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Manure and plant extracts for foliar nutrition in organic farming: A Review

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Abstract
Indiscriminate use of inorganic fertilizers has bought threat to soil health in respect of physical, chemical and biological properties of soil. Therefore, it is necessary to minimize the usage of inorganic fertilizers by substituting with organics. It is well established fact that the improvement of quality and productivity of the crops could be made possible with combined application of organic manure and balanced chemical fertilizers. One of the techniques widely used for correcting imbalanced nutrition is through foliar spray of nutrients. The foliar spray of organics contribution is to be adjudicated in terms of quick supply of nutrients, plant hormones, stimulants, and other beneficial substances to the plants, which ultimately improves physiological and biochemical processes in plants and is more critical in the context of sustainable agriculture.

Keywords: soil health, foliar spray, organic fertilizers, physiological, biochemical process

Introduction
Organic farming is an internationally regulated, legally enforced and standardized alternative agricultural paradigm that relies on ecological processes, biodiversity and cycles adapted to local conditions with the aim of sustaining the health of soils, ecosystems and people. Originating in Germany in the early 19th century from the pseudoscientific roots of biodynamic farming, organic farming has evolved into an ecologically friendly substitute of conventional farming systems which have been shown to have adverse environmental and health impacts due to intensive use of synthetic inputs such as pesticides, herbicides and fertilizers. The substitution of synthetically manufactured agricultural inputs, such as chemical fertilizers, by minimally processed naturally-occurring organic inputs, such as organic fertilizers, forms the core tenet of organic farming.

Foliar fertilization or foliar feeding entails the supply of nutrients, plant hormones, stimulants, and other beneficial substances in liquid form to plant through areal parts of the plants viz; leaves and stems and other sites to realize enhanced yield and quality, resistance to pest, improved drought tolerance, and also be used to aid plants in recovery from transplant shock, hail damage, or the results of other weather extremes. Plant response is dependent on species, fertilizer form, concentration, and frequency of application, as well as the stage of plant growth. It is being practiced in both conventional and alternative production systems, when a quick growth response is required particularly under unfavorable condition, where in plants roots unable to extract nutrients due to extremes of cold or dry situation and nutrients are locked in soil. It is also practiced In order to make availability of immobile or slow mobile essential nutrients to later crop growth stage. The improved "Sustainability" and "Environmental considerations" could be a major focus for the organic agriculture and was largely depends on the use of more environmental friendly organic-based materials which are more readily available. Many organic-based foliar fermented liquid fertilizers like organic acids, amino acids, sugars, alcohols, plant growth regulators, macro and micronutrients could exist in organic-based bio-stimulants. These certainly favour plant growth and regulation and adaptability to the surrounding environment interms of Improvement in yield and quality parameters in addition to enhanced tolerance to biotic and abiotic stresses. The options available for foliar supplementation of nutrients include use of various organic manures *viz*., FYM, compost, vermin-compost, green manures, bio-fertilizers *etc*., along with other nutrient management practices like use of fermented organics or liquid organic manures*viz*., panchagavya, jeevamrutha, beejamrutha, vermin-wash *etc*.

The advantage of liquid organic manure is that they disperse in water and it is rapidly up taken by plants when compared to solid organic fertilizers and interestingly plant can absorb nutrients about 20 times faster through the leaves than applied through the soil, helping in overcoming temporary, acute nutrient shortages in the crops. The uniqueness of organics is that they provides growth promoting hormones and immunity boosters for plants (Xu and Xu, 2000; Sreenivasa and Naik, 2011) [57, 27].

1. Chemical composition and Preparation of Manure/plant extracts

Seaweed extracts are among the most common foliar feeds in organic farming, Compost tea has become popular as a foliar spray material because of its nutrient content and disease-suppressive characteristics. Other soluble organic materials and those from which extracts are easily made include manure teas, humates, molasses, milk, B vitamins, and herbal extracts of plants or weeds. In India, The widely used homemade liquid fermented foliar fertilizers are, panchagayya panchamruth, Fym extract and humic acid etc.

