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Significance of liquid organic manures in sustainable crop production: A review

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Abstract
The organic manures provide a way for reducing the indiscriminate use of chemical fertilizers and help to maintain the soil health with a positive impact on organic matter recycling. The liquid organic manures helps to achieve higher growth and development of the crops through improved physiological and biochemical processes of the plant, as their application results in rapid availability of macronutrients, micronutrients, growth regulators and other beneficial substances to the plants in addition to enhanced tolerance to biotic and abiotic stresses. They also increase the beneficial microflora of the soil and their activity to a large extent upon soil application and thereby increase the availability of soil nutrients. These liquid organic manures are low cost production technologies as they can be easily prepared from naturally and locally available materials by the farmers, thereby they also offers ecofriendly nature. Thus use of liquid organic manures in agriculture play prime role to sustain the soil fertility and crop productivity.

Keywords: liquid organic manures, crop productivity, micro flora, soil fertility

Introduction

At present ever increasing population is exerting tremendous pressure on agriculture to meet their nutritional food requirement across the world. In order to achieve the current demand of food requirement, farmers are relying more on chemical fertilizers to achieve higher productivity per unit area. However, the efficiency of the chemical fertilizers already reached a plateau due to their indiscriminate use and resulted in poor soil fertility status of the agriculture fields in addition to accumulation of toxic substances in the harvested produces. Also the cost of inorganic fertilizers is increasing enormously to an extent that they are not affordable by the small and marginal farmers. In this regard there is a need to identify the suitable substitute in place of chemical fertilizers which are economically cheaper and ecofriendly. In this juncture, the use of organic fertilizers either bulky or liquid organic manures plays an important role to sustain the soil health as well as productivity of the crops (Verma *et al*., 2018) [45].

In particular the use of liquid organic manures not only helps to achieve higher yield but also a low-cost production approach, thus helps to realize higher returns by the farmers (Devakumar *et al*., 2014) [13]. The beneficial microorganisms will survive in the liquid organic manures and are helpful in phosphate solubilization, nitrogen fixation *etc*. Upon their application, they will enhance the soil microbial population and their activity to a larger extent in soil and inturn have positive effect on growth and development of crops (Boraiah *et al.*, 2017) [7]. The liquid organic manures easily disperse in water and are readily available to plants compared to bulky organic manures and interestingly plants can absorb nutrients through the leaves about 20 times faster when applied as foliar spray than applied through the soil, thereby helps to overcome temporary and acute nutrient shortages in the crops (Dhanoji *et al*., 2018) [14]. The jeevamrutha, beejamrutha, panchagavya, sanjivak, amrithpani, vermiwash, cow urine and enriched biodigester liquid manure are easily available ecofriendly liquid organic manures which contains macro nutrients, essential micro-nutrients, amino acids, vitamins, growth promoting substances like IAA, GA and beneficial micro-organisms (Chongre *et al*., 2019) [9]. Recently, the natural seaweeds are also being used as substitute in place of synthetic fertilizers and seaweed extracts are marketed as liquid fertilizers and bio-stimulants as they contain multiple growth regulators such as cytokinin, auxins, gibberellins, betaines in addition to macronutrients (Ca, K and P) and micronutrients (Fe, Cu, Zn, B, Mn, Co and Mo) which plays a major role in plant growth and development (Begum *et al*., 2018) [3]. Thus in the present review we are discussing about the effect of different liquid organic manures on growth, yield and quality of crops as well as their beneficial effects on soil properties.

