrients

Data pertaining to the micronutrient content of fish jaggery extract and egg extract are given in Table 8. The storage time had no significant effect on the micronutrient content. Iron content in fish jaggery extract ranged from 41.75-49.55 ppm. In the case of egg extract, iron content was absent in some of the treatments (10 weeks and 12 weeks old preparation). The Zn content ranged from 13.03-22.68 ppm in fish jaggery extract and .5.10-7.03 ppm in egg extract. In fish jaggery extract, the Mn content varied from 2.25-2.88 ppm and in egg extract, 1.03-1.73 ppm.

Copper was absent in both the liquid organic manures.

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Table 6. Nitrogen, phosphorus and potassium content of liquid organic manures during storage

Treatments		N (%)		P (ppm)		K (%)	
		Fish jaggery extract	Egg extract	Fish jaggery extract	Egg extract	Fish jaggery extract	Egg extract
T_1	Fresh	1.04[a]	0.58[a]	960[a]	140[a]	0.59[a]	0.23[a]
T_2	1 WOP	0.81[a]	0.68[a]	970[a]	130[a]	0.61[a]	0.29[a]
T_3	2 WOP	1.14[a]	0.58[a]	980[a]	110[a]	0.69[a]	0.29[a]
T_4	4 WOP	1.34[a]	0.59[a]	860[a]	120[a]	0.60[a]	0.28[a]
T_5	6 WOP	0.96[a]	0.61[a]	960[a]	110[a]	0.55[a]	0.23[a]
T_6	8 WOP	1.10[a]	0.62[a]	890[a]	130[a]	0.68[a]	0.30[a]
T_7	10 WOP	0.96[a]	0.64[a]	990[a]	140[a]	0.59[a]	0.30[a]
T_8	12 WOP	0.99[a]	0.57[a]	890[a]	120[a]	0.57[a]	0.25[a]
T_9	16 WOP	1.25[a]	0.59[a]	880[a]	130[a]	0.50[a]	0.24[a]
T_{10}	20 WOP	1.40[a]	0.67[a]	950[a]	120[a]	0.65[a]	0.23[a]
T_{11}	24 WOP	1.46[a]	0.59[a]	860[a]	140[a]	0.67[a]	0.25[a]

- In a column, means followed by common letters do not differ significantly at 5% level in DMRT
- WOP – Weeks Old Preparation

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Table 7. Calcium, magnesium and sulphur content of liquid organic manures during storage

Treatments		Ca (ppm)		Mg (ppm)		S (ppm)	
		Fish jaggery extract	Egg extract	Fish jaggery extract	Egg extract	Fish jaggery extract	Egg extract
T_1	Fresh	1187[a]	1256[a]	130[a]	123[a]	1090[a]	630[a]
T_2	1 WOP	1225[a]	1238[a]	133[a]	124[a]	1120[a]	610[a]
T_3	2 WOP	1290[a]	1253[a]	134[a]	123[a]	1150[a]	620[a]
T_4	4 WOP	1221[a]	1139[a]	131[a]	126[a]	1140[a]	680[a]
T_5	6 WOP	1172[a]	1265[a]	130[a]	121[a]	1130[a]	690[a]
T_6	8 WOP	1210[a]	1246[a]	132[a]	121[a]	1090[a]	660[a]
T_7	10 WOP	1259[a]	1187[a]	132[a]	123[a]	1130[a]	560[a]
T_8	12 WOP	1190[a]	1249[a]	129[a]	119[a]	1150[a]	620[a]
T_9	16 WOP	1220[a]	1367[a]	130[a]	122[a]	1120[a]	690[a]
T_{10}	20 WOP	1167[a]	1323[a]	131[a]	117[a]	1150[a]	580[a]
T_{11}	24 WOP	1161[a]	1345[a]	132[a]	122[a]	1100[a]	630[a]

□In a column, means followed by common letters do not differ significantly at 5% level in DMRT

□WOP – Weeks Old Preparation

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Table 8. Iron, zinc and manganese content of liquid organic manures during storage

Treatments		Fish jaggery extract			Egg extract		
		Fe (ppm)	Zn (ppm)	Mn (ppm)	Fe (ppm)	Zn (ppm)	Mn (ppm)
T_1	Fresh	44.90[a]	20.50[a]	2.50[a]	16.95	5.10[a]	1.50[a]
T_2	1 WOP	46.93[a]	13.95[a]	2.35[a]	13.23	6.63[a]	1.20[a]
T_3	2 WOP	42.78[a]	16.73[a]	2.70[a]	14.00	5.90[a]	1.03[a]
T_4	4 WOP	43.03[a]	22.68[a]	2.80[a]	5.93	5.83[a]	1.65[a]
T_5	6 WOP	43.93[a]	14.13[a]	2.45[a]	7.25	6.95[a]	1.15[a]
T_6	8 WOP	41.75[a]	16.10[a]	2.88[a]	7.93	5.10[a]	1.12[a]
T_7	10 WOP	49.55[a]	16.48[a]	2.68[a]	Traces	6.73[a]	1.38[a]
T_8	12 WOP	43.90[a]	13.75[a]	2.25[a]	Traces	7.45[a]	1.73[a]
T_9	16 WOP	49.53[a]	13.03[a]	2.53[a]	0.75	6.68[a]	1.40[a]
T_{10}	20 WOP	48.80[a]	19.48[a]	2.60[a]	0.98	7.03[a]	1.13[a]
T_{11}	24 WOP	44.08[a]	17.43[a]	2.68[a]	9.33	5.95[a]	1.30[a]

□In a column, means followed by common letters do not differ significantly at 5% level in DMRT

□WOP – Weeks Old Preparation

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4.1.8. Microbial population

There were variations in microbial population among the treatments of different storage period for fish jaggery extract and egg extract (Table 9).

In fish jaggery extract, it was noticed that 10 weeks old preparation had the highest bacterial population (27.33 x 10^2 cfu ml^{-1}) and the lowest in 2 and 12 weeks old preparations (3.33 x 10^2 cfu ml^{-1}). Fungal population was found to be the highest in 12 weeks old preparation (10.00 x 10^3 cfu ml^{-1}), while the presence was not detected in fresh preparation of fish jaggery extract.

The highest bacterial and fungal population in egg extract was seen in 6 weeks old preparation *i.e.*, 23.67 x 10^2 cfu ml^{-1} and 27.67 x 10^3 cfu ml^{-1} respectively.

Actinomycetes and *Escherichia coli* were absent in all the treatments of fish jaggery extract and egg extract.

4.1.9. Maggot population

No maggots were noticed in both the liquid organic manures *viz,*. fish jaggery extract and egg extract throughout the storage period.

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Table 9. Population of total bacteria and fungi in liquid organic manures

Treatments		Fish jaggery extract		Egg extract	
		Bacteria ($x10^2$ cfu ml^{-1})	Fungi ($x10^3$ cfu ml^{-1})	Bacteria ($x10^2$ cfu ml^{-1})	Fungi ($x10^3$ cfu ml^{-1})
T_1	Fresh	0.88^{bc} (8.00)	0.00^{c} (0.00)	1.14^{b} (14.33)	0.32^{c} (1.33)
T_2	1 WOP	0.78^{c} (6.33)	0.00^{c} (0.00)	0.73^{cd} (6.00)	0.00^{c} (0.00)
T_3	2 WOP	0.52^{c} (3.33)	0.85^{ab} (6.33)	0.74^{cd} (5.67)	0.00^{c} (0.00)
T_4	4 WOP	1.33^{ab} (22.33)	0.63^{bc} (3.33)	1.18^{b} (15.33)	0.32^{c} (1.33)
T_5	6 WOP	0.87^{bc} (7.67)	0.83^{ab} (7.00)	1.37^{a} (23.67)	1.45^{a} (27.67)
T_6	8 WOP	0.62^{c} (4.33)	0.40^{bc} (1.67)	0.79^{cd} (6.67)	0.86^{b} (6.67)
T_7	10 WOP	1.30^{a} (27.33)	0.72^{bc} (4.33)	0.97^{bc} (10.67)	0.00^{c} (0.00)
T_8	12 WOP	0.43^{c} (3.33)	0.97^{a} (10.00)	0.59^{d} (4.00)	0.89^{b} (7.33)
T_9	16 WOP	0.84^{bc} (9.33)	0.42^{bc} (1.67)	0.82^{cd} (6.67)	0.00^{c} (0.00)
T_{10}	20 WOP	0.80^{c} (6.67)	0.40^{bc} (1.67)	1.21^{b} (16.33)	0.40^{c} (1.67)
T_{11}	24 WOP	0.63^{c} (4.33)	0.42^{bc} (1.67)	0.52^{d} (3.33)	0.00^{c} (0.00)

- In a column, means followed by common letters do not differ significantly at 5% level in DMRT
- WOP – Weeks Old Preparation
- Log transformed values; original values, are given in parenthesis

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4.1.10. Selection of treatments

Arunachalam and Bandyopadhyay (1984) proposed a method of decision making for a number of dependent parameters. All the parameters were analysed statistically and subjected to this method for finding out the best treatments. For both fish jaggery extract and egg extract, scoring was done separately and the treatments receiving the highest rank scores were selected. Table 10 shows the ranking order. The best treatments for the second experiment were selected as 2 weeks old preparation (T_3) and 4 weeks old preparation (T_4) of fish jaggery extract and 4 weeks old preparation (T_4) and 6 weeks old preparation (T_5) of egg extract.

Table 10. Rank of treatments after scoring

Rank	Treatments	
	Fish jaggery extract	**Egg extract**
1	T_3 - 2 WOP	T_4 - 4 WOP
2	T_4 - 4 WOP	T_5 - 6 WOP
3	T_7 -10 WOP	T_{11} -24 WOP
4	T_6 - 8 WOP	T_{10} -20 WOP
5	T_9 - 16 WOP	T_9 - 16 WOP
6	T_2 - 1 WOP	T_6 - 8 WOP
7	T_8 - 12 WOP	T_7 -10 WOP
8	T_5 - 6 WOP	T_3 - 2 WOP
9	T_{10} -20 WOP	T_2 - 1 WOP
10	T_{11} -24 WOP	T_1 - Fresh
11	T_1 - Fresh	T_8 - 12 WOP

*WOP: Week(s) Old Preparation

4.1.11. Protein content

Protein content of fresh preparation of fish jaggery extract and egg extract was 7.04 and 7.65 mg per 100 ml respectively. The best treatments of fish jaggery extract *i.e.*, 2 and 4 weeks old preparations contained 7.20 and 7.58 mg of protein per 100 ml sample respectively. In the case of egg extract, 100 ml of the best treatments (4 and 6 weeks old preparations) contained 16.55 and 24.84 mg of protein respectively (Table 11).

4.1.12. Amino acid content

The fresh as well as the best treatments of fish jaggery extract and egg extract showed the presence of amino acids like alanine, valine, glycine, leucine, serine, histidine, threonine and methionine (Table 11).

Table 11. Protein and amino acid content of fresh preparation and best treatments

Sl. No.	Treatment	Protein (mg 100 ml^{-1})	Amino acids
1.	Egg extract fresh preparation	7.65	Alanine Valine Glycine Leucine Serine Histidine Threonine Methionine
2.	Egg extract 4WOP	16.55	
3.	Egg extract 6WOP	24.84	
4.	Fish jaggery extract fresh preparation	7.04	
5.	Fish jaggery extract 2WOP	7.20	
6.	Fish jaggery extract 4WOP	7.58	

*WOP: Week(s) Old Preparation

4.2. Experiment II

Effect of fish jaggery extract and egg extract on the growth and yield of okra

Based on the results of experiment I (Influence of shelf life on quality of fish jaggery extract and egg extract), two treatments were selected from both fish jaggery extract and egg extract for the conduct of second experiment. The treatments selected were T_3 (2 weeks old) and T_4 (4 weeks old) preparations of fish jaggery extract and T_4 (4 weeks old) and T_5 (6 weeks old) preparations of egg extract. These treatments were applied both as foliar spray as well as soil application.

4.2.1. Soil Analysis

4.2.1.1. pH

The treatment with fish jaggery extract, egg extract, water spray and POP recommendation showed no significant difference on pH of the soil after the experiment (Table 12). The initial pH of soil was 6.18. There was a trend of increase in soil pH, which varied from 6.35 in foliar spray of 6 weeks old preparation of egg extract to 6.74 in soil application of 4 weeks old preparation of egg extract.

