ISSN: 2347-4688, Vol. 7, No.(1) 2019, pg. 04-18

Current Agriculture Research Journal

www.agriculturejournal.org

Secondary and Micronutrient Management Practices in Organic Farming- An Overview

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Abstract

Modern agriculture, no