Effect on growth and yield of crops

The liquid organic manures contains small quantities of macronutrients, micronutrients and growth promoting substances in addition to huge beneficial microbial population, thus when applied to the crop either as foliar spray or through soil they trigger the necessary plant growth and development which ultimately led to better crop yield. Ramesh *et al*. (2015) [33] reported that foliar spray of 5% jeevamrutha at 20, 40 and 60 DAS recorded significantly higher plant height (202.57 cm), leaf area index (8.09), cob length (22.38 cm), cob girth (14.07 cm), number of grains per cob (438.73), grain yield (5863 kg ha^{-1}) and stover yield of maize (8119 kg ha^{-1}) but it was found on par with 5% beejamrutha application at 20, 40 and 60 DAS. They also opined that higher availability of growth promoting substances like IAA, GA, cytokinin, kinetin, essential plant nutrients and effective microorganisms which were present in jeevamrutha and beejamrutha may directly influenced the photosynthetic activity and assimilate partitioning from source to sink and might have resulted in higher grain yield of maize. Combined application of recommended dose of fertilizers and 4 sprays of 3% panchagavya at 15, 25, 35 and 45 DAS resulted in higher plant height (199 cm), leaf area index (5.77), green cob yield (7476 kg ha^{-1}) and fodder yield (33.37 t ha^{-1}) of baby corn when compared to sole application of recommended dose of fertilizers (Loganathan and Wahab, 2014) [23]. Safiullah *et al*. (2018)[35] also observed higher plant height (191.78 cm), green cob yield (16.15 t ha^{-1}) and fodder yield (20.07 t ha^{-1}) of sweet corn with the application of jeevamrutha @ 600 L ha^{-1} three times through irrigation water. In case of transplanted rice, 41.47 and 53.66 per cent increase in grain and straw yield with the application of 15% *Kappaphycus*-sap (Seaweed extract) + recommended dose of fertilizers was reported by Pramanick *et al.* (2014) [29]. Along with recommended dose of fertilizers, soaking of seeds in 3% panchagavya and 3% panchagavya spray at tillering and jointing stage resulted in higher number of tillers (2.98 $plant^{-1}$), spike length (8.85 cm), number of grains (48.83 $spike^{-1}$), grain yield (4558 kg ha^{-1}) and straw yield (6705 kg ha^{-1}) of wheat than recommended dose of fertilizers applied alone (Pagar *et al.*, 2016) [27]. Foliar application of 3% panchagavya recorded higher ear head length (20.70 cm), ear head weight (6.49 g), seed yield (5.98 g $plant^{-1}$), thousand seed weight (4.89 g) and seed yield (22.11 q ha^{-1}) of foxtail millet and the magnitude of increase in yield was 13 per cent over control (Atish *et al.*, 2019) [2].

In groundnut, combined application of panchagavya at 4% as foliar spray and jeevamrutha at 500 L ha^{-1} as soil application recorded significantly higher pod yield (1563 kg ha^{-1}) and haulm yield (30.86 kg ha^{-1}) as against the yield under recommended dose of fertilizers (Patel *et al.*, 2018) [28]. In blackgram, Choudhary *et al*. (2017) [11] revealed that application of 4% panchagavya at branching and flowering stages registered significantly maximum dry matter (7.20 g $plant^{-1}$), leaf area index (1.92), number of pods (27.42 $plant^{-1}$), number of seeds (6.78 pod^{-1}), test weight (38.46 g), seed yield (801 kg ha^{-1}) and straw yield (1735 kg ha^{-1}) over control and they attributed higher yield of blackgram to balanced nutrition provided by panchagavya application resulted in better development and robust growth of blackgram. Panchagavya contains essential nutrients like N, P, K, S, Fe and Zn and beneficial micro-organisms such as *Azospirillum*, *Azotobactor*, *Phosphobacteria* and *Pseudomonas* besides *Lactobacillus* (Yadav and Lourduraj, 2006) [47] which promotes the plant growth parameters. Whereas in case of green gram, higher number of pods (25.1 $plant^{-1}$), number of seeds (11.1 pod^{-1}), test weight (37.1 g), seed yield (1085 kg ha^{-1}) and straw yield (3224 kg ha^{-1}) were recorded with the application of FYM @ 12 kg N equivalent at land preparation + Panchagavya @ 8 kg N equivalent through irrigation water at 30 DAS and 45 DAS in equal splits (Chongre *et al.*, 2019) [9]. Similar kind of higher growth and yield parameters of green gram with the application of 15% *Kappaphycus*-sap (Seaweed extract) + recommended dose of fertilizers was also reported by Pramanick *et al*. (2013) [30]. Whereas, the higher growth and yield attributing parameters with 15% seaweed extract from *Kappaphycus alvarezii* application resulted in 57% higher grain yield of soybean (Rathore *et al.*, 2009) [34]. Application of jeevamrutha at 1000 L ha^{-1} and panchagavya at 7.5% recorded significantly higher growth parameters like number of branches (9.37), number of leaves (28.6), leaf area index (1.87) and yield attributes like number of pods (22.16 $plant^{-1}$), number of seeds (16.02 pod^{-1}), seed weight (9.98 g $plant^{-1}$) and ultimately higher grain yield (1478 kg ha^{-1}) and haulm yield (5183 kg ha^{-1}) of cowpea compared to control (Sutar *et al.*, 2019) [41].