1. **Panchagavya: -** The word Panchagavya refers to a product obtained from five (panch) gavya (components). It is a organic liquid fermented product of 5 main ingredients *viz;* cow dung (7.00 kg), cow ghee (1.00 kg), cow urine (10.00 litres), water (10.00 litres), cow milk (3.00 litres), cow curd (2.00 litres), tender coconut water (3.00 litres), jaggery (3.00 kg), well ripened poovan banana (12 nos.). After soaking for 30 days, the solution was strained through cheesecloth and then applied with ordinary sprayers.
2. **Jeevamruta:** The word Jeevamruta refers to life (jeeva) supporting holy liquid (amruth). Jeevamrutha is prepared by mixing 10 kg local cow dung with 10 litres cow urine, add 2 kg local jaggery, 2 kg pulse flour and handful of garden soil and the volume made upto 200 litres. Keep the drum in shade covering with wet gunny bag and stir the mixture clockwise thrice a day and incubate. Though it can be used even after 6-7 days, its quite a challenge getting near the mixture due to overpowering stench, hence advisable to use this within 3-4 days of preparation. Vasanthkumar (2006) [47].
3. **Manure extracts:** Tdhe most widely used soil amendment is farmyard manure (FYM), a mixture of animal waste and straw, rich in organic C, and all other nutrients particularly N P K.

Basically there are two (Diver, 1998) extraction methods. Viz, non-aerated and aerated methods. However, aerobic improves quality of extracted tea, probably because aeration extend extraction period by several days, which improves quality of extracted tea, While anaerobic go very quickly and aerobic microbes in the slurry will pull all the oxygen out of the water. As a result inferior tea could be obtained with fewer available nutrients and organic acids harmful to plant growth (Merill *et al., 1*998).

The method of FYM extraction tea was developed by William, 1995 and was improved by Heinrich, 1998. where compost tea was obtained by covering compost with tap water at a ratio between 1:5 to 1:8 (v/v), stirred once and allowed to ferment outdoors between 15° and 20°C. After soaking period-extraction time, the solution was strained through cheesecloth and then applied with ordinary sprayers. Compost tea is a product of showering recirculated water through a poroc bag of compost suspended over an open tank to provide aerobic condition (Riggle, 1996) and the product is aerated Compost tea if it is in closed tank means it is non aerated compost tea (Merril and Mc keon, 2001) and El-Ghamry (2011) [7] stated the procedure of preparing FYM extract as, 10 kg of well decomposed FYM compost was taken and blended with ethanol or water with a ratio of 1: 10 (w/v). Then the mixture was stirred daily and filtrated after 7 days. One litre of the FYM extract was diluted by the extractant used with 1:10 ratio (v/v).

iv) Vermi wash

It is a collection of excretory products and mucus secretion of earthworms (drilospheres.) Vermiwash, if collected properly, is a clear and transparent, pale yellow coloured fluid. Vermiwash can be produced by allowing water to percolate through the tunnels made by the earthworms on the coconut leaf - cow dung substrate kept in a plastic barrel. Water is allowed to fall drop by drop from a pot hung above the barrel into the vermicomposting system. But barrels are not a must for Vermi wash preparation. Vermiwash units can be set up either in barrels or in buckets or even in small earthen pots. Vermiwash is diluted with water (10%) before spraying. This has been found to be very effective on several plants. If need be vermiwash may be mixed with cow's urine and diluted (1 litre of vermiwash, 1 litre of cow's urine and 8 litres of water) and sprayed on plants to function as an effecting foliar spray and pesticide.

Table 1: Chemical composition of different liquid organic fertilizers

Parameters	Liquid organic fertilizers			
	Compost Tea	Vermi Wash	Panchagavya	Jeevambruth
P^H	8.3	8.16	6.82	7.07
EC dsm^{-1}	1.55	2.31	1.88	3.40
Organic C (ppm)	10000	9220^4	8000	8000
Total N (ppm)	1000	2830	1000	770
Total P (ppm)	6270	7860	175.4	166
Total K (ppm)	8260	7260	194.1	126
Ca (ppm)	39.2	41.95	-	-
Mg (ppm)	20.2	6.21	-	-
Zn (ppm)	3.37	0.02	1.27	4.29
Fe (ppm)	33.37	0.06	29.71	282
Mn (ppm)	0.66	0.58	1.84	10.10
Bacteria cfc u/ml	$15*10^5$	$60.03*10^5$	$26.1*10^5$	$20.4*10^5$
Fungus	$10*10^4$	$22.0*10^4$	$18*10^3$	$13.8*10^3$
Actinimycets	-	$3.0*10^2$	$4.20*10^3$	$3.60*10^3$
PSB	-	$10.3*10^5$	$5.70*10^2$	$4.50*10^2$
Auxin (µ g/kg)	-	-	9.15	-
GA (µ g/kg)	-	-	4.0	-