4.2.1.2. Organic carbon

The organic carbon content of soil influenced by different treatments is presented in Table 12. The value ranged from 0.94 per cent in POPR to 1.31 per cent in soil application of 6 weeks old preparation of egg extract, though there was no significant influence on organic carbon content of soil due to different treatments.

4.2.1.3. Available nitrogen

The initial status of available N in soil was 188.16 kg ha^{-1} (Table 13). After the crop, the highest content was in POPR (266.56 kg ha^{-1}) followed by soil application of 6 weeks old preparation, foliar spray of 4 weeks old preparation of egg extract and soil application of 2 weeks old preparation of fish jaggery extract

(177.71 kg ha^{-1}), which were on par. Foliar spray of 4 weeks old preparation of fish jaggery extract resulted in the lowest content of available N (125.44 kg ha^{-1}).

4.2.1.4. Available phosphorus

The data pertaining to available P content of soil after the experiment is given in Table 13. Soil application of fish jaggery extract (4 weeks old preparation) @ 10 per cent (T_2) resulted in the highest available P (64.86 kg ha^{-1}) compared to the other treatments. The initial value was 28.61 kg ha^{-1} and the lowest value of 32.09 kg $ha^{-1}$was recorded for the treatment T_1 (soil application of 10 per cent fish jaggery extract of 2 weeks old preparation).

4.2.1.5. Available potassium

The initial status of available potassium was 446.09 kg ha^{-1}. Table 13 shows that the potassium content was significantly influenced by the treatments, though it decreased after the crop. The soil application of 6 weeks old preparation of egg extract (380.77 kg ha^{-1}), which was on par with soil application of 4 weeks old preparation of egg extract (373.12 kg ha^{-1}) enhanced the available potassium status of the soil. The least was recorded in water spray (283.36 kg ha^{-1}).

4.2.1.6. Total microbial count in the rhizosphere of okra

The data pertaining to the total microbial population in soil are shown in Table 14. The treatments were significantly different in the case of total microbial population. The initial count of bacteria, fungi and actinomycetes were 9.50 x 10^4, 11.00 x 10^3 and 5.00 x 10^4 cfu g^{-1} of soil respectively.

Bacterial population was the highest (41.00 x 10^4 cfu g^{-1} of soil) in T_8 (foliar spray of 6 weeks old preparation of egg extract). The lowest count (11.50 x 10^4 cfu g^{-1} of soil) was in T_5 (soil application of 4 weeks old egg extract).

The highest fungal count of 60.33 x 10^3 cfu $g^{-1}$was recorded in the treatment T_5 (soil application of 4 weeks old preparation of egg extract), while the lowest was in T_6 (soil application of 6 weeks old preparation of egg extract) being

12.50 x 10^3 cfu g^{-1} of soil, which in turn was on par with foliar spray of 4 weeks old egg extract (13.67 x10^3 cfu g^{-1}).

The treatment T_4 (foliar spray of 4 weeks old preparation of fish jaggery extract) resulted in the highest value of actinomycetes (8.67 x 10^4 cfu g^{-1}), which was on par (8.00 x 10^4 cfu g^{-1}) with the treatment T_1 (soil application of 2 weeks old preparation of fish jaggery extract. The lowest population (3.33 x 10^4 cfu g^{-1}) was noticed in T_3 (foliar spray of 2 weeks old preparation of fish jaggery extract).

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Table 12. Effect of treatments on pH and organic carbon content of soil

Treatments		pH	OC (%)
T_1	2 weeks old fish jaggery extract – soil application (10%)	6.49[a]	1.07[a]
T_2	4 weeks old fish jaggery extract – soil application (10%)	6.60[a]	1.24[a]
T_3	2 weeks old fish jaggery extract – foliar spray (0.2%)	6.58[a]	1.27[a]
T_4	4 weeks old fish jaggery extract –foliar spray (0.2%)	6.36[a]	1.07[a]
T_5	4 weeks old egg extract – soil application (10%)	6.74[a]	1.05[a]
T_6	6 weeks old egg extract – soil application (10%)	6.41[a]	1.31[a]
T_7	4 weeks old egg extract – foliar spray (0.2%)	6.47[a]	1.26[a]
T_8	6 weeks old egg extract – foliar spray (0.2%)	6.35[a]	1.14[a]
T_9	Water spray	6.44[a]	1.05[a]
T_{10}	POPR, KAU	6.51[a]	0.94[a]
	Initial value	6.18	0.84

□In a column, means followed by common letters do not differ significantly at 5% level in DMRT

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Table 13. Effect of treatments on available N, P and K content in soil

Treatments		Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})
T_1	2 weeks old fish jaggery extract – soil application (10%)	177.71^{b}	32.09^{d}	320.16^{d}
T_2	4 weeks old fish jaggery extract – soil application (10%)	156.73^{bcd}	64.86^{a}	330.84^{cd}
T_3	2 weeks old fish jaggery extract – foliar spray (0.2%)	172.48^{b}	43.82^{bc}	366.63^{ab}
T_4	4 weeks old fish jaggery extract – foliar spray (0.2%)	125.44^{d}	35.80^{cd}	325.97^{d}
T_5	4 weeks old egg extract – soil application (10%)	177.71^{b}	45.28^{bc}	373.12^{a}
T_6	6 weeks old egg extract – soil application (10%)	177.71^{b}	38.00^{cd}	380.77^{a}
T_7	4 weeks old egg extract – foliar spray (0.2%)	167.25^{bc}	52.10^{b}	342.61^{bcd}
T_8	6 weeks old egg extract – foliar spray (0.2%)	141.12^{cd}	42.42^{bcd}	353.98^{abc}
T_9	Water spray	156.80^{bc}	41.85^{bcd}	283.36^{e}
T_{10}	POPR, KAU	266.56^{a}	40.68^{cd}	328.08^{cd}
	Initial value	188.16	28.61	446.09

In a column, means followed by common letters do not differ significantly at 5% level in DMRT

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Table 14. Effect of treatments on total microbial population in the rhizosphere of okra

Treatments		Bacteria ($x10^4$ cfu g^{-1})	Fungi ($x10^3$ cfu g^{-1})	Actinomycetes ($x10^4$ cfu g^{-1})
T_1	2 weeks old fish jaggery extract – soil application (10%)	1.46^{c} (29.00)	1.60^{b} (40.00)	0.90^{a} (8.00)
T_2	4 weeks old fish jaggery extract – soil application (10%)	1.57^{b} (37.00)	1.57^{b} (37.50)	0.69^{bc} (5.00)
T_3	2 weeks old fish jaggery extract – foliar spray (0.2%)	1.33^{de} (21.50)	1.42^{bcd} (26.67)	0.49^{c} (3.33)
T_4	4 weeks old fish jaggery extract – foliar spray (0.2%)	1.39^{d} (24.50)	1.28^{cd} (19.33)	0.93^{a} (8.67)
T_5	4 weeks old egg extract – soil application (10%)	1.05^{g} (11.50)	1.78^{a} (60.33)	0.54^{c} (3.50)
T_6	6 weeks old egg extract – soil application (10%)	1.23^{f} (17.00)	1.10^{d} (12.50)	0.65^{bc} (4.50)
T_7	4 weeks old egg extract – foliar spray (0.2%)	1.31^{ef} (20.50)	1.14^{d} (13.67)	0.77^{b} (6.00)
T_8	6 weeks old egg extract – foliar spray (0.2%)	1.61^{a} (41.00)	1.60^{b} (39.00)	0.65^{bc} (4.50)
T_9	Water spray	1.57^{b} (37.00)	1.64^{b} (43.50)	0.69^{bc} (5.00)
T_{10}	POPR, KAU	1.59^{ab} (39.00)	1.53^{bc} (33.50)	0.59^{c} (4.00)
	Initial value	9.50	11.00	5.00

□In a column, means followed by common letters do not differ significantly at 5% level in DMRT

□Log transformed values; original values, are given in parenthesis

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4.2.2. Biometric observations

4.2.2.1. Plant height

Plant height at 30 DAS did not show any significant variation among treatments, whereas significant difference was noticed at 60 DAS (Table 15). At 30 DAS, the height of plants varied from 18.53 to 23.33 cm. The highest value of 114.00 cm was observed at 60 DAS in the treatment receiving soil application of 6 weeks old preparation of egg extract followed by soil application of 4 weeks old preparation of fish jaggery extract (108.70 cm). The least height was obtained in the treatment receiving foliar spray of 6 weeks old preparation of egg extract (70.60 cm), which was on par with water spray (75.00 cm) and foliar spray of 4 weeks old fish jaggery extract (73.40 cm).

4.2.2.2. Number of leaves per plant

The treatments comprising liquid organic formulations, water spray and POPR had no significant variation in the number of leaves at 30 DAS (Table 15). The number of leaves varied from 7 to 10. At 60 DAS, the highest number of leaves was observed in the treatment receiving soil application of 2 weeks old preparation of fish jaggery extract (25) followed by soil application of 4 weeks old preparation of fish jaggery extract. The lowest number was observed in foliar application of 4 weeks old preparation of fish jaggery extract (14).

4.2.2.3. Days to first flowering

The treatments showed no significant effect on days to first flowering. The days taken for first flowering varied from 31 to 32 days (Table 16).

4.2.2.4. Days to first harvest

Data pertaining to the days to first harvest of okra fruits are given in Table 16. It shows that, the treatments had no significant effect on days to first harvest.

4.2.2.5. Number of harvests

Various treatments including liquid organic manures, water spray and POPR had no significant influence on number of harvests and the number varied from 15 to 17 (Table 16).

4.2.2.6. Duration of the crop

Table 16 reveals the influence of different treatments on the duration of okra. The results showed that the treatments had no significant effect on the duration of the crop. Okra was maintained in the experimental plot for 92 days.

4.2.2.7. Total dry matter production

Dry matter production was significantly influenced by various treatments including liquid organic manures, water spray and POPR (Table 17). The highest dry matter (5.66 t ha^{-1}) was observed with soil application of 2 weeks old preparation of fish jaggery extract followed by soil application of 6 weeks old preparation of egg extract (2.35 t ha^{-1}) and POPR (2.25 t ha^{-1}), which were on par. The lowest dry matter was recorded in foliar spray of 6 weeks old preparation of egg extract (1.34 t ha^{-1}).

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Table 15. Effect of treatments on plant height and number of leaves of okra

Treatments		Plant height (cm)		Number of leaves/ plant	
		30 DAS	60 DAS	30 DAS	60 DAS
T_1	2 weeks old fish jaggery extract – soil application (10%)	23.33^{a}	104.90^{abc}	9^{a}	25^{a}
T_2	4 weeks old fish jaggery extract – soil application (10%)	23.17^{a}	108.70^{ab}	9^{a}	22^{ab}
T_3	2 weeks old fish jaggery extract – foliar spray (0.2%)	22.93^{a}	87.77^{d}	9^{a}	19^{b}
T_4	4 weeks old fish jaggery extract –foliar spray (0.2%)	18.53^{a}	73.40^{e}	7^{a}	14^{c}
T_5	4 weeks old egg extract – soil application (10%)	21.70^{a}	91.73^{d}	9^{a}	20^{b}
T_6	6 weeks old egg extract – soil application (10%)	22.93^{a}	114.00^{a}	10^{a}	22^{b}
T_7	4 weeks old egg extract – foliar spray (0.2%)	21.27^{a}	96.20^{cd}	8^{a}	21^{b}
T_8	6 weeks old egg extract – foliar spray (0.2%)	20.17^{a}	70.60^{e}	9^{a}	22^{b}
T_9	Water spray	23.07^{a}	75.00^{e}	9^{a}	19^{b}
T_{10}	POPR, KAU	21.90^{a}	98.10^{bcd}	8^{a}	21^{b}

In a column, means followed by common letters do not differ significantly at 5% level in DMRT

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Table 16. Effect of treatments on days to first flowering, harvest and duration of okra

