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REVIEW ARTICLE

EFFECT OF ORGANIC LIQUID MANURES ON CROP GROWTH AND PRODUCTIVITY

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ABSTRACT

Unscientific use of chemicals in agriculture leads to several health hazards and environmental problems. To protect our crops and the environment we have to follow sustainable and eco-friendly agriculture, which minimizes the use of harmful and energy intensive inputs and adopts use of organic manures and bio fertilizers. Among the several methods of eco friendly agriculture, liquid nutrition occupies an important position. Foliar nutrition with organic compounds in vegetables is especially important as they provide quality foods, which are very important for providing health security to people. India has vast potential of organic resources and the extract prepared from these resources can be effectively utilized to sustain yield, improve physical, chemical and biological properties of soil and to maintain soil health. Commonly used liquid manures are compost tea, vermiwash, biogas slurry and cow's urine along with the extracts of oil cakes like groundnut cake, poultry manure and neem cake. Several studies were conducted on the nutrient content of common organic liquid manures. Biogas slurry, the common by product of biogas has a nutrient content of 0.5-1.0 % N; 0.5-0.8 % P and 0.6-1.5 % K (Dhobighat *et al*., 1991). The nutrient content of cow's urine was reported to be 0.9-1.2% N, 0.2-0.5% P and 0.5-1% K (Bertram, 1999). Vermiwash contains 0.5% N, 0.39% P and 0.46% K (Jasmine, 1999). Compost tea is rich in soluble nutrients, but the tea collected during early stages of composting may contain pathogens (Diver, 2002). As per the reports of Ingham (2003), the nutrient content of compost tea is 0.5-0.75% N, 0.25-0.5% P and 0.5-0.75% K.

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INTRODUCTION

Organic liquid manures on soil properties

Tisdale *et al.* (1982) reported that organic amendments like vermicompost and vermiwash promote humification, increased microbial activity and enzyme production, which, in turn bring about the aggregate stability of soil particles, resulting in better aeration. According to Haynes (1986), vermiwash has the property of binding mineral particles like calcium, magnesium and potassium in the form of colloids of humus and clay, facilitating stable aggregates of soil particles for desired porosity to sustain plant growth. Scheuerell *et al.* (2002) noticed the beneficial effect of compost tea as a source of nutrients for both plant and microbial uptake. The microbial functions of compost tea included mineralization of plant nutrients, fixation of nitrogen and competition with disease causing microbes and degradation of toxic pesticides. Sayre (2003) opined that compost tea as one of the liquid manures that enhanced nutrient status of the soil. Coconut leaf vermiwash application increased the crop production capacities of soil by enhancing the organic carbon content in the soil and also improved the physical, chemical and biological properties of the soil (Gopal *et al*., 2010). Jeevamrut, a promising liquid manure could act as a good soil tonic which enhanced the soil physical, chemical and biological properties (Palekar, 2006). Vasanthkumar (2006) reported that soil application of jeevamrut at very low rate act as a tonic to soil besides improving soil health. Ryan (2007) observed the beneficial effect of compost tea on improvement of soil structure and health. He also reported that the nutrient status of the soil was improved by the application of compost tea. Mohan (2008) observed that organic promoters like panchagavya and EM solution could improve the nutrient status of the soil. Sreenivasa *et al.* (2009) reported that the nitrogen fixation and P solubilisation capacity of the soil could be increased by the inoculation of bacterial isolates from beejamrutha. Thus, liquid manures, owing to their ability to facilitate slow release of nutrients, enhancement of soil microbial activity, improvement of soil aggregation, soil properties and soil health.