In case of capsicum, higher fruit yield of about 465.13 and 465.92 q ha^{-1} was recorded with the application of cow urine (2500 L ha^{-1} at vegetative and flowering stages) + jeevamrutha (500 L ha^{-1} at 25, 50, 75 and 100 DAT) and 6% panchagavya spray + jeevamrutha (500 L ha^{-1}) both at 25, 50, 75 and 100 DAT, respectively (Boraiah *et al.*, 2017) [7]. Similar kind of higher growth and yield parameters of capsicum with foliar spray of 2.5% panchagavya and neem oil 4 ml per liter alternatively at 10 days interval (6 sprays) was also reported by Mishra *et al.* (2015)[24]. The higher yield parameters such as number of fruits (19 $plant^{-1}$) and fruit weight (30.67 mg $fruit^{-1}$) of okra was recorded in the plants sprayed with 3% concentration of panchagavya when compared with control and other concentrations (1, 5 and 7%) (Rakesh *et al.*, 2017)[32]. The higher fruit yield of okra (69.75 q ha^{-1}) with foliar spray of liquid seaweed fertilize at 2.5% concentration during flower initiation stage and subsequent sprays at three weeks interval was also reported by Zodape *et al.* (2008) [48]. In case of radish, higher marketable yield (49.25 t ha^{-1}) was achieved with foliar spray of vermiwash at 1:4 (water: vermiwash) proportion when compared to control (Jadhav *et al.*, 2014) [19]. The soil treatment of recommended dose of fertilizers + beejamrutha (seed treatment) + jeevamrutha (soil application) + panchagavya (3% foliar spray) resulted in increased plant height (143.21 cm), root length (19.80 cm), dry matter (7.94 g $plant^{-1}$), number of fruits (23.25 $plant^{-1}$) and fruit weight (316.64 g $plant^{-1}$) of tomato compared to other treatments and control (Nileema *et al.*, 2011) [26].

Effect on quality of crops

The higher total reducing sugar (3.19%) and total non-reducing sugar (19.57%) content of sweet corn was noticed with the application of panchagavya @ 600 L ha^{-1} and jeevamrutha @ 600 L ha^{-1} three times through irrigation water, respectively (Safiullah *et al.*, 2018) [35]. Maximum carbohydrate content in maize grain (63.9%) was recorded with the application of 15% K sap (Seaweed sap) along with 100% recommended dose of fertilizers and which was superior over rest of the combinations as well as control (Singh *et al*., 2015) [40]. Whereas, higher protein content of wheat (12.75%) with soaking of seeds in 3% panchagavya and 3% panchagavya spray at tillering and jointing stage in addition to recommended dose of fertilizers was also reported by Pagar *et al.* (2016) [27]. Increased nutrient content in wheat grains with foliar application of *Kappaphycus alvarezii* and *Gracilaria edulis* sap at 7.5% concentration was reported by Shah *et al.* (2013) [36] and they also recorded higher fat (2.14%) and protein content (15.64%) with foliar application of 7.5% *Kappaphycus alvarezii* sap at vegetative, tillering and grain filling stages of crop growth period. Similar kind of increased crude protein content in rice grains with the application of seaweed sap spray upto 15% concentration and increased micro-nutrient content in rice grains like Cu and Zn up to 10% concentration while Fe and Mn upto 5% concentration in addition to recommended dose of fertilizers was also reported by Layek *et al*. (2017) [22].