Treatments		Days to first flowering	Days to first harvest	Number of harvests	Duration of the crop (Days)
T_1	2 weeks old fish jaggery extract – soil application (10%)	31[a]	37[a]	16[a]	92.00[a]
T_2	4 weeks old fish jaggery extract – soil application (10%)	31[a]	37[a]	17[a]	91.33[a]
T_3	2 weeks old fish jaggery extract – foliar spray (0.2%)	31[a]	37[a]	16[a]	92.00[a]
T_4	4 weeks old fish jaggery extract –foliar spray (0.2%)	31[a]	37[a]	15[a]	91.33[a]
T_5	4 weeks old egg extract – soil application (10%)	31[a]	37[a]	16[a]	92.00[a]
T_6	6 weeks old egg extract – soil application (10%)	31[a]	37[a]	17[a]	92.00[a]
T_7	4 weeks old egg extract – foliar spray (0.2%)	30[a]	36[a]	17[a]	92.00[a]
T_8	6 weeks old egg extract – foliar spray (0.2%)	32[a]	37[a]	16[a]	92.00[a]
T_9	Water spray	31[a]	37[a]	16[a]	91.33[a]
T_{10}	POPR, KAU	32[a]	38[a]	15[a]	91.33[a]

In a column, means followed by common letters do not differ significantly at 5% level in DMRT

Table 17. Effect of treatments on total dry matter production of okra

Treatments		Dry matter (t ha^{-1})
T_1	2 weeks old fish jaggery extract – soil application (10%)	5.66^{a}
T_2	4 weeks old fish jaggery extract – soil application (10%)	2.12^{bc}
T_3	2 weeks old fish jaggery extract – foliar spray (0.2%)	1.96^{bc}
T_4	4 weeks old fish jaggery extract –foliar spray (0.2%)	1.77^{bc}
T_5	4 weeks old egg extract – soil application (10%)	2.10^{bc}
T_6	6 weeks old egg extract – soil application (10%)	2.35^{b}
T_7	4 weeks old egg extract – foliar spray (0.2%)	2.10^{bc}
T_8	6 weeks old egg extract – foliar spray (0.2%)	1.34^{c}
T_9	Water spray	1.51^{bc}
T_{10}	POPR, KAU	2.25^{b}

In a column, means followed by common letters do not differ significantly at 5% level in DMRT

4.2.3. Yield and yield attributes

4.2.3.1. Number of fruits per plant

The treatments significantly influenced the number of fruits per plant (Table 18). The highest number of fruits was obtained from soil application of 6 weeks old egg extract (28) followed by soil application of 4 weeks old preparation of egg extract (23). Foliar spray of 4 weeks old preparation of fish jaggery extract resulted in the lowest number of fruits per plant (11).

4.2.3.2. Weight of fruits per plant

Various treatments like liquid organic manures, water spray and POPR significantly influenced the weight of fruits per plant (Table 18). Soil application of 2 weeks old preparation of fish jaggery extract resulted in the highest yield of okra fruits (403.53 g/ plant). The lowest yield was from the treatment receiving foliar spray of 4 weeks old preparation of fish jaggery extract (197.00 g/ plant).

4.2.3.3. Yield per hectare

Treatments imparted significant effect on the yield of okra (Table 18). The highest yield was noticed with soil application of 2 weeks old preparation of fish jaggery extract (22.42 t ha^{-1}) and the lowest in foliar spray of 4 weeks old preparation of fish jaggery extract (10.94 t ha^{-1}).

4.2.3.4. Number of seeds per pod

The data regarding the number of seeds per pod is given in Table 19. The results revealed that there was a significant effect of treatments on the number of seeds. Foliar spray of 6 weeks old egg extract (65.67), which was on par with water spray (65.00) produced the highest number of seeds per pod. The lowest number was observed with POPR (56.00).

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4.2.3.5. Seed weight

The highest 100 seed weight was observed in foliar spray of 4 weeks old preparation of egg extract (5.41 g) followed by soil application of 4 weeks old preparation of egg extract (5.11 g). POPR (4.25 g) resulted in the lowest value, which was on par with water spray (4.36 g) (Table 19).

4.2.3.6. Shelf life

The data pertaining to the shelf life of okra fruits is given in Table 20. There was a significant variation among the treatments regarding shelf life. The treatment *viz*., foliar spray of 6 weeks old preparation of egg extract resulted in the maximum shelf life of 8.67 days, followed by foliar spray of 4 weeks old preparation of egg extract, which was on par with soil application of 2 weeks old preparation of fish jaggery extract (8 days). The minimum shelf life was observed with soil application of 6 weeks old preparation of egg extract (4.5 days).

4.2.4. Incidence of pest and diseases

In the course of field experimentation, pest and disease attack was not that much severe. Aphid (*Aphis gossypii*) attack was seen uniformly in all the plots during the initial stages of crop growth. Beauveria (1%), neem soap and neem garlic emulsion sprays were given for the control of aphid.

4.2.5. B: C Ratio

Table 21 represents the economic analysis of okra influenced by different treatments. Treatment receiving soil application of 2 weeks old preparation of fish jaggery extract generated the highest gross returns (Rs. 8,96,800 ha^{-1}), net returns (Rs. 5,11,312 ha^{-1}) and B: C ratio (2.33), followed by foliar spray of 4 weeks old egg extract (2.24) and water spray (2.24).

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Table 18. Effect of treatments on yield and yield attributes of okra

Treatments		Number of fruits/ plant	Weight of fruits/ plant (g)	Yield (t ha^{-1})
T_1	2 weeks old fish jaggery extract – soil application (10%)	21^{bc}	403.53^{a}	22.42^{a}
T_2	4 weeks old fish jaggery extract – soil application (10%)	15^{e}	278.64^{bcd}	15.48^{bcd}
T_3	2 weeks old fish jaggery extract – foliar spray (0.2%)	17^{cde}	319.48^{abc}	17.75^{abc}
T_4	4 weeks old fish jaggery extract –foliar spray (0.2%)	11^{f}	197.00^{d}	10.94^{d}
T_5	4 weeks old egg extract – soil application (10%)	23^{b}	372.95^{ab}	20.72^{ab}
T_6	6 weeks old egg extract – soil application (10%)	28^{a}	342.31^{ab}	19.02^{ab}
T_7	4 weeks old egg extract – foliar spray (0.2%)	15^{de}	325.17^{abc}	18.07^{abc}
T_8	6 weeks old egg extract – foliar spray (0.2%)	17^{cde}	291.92^{bcd}	16.22^{bcd}
T_9	Water spray	20^{bcd}	293.33^{bcd}	16.30^{bcd}
T_{10}	POPR, KAU	17^{cde}	226.65^{cd}	12.59^{cd}

In a column, means followed by common letters do not differ significantly at 5% level in DMRT

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Table 19. Effect of treatments on number and weight of seeds of okra

Treatments		Number of seeds/ pod	Hundred seed weight (g)
T_1	2 weeks old fish jaggery extract – soil application (10%)	60.33^{bc}	4.55^{bcd}
T_2	4 weeks old fish jaggery extract – soil application (10%)	64.00^{ab}	4.64^{bcd}
T_3	2 weeks old fish jaggery extract – foliar spray (0.2%)	60.33^{bc}	4.59^{bcd}
T_4	4 weeks old fish jaggery extract –foliar spray (0.2%)	56.33^{cd}	4.43^{cd}
T_5	4 weeks old egg extract – soil application (10%)	63.67^{ab}	5.11^{ab}
T_6	6 weeks old egg extract – soil application (10%)	57.00^{cd}	4.60^{bcd}
T_7	4 weeks old egg extract – foliar spray (0.2%)	62.00^{ab}	5.41^{a}
T_8	6 weeks old egg extract – foliar spray (0.2%)	65.67^{a}	4.97^{abc}
T_9	Water spray	65.00^{a}	4.36^{d}
T_{10}	POPR, KAU	56.00^{a}	4.25^{d}

In a column, means followed by common letters do not differ significantly at 5% level in DMRT

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Table 20. Effect of treatments on shelf life of okra fruits

Treatments		Shelf life of fruits (days)
T_1	2 weeks old fish jaggery extract – soil application (10%)	8.00^{ab}
T_2	4 weeks old fish jaggery extract – soil application (10%)	7.33^{bc}
T_3	2 weeks old fish jaggery extract – foliar spray (0.2%)	7.00^{c}
T_4	4 weeks old fish jaggery extract –foliar spray (0.2%)	7.00^{c}
T_5	4 weeks old egg extract – soil application (10%)	7.00^{c}
T_6	6 weeks old egg extract – soil application (10%)	4.50^{e}
T_7	4 weeks old egg extract – foliar spray (0.2%)	8.00^{ab}
T_8	6 weeks old egg extract – foliar spray (0.2%)	8.67^{a}
T_9	Water spray	7.67^{bc}
T_{10}	POPR, KAU	6.00^{d}

In a column, means followed by common letters do not differ significantly at 5% level in DMRT

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Table 21. Effect of treatments on economics of okra

Treatments		Total cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B: C ratio
T_1	2 weeks old fish jaggery extract – soil application (10%)	3,85,487	8,96,800	5,11,312	2.33
T_2	4 weeks old fish jaggery extract – soil application (10%)	3,85,487	6,19,200	2,33,712	1.61
T_3	2 weeks old fish jaggery extract – foliar spray (0.2%)	3,20,888	7,10,000	3,89,111	2.21
T_4	4 weeks old fish jaggery extract –foliar spray (0.2%)	3,20,888	4,37,600	1,16,711	1.36
T_5	4 weeks old egg extract – soil application (10%)	6,60,179	8,28,800	1,68,620	1.26
T_6	6 weeks old egg extract – soil application (10%)	6,60,179	7,60,800	1,00,620	1.15
T_7	4 weeks old egg extract – foliar spray (0.2%)	3,22,254	7,22,800	4,00545	2.24
T_8	6 weeks old egg extract – foliar spray (0.2%)	3,22,254	6,48,800	3,26,545	2.01
T_9	Water spray	2,90,888	6,52,000	3,61,111	2.24
T_{10}	POPR, KAU	2,72,888	5,03,600	2,30,711	1.85

Discussion

5. DISCUSSION

An experiment entitled "Validation of liquid organic manures and their effect on crop productivity" was conducted to find out the shelf life of two liquid organic manures (fish jaggery extract and egg extract) and their effect on okra productivity during 2016-2017 at College of Horticulture, Vellanikkara, Thrissur. The major findings regarding the experiment are discussed in this chapter.

5.1. Experiment I

Influence of shelf life on quality of fish jaggery extract and egg extract

5.1.1. Influence of shelf life on physico-chemical properties of liquid organic manures

The liquid organic manures *viz*., fish jaggery extract and egg extract showed a change in colour and odour in the course of study during the period of storage. For the fresh preparation of fish jaggery extract and egg extract, the colour was light brown and cream and at the end it became dark brown and dark yellow respectively. Initially fish jaggery extract had a fruity smell, which became stronger foul smell in later periods. Mild rotten lemon smell had become stronger in the case of egg extract. Fermentation of ingredients in the liquid organic manures resulted in the production of substances like methane, volatile amines and fatty acids and this might be the reason for odour change (Harison and McAllan, 1980). The change in odour might also be due to microbial decomposition occurring in the liquid manures during storage.

Mould growth was seen on the surface of fresh preparation of fish jaggery extract and after that it reduced. The initial growth may be attributed to the presence of residual oxygen available in the air tight container. After the complete utilization of oxygen, the growth was restricted. No mould growth was observed throughout the storage period in the case of egg extract. Maggots were not observed in both the liquid manures throughout the storage period.

The pH of both liquid manures was highly acidic. During the storage period, pH was found to be non significant in fish jaggery extract and egg extract.

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Similar results were obtained by Vemaraju (2014) in the case of fish jaggery extract. The low pH of the liquid manures may be attributed to the fermentation during storage. The presence of ammonifiers, nitrifiers, phosphate solubilizers and *Lactobacillus acidophilus* in fish jaggery extract might have lead to fermentation and formation of lactic acid, acetic acid and carbonic acid, which reduced the pH to 4.0 as reported by Vincent *et al.* (2014).The study revealed that the storage time had no effect on EC of both liquid manures.

In general, the organic carbon content of fish jaggery extract increased during storage with the highest value of 55.03 per cent (12 weeks old preparation), while it was stable throughout the storage period in the egg extract (56.56 to 57.24 per cent) as depicted in Fig. 2.

Macronutrients like N, P and K were found in both liquid manures. The storage time had no effect on the total macronutrient content. Secondary nutrients like Ca, Mg and S showed no significant difference due to storage of liquid manures. In both the liquid manures, micronutrients like Fe, Zn and Mn were found. The micronutrient content were non significant in fish jaggery extract and egg extract.