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Organic liquid manures on growth of crops

Ismail (1995) reported that vermiwash was very effective for foliar application in nurseries, lawns and orchids for obtaining maximum growth. He also observed in 1997 that this collection of excretory and secretory products of earthworms, along with major and micronutrients enhanced the growth of plants. Jasmine (1999) noticed that soil application of vermiwash @12.5 % concentration enhanced tomato growth. The positive effect of vermiwash on crop growth was also reported by Buckerfield *et al.* (1999) who observed that weekly foliar applications of vermiwash increased radish growth. Lalitha *et al.* (2000) reported that soil application of organic inputs like vermicompost in combination with vermiwash resulted in better growth of plants by slow release of nutrients. They also noticed that vermiwash provided additional growth promoters like gibberellin, cytokinin and auxins along with major nutrients resulting in improved growth of plants. Ramesh and Thirumurugan (2001) noticed that vermiwash used for seed pelleting and foliar nutrition resulted better growth of soybean. The growth of paddy was also increased with the foliar application of vermiwash (Thangavel, 2003).

Vermiwash contains enzymes and secretions of earthworms which can stimulate the growth of crops. Apart from organic acids it also contains a rich source of soluble plant nutrients stimulating crop growth (Shivsubramanian and Ganeshkumar, 2004). Shivsubramanian and Ganeshkumar (2004) opined that the growth of marigold was significantly increased by the application of vermiwash diluted with water (1:2 ratio). Field experiments conducted at Kerala Agricultural University revealed that soil and foliar application of vermiwash @ 50 ml plant^{-1} provided maximum growth in bhindi (Nishana, 2005). It was also observed that soil application of neemcake (0.5 t ha^{-1}) and foliar nutrition of vermiwash (1:1 dilution) increased crop vigour in chilli (George, 2006). Prabhu (2006) reported the presence of large number of beneficial microorganisms in vermiwash that helped to increase the growth of the plants. He also reported that vermiwash improved the germination percentage and seedling vigour of cowpea and paddy seeds. The spinach and onion growth was significantly higher in plot treated with vermiwash @ 1:5 v/v and 1:10 v/v in water respectively (Abdullah, 2008). Lalitha and Ansari (2008) noticed that vermiwash and vermicompost are enriched in certain metabolites and vitamins that belong to the B group or pro vitamin D which helped to enhance plant growth in bhindi. Foliar nutrition with vermiwash from coconut leaf improved growth of bhindi, nodulation of cowpea and germination of paddy seeds (Gopal *et al*., 2010).

Experiments conducted by Abdulla and Sukhraj (2010) revealed that combined application of vermicompost and vermiwash was beneficial in improving the growth and yield of bhindi. Ingham (2003) reported that compost tea contained soluble nutrients that enhanced crop growth when applied as foliar spray. Sayre (2003) and Ryan (2007) also observed that the health and growth of crops was improved by foliar application of compost tea. According to Mohan (2008), organic promoters like panchagavya and EM solution enhanced the yield of brinjal. Combined application of liquid manures like beejamrut, jeevamrut and panchagavya recorded significantly higher growth in chilli (Chandrakala, 2008) The liquid extract of seaweeds popularly known as seaweed liquid fertilizers could be used as foliar spray for inducing faster growth in cereal crops, vegetables, fruits, orchards and horticultural plants (Metha, 1967). Kannan and Tamilselvan (1990) observed that soil application of seaweed liquid fertilizer of *Enteromorpha clathrata* and *Hypneamus ciformis* increased the growth characteristics of green gram, black gram and rice. Effective Microorganisms (EM) is a mixture of live cultures of microorganisms isolated from fertile soils in nature and useful for crop production. EM preparations generally contain *Lactobacillus*, photosynthetic bacteria, yeasts and other beneficial microorganisms which increase the crop growth (Yamada *et al*., 2003).