Foliar application of panchagavya at 4% concentration during branching and flowering stage of blackgram resulted in higher protein content in seed (22.36%) along with increased nutrient content (N, P, K, S, Zn and Fe) both in seed and straw (Choudhary *et al*., 2017) [10]. In case of soybean, higher protein content (1.37 mg g^{-1} tissue) and ascorbic acid content (0.72 mg g^{-1} tissue) of seed with combined application of panchagavya at 10%, humic acid at 2% and micro herbal fertilizer at 10 g per pot was also reported by Vijayakumari *et al*. (2012) [46]. Higher oil content (40.7%), protein content (22.4%), oil yield (685.1 kg ha^{-1}) and protein yield (377.7 kg ha^{-1}) of groundnut with combined application of farm yard manure (7.5 t ha^{-1}), *Rhizobium,* phosphorus solubilizing bacteria (10 kg each ha^{-1}) and 3% panchagavya at 30, 60 and 75 days after sowing was noticed by Kumar *et al.* (2011) [20]. Similar kind of higher oil and protein content and their respective yields in groundnut was also reported by Bhanuvally *et al.* (2014) [4]. Application of 0.6% *Gracilaria dendroides* extract recorded higher oil content (42.56%), potassium content (46.33 mg kg^{-1}) and crude protein (37.74%) of sunflower seed while higher sodium content (14.07 mg kg^{-1}) was noticed with 0.4% *Ulva lactuca* extract application (Hannan and Salem, 2011) [18].

In capsicum, Mishra *et al.* (2015)[24] observed higher total soluble solids (6.17^{O} Brix), chlorophyll content (4.15 mg g^{-1}) and ascorbic acid content (168.3 mg $100g^{-1}$) with foliar spray of 2.5% panchagavya and neem oil 4 ml per liter alternatively at 10 days interval (6 sprays). Whereas, Boraiah *et al.* (2018) [6] recorded higher capsaicin content (0.39%) in capsicum with cow urine (2500 L ha^{-1} at vegetative and flowering stages) + jeevamrutha (500 L ha^{-1} at 25, 50, 75 and 100 DAT) application. The higher carbohydrates (6.25 g), protein (1.37 g), dietary fibre (1.22 g) and vitamin C content (13 mg) per 100 g edible portion of okra with foliar spray of liquid seaweed fertilize at 2.5% concentration during flower initiation stage and subsequent sprays at three weeks interval was also reported by Zodape *et al.* (2008)[48] and they also observed higher content of nutrients in okra fruit (P, K, Na, Ca and Mg) when compared to other concentrations and control. Similarly Ansari and Sukhraj (2010) [1] also recorded higher per cent of fats and protein in okra with combined application of vermicompost and vermiwash compare to control. The higher total soluble solids, ascorbic acid and protein content of bitter gourd with three sprays of panchagavya at 20, 40 and 60 DAS and three sprays of vermiwash at 25, 50 and 75 DAS application was also reported by Gajjela and Chatterjee (2019) [15].

Effect on nutrient uptake of crops

Combined application of bee jamrutha + jeevamrutha + pan chagavya recorded significantly higher uptake of N, P and K (102.74, 11.99 and 98.65 kg ha^{-1}, respectively) as compared to beejamrutha + jeevamrutha application (60.61, 12.98 and 58.47 kg ha^{-1}, respectively) under chilli crop (Chandrakala *et al*., 2007) [8]. Higher uptake of N, P and K (161.5, 32.2 and 145.5 kg ha^{-1}, respectively) with the application of FYM at 12.5 t ha^{-1} and cattle urine at 34300 L ha^{-1} in maize was reported by Veeresha (2010)[44]. Similarly higher NPK uptake by onion with 10 t ha^{-1} FYM along with 100 kg N equivalent cow urine was also revealed by the Gopakkali *et al.* (2011) [17]. Whereas Naik (2011) [25] reported higher NPK uptake (182.5, 38.5 and 181.1 kg ha^{-1}, respectively) in maize with the application of FYM at 12.5 t ha^{-1} + biodigester liquid manure equivalent to 150 kg N ha^{-1}. In fingermillet similar kind of higher nitrogen (92.3 kg ha^{-1}), phosphorus (15.45 kg ha^{-1}) and potassium (82.2 kg ha^{-1}) uptake with 10 t ha^{-1} FYM+ bio-digester liquid manure equivalent to 35 kg N ha^{-1} was also reported by Siddaram (2012) [39]. The higher uptake of NPK in cowpea with jeevamrutha at 1000 L ha^{-1} as soil application and 7.5% panchagavya as foliar spray was reported by Sutar *et al*. (2017) [42].