5.1.2. Influence of shelf life on biological properties of liquid organic manures

The study revealed that storage periods had a significant effect on total microbial count in both liquid organic manures (Fig. 3; Fig. 4). The highest bacterial count was noticed in 10 weeks old preparation of fish jaggery extract ($27.33x10^2$ cfu ml^{-1}) and 6 weeks old preparation of egg extract ($23.67x10^2$ cfu ml^{-1}). The fresh preparation had a bacterial count of $8.00x10^2$ cfu ml^{-1}, which increased to $27.33x10^2$ cfu ml^{-1}(10 weeks old preparation) and then reduced to $4.33x10^2$ cfu ml^{-1} in 24 weeks old preparation. In the case of egg extract, the count increased from $14.33x10^2$ cfu ml^{-1} (fresh preparation) to $23.67x10^2$ cfu ml^{-1} (6 weeks old preparation) and then decreased to $3.33x10^2$ cfu ml^{-1} in 24 weeks old preparation.

Fungal population was absent up to one week after preparation of fish jaggery extract and it increased to the highest count in 12 weeks old preparation ($10.00x10^3$ cfu ml^{-1}).Then it became stable *i.e.*, $1.67x10^3$ cfu ml^{-1} in 16, 20 and 24 weeks old preparations. Six weeks old preparation showed the highest fungal count ($27.67x10^3$ cfu ml^{-1}) in egg extract. In the case of 1, 2 10, 16 and 24 weeks old preparations, fungi were absent. In both the liquid organic manures, actinomycetes and *Escherichia coli* were absent.

The physical, chemical and biological properties of liquid organic manures were subjected to different reactions during different storage periods. Occurrence of fermentation might be the major reason for changes in these properties. The higher microbial as well as the nutrient content in these liquid organic manures made them potent organic source for crop productivity.

5.1.3. Influence of shelf life on protein and amino acid content

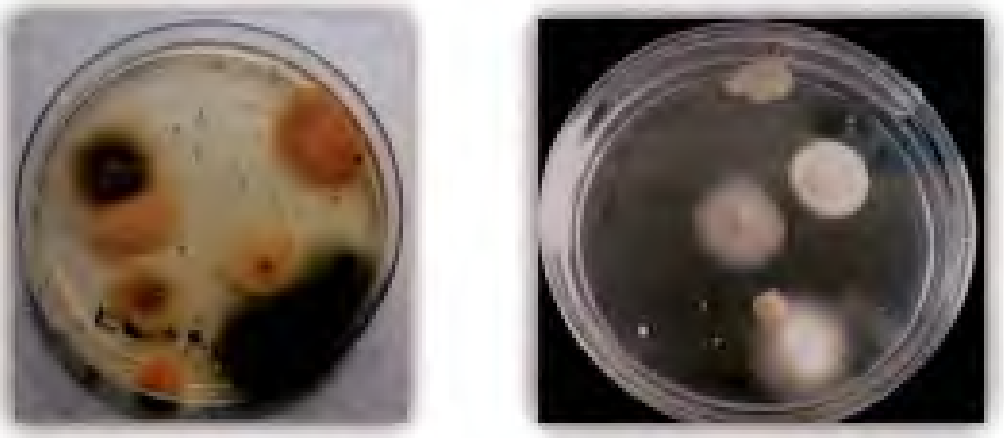
The protein and amino acid content in fresh as well as the best treatments of fish jaggery extract and egg extract revealed that compared to fresh preparation, the content was more in the best treatments. Presence of amino acids *viz.*, alanine, valine, glycine, leucine, serine, histidine, threonine and methionine could be detected in fresh and best treatments of both the formulations.

Plate 8. Total microbial population in liquid organic manures

(a) Fish jaggery extract **(b) Egg extract**

T_5 (6 WOP) T_7 (10 WOP)

Bacteria



T_3 (2 WOP) T_{10} (20 WOP)

Fungi

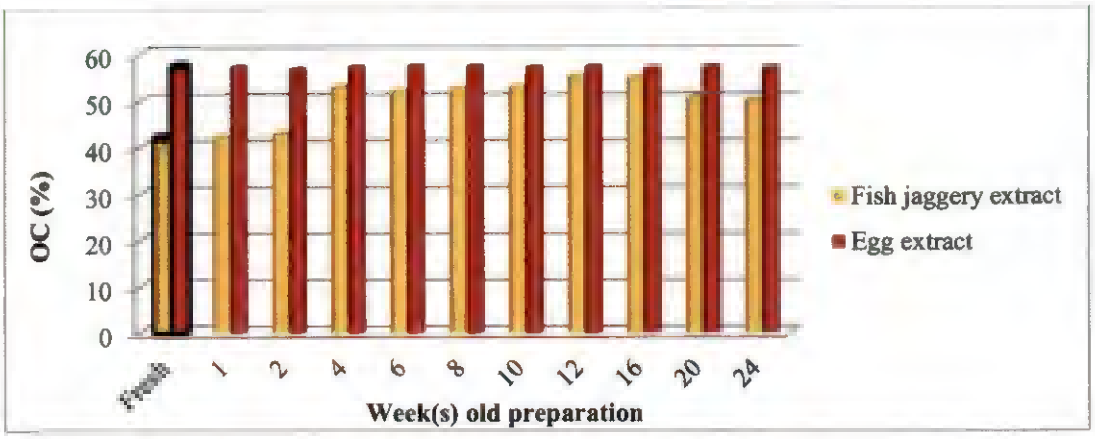


Fig.2. Effect of storage on organic carbon content of liquid organic manures

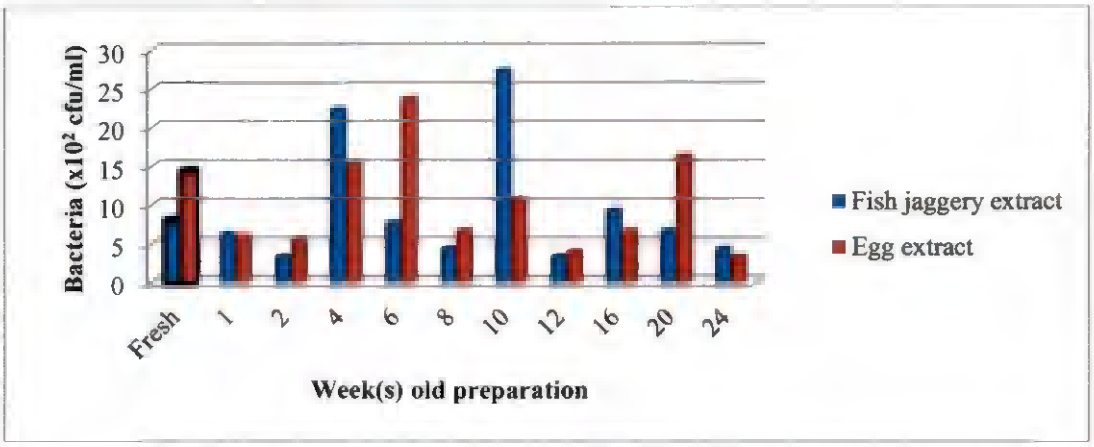


Fig.3. Effect of storage on bacterial population of liquid organic manures

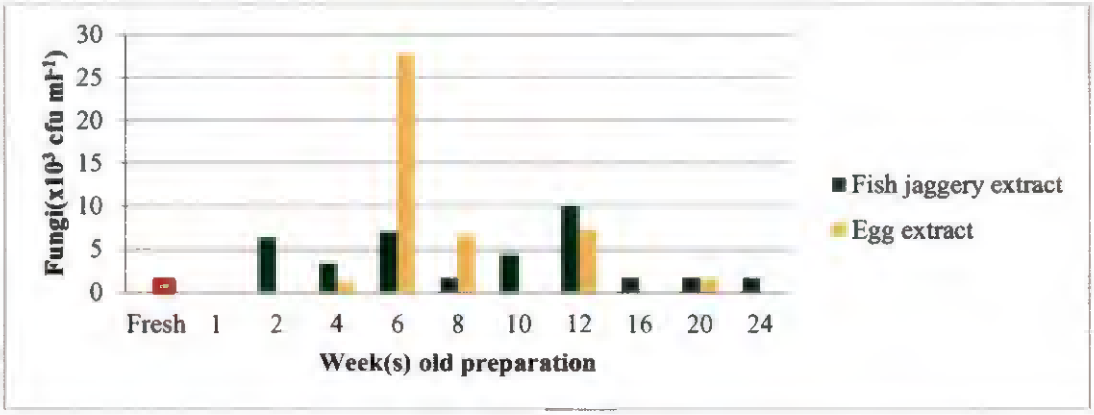


Fig.4. Effect of storage on fungal population of liquid organic manures

5.2. Experiment II

Effect of fish jaggery extract and egg extract on growth and yield of okra

5.2.1. Soil parameters

The soil in the experimental plot was near neutral with a pH of 6.18. The treatments had no significant influence on the pH of soil after the experiment. But there was a general increase due to treatments. Soil pH varied from 6.35 to 6.74. Application of lime and organic manures might be the reason for the increase in pH. Lal *et al.* (2000) reported an increase in pH after the addition of organic manures in the soil. Vemaraju (2014), Krishnan (2014) and Rameeza (2016) also reported an increase in pH after cropping due to the application of organic manures. Organic carbon content in the soil was not significantly influenced by the treatments. However, the value was increased to 1.31 per cent after the experiment. The lowest content was recorded in POPR (0.94 %). The increase in organic carbon content might be attributed to the application of organic manures like coir pith compost, poultry manure, cow dung and liquid organic manures.

The content of macronutrients like N, P and K was significantly affected by the treatments (Fig. 5; Fig. 6; Fig. 7). The initial content of available N was 188.16 kg ha^{-1}. The content decreased after the experiment and it was significantly influenced by the treatments. The decrease in available N in soil might be due to the higher uptake of the nutrient by the plants. The highest content was noted for the treatment POPR (266.56 kg ha^{-1}) and the lowest was in foliar spray of 4 weeks old preparation of fish jaggery extract (125.44 kg ha^{-1}). In 2 and 4 weeks old preparations of fish jaggery extract, it was found that the content was more in the treatments receiving 2 weeks old preparation. The treatment receiving 4 weeks old preparation of egg extract contained more available N compared to 6 weeks old preparation. By comparing soil and foliar application of these liquid manures, it can be see that the content of available N is more in soil applied treatments.

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Available P content in the soil was significantly influenced by the treatments. The initial content was 28.61 kg ha^{-1}. Among the treatments, soil application of 4 weeks old preparation of fish jaggery extract resulted in the highest available P of 64.86 kg $ha^{-1}$and the lowest content was recorded for soil application of 2 weeks old preparation of fish jaggery extract (32.09 kg ha^{-1}). Compared to the initial status, the available P content increased in all the treatments. Similar results were reported by Rameeza (2016) and Vemaraju (2014). The addition of organic substances might have improved the activity of phosphorus solubilising bacteria, which in turn increased the P availability as reported by Ninan *et al.* (2013). It can be seen that the available P content was more in foliar applied treatments of 2 weeks old preparation but, in 4 weeks old one, soil applied treatments contained more available P. In the case of egg extract, in both 4 and 6 weeks old preparations, the content was more in foliar applied plots.

The available K content in the soil before the experiment was 446.09 kg ha^{-1} and it decreased after the experiment. The decrease in the content might be due to the plant uptake. Soil application of 6 weeks old preparation and 4 weeks old preparation of egg extract resulted in the highest available potassium in soil (380.77 and 373.12 kg ha^{-1}). In the case of 2 weeks old preparation of fish jaggery extract, the K content was oliar applied plots than the soil applied one. In egg extract, treatments receiving soil application of 4 and 6 weeks old preparations showed higher content than foliar sprayed plots.

The microflora in soil (bacteria, fungi and actinomycetes) was significantly influenced by the treatments (Fig. 8; Fig. 9; Fig. 10). The bacterial count increased in all the treatments with the highest in foliar spray of 6 weeks old preparation of egg extract (41.00 x 10^4cfu g^{-1}) and the lowest in soil application of 4 weeks old egg extract (11.50 x 10^4cfu g^{-1}). Soil application of 4 weeks old preparation of egg extract had the highest count of fungi (60.33 x 10^3cfu g^{-1}) and soil application of 6 weeks old preparation of egg extract had the lowest (12.50 x 10^3cfu g^{-1}). Increase in the count of soil bacteria and fungi after the application of liquid manures in soil was also reported by Rameeza (2016).