In recent times organic farming is gaining place in India and elsewhere in the world. The use of organics in crop production is nothing new to our agriculture and many organics like farmyard manure, compost, neem cake, vermicompost, poultry manure etc. are used as a substitute for chemical fertilizers to supply plant nutrients in traditional farming which also helps to sustain soil organic carbon and maintain favorable soil condition for crop growth. During the transitory period of organic farming, the use of farmyard manure and compost as source of plant nutrients, the fertility of soil depletes leading to low yield in initial years of cultivation (Natarajan, 2002) [26]. Besides, the decomposition of bulky organic materials takes longer time to meet the immediate nutrient requirement of plants. Thus, in recent years, fermented liquid organic fertilizers,

Table 2: The existing research findings on foliar application of various liquid organic fertilizers and their effects on different crops

Sl. No.	Name of the Researchers	Crops	Study parameters
			a) Morphological parameters
1.	Velmurugan (2005) [49]	Radish	Observed that seed treatment + foliar application of panchagavya (3%) produced the tallest plant height (26.75 cm), higher number of leaves (14.0) as compared to other treatments.
2.	Sanjutha *et al.* (2008) [37]	Kalmegh	The application of FYM at 15 t ha^{-1} + NPK at 75:75:50 kg ha^{-1} + panchagavya at 3 per cent foliar spray on Kalmegh crop recorded the highest plant height (54.10 cm), number of branches (27.40) and number of leadves (105.67) when compared to other treatments.
3.	Venkataramana *et al.* (2009) [50]	Mulberry	They concluded that treatment with 200ppm vermiwash (T_4) and 200 ppm cow dung wash (T_7) gave higher plant height (199.50 cm and 198.60 cm), length of shoots (189 cm and 186 cm) and number of branches (13 and 12) respectively as compared to other treatments.
4.	El-Hameed (2009)	Wheat	Data showed that adding 75 kg N fed^{-1} gave the highest mean values for all plant growth characteristics under study (plant height, leaf area) and foliar application of FYM extract (20%) gave the best results for most characteristics under study.
5.	El-Ghamry (2011) [7]	Potato	In this experiment he used various treatments as mineral fertilizers, FYM, FYM extracts and FYM sediments. Among these treatments, the treatment with FYM extract + FYM sediment gave higher values in terms of plant height (54.86 cm), number of leaves per plant (39.94) and leaf area (0.45 m^2 $plant^{-1}$) at 90 DAS which were near to the value of mineral fertilizers (NPK).
6.	Nileema *et al.* (2011) [27]	Tomato	The soil treatment of RDF+ beejamruth (seed treatment) + jeevamruth (soil application) + panchagavya (3% foliar spray) showed improvement in plant height (143.21 cm), root length (19.80 cm) and dry matter (7.94 g $plant^{-1}$), compared to other treatments and control. Further the plant nutrient concentrations (N, P and K) were the highest with the application of liquid organic manures + RDF followed by beejamruth + jeevamruth + panchagavya.
7.	Suresh *et al.* (2011) [43]	Blackgram	The foliar application of panchagavya resulted in significant improvement in plant height (42.6 cm), number of branches per plant (10), when compared with NPK and control. Hence, they concluded that three percent panchagavya foliar spray given at 15^{th}, 25^{th}, 35^{th} and 45^{th} days of interval period is suitable for obtaining higher growth and yield.