Effect on soil chemical and biological properties

The foliar spray of panchagavya @ 4% + jeevamrutha @ 500 L ha^{-1} as soil application resulted in maximum number of *Rhizobium*, *Azospirillum* and *Azotobacter* population in experimental soil of *kharif* groundnut in addition to enhanced available phosphorus, potassium and organic carbon in the soil (Patel *et al.*, 2018) [28]. The higher available nitrogen (269.9 kg ha^{-1}), phosphorus (45.9 kg ha^{-1}), potassium (389.1 kg ha^{-1}), iron (6.22 ppm), zinc (1.77 ppm), copper (0.68 ppm) and manganese (9.87 ppm) content under rainfed groundnut crop with combined application of vermicompost (3 t ha^{-1}) + panchagavya spray (3% @ 30, 60 and 75 DAS) + liquid manure (2000 L ha^{-1}) + jeevamrutha (2000 L ha^{-1}) was also reported by Bhanuvally *et al.* (2014) [5]. The maximum population of general bacteria, fungi and actinomycetes (50.33×10^5, 32.33×10^4 and 20.33×10^3 CFU g^{-1} soil, respectively) at the end of the experiment as against the initial population (40.33×10^5, 20.33×10^4 and 15.33×10^3 CFU g^{-1} soil, respectively) were recorded with jeevamrutha @ 1000 L ha^{-1} and panchagavya at 7.5% application to fieldbean crop (Devakumar *et al*., 2018) [12]. Similar kind of higher microbial population with jeevamrutha at 400 L $acre^{-1}$ and 7.5 per cent panchagavya application in fieldbean was also reported by Lavanya *et al*. (2016) [21]. Sharada (2013) [37] noticed higher populations of soil microflora *viz.*, bacteria, fungi, actinomycetes, free living nitrogen fixers and PSB at different growth stages of both greengram and *rabi* sorghum with combined application of organic manures along with panchagavya spray as compared to RDF. Improvement in the soil available nutrient status (N, P, K, Ca and Mg) upon combined application of vermicompost and vermiwash under samba rice cultivated soil was reported by Tharmaraj *et al.* (2011) [43]. Similar kind of higher nitrogen, phosphorus and potassium content of soil after harvest of aerobic rice (272.7, 37.2 and 211.6 kg ha^{-1}, respectively) with the application of FYM at 10 t ha^{-1} as a basal dose and cattle urine at 100 per cent N equivalent basis was also observed by Rajanna *et al*. (2012)[31]. Shashidhar (2014) [38] also noticed improved soil physical, chemical and biological properties as compared to recommended practices with the application of enriched biodigester liquid manure at 25 kg N equivalent ha^{-1} + three sprays of panchagavya at 3%. Boraiah *et al.* (2017) [7] observed higher nitrogen fixer's population (23.86, 24.49 × 10^3 CFU g^{-1} soil at 60 DAT and 16.79, 17.37 × 10^3 CFU g^{-1} soil at harvest during *kharif* and summer, respectively) and P-solubilizers population (27.90, 31.50 × 10^3 CFU g^{-1} soil at 60 DAT and 26.68, 30.43 × 10^3 CFU g^{-1} soil at harvest during *kharif* and summer, respectively) with jeevamrutha application under capsicum crop. Similarly in case of chilli Gangadhar *et al*. (2020) [16] revealed that application of jeevamrutha at 2000 L ha^{-1} resulted in higher microbial population in soil *viz.*, bacteria (28.27 and 31.59 × 105 CFU g^{-1} soil), actinomycetes (24.32 and 26.82 × 103 CFU g^{-1} soil), fungi (17.63 and 20.46 × 104 CFU g^{-1} soil) and PSB (33.76 and 34.83 × 105 CFU g^{-1} soil) during both 2017 and 2018, respectively as compared to microbial consortia and NCOF decomposer application.