Plate 9. Total microbial population in the rhizosphere of okra

Bacteria

Actinomycetes

Fungi

The count of actinomycetes was comparatively lower in all the treatments. The highest count was noticed in foliar spray of 4 weeks old preparation of fish jaggery extract (8.67 x 10^4 cfu g^{-1}) and the lowest in foliar spray of 2 weeks old preparation of fish jaggery extract (3.33 x 10^4 cfu g^{-1}). It was found that soil application of 2 weeks old preparation of fish jaggery extract resulted in higher bacterial, fungal and actinomycetes populations than the foliar application. In the case of 4 weeks old preparation, population of bacteria and fungi were more in soil applied plots and that of actinomycetes was higher in foliar sprayed plots. For both 4 and 6 weeks old preparation of egg extract, the bacterial count was more in foliar applied treatments, whereas fungal count was more in soil applied plots of 4 weeks old preparation and foliar applied plots of 6 weeks old preparation. Actinomycetes count was higher in foliar applied treatments than soil applied in the case of 4 weeks old preparation of egg extract. The application of organic manures and liquid organic manures had contributed to an increase in the population of soil microorganisms like bacteria and fungi. Naturally occurring beneficial microorganisms predominantly bacteria, yeast, actinomycetes and certain fungi were also reported by Sreenivasa *et al.* (2009) in organic liquid manures.

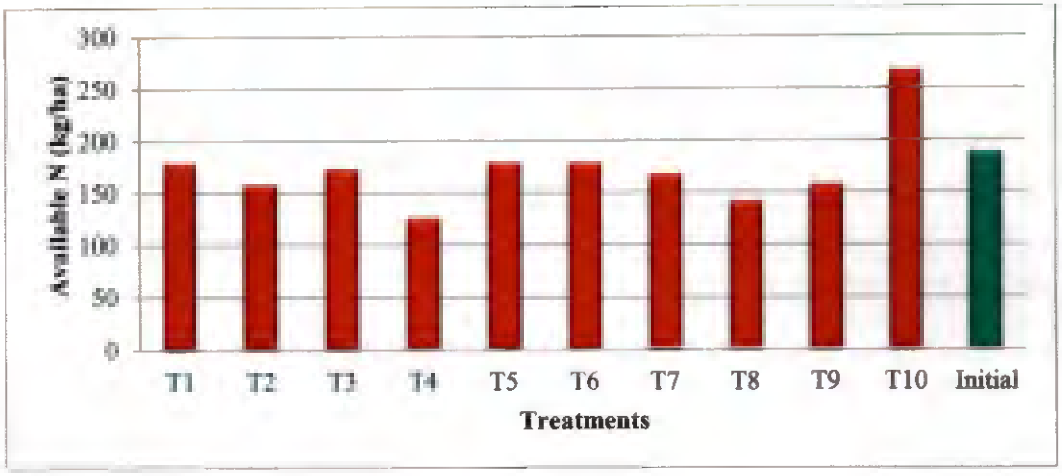

Fig.5. Effect of treatments on available N content in soil

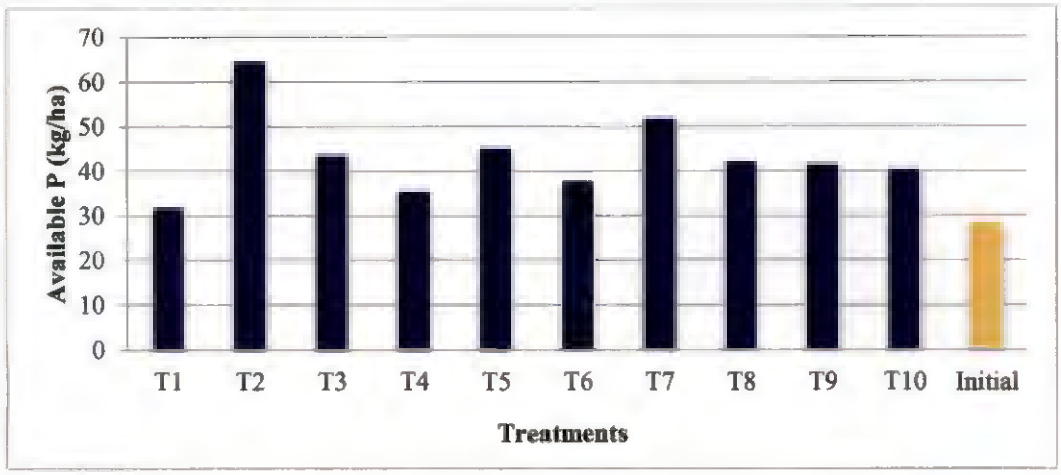

Fig.6. Effect of treatments on available P content in soil

T_1: 2 weeks old fish jaggery extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_2: 4 weeks old fish jaggery extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_3: 2 weeks old fish jaggery extract @ 0.2% (Foliar spray at fortnightly intervals)

T_4: 4 weeks old fish jaggery extract @ 0.2% (Foliar spray at fortnightly intervals)

T_5: 4 weeks old egg extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_6: 6 weeks old egg extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_7: 4 weeks old egg extract @ 0.2% (Foliar spray at fortnightly intervals)

T_8: 6 weeks old egg extract @ 0.2% (Foliar spray at fortnightly intervals)

T_9: Water spray

T_{10}: Raising crop adopting Package of Practices Recommendations, KAU

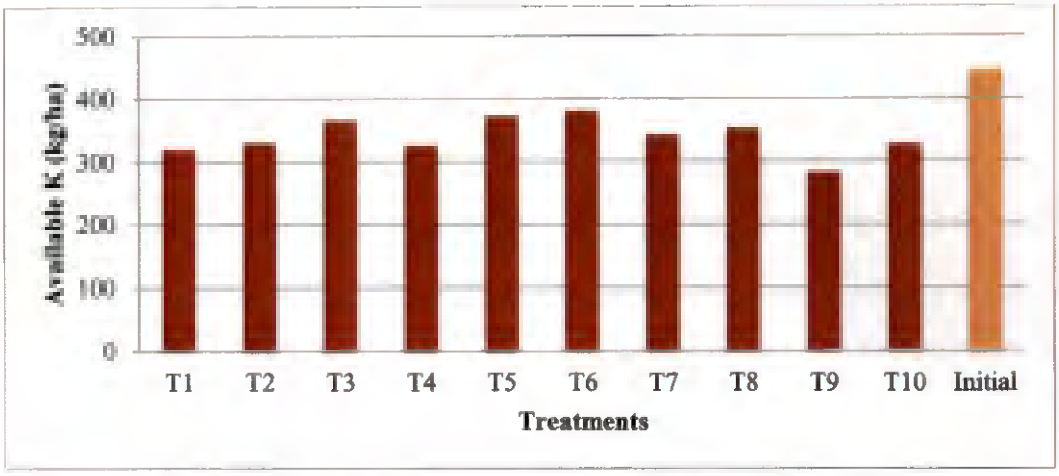

Fig.7. Effect of treatments on available K content in soil

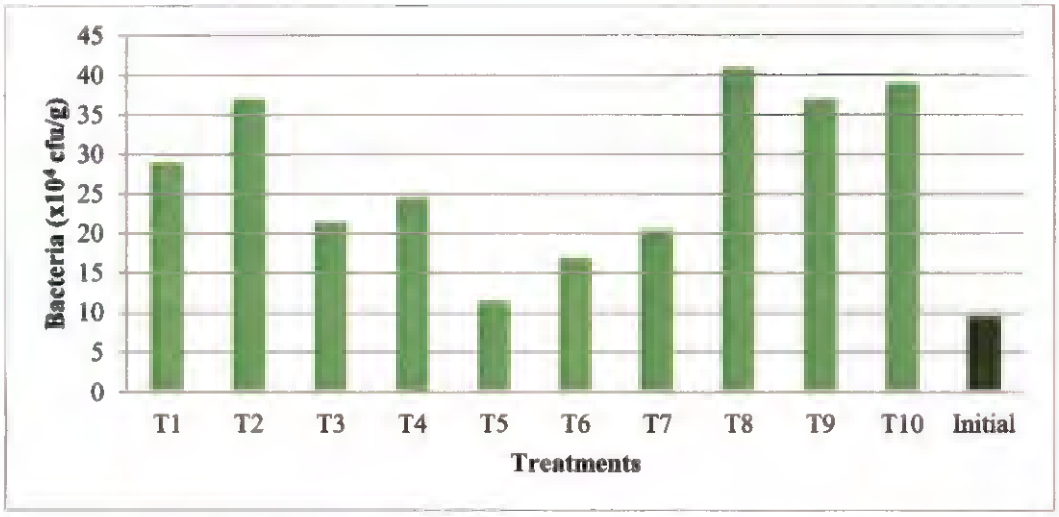

Fig.8. Effect of treatments on bacterial count in soil

T_1: 2 weeks old fish jaggery extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_2: 4 weeks old fish jaggery extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_3: 2 weeks old fish jaggery extract @ 0.2% (Foliar spray at fortnightly intervals)

T_4: 4 weeks old fish jaggery extract @ 0.2% (Foliar spray at fortnightly intervals)

T_5: 4 weeks old egg extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_6: 6 weeks old egg extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_7: 4 weeks old egg extract @ 0.2% (Foliar spray at fortnightly intervals)

T_8: 6 weeks old egg extract @ 0.2% (Foliar spray at fortnightly intervals)

T_9: Water spray

T_{10}: Raising crop adopting Package of Practices Recommendations, KAU

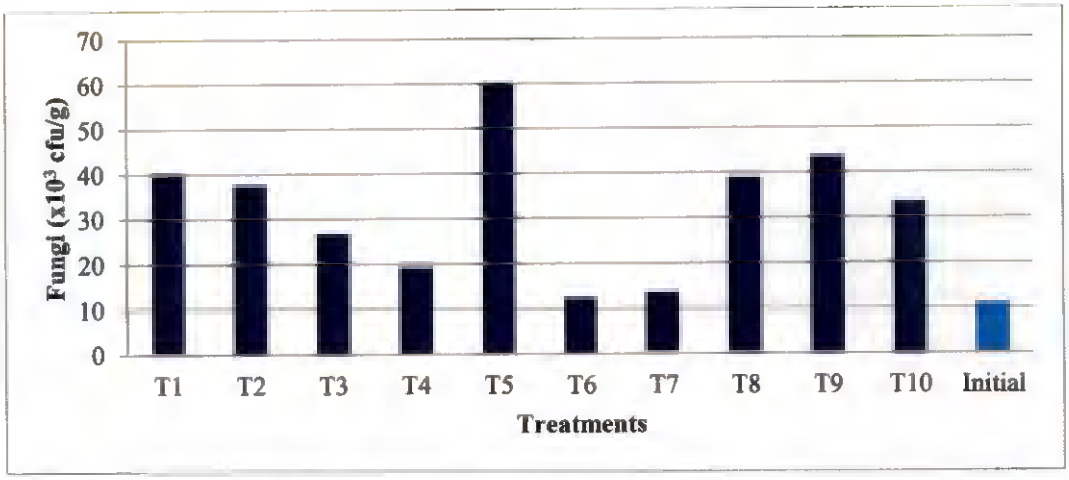

Fig.9. Effect of treatments on fungal count in soil

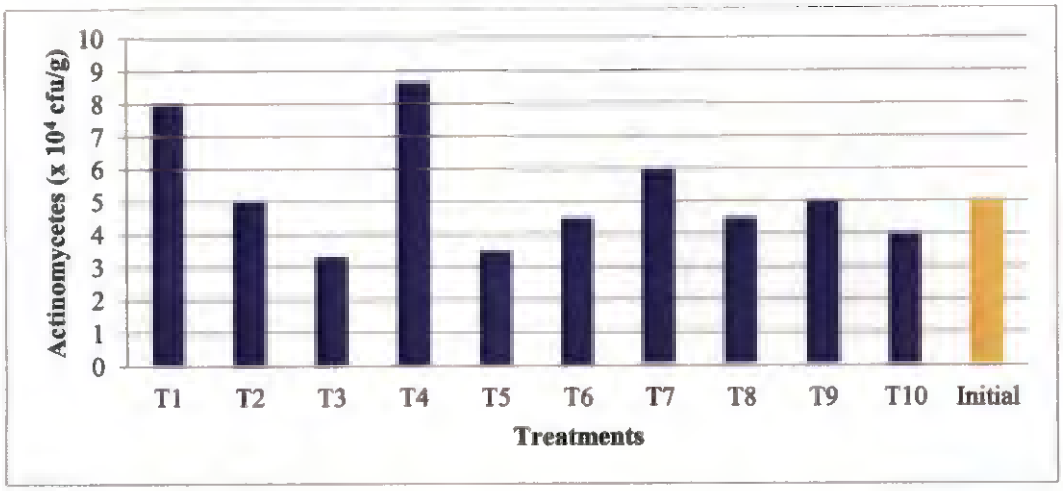

Fig.10. Effect of treatments on actinomycetes count in soil

T_1: 2 weeks old fish jaggery extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_2: 4 weeks old fish jaggery extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_3: 2 weeks old fish jaggery extract @ 0.2% (Foliar spray at fortnightly intervals)