According to Palekar (2006), beejamruth is a source of nutrients used for seed or seedling treatment to increase the germination capacity of seed and growth of seedlings. Several beneficial bacteria are also present in beejamruth and inoculation of these bacterial isolates resulted in improvement in seed germination, seedling length and seed vigour in soybean (Sreenivasa *et al*., 2009). The experiment conducted by Gore (2009) revealed that use of a combination of beejamruth, jeevamruth and panchagavya at 75 and 160 days after sowing of tomato increased the enzymatic activities, plant growth, root length and N, P and K concentration. Sangeetha (2010) reported that nodule formation in pulses was the highest in soil amended with low levels of seaweed based panchagavya (panchagavya : soil in 1: 100 ratio) Application of plant growth promoting rhizobacteria (PGPR) to the foliage or the floral parts of apple increased growth of the plant (Lutfi *et al.,* 2007). Mallesh (2008) opined that amongst the rhizopshere microorganisms, PGPR has been considered important in sustainable agriculture due to their plant growth promotional ability. PGPR @ 2% seed inoculation significantly enhanced seed germination and seedling vigour of maize (Gholami *et al.,* 2009). They also reported that inoculation of maize seeds with different bacterial strains in both sterile and non-sterile soil significantly increased plant height, 100 seed weight, number of seed per ear, leaf and shoot dry weight and leaf surface area.

On perusal of the research work cited above, it could be inferred that liquid manures could enhance plant growth as evident by increased seed germination, seedling growth, root length, plant height, seedling vigour etc.

Organic liquid manures on yield of crops

Buckerfield *et al.* (1999) observed that weekly applications of vermiwash increased radish yield by 7.3 %. Yield improvement in tomato by soil application of vermiwash @12.5 % concentration was reported by Jasmine (1999). Studies by Lozek and Gracova (1999) revealed that application of vermisol increased yield by 7.3 % in chilli. Application of organic inputs like vermicompost in combination with vermiwash resulted in better yield of crops by slow release of nutrients for absorption and supplementation of gibberellins, cytokinins and auxins (Lalitha *et al.,* 2000). Jasmin *et al.*, (2003) opined that the yield of tomato was significantly increased by the application of vermiwash. Vermiwash at

50 % cocentration along with full NPK applied plots produced maximum number of seeds per fruit. The highest fruit yield of 18.35 t ha^{-1} was recorded by the same treatment. According to Thangavel (2003) the yield of paddy was improved by foliar application of vermiwash. Studies conducted by Shivsubramanian *et al*. (2004) revealed that the enzymes present in the vermiwash and secretions of earthworms stimulated the yield of crops. He also noticed enhanced productivity of marigold by the application of vermiwash. Nishana (2005) reported that soil and foliar application of vermiwash @ 50 ml $plant^{-1}$ registered maximum yield in bhindi. The combined use of neem cake (0.5 t ha^{-1}) as soil application and foliar application of vermiwash (1:1 ratio) increased the crop vigour and fruit yield of chilli (George, 2006). Foliar application of vermiwash (1:1 dilution) significantly increased dry chilli yield (George *et al.,* 2007). Abdullah (2008) observed that the yield of spinach and onion were significantly enhanced by foliar nutrition of vermiwash at 1:5 v/v and 1:10 v/v in water respectively. Lalitha and Ansari (2008) noticed that use of vermiwash enhanced the yield of bhindi.

Use of vermiwash from coconut leaf vermicompost improved the yield of bhindi (Gopal *et al*., 2010). Use of seaweed liquid fertilizers as foliar spray induced higher yield in cereal crops, vegetables, fruits, orchards and horticultural plants (Metha, 1967). Dahiya and Vasudevan (1986) reported that application of biogas slurry was beneficial in replacing half of the fertilizer nitrogen and to produce better yield in vegetables. The soil application of seaweed liquid fertilizer of *Enteromorpha clathrata* and *Hypneamus ciformis* increased the yield of green gram, black gram and rice (Kannan *et al*., 1990). Kungkaew *et al*., (2004) observed that bio gas slurry along with chemical fertilizers in 1:1 ratio was effective in improving the crop yields of sweet corn, tomato and strawberry. Ingham (2003) observed that compost tea contained soluble nutrients that enhanced crop yield. The beneficial organisms present in the EM solution increased the yield of crops (Yamada *et al*., 2003). Sayre (2010) reported that application of compost tea at fort nightly interval increased the marketable yield of potato by 18 to 19 %. Chandrakala (2008) reported that the combined application of beejamrut, jeevamrut and panchagavya increased yield and drymatter production in chilli. The yield of brinjal could be increased by 33 % by the application of organic promoters like panchagavya and EM solution (Mohan, 2008). Gore (2009) observed that application of a combination of beejamruth, jeevamruth and panchagavya (1:1:2 ratio) at 75 DAS and 160 DAS increased tomato yield. The effectiveness of floral and foliar application of PGPR on yield improvement of apple was reported by Lutfi *et al*. (2007).