Conclusion

The improved performance of liquid organic manures either applied alone or in combination with the bulky organic manures or chemical fertilizers was noticed in all the studies with respect to growth, yield, quality and nutrient uptake of different agriculture and horticulture crops. Also these liquid organic manures play an important role in sustaining the soil health through improved soil available nutrients and increased beneficial microbial population. Thus, use of liquid organic manures helps to avoid the dependency of farmers on chemical fertilizers and provide a way for sustaining the crop productivity in agriculture.

References

1. Ansari AA, Sukhraj K. Effect of vermiwash and vermicompost on soil parameters and productivity of okra (*Abelmoschus esculentus*) in Guyana. African J Agri Res. 2010; 5(14):1794-1798.
2. Atish Bharamaraj Badiger, Shivmurty D, Hunje R. Effect of foliar organic nutrients and time of application on seed yield and yield attributes of foxtail millet (*Setaria italica* L.). Int. J Chem Stud. 2020; 8(1):1718-1721.
3. Begum M, Bordoloi BC, Singha DD, Ojha NJ. Role of seaweed extract on growth, yield and quality of some agricultural crops: A review. Agric. Reviews. 2018; (39):321-326.
4. Bhanuvally M, Rajanaika, Mudalagiriyappa, Ramesha YM, Yogeeshappa H. Effect of different organic sources of nutrients on growth, yield, quality and economics of groundnut (*Arachis hypogaea* L.). Int. J Agric Sci. 2014; 5(2):127-132.
5. Bhanuvally M, Rajanaika, Mudalagiriyappa, Ramesha YM, Yogeeshappa H. Effect of different organic sources of nutrients on physical, chemical and biological properties of soil after the harvest of groundnut (*Arachis hypogaea* L.). Int. J Agric Sci. 2014; 5(2):121-126.
6. Boraiah B, Deva kumar N, Palanna KB. Yield and quality parameters of capsicum (*Capsicum annuum* L. var. grossum) as influenced by organic liquid formulations. Int. J Pure App. Bio sci. 2018; 6(1):333-338.
7. Boraiah B, Deva kumar N, Shubha S, Palanna KB. Effect of panchagavya, jeevamrutha and cow urine on beneficial microorganisms and yield of capsicum (*Capsicum annuum* L. var. grossum). Int. J Curr. Microbiol. App. Sci. 2017; 6(9):3226-3234.
8. Chandrakala M, Hebsur NS, Bidari BI, Radder BM. Effect of FYM and fermented liquid manures on nutrients uptake by chilli (*Capsicum annum* L.) and soil nutrient status at harvest. J Asian Hort. 2007; 4(1):19-24.
9. Chongre S, Mondal R, Biswas S, Munshi A, Mondal R, Pramanick M, *et al*. Effect of liquid manure on growth and yield of summer green gram (*Vigna radiata* L. Wilczek). Curr. J App. Sci. Technol. 2019; 38(6):1-7.
10. Choudhary GL, Sharma SK, Choudhary S, Singh KP, Kaushik MK, Bazaya BR, *et al*. Effect of panchagavya on quality, nutrient content and nutrient uptake of organic blackgram [*Vigna mungo* (L.) Hepper]. J Pharmacogn. Phytochem. 2017; 6(5):1572-1575.