T_4: 4 weeks old fish jaggery extract @ 0.2% (Foliar spray at fortnightly intervals)

T_5: 4 weeks old egg extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_6: 6 weeks old egg extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_7: 4 weeks old egg extract @ 0.2% (Foliar spray at fortnightly intervals)

T_8: 6 weeks old egg extract @ 0.2% (Foliar spray at fortnightly intervals)

T_9: Water spray

T_{10}: Raising crop adopting Package of Practices Recommendations, KAU

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5.2.2. Biometric characteristics

Organic manures are slow acting substances. In this study, the treatment application started 20 DAS. So the plant height and number of leaves per plant in the initial stages of growth (30 DAS) did not vary significantly according to the treatments. At 60 DAS, both the parameters were influenced by the treatments. Soil application of 6 weeks old preparation of egg extract resulted in taller plants (114.00 cm) at 60 DAS among the different treatments (Fig. 11). Alagesan *et al.* (2009) also noticed an increase in the height of tomato plants by the application of egg lime mix with *Panchagavya* both as foliar and soil than control. The highest number of leaves per plant at 60 DAS was noted in soil application of 2 weeks old preparation of fish jaggery extract (25) as seen in Fig. 12. For plant height and number of leaves per plant at 60 DAS soil application of both 2 and 4 weeks old preparation resulted in higher value compared to foliar spray. In the case of egg extract, foliar spray of both 4 and 6 weeks old preparation resulted in greater plant height and number of leaves than soil application. The improvement in physical, chemical and biological properties of soil might be the reason for increased plant growth.

Though the treatments had no significant effect on days to first flowering, days to first harvest, number of harvests and duration of the crop, the organic treatments showed the tendency for early flowering and harvest than the treatment receiving POPR. The foliar spray of liquid organic manures like fish amino acid and *Panchagavya* has contributed earliness in flowering as reported by Krishnan (2014) in cucumber and Vemaraju (2014) in oriental pickling melon.

Among the treatments, soil application of 2 weeks old preparation of fish jaggery extract (T_1) registered the highest total dry matter production (5.66 t ha^{-1}). The same trend was observed by Murray and Anderson (2004) in tomato and pepper transplants, where the application of fish emulsion increased the seedling growth and dry weight. It was also noticed that dry matter production of okra crop was more in soil applied plots than foliar applied plots in the case of both fish jaggery and egg extract (Fig. 13).

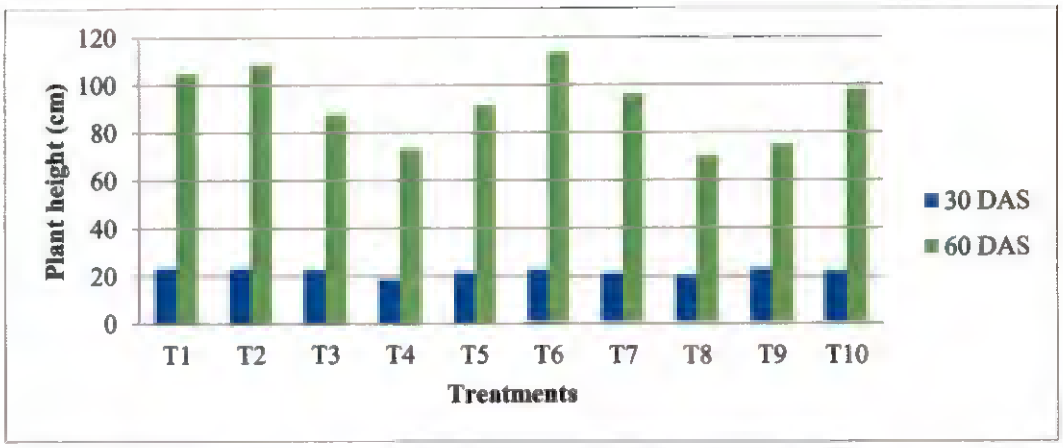

Fig.11. Effect of treatments on plant height

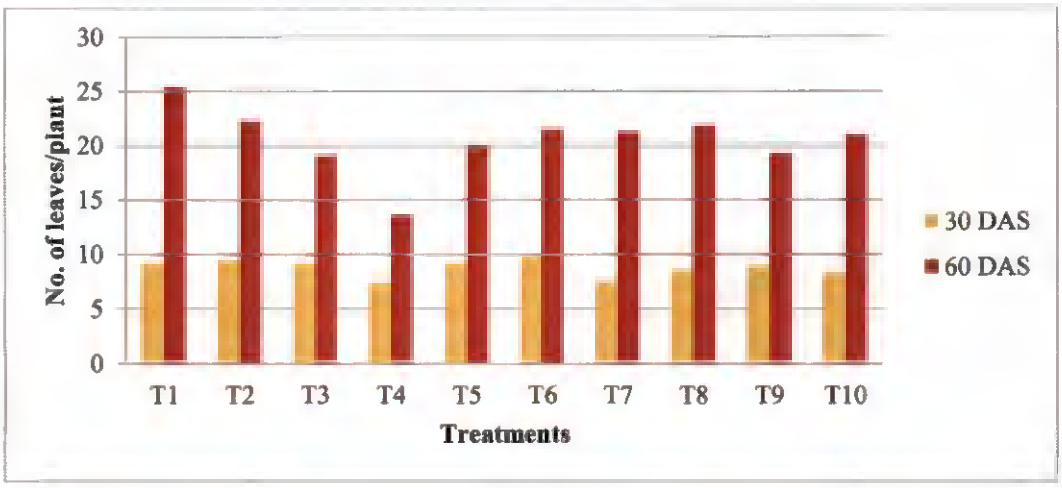

Fig.12. Effect of treatments on number of leaves per plant

T_1: 2 weeks old fish jaggery extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_2: 4 weeks old fish jaggery extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_3: 2 weeks old fish jaggery extract @ 0.2% (Foliar spray at fortnightly intervals)

T_4: 4 weeks old fish jaggery extract @ 0.2% (Foliar spray at fortnightly intervals)

T_5: 4 weeks old egg extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_6: 6 weeks old egg extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_7: 4 weeks old egg extract @ 0.2% (Foliar spray at fortnightly intervals)

T_8: 6 weeks old egg extract @ 0.2% (Foliar spray at fortnightly intervals)

T_9: Water spray

T_{10}: Raising crop adopting Package of Practices Recommendations, KAU

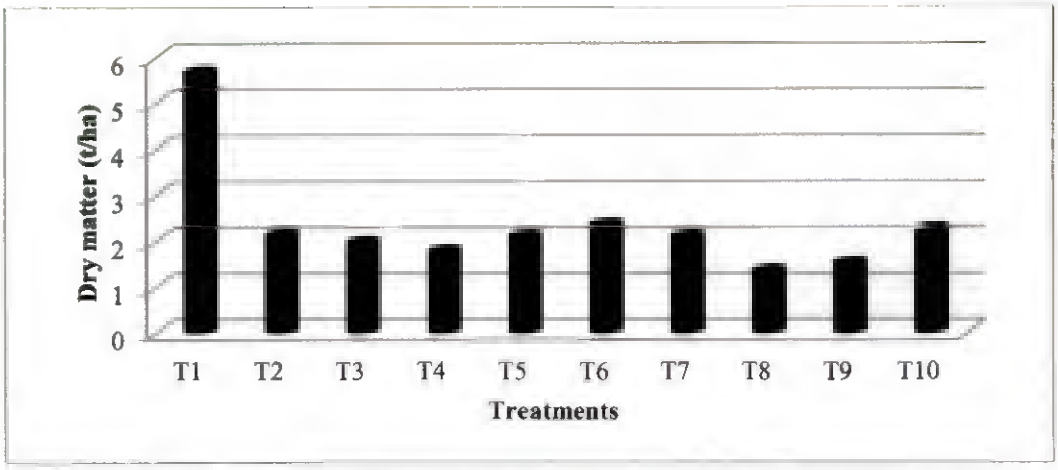

Fig.13. Effect of treatments on total dry matter production

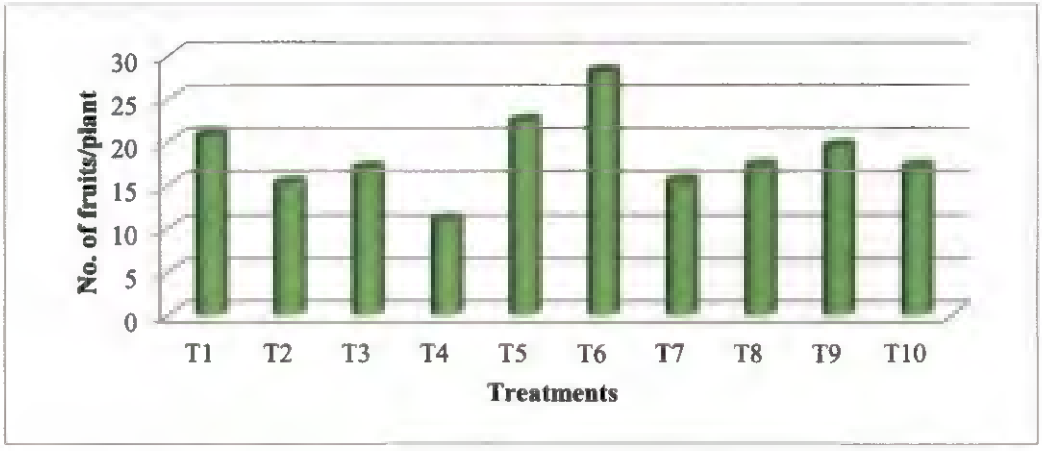

Fig.14. Effect of treatments on number of fruits per plant

T_1: 2 weeks old fish jaggery extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_2: 4 weeks old fish jaggery extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_3: 2 weeks old fish jaggery extract @ 0.2% (Foliar spray at fortnightly intervals)

T_4: 4 weeks old fish jaggery extract @ 0.2% (Foliar spray at fortnightly intervals)

T_5: 4 weeks old egg extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_6: 6 weeks old egg extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_7: 4 weeks old egg extract @ 0.2% (Foliar spray at fortnightly intervals)

T_8: 6 weeks old egg extract @ 0.2% (Foliar spray at fortnightly intervals)

T_9: Water spray

T_{10}: Raising crop adopting Package of Practices Recommendations, KAU

5.2.3. Yield and yield attributes

The yield and yield attributes of okra were significantly influenced by the different treatments. Soil application of 6 weeks old preparation of egg extract resulted in the highest number of fruits per plant (28) as seen in Fig. 14. Similar result was obtained by Alagesan *et al.* (2009) in tomato plants. The highest weight of fruits per plant (Fig. 15) was obtained in soil application of 2 weeks old preparation of fish jaggery extract (403.53 g plant^{-1}). The presence of hormones and growth regulators in the liquid organic manures might be the reason for better fruit production. The study revealed that soil application of 2 weeks old preparation of fish jaggery extract recorded the highest yield of okra (22.42 t ha^{-1}). The increase in yield in this treatment over POPR was 43.84 per cent (Fig. 16). The results agree with the findings of Aung and Flick (1980), where fish soluble applied at weekly or biweekly intervals gave comparable growth and yield of sand-culture-grown tomatoes. The results on number and weight of fruits per plant and yield per hectare showed that treatments receiving soil application of 2 and 4 weeks old preparation of fish jaggery extract and 4 and 6 weeks old preparation of egg extract recorded higher values compared to their foliar sprays.

The highest number of seeds per pod was noticed in foliar spray of 6 weeks old egg extract (65.67) which were on par with water spray (65.00). The treatments receiving soil application of 4 weeks old preparation of fish jaggery extract resulted in higher number of seeds as compared to foliar spray. Foliar spray of 6 weeks old preparation of egg extract resulted in higher number of seeds as compared to soil application (Fig. 17).