Organic liquid manures on quality of fruits and vegetables

Adams (1986) reported that vermiwash application had a positive effect in bringing colour to tomato fruits, due to the presence of nitrogen and other micronutrients which enhanced the synthesis of lycopene. Whapham *et al*. (1993) observed that the application of seaweed liquid fertilizer of *Ascophyllum nodosum* increased the chlorophyll levels of cucumber cotyledons and tomato plants. Studies by Lozek and Gracova (1999) revealed that application of vermiwash resulted in decrease in fruit nitrate content in chilli by 15 %. Zaller (2006) reported that foliar applications of vermicompost leachate improved lycopene content in tomato. Modified formulations of panchagavya was found to enhance the biological efficiency of the crop plants and the quality of fruits and vegetables (Natarajan, 2002). Shivamurthy and Patel (2006) noticed the effectiveness of cow's urine for seed treatment in enhancing the chlorophyll a and chlorophyll b content thereby contributing to yield improvement in wheat. Ryan (2007) opined that the quality of crop produce could be improved by the application of compost tea.

According to Mohan (2008) foliar application of organic promoters like panchagavya and EM solution increased quality of fruits. Gore (2009) reported that use of beejamruth + jeevamruth + panchagavya at 75 DAS and 160 DAS as foliar spray increased the lycopene content in tomato.

Organic liquid manures on pest and disease resistance

Weltzien (1992) reported the effectiveness of compost tea as surface spray for the control of foliar diseases of plants. Compost tea could reduce the severity of diseases like powdery mildew and downy mildew of grape, grey mould of strawberries and late blight of potato (Elad *et al.,* 1994); butter cup infestation and tomato blight (Touart, 2000). Scheuerell *et al.* (2002) observed that compost tea as foliar spray reduced the incidence of pests and diseases in crops by competition with disease causing microbes and degradation of toxic pesticides. The effectiveness of compost tea in controlling the bacterial spot of tomato was reported by (Al-Dahmaniel *et al*., 2003). According to Sayre (2003), compost tea had the capacity to manage many pests and diseases of crop plants. Ingham (2003) opined that the plant exudates, both from roots and leaves, enhanced the disease - suppressive bacteria and fungi that occur in aerobic compost tea. Scheuerell (2003) noticed that non aerated compost tea preparation takes longer time for fermentation. This enabled accumulation of antibiotics in the non aerated compost tea which activate natural plant defence responses thereby help in disease suppression. Verngrubinger (2005) observed that compost tea was helpful to fight off diseases by inoculating plants with beneficial micro organisms. The application of compost tea for reducing the incidence of foliar diseases was also reported by Linda (2007). Ryan (2007) opined that compost tea improved the drought tolerating capacity of the plants and suppressed pests and diseases. An improvement in pest and disease resistance due to the application of EM in vegetables was noticed by Tuat and Trinh (2002). Giraddi *et al*. (2003) reported a significant reduction in pest population and leaf curl index in chilli treated with vermiwash (soil drench 30 days after transplanting and foliar sprays at 60 and 75 days after transplanting). The efficiency of vermiwash in imparting resistance to many pest and diseases was also reported by Shivsubramanian *et al.* (2004). Subasashri (2004) observed the suitability of vermiwash as an effective bio pesticide in many vegetable crops. Prabhu (2006) inferred vermiwash as a good bio control agent that protects the plant from a number of infestations. He also observed that foliar applications of vermiwash improved pest and disease resistance in tomato by suppressing *Phytophthora* disease.