11. Choudhary GL, Sharma, SK, Singh KP, Choudhary S, Bazaya BR. Effect of panchagavya on growth and yield of organic blackgram [*Vigna mungo* (L.) Hepper]. Int. J Curr. Microbiol. App. Sci. 2017; 6(10):1627-1632.
12. Devakumar N, Lavanya G, Rao GE. Influence of jeevamrutha and panchagavya on beneficial soil microbial population and yield of organic fieldbean (*Dolichos lablab* L.). Mysore J Agric. Sci. 2018; 52(4):790-795.
13. Deva kumar N, Shubha S, Gowder SB, Rao GE. Microbial analytical studies of traditional organic preparations beejamrutha and jeevamrutha. Building Organic Bridges. 2014; 2:639-642.
14. Dhanoji MM, Meena MK, Naik MC. Manure and plant extracts for foliar nutrition in organic farming: A Review. Int. J Chem. Stud. 2018; 6(6):1447-1454.
15. Gajjela S, Chatterjee R. Effect of foliar application of panchagavya and vermiwash on yield and quality of bitter gourd (*Momordica charantia* L.). Int. J Chem. Stud. 2019; 7(3):218-224.
16. Gangadhar K, Devakumar N, Vishwajith, Lavanya G. Influence of different sources of organic manures and decomposers on enzymatic activity and microbial dynamics of rhizosphere soil of chilli (*Capsicum annum* L.). Int. J Curr. Microbiol. App. Sci. 2020; 9(1):542-555.
17. Gopakkali P, Channanaik GA, Rajanna HG, Sannathimmappa, Veeresha, Manjunatha KB. Growth and yield of rice (*Oryza sativa* L.) as influenced by various levels of FYM and cattle urine application in Bhadra Command Area of Karnataka. Int. J Forest. Crop Improv. 2011; 2(1):40-43.
18. Hanan EO, Salem MA. Effect of seaweed extracts as foliar spray of sunflower yield and oil content. Egyptian J Phycol. 2011; 12:57-69.
19. Jadhav PB, Kireeti A, Patil NB, Dekhane SS, Patel DJ. Effect of different levels of vermiwash spray on growth and yield of Radish cv. local variety. Asian J Hort. 2014; 9(2):449-452.
20. Kumar R, Gowda HS, Venkate J, Sridhar D, Poornima DS. Effect of integrated organic sources of nutrients on quality and economics of groundnut (*Arachis hypogaea* L.). Adv. Res. J Crop Improv. 2011; 2(1):81-85.
21. Lavanya G, Deva kumar N, Latha B, Kumar RC. Influence of jeevamrutha and panchagavya on beneficial soil microbial population in organic fieldbean. In: National Conference on Sustainable and Self Sufficient Production of Pulses through an Integrated Approach. Bengaluru, 2016, 98.
22. Layek J, Das A, Ram krushna GI, Sarkar D, Ghosh A, Zodape ST, Lal R, *et al*. Seaweed extract as organic bio-stimulant improves productivity and quality of rice in eastern Himalayas. J Appl. Phyco. 2017; 30:547-558.
23. Loganathan V, Wahab K. Influence of panchagavya foliar spray on the growth attributes and yield of baby corn (*Zea mays*) cv. COBC 1. J App. Natural Sci. 2014; 6(2):397-401.
24. Mishra N, Sahu, GS, Mishra PP, Ray M. Effect of panchagavya on growth and yield of capsicum. Int. J Tropical Agric. 2015; 33(4):1-4.
25. Naik S. Effect of farmyard manure and bio digester liquid manure on growth and yield of rainfed maize (*Zea mays* L.). M.Sc. (Agri.) Thesis, Univ. Agric. Sci., Bengaluru, 2011.

26. Nileema S, Gore, Sreenivasa MN. Influence of liquid organic manures on growth, nutrient content and yield of tomato (*Lycopersicon esculentum* Mill.) in the sterilized soil. Karnataka J Agric. Sci. 2011; 24(2):153-157.
27. Pagar RD, Jangilwad BD, Chaudhary KM. Effect of panchagavya on growth and yield of wheat (*Triticum aestivum* L.). Adv. Life Sci. 2016; 5(3):756-760.
28. Patel DM, Patel IM, Patel BT, Singh NK, Patel CK. Effect of *Panchgavya* and *jivamrut* on yield, chemical and biological properties of soil and nutrients uptake by *kharif* groundnut (*Arachis hypogaea* L.). Int. J Chem. Stud. 2018; 6(3):804-809.
29. Pramanick B, Brahmachari K, Ghosh A, Zodape S. Effect of seaweed saps on growth and yield improvement of transplanted rice in old alluvial soil of West Bengal. Bangladesh J Bot. 2014; 43(1):53-58.
30. Pramanick B, Brahmachari K, Ghosh A. Effect of seaweed saps on growth and yield improvement of green gram. African J Agric. Res. 2013; 8(13):1180-1186.
31. Rajanna GA, Murali K, Gopakkali P, Nayak, P, Sudhakar TM, Lakshmipathy RN, *et al*. Effect of different sources and time application of organic manures on residual fertility and nutrient balance in aerobic rice (*Oryza sativa* L.). Crop Res. 2012; 43(1-3):5-9.
32. Rakesh S, Poonguzhali S, Saranya B, Suguna S, Jothibasu K. Effect of panchagavya on growth and yield of *Abelmoschus esculentus* cv. Arka Anamika. Int. J Curr. Microbiol. App. Sci. 2017; 6(9):3090-3097.
33. Ramesh S, Sudhakar P, Elankavi S. Effect of liquid organic supplements on growth and yield of maize (*Zea mays* L.). Int. J Curr. Res. 2015; 07(11):23119-23122.
34. Rathore SS, Chaudhary DR, Boricha GN, Ghosh A, Bhatt BP, Zodape ST, *et al*. Effect of seaweed extract on the growth, yield and nutrient uptake of Soybean (*Glycine max*) under rainfed conditions. South African J Bot. 2009; 75:351-355.
35. Safiullah K, Durani A, Durrani H, Akbar M. Effect of Solid and Liquid Organic Manures on Growth, Yield and Economics of Sweet Corn (*Zea mays* L. *Var*. *Saccharata Sturt*) under South Gujarat Condition, Int. J Pure App. Biosci. 2018; 6(2):567-574.
36. Shah MT, Sudhakar T, Zodape, Chaudhary DR, Eswaran K, Chikara J Seaweed sap as an alternative liquid fertilizer for yield and quality improvement of wheat. J Plant Nutri. 2013; 36(2):192-200.
37. Sharada. Studies on nutrient management practices through organics in greengram - *rabi* sorghum cropping system. M.Sc. (Agri.) Thesis, Univ. Agric. Sci., Raichur, India, 2013.
38. Shashidhar GC. Development and evaluation of organic Production package for table purpose groundnut varieties in dry zones of Karnataka. Ph.D. Thesis, Univ. Agric. Sci., Bengaluru, 2014.
39. Siddaram. Effect of farm yard manure and bio-digester liquid manure on the performance of aerobic rice-fieldbean cropping sequence. Ph. D. Thesis, Univ. Agric. Sci., Bangalore, Karnataka, India, 2012.
40. Singh S, Singh MK, Pal SK, Perween S, Kumari J, Zodape ST, *et al*. Seaweed sap as productivity booster of maize. The Bioscan. 2015; 10(3):1303-1305.
41. Sutar R, Sujith GM, Deva kumar N. Growth and yield of Cowpea [*Vigna unguiculata* (L.) Walp] as influenced by jeevamrutha and panchagavya application. Legume Res. 2019; (42):824-828.
42. Sutar R, Sujith GM, Deva kumar N. Nutrient status and microbial activity as influenced by jeevamrutha and panchagavya in cowpea [*Vigna unguiculata* (L.) Walp.] Grown on *Alfisols*. Crop Res. 2017; 52(6):218-223.
43. Tharmaraj K, Ganesh P, Kolanjinathan K, Kumar SR, Anandan A. Influence of vermicompost and vermiwash on physico chemical properties of rice cultivated soil. Curr. Bot. 2011; 2(3): 18-21.
44. Veeresha. Development of nutrient management practices for organic maize (*Zea mays* L.) production under irrigated condition. M.Sc. (Agri.) Thesis, Univ. Agric. Sci. Bengaluru, 2010.
45. Verma S, Ajay Babu, Alok Patel, Singh SK, Pradhan SS, Verma SK, *et al*. Significance of vermiwash on crop production: A review. J Pharmacogn. Phytochem. 2018; 7(2):297-301.
46. Vijakumari B, Hiranmai YR, Gowri P, Kandari LS. Effect of panchagavya, humic acid and micro herbal fertilizer on yield and post-harvest soil of soya bean (*Glycine max* L.). Asian J Scientific information. 2012; 11(2):83-86.
47. Yadav BK, Lourdraj CA. Effect of organic manures and panchagavya spray on yield attributes and economics of rice (*Oryza sativa*). Crop Res. 2006; 31:1-5.
48. Zodape ST, Kawarkhe VJ, Patolia JS, Warade AD. Effect of liquid seaweed fertilizer on yield and quality of okra (*Abelmoschus esculentus* L.), J Sci. Ind. Res. 2008; 67:1115-1117.