The treatments had a significant effect on 100 seed weight of okra (Fig. 18). Foliar spray of 4 weeks old preparation of egg extract showed the highest 100 seed weight (5.41 g) followed by the soil application of 4 weeks old preparation of egg extract (5.11 g). The lowest weight was recorded by POPR (4.25 g). In the case of fish jaggery extract (4 weeks old preparation), 100 seed weight was higher in soil applied plots than its foliar spray. But in the case of egg extract, foliar applied plots of 4 and 6 weeks old preparations recorded higher seed weight than soil application.

Plate 10. Crop at harvest

The shelf life could be extended in all the treatments receiving organic management practices. Foliar spray of 6 weeks old preparation of egg extract (T_8) had the maximum shelf life of okra fruits *i.e.* 8.67 days followed by foliar spray of 4 weeks old preparation of egg extract and soil application of 2 weeks old preparation of fish jaggery extract (8 days). Soil application of 2 and 4 weeks old preparations of fish jaggery extract led to higher shelf life than their foliar spray whereas foliar spray of 4 and 6 weeks old preparations of egg extract recorded higher shelf life than their soil application (Fig. 19). Organic manures influenced the respiration and enzyme activity in fruits by altering the biological and physiological activities. The decrease in enzyme activity and respiration might have lead to higher shelf life.

5.2.4. Incidence of pests and diseases

Pests and disease attack was not that much severe in the experimental field. Aphid (*Aphis gossypii*) attack was seen uniformly in all plots in the initial stages of crop growth. Beauveria (1 %), neem soap and neem garlic emulsion sprays were given for the control of aphid. The pest and disease resistance might be due to the organic management practices as well as the liquid organic manure application.

5.2.5. Economic analysis

The economics of okra cultivation was influenced by different treatments (Fig. 20). All the treatments *i.e.* application of liquid organic manures, water spray and POPR were profitable. The treatment receiving soil application of 2 weeks old preparation of fish jaggery extract (@ 10%) generated the highest gross return, net return and B: C ratio. The higher B: C ratio may be attributed to the higher yield obtained through the application of liquid organic manures.

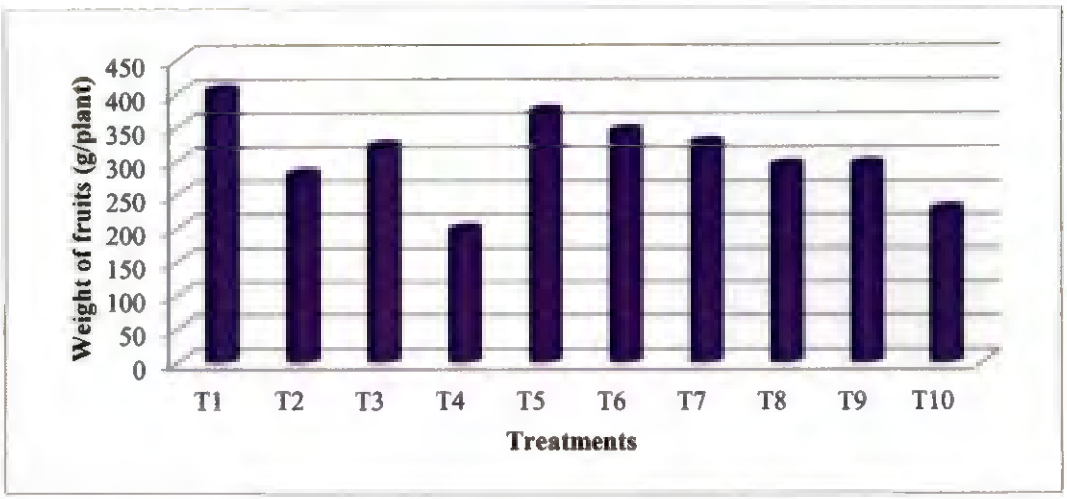

Fig.15. Effect treatments on weight of fruits per plant

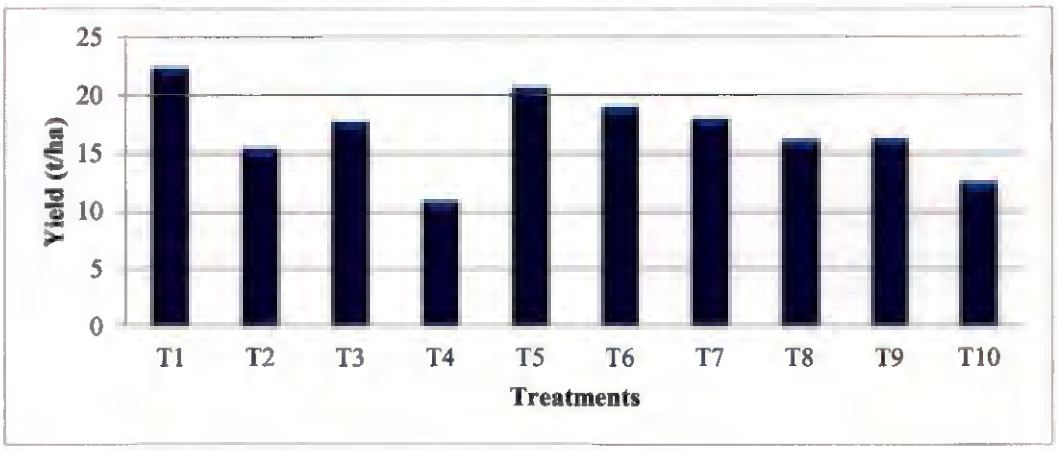

Fig.16. Effect of treatments on yield of okra

T_1: 2 weeks old fish jaggery extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_2: 4 weeks old fish jaggery extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_3: 2 weeks old fish jaggery extract @ 0.2% (Foliar spray at fortnightly intervals)

T_4: 4 weeks old fish jaggery extract @ 0.2% (Foliar spray at fortnightly intervals)

T_5: 4 weeks old egg extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_6: 6 weeks old egg extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_7: 4 weeks old egg extract @ 0.2% (Foliar spray at fortnightly intervals)

T_8: 6 weeks old egg extract @ 0.2% (Foliar spray at fortnightly intervals)

T_9: Water spray

T_{10}: Raising crop adopting Package of Practices Recommendations, KAU

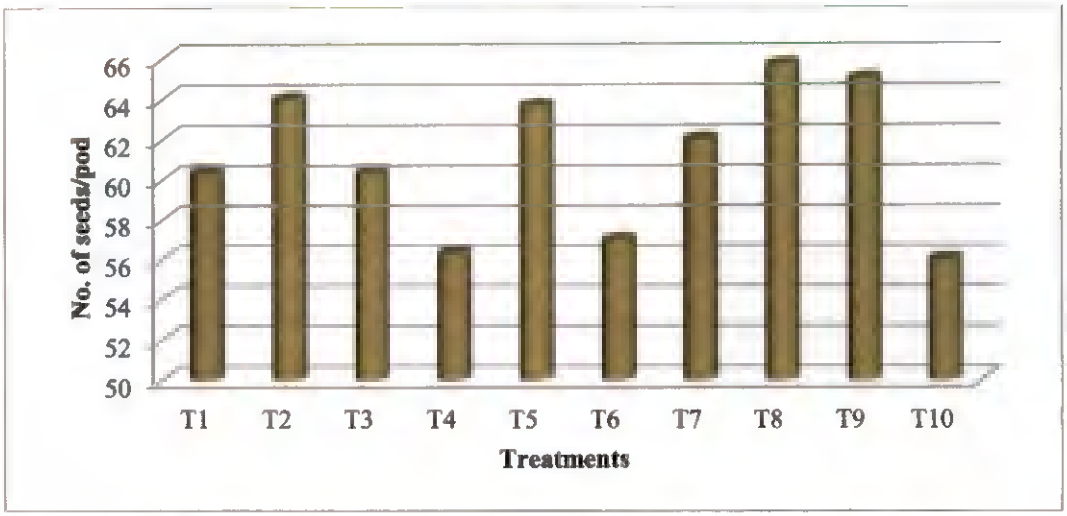

Fig.17. Effect of treatments on number of seeds per pod

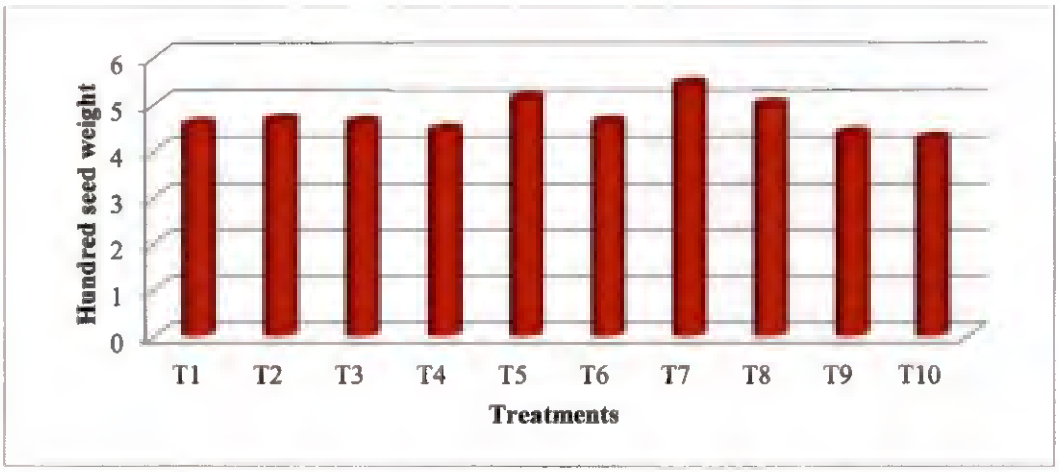

Fig.18. Effect of treatments on seed weight

T_1: 2 weeks old fish jaggery extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_2: 4 weeks old fish jaggery extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_3: 2 weeks old fish jaggery extract @ 0.2% (Foliar spray at fortnightly intervals)

T_4: 4 weeks old fish jaggery extract @ 0.2% (Foliar spray at fortnightly intervals)

T_5: 4 weeks old egg extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_6: 6 weeks old egg extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_7: 4 weeks old egg extract @ 0.2% (Foliar spray at fortnightly intervals)

T_8: 6 weeks old egg extract @ 0.2% (Foliar spray at fortnightly intervals)