Complete suppression of mycelial growth of *Sclerotiana sclerotiorum* in cucumber was possible by the addition of different herbal plant extracts with fresh cow's urine and cowdung (Basak *et al.,* 2002). Solaiappan (2002) reported that the bacteria present in panchagavya acted as biocontrol agent. Sreenivasa *et al.,* (2009) noticed similar results and reported that the beneficial microorganisms of beejamrut protected the crop from harmful soil-borne and seed-borne pathogens. Increased productivity and disease resistance in plants was observed by using a modified formulation of panchagavya-panchagavya amended seaweed extract (Sangeetha, 2010). The efficiency of PGPR as a biopesticide was examined by Nakkeeran *et al.,* (2005). They reported that use of PGPR for seed treatment, bio-priming, seedling dip, soil application, foliar spray, fruit spray, sucker treatment and sett treatment were better for the management of pest and diseases of crop plants, in addition to plant growth promotion. Behadur *et al.,*(2007) observed that foliar application of PGPR increased anti fungal compounds in pea (*Pisum sativum*) against powdery mildew pathogen *Erysiphe pisi.* Mallesh (2008) reported that PGPR have emerged as the biggest group of beneficial soil microorganisms, involved in the control of a number of plant diseases and pests by virtue of their ability to synthesize a wide range of antagonistic secondary metabolites. Reddy *et al*. (2011) noticed that application of PGPR suppressed the sheath blight disease caused by *Rhizactonia solani* in rice.

Liquid manures on the production of growth promoting hormones

Seaweed liquid extract contained growth promoting hormones like auxins (IAA and IBA), cytokinins, gibberellins, trace elements, vitamins, amino acids, antibiotics and micronutrients for achieving higher agricultural production (Booth,1965). Beejamruth contains several growth hormones which promote the growth of plants (Palekar, 2006). According to Sreenivasa *et al.,* (2009) the bacterial isolates from beejamruth were capable of the production of the growth promoters like IAA and GA. Vermiwash was identified as a bio-liquid rich in nutrients and plant growth hormones (Gopal *et al*., 2010). The liquid manure facilitate the production of growth hormones like IAA, IBA, cytikinins, gibberellins and also have the capacity to produce certain vitamins, trace elements, amino acids, antibiotics, enzymes and micronutrients required for plant growth.

Liquid manures on nutrient content of plants

Palekar (2006) revealed that availability and uptake of nutrients by crops was increased by the application of jeevamrut. Gopal *et al*. (2010) inferred that the nutrient content of plant was increased by the application of coconut leaf vermiwash. Similar observation was also made by Lutfi *et al*. (2007) who observed an increase in nutrient content of apple by floral and foliar application of PGPR.

Liquid manures and microbial activity

Ingham (2005) reported that the compost tea contained populations of several beneficial microorganisms and also the well made compost tea will be dominated by beneficial bacteria or fungi. He also observed that greater the amount of soluble material in the compost tea, the more food resources would be there for the growth of beneficial bacteria and fungi, and microbial activity will be improved.

According to Palekar (2006) the enormous amount of microbes present in jeevamruth enhanced microbial activity in soil. Ryan (2007) also opined compost tea as one of the liquid manure for enhancing microbial activity of soil. Studies conducted by Sreenivasa *et al.* (2009) revealed that the beneficial micro organisms in beejamruth enhanced the microbial activity of the soil. Gopal *et al*. (2010) reported that application of coconut leaf vermiwash increased the population of soil microorganisms, particularly plant beneficial ones, and their activities facilitated increased uptake of the nutrients. The microbial activity of soil could be improved by the application of liquid manures due to the enormous amount of beneficial microbes (bacteria and fungi) present in it.

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