8.	Tharmaraj *et al.* (2011) [46]	Rice	The combination of vermicompost and vermiwash recorded increased number of leaves (19), leaf length (9 cm), height of the plant (23 cm) and root length (15 cm) as compared to other treatments.
9.	Patil *et al.* (2012) [30]	Chickpea	Reported that application of panchagavya (3%) at 15 days after flowering on chickpea crop increased plant height (37.01 cm), number of branches per plant (5.22) and root nodules (20.50) which might have been due to the growth enzymes present in panchagavya which favoured rapid cell division and multiplication
10.	Rajan *et al.* (2012) [31]	Cowpea and Rice	The seeds which received spray of 100 per cent vermiwash showed higher shoot length (20.63 cm), root length (4.79 cm), number of leaves (7.33), number of branches (3.24) in cowpea and highest germination percent (100%), shoot length (7.2 cm) and root length (8.2 cm) as compared to other treatments.
11.	Sunil *et al.* (2012) [42]	Cumin	They reported that application of neem + panchagavya spray at 30 per cent, 54 per cent and 80 per cent at 55 & 80 DAS recorded higher plant dry matter compared to control
12.	Mangesh *et al.* (2013)	Groundnut	Found out that treatment with humic acid (300 ppm) in cow dung wash had higher plant height (53.28 cm), number of branches at maturity (8.37), leaf area at different stages (1.15 dm^2, 2.15 dm^2, 4.56dm^2 and 5.26 dm^2), total dry matter per plant at various growth phases (1.20 g, 4.21 g, 9.87 g and 14.43 g). Although, humic acid (350 ppm) also showed similar results
13.	Leo *et al.* (2013) [18]	Pigeonpea	The short-term plant growth test with *Cajanus cajan* seeds treated with panchagavya showed enhanced length of root (19.4 cm) and shoot (16.9 cm) length, dry mass (147 mg) and leaf area (14.57 cm^2), after 15 days of sowing compared to other manures.
14.	Mohsen (2013) [25]	Cucumber	the treatment 20 ppm humic acid + 100 mg per litre potassium was best among other treatments, showing higher plant height (218.87 cm), dry weight of plant (5.8 g) and number of leaves per plant (31.56).
15.	Rekha *et al.* (2013) [36]	Blackgram	The treatments, vermicompost 50 per cent and vermiwash 100 µml gave higher shoot length (15.2 cm and 14.15 cm), internode length (2.1 cm and 4.04 cm), number of leaves (22.5 and 16.17) and number of branches (8.16 and 6.17) when compared to other treatments in two years
16.	Jadhav *et al.* (2014)) [12]	Radish	The vermiwash was sprayed at different concentrations which were mixed in the ratios of 1:1, 1:2, 1:3 and 1:4. The treatment sprayed with 1:4 (vermiwash and water) gave higher leaf length (41.62 cm), single radish leaf weight (14.48 g) and total number of leaves per plant (11.57) compared to other treatments.
17.	Kapase *et al.* (2014) [13]	Chickpea	The most effective treatment combination was 50 ppm NAA + 500 ppm humic acid through vermicompost which enhanced plant height at all the stages *viz.*, 45, 65 and 85 DAS at 32.82 cm, 50.91 cm, 55.22 cm respectively. Similar results for number of branches (2.93, 4.60, 4.65), leaf area per plant (1.41 dm^2, 1.75 dm^2, 1.99 dm^2) and total dry matter production per plant (1.20 g, 3.78 g, 5.48 g) were also observed at 45, 65 and 85 DAS.

18.	Asha and Sheela (2015) [3]	Amaranthus	Among various treatments, the treatment with combination extracts of composite manure prepared by mixing groundnut cake, neem cake and poultry manure (in 1:0.5:0.5 ratio) recorded the significantly higher plant height, number of leaves at and total dry matter production irrespective of harvesting stage as compared to other treatments.
19.	Makkar *et al.* (2017) [21]	Linseed	The treatment with 50 per cent vermicompost + 50 per cent soil and vermiwash foliar spray gave greater shoot length (138.4 cm), root length (18.27 cm), root weight (2.99 g), shoot weight (20.02 g) and plant biomass (20.45 g) as compared to other treatments.
20.	Dekhane *et al.* (2017)	Rice	They found that the combination of seedling dip in azotobacter + vermiwash 2 per cent + banana pseudo stem sap 2 per cent was the most effective with higher plant height (118.5 cm) and number of tillers (19.7) compared to other individual treatments.
21.	Maheswari *et al.* (2017) [19]	Lablab Beans	Pot studies enhanced the effect at the end of sixth week with higher shoot lengths (56.24±0.14 cm), length of internodes (9.40±0.17 cm), number of leaves (20.88±1.01) and leaf surface area (18.59±0.24 cm^2) as compared to other treatments.
22.	Patel *et al.* (2017) [27]	Fenugreek	Found that panchamrutha increased the leaves dry weight (56.7 mg), shoot dry weight (101.6 mg), root dry weight (22.2 mg), pod dry weight (62.8 mg) and whole plant dry weight (233.5 mg) over the control treatments
23.	Thakur *et al.* (2017) [45]	Blackgram	The treatment pulse magic at 2 per cent exhibited higher plant height (35.5 cm), number of branches (5.23), leaf area (1.60 dm^2 $plant^{-1}$) and total dry matter accumulation (23.74 g $plant^{-1}$) as equated to other treatments
			b) Physiological parameters
24.	Sanjutha *et al.* (2008) [37]	Kalmegh	Observed that soil application of FYM at 15 t ha^{-1} + NPK at 75:75:50 kg ha^{-1} + panchagavya at 3 per cent foliar spray recorded the highest leaf area index (1.03)
25.	Patil *et al.* (2012) [30]	Chickpea	Found that foliar application of panchagavya (3%) at 15 days after flowering on chickpea crop gave higher leaf area index (1.31) which might be due to the growth enzymes present in panchagavya which might have favored rapid cell division and multiplication.
26.	Ananda and Murty (2017) [1]	Groundnut & Finger millet	They found that the treatment with enriched bio digester at 25kg N equivalent per hectare + panchagavya at 3 per cent gave higher leaf area index (LAI) at 60 DAS (3.20) as compared to other treatments
27.	Patel *et al.* (2017) [27]	Fenugreek	Found that panchamrutha increased the relative growth rate (0.002 g g^{-1} day), net assimilation rate (-0.004 g dm^2 day^{-1}) and leaf weight ratio (28.24) over the other treatments.
28.	Mangesh *et al.* (2013) [23]	Groundnut	Foliar application of 300 ppm humic acid in cow dung wash had higher relative growth rates (RGR) at 35-20 DAS (0.084 g g^{-1} day^{-1}), 50-35 DAS (0.057 g g^{-1} day^{-1}) and 65-50DAS (0.025 g g^{-1} day^{-1}) and net assimilation rate (NAR) at 35-20 DAS (0.125 g dm^2 day^{-1}), 50-35 DAS (0.117 g dm^2 day^{-1}) and 65-50 DAS (0.015 g dm^2 day^{-1}) as equated to other treatments.
			c) Biochemical parameters
29.	Sanjutha *et al.* (2008) [37]	Kalmegh	Application of FYM at 15 t ha^{-1} + NPK at 75:75:50 kg ha^{-1} + panchagavya at 3 per cent foliar spray recorded the highest chlorophyll content *i.e.*, SPAD reading (52.42).
30.	Venkataramana *et al.* (2009) [50]	Mulberry	They concluded that treatment with 200 ppm vermiwash and 200 ppm cow dung wash gave higher chlorophyll a (3.86 mg g^{-1} fresh wt. and 3.26 mg g^{-1} fresh wt.), chlorophyll b (0.89 mg g^{-1} fresh wt. and 0.84 mg g^{-1} fresh wt.) and total chlorophyll (4.85 mg g^{-1} and 4.60 mg g^{-1}) respectively in consecutive two years.
31.	Velmurugan (2005) [49]	Radish	He observed that seed treatment + foliar application of panchagavya (3%) produced the tallest plant height (26.75 cm), higher number of leaves (14.0) as compared to other treatments
32.	Suresh *et al.* (2011) [43]	Blackgram	Results of the experiment revealed that foliar application of panchagavya recorded significant improvement in chlorophyll content (chlorophyll a, b and total 2.2, 0.9 and 3.2 mg g^{-1}) and N content of root nodules (5.50 g) as compared with NPK and control
33.	Leo *et al.* (2013 [18]	Tur	Seeds treated with panchagavya showed enhanced chlorophyll content (23 SPAD units) and photosynthetic activity (18.8 µmol m^{-2} s^{-1}) after 15 days of sowing compared to other organic manure treatments.
34.	Mohsen (2013) [25]	Cucumber	The treatment with 20ppm HA + 100 mg per litre potassium gave significantly higher chlorophyll content (18.78- SPAD value) as compared to other treatments
35.	Deotale *et al.* (2017)) [4]	Pigeonpea	The treatment with 300 ppm humic acid + 50 ppm NAA showed higher leaf chlorophyll content at 45 DAS (1.180 mg g^{-1}), leaf nitrogen content at 45 DAS (2.769%) and leaf phosphorus content at 45 DAS (0.282%) as compared to other treatments
36.	Khandaker *et al.* (2017) [14]	Okra	The application of farm yard manure showed increased growth, quality and yield performance as compared to control. The application of FYM significantly increased total chlorophyll content (14 SPAD units) over the control (8 SPAD units).
			d) Quality parameters
37.	Venkataramana *et al.* (2009) [50]	Mulberry	Concluded that treatment with 200 ppm vermiwash and 200 ppm cow dung wash gave higher protein (33.50% and 30.00%) and total carbohydrate (42.35% and 40.00%) respectively as compared to other treatments.
38.	Ravi *et al* (2011) [35]	Groundnut	Found that the treatment RDF + panchagavya spray 3 per cent at 30, 60 and 75 DAS showed higher oil percentage (40.7), protein percentage

			(22.4), oil yield (685.1 kg ha^{-1}) and protein yield (377.7 kg ha^{-1}) as compared to other treatments
39.	Vijakumari *et al.* (2012) [52]	Soybean	Seeds soaked in panchagavya (1%) + humic acid (1%) for 8 hours gave higher protein content of the harvested seeds (1.25 mg g^{-1} tissue) and ascorbic acid content of harvested seeds (0.48 mg g^{-1} tissue) as compared to other treatments
40.	Waghmode *et al.* (2015) [55]	Sweet corn	Found that treatments with cow urine spray 10 per cent and panchagavya spray 3 per cent at grand growth period and tasselling stage gave higher protein content (9.27% and 9.21%), reducing sugar (3.34% and 3.50%), non-reducing sugar (19.76% and 1.21%), total sugar (23.10% and 22.56%), TSS (12.22% and 11.96%) and total carbohydrates (73.26% and 76.36%) compared to other treatments
41	Gopal *et al.* (2017) [10]	Blackgram	The panchagavya (4%) spray showed significantly higher protein content in seed (22.36%) as compared to other treatments
			e) Yield and Yield components
42.	Somasundram *et al.* (2003)	Greengram	There was significantly higher number of seeds per pod (12.9) and grain yield (17.87 q ha^{-1}) recorded with panchagavya (3%) as compared to other treatments
43.	Ansari (2008) [2]		spinach and onion was significantly higher in plots treated with vermiwash (1:5 v/v in water) and vermiwash (1:10 v/v in water). While yield of potato was higher in plots treated with vermicompost (6 t ha^{-1}) as compared to other treatments.
44.	Sanjutha *et al.* (2008) [37]	Kalmegh	Application of FYM at 15 t ha^{-1} + NPK at 75:75:50 kg ha^{-1} + panchagavya at 3 per cent foliar spray in kalmegh (*Andrographis paniculate*), recorded significantly higher dry leaf yield (619.06 kg ha^{-1}) and dry herbage yield (1993.10 kg ha^{-1}) as compared to other treatments.
45.	El-Hameed (2009)	Wheat	The results showed adding of 75 kg N fed^{-1} gave significantly higher yield characters under study (spike length, grain & straw yield) also increasing N, P and K concentration and uptake by wheat grains as compared to other treatments.
46.	Venkataramana *et al.* (2009) [50]	Mulberry	Treatment with 200 ppm vermiwash and 200 ppm cow dung wash gave higher number of leaves (155 and 152), weight of leaves per plant (1.200 kg and 1.170 kg), leaf yield (72600 kg ha^{-1} yr^{-1} and 70902 kg ha^{-1} yr^{-1}), leaf moisture (73% and 71.50%) and leaf moisture retention capacity (85% and 82%), respectively
47.	Kumawat *et al.* (2010) [17]	Groundnut-Cumin and Clusterbean-Cumin	The results showed that foliar application of neem plus panchagavya at branching and flowering increased yield of crops in both the cropping systems. The increase in yield in cluster bean and cumin was 64 and 199 per cent, respectively, under cluster bean-cumin system as compared to other treatments. While groundnut and cumin yield were 118 and 156 per cent higher, respectively, under groundnut-cumin system. In comparison to clusterbean-cumin system, higher cumin equivalent yield was recorded under groundnut-cumin system with neem + panchagavya (1259 kg ha^{-1}) followed by tumba + panchagavya (1068 kg ha^{-1}).
48.	El-Ghamry (2011) [7]	Potato	These treatments, the treatment with FYM extract + FYM sediment gave higher values for number of tuber per plant at 90 DAS (5.44) and tuber weight per plant (467.33 g) which were near to the value of mineral fertilizers (NPK).
49.	Maral (2012) [12]	Groundnut	The combination of the humic acid at 40 mg l^{-1} and nitrogen as basal dose (75 kg ha^{-1}) recorded the highest seed yield of (2858 kg ha^{-1}) over other treatments. Similarly, higher biological yield (7857.3 kg ha^{-1}) was recorded.
50.	Vijakumari *et al.* (2012) [52]	Soybean	Seeds soaked in panchagavya (1%) + humic acid (1%) + micro herbal fertilizer (1%) for 8 hours gave higher pods per plant (9.7) and seeds per plant (21) compared to that of other treatments
51.	Vimalendran and Wahab (2013) [53]	Babycorn	Among various treatments, 4 sprays of panchagavya (3%) at 15, 25, 35 and 45 DAS gave higher number of cobs (2.95), cob length (26.66 cm), cob width (4.46 cm), individual cob weight (29.69 g) and yield (7476 kg ha^{-1}) as compared to other treatments.
52.	Waghmode *et al.* (2015) [55]	Sweet corn	The treatments with cow urine spray 10 per cent and panchagavya (3%) at grand growth period and tasselling stage gave higher fresh cob yield (5078 kg ha^{-1} and 5262 kg ha^{-1}), fresh grain weight per plant (166.1 g and 169.8 g), dry grain weight per plant (69.85 g and 70.66 g), cob girth (13.89 cm and 13.71 cm) and cob length (13.29 cm and 12.88 cm).
53.	Raju *et al.* (2016) [32]	Pigeonpea	The treatment with pulse magic (1%) at 50% flowering stage and 15 days after first spray gave significantly higher number of pods per plant (1365), seed yield (538.45 g $plant^{-1}$), test weight (11.34 g) and seed yield (28.57 q ha^{-1}) over control treatment (1294, 461.87 g $plant^{-1}$, 11.1 g and 25.14 q ha^{-1} respectively).
54.	Gopal *et al.* (2017) [10]	Blackgram	Significantly highest seed yield (801 kg ha^{-1}), straw yield (1735 kg ha^{-1}) and biological yield (2536 kg ha^{-1}) were obtained in panchagavya 4 per cent spray.
55.	Makkar *et al.* (2017) [21]	Linseed	The treatment with 50 per cent vermicompost as soil application + 50 per cent vermiwash as foliar spray gave greater capsule number per plant (240.83), capsule weight per 100 capsules (5.55 gm), number of seeds per capsule (7.44), ratio of ripe to unripe fruit (13.02), yield in first harvest (95.27%), seed yield per plant (13.23 gm) and harvest index (66.75%) as compared to other treatments

effective microorganisms as foliar fertilizers have been introduced in modern agriculture to produce food with good quality and safety (Galindo *et al.,* 2007) [9]. Organic liquid manures contain not only macro, micro nutrients, vitamins, essential amino acids but also growth promoting substances like IAA, GA and beneficial microorganisms (Vasumathi 2001 [48], Sreenivasa *et al,* 2009 and Devakumar *et al.,* 2008 and 2011) [41, 5, 6]. The role of foliar applied organics like panchagavya in production of many plantation crops had been already well documented in India (Selvaraj, 2003) [38]. The escalating price of chemical fertilizers in recent years, limit their use in crop production. Therefore, the nutrient requisition through chemical fertilizers, if supplemented with low expense natural sources, crop production can be economized in addition to improvement in the soil health and factor productivity on sustainable basis. The uses of above organic manure and plant extracts are well marked in various crops which are reviewed in this article and some of them are listed in the following Table 2.

Conclusions

Generally all liquid manures having higher nutrient content than common solid organic fertilizers used by farmers. All the liquid manures had an equally higher primary and secondary minerals content which is greater than the mineral content of most organic fertilizers used by small farmers in developing country like India. Foliar organic nutrition is a simple, inexpensive technique to enhance the quality and yield of the crop. It is an excellent practice to increase the agricultural productivity while maintaining their quality. It is evident that foliar organic nutrients enhanced the yield, yield components and quality of crops by improving the morphological, physiological and biochemical characters. It can be clinched that foliar organic extract of panchagavya is more effective as compared to other organic extracts for better yield and quality performance in various crops.

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