T_9: Water spray

T_{10}: Raising crop adopting Package of Practices Recommendations, KAU

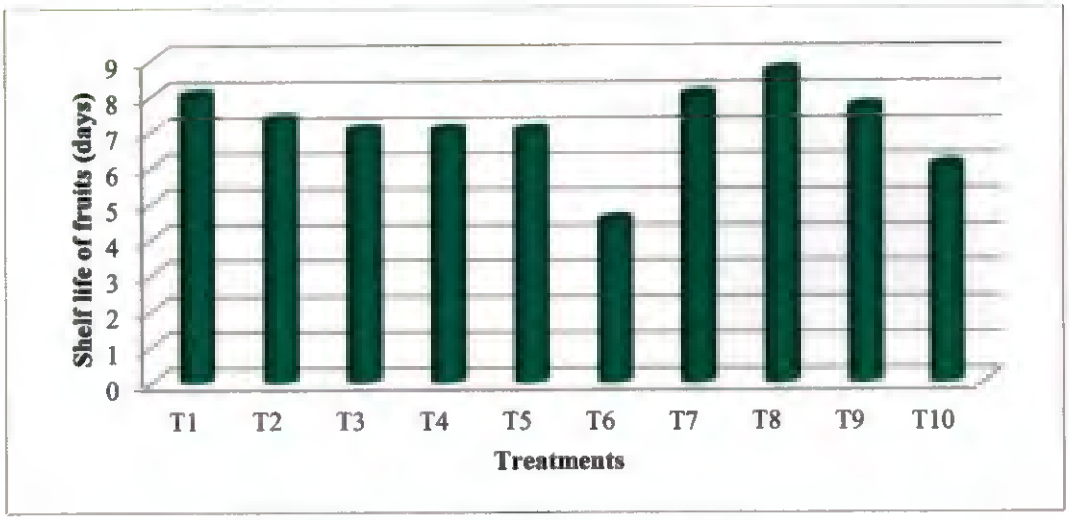

Fig.19. Effect of treatments on shelf life of fruits

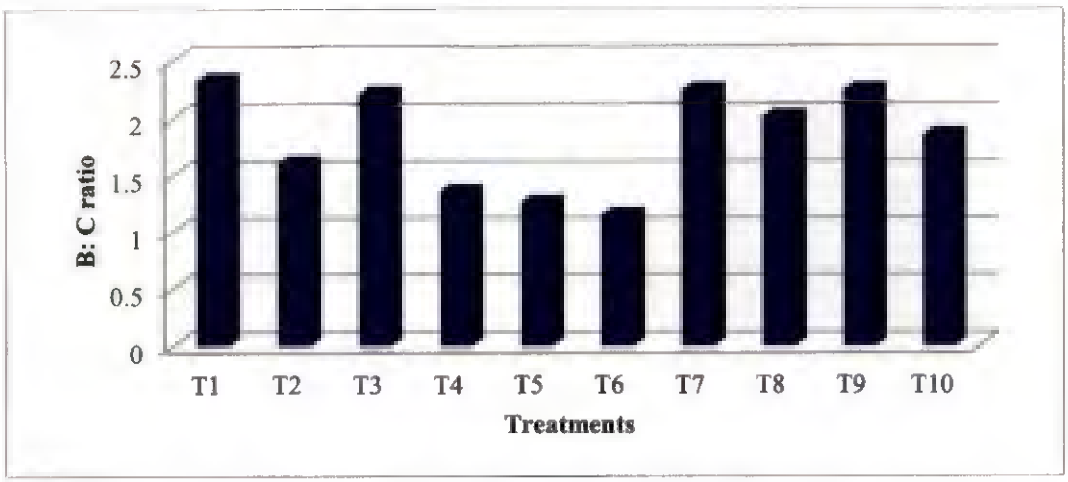

Fig.20. Effect of treatments on B: C ratio of okra

T_1: 2 weeks old fish jaggery extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_2: 4 weeks old fish jaggery extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_3: 2 weeks old fish jaggery extract @ 0.2% (Foliar spray at fortnightly intervals)

T_4: 4 weeks old fish jaggery extract @ 0.2% (Foliar spray at fortnightly intervals)

T_5: 4 weeks old egg extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_6: 6 weeks old egg extract @ 10% (Soil application at 20 DAS @1L/ plant)

T_7: 4 weeks old egg extract @ 0.2% (Foliar spray at fortnightly intervals)

T_8: 6 weeks old egg extract @ 0.2% (Foliar spray at fortnightly intervals)

T_9: Water spray

T_{10}: Raising crop adopting Package of Practices Recommendations, KAU

CONCLUSION

The study on "Validation of liquid organic manures and their effect on crop productivity" revealed the possibility of keeping the liquid organic manures *viz.*, fish jaggery extract and egg extract up to one and a half month without deteriorating the quality. Application of organic manures along with fish jaggery extract and egg extract has improved the soil health by enhancing the physical, chemical and biological properties. Soil application and foliar spray of fish jaggery extract and egg extract has proved to be supplementing the growth and yield of okra. The treatment receiving soil application of 2 weeks old preparation of fish jaggery extract @ 10% recorded the highest number of leaves, total dry matter production, fruit yield per plant, total yield and B: C ratio (2.33).

Future line of work

1. Identification of microorganisms in liquid organic manures
2. Confirmation studies on nutrient content and uptake
3. Effect on quality parameters
4. Changes in physiological processes of plants
5. Anatomical studies of plants treated with liquid organic manures

Summary

6. SUMMARY

The present investigation on "Validation of liquid organic manures and their effect on crop productivity" was conducted during 2016-2017 at College of Horticulture, Kerala Agricultural University, Vellanikkara, Thrissur. Fish jaggery extract and egg extract were selected for the study and okra (variety Arka Anamika) was used as test crop to find out the effect of liquid organic manures on productivity. The summary of salient findings is furnished below.

Experiment I

Influence of shelf life on quality of fish jaggery extract and egg extract

- Increase in storage period changed the colour and odour of fish jaggery extract and egg extract. The colour became darker and odour became stronger.
- There was mould growth on the surface of fresh preparation of fish jaggery extract while it was absent in egg extract.
- Maggots were absent in both the liquid manures during the storage period.
- Fish jaggery extract (3.05-3.33) and egg extract (2.89-4.88) were highly acidic in nature.
- The organic carbon content in fish jaggery extract increased due to storage while there was no change in the egg extract.
- The macro and micro nutrient content was stable throughout the storage periods.
- The highest count of bacteria and fungi in egg extract was found in 6 weeks old preparation. In fish jaggery extract, the highest bacterial and fungal count was in 10 weeks old preparation and 12 weeks old preparation respectively. Both the liquid manures were free from actinomycetes and *Escherichia coli*.
- Protein and amino acids were detected in both liquid manures.

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Experiment II

Effect of fish jaggery extract and egg extract on growth and yield of okra

- There was no significant variation in pH and organic carbon due to treatments but the organic carbon content increased in treatments receiving organic practices.
- The highest available N, P and K was in the treatments receiving POPR (266.56 kg ha^{-1}), soil application of 4 weeks old preparation of fish jaggery extract @ 10% (64.86 kg ha^{-1}) and soil application of 6 weeks (380.77 kg ha^{-1}) and 4 weeks (373.12 kg ha^{-1}) old preparation of egg extract respectively.
- Bacterial count was the highest ($41.00x10^4$ cfu g^{-1} of soil) in the treatment with foliar spray of 6 weeks old preparation of egg extract (@ 0.2%). The treatment with soil application of 4 weeks old preparation of egg extract (@ 10%) had the highest fungal population ($60.33\ x10^3$ cfu g^{-1}). The actinomycetes count was the highest in treatments with foliar spray of 4 weeks old fish jaggery extract @ 0.2% ($8.67x10^4$ cfu g^{-1}) and soil application of 2 weeks old preparation of fish jaggery extract @ 10% ($8.00\ x10^4$ cfu g^{-1}).
- The plant height was the highest at 60 DAS in the treatment receiving soil application of 6 weeks old preparation of egg extract @ 10%.
- The treatment receiving soil application of 2 weeks old preparation of fish jaggery extract @ 10% resulted in higher leaf production.
- Dry matter production of okra was more in the treatment receiving soil application of 2 weeks old preparation of fish jaggery extract @ 10%.
- The highest number of fruits was recorded in the treatment receiving soil application of 6 weeks old preparation of egg extract @ 10%.
- The weight of fruits and total yield were the highest in the treatment receiving soil application of 2 weeks old preparation of fish jaggery extract @ 10% *i.e.*, 403.53 g plant ^{1} and 22.42 Mg ha^{-1} respectively.

- The increase in yield in the treatment receiving soil application of 2 weeks old preparation of fish jaggery extract over POPR was 43.84%.
- The highest number of seeds was observed in the treatment receiving foliar spray of 6 weeks old egg extract @ 0.2 % and water spray
- The treatment receiving foliar spray of 4 weeks old preparation of egg extract @ 0.2% had the highest 100 seed weight and the lowest was in the treatment receiving POPR.
- The highest shelf life of okra fruits was noticed in the treatment receiving foliar spray of 6 weeks old preparation of egg extract @ 0.2%.
- The highest B: C ratio was obtained in the treatment receiving soil application of 2 weeks old preparation of fish jaggery extract.

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Appendix

Appendix I. Meteorological data during the crop growing period

Date	Max. Temperature (°C)	Min. Temperature (°C)	Mean RH (%)	Mean sunshine hours (h)	Rainfall (mm)	Number of rainy days (Mean)	Evaporation (cm)
22/1 - 28/1	33.9	25.5	51	4.6	00.0	0	5.9
29/1 - 4/2	35.1	23.5	1	8.5	00.0	0	5.2
5/2 - 11/2	35.7	23.0	46	9.2	00.0	0	5.1
12/2 - 18/2	35.4	23.8	43	10.1	00.0	0	7.8
19/2 - 25/2	36.3	22.9	63	6.7	00.0	0	4.4
26/2 - 4/3	37.4	24.5	50	7.0	00.0	0	6.3
5/3 - 11/3	35.2	24.5	71	7.0	02.7	0	3.8
12/3 -18/3	34.9	23.8	70	7.1	10.2	1	3.8
19/3 - 25/3	36.3	25.0	70	7.2	00.3	0	4.1
26/3 - 1/4	38.0	25.6	65	9.1	00.0	0	4.9
2/4 - 8/4	36.3	26.0	69	7.3	00.0	0	4.3
9/4 - 15/4	35.6	26.1	72	4.9	18.6	1	3.4
16/4 - 22/4	34.8	26.1	71	6.4	00.0	0	3.6
23/4 - 29/4	35.6	26.1	69	6.5	00.5	0	3.8
30/4 - 6/5	36.3	24.7	69	8.2	28.4	3	4.6

VALIDATION OF LIQUID ORGANIC MANURES AND THEIR EFFECT ON CROP PRODUCTIVITY

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(2015-11-019)

ABSTRACT OF THE THESIS

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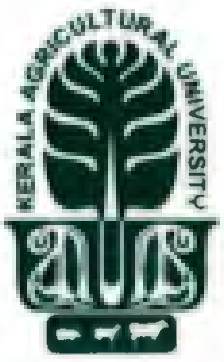

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ABSTRACT

The study entitled "Validation of liquid organic manures and their effect on crop productivity" was conducted in the Department of Agronomy, College of Horticulture, Vellanikkara during 2016 - 2017 to find out the shelf life of fish jaggery extract and egg extract and their effect on growth and yield of okra. The study consisted of two experiments.

The objective of the first experiment was to study the characteristics of two liquid organic manures, fish jaggery extract and egg extract, which were stored for 1, 2, 4, 6, 8, 10, 12, 16, 20 and 24 weeks. Fresh preparations as well as the stored samples were analyzed for various quality parameters. Both liquid manures were highly acidic in nature with pH values ranging from 3.05 to 3.33 in fish jaggery extract and 2.89 to 4.88 in egg extract. The N, P and K contents in fresh fish jaggery extract were 1.04 %, 0.042 % and 0.29 % and the corresponding values in fresh egg extract were 0.22 %, 0.006 % and 0.23 %. There was no change in N content of fish jaggery extract due to storage, while the highest N content in egg extract was observed in 6 weeks after storage (1.11 %). The highest P content was in 10 weeks old preparation of fish jaggery extract (1220 ppm) and 24 weeks old preparation of egg extract (440 ppm). Ten weeks (0.73 %) and two weeks old preparation (0.71 %) of fish jaggery extract and four weeks old egg extract (0.44 %) had higher K content. Secondary and micronutrients were also present in both liquid manures.

The total microbial population *viz.*, bacteria and fungi were significantly influenced by the storage period. The highest bacterial count was observed in 10 weeks old fish jaggery extract (27.33×10^2 cfu $ml^{-1)}$ and 6 weeks old egg extract (23.67×10^2 cfu ml^{-1}). Fungal population was the highest in 12 weeks old fish jaggery extract (10.00×10^3 cfu ml^{-1}) and 6 weeks old egg extract (27.67×10^3 cfu ml^{-1}). Actinomycetes and *Escherichia coli* were absent in fish jaggery extract and egg extract, even at 24 weeks of storage.

The second part of the study was a field experiment on "Effect of fish jaggery extract and egg extract on growth and yield of okra". The treatments consisted of soil application of liquid organic manures (10 % solution @1 L/plant: T_1, T_2, T_5 and T_6), foliar spray (@ 0.2 %: T_3, T_4, T_7 and T_8), water spray (T_9) and manuring and fertilizer application as per Package of Practices Recommendations, KAU (T_{10}). Organic manures were applied as per the Package of Practices Recommendations (Ad hoc) for organic farming to all the treatments except in T_{10}. Soil application of liquid organic manures was done at 20 DAS and foliar spray at fortnightly intervals (5 times) was started at 20 DAS.

Soil application of two weeks old preparation of fish jaggery extract (10%) produced the highest number of leaves at 60 DAS (25.40), total dry matter production at final harvest (5.66 t ha^{-1}), fruit yield per plant (403.54 g) as well as total yield (22.42 t ha^{-1}) resulting in the highest gross return, net return and B: C ratio (2.33).

The results revealed the possibility of storing fish jaggery extract upto one month and egg extract upto one and half month after preparation without quality deterioration. In field experiment, soil application as well as foliar spray of fish jaggery extract or egg extract helped to enhance the soil and crop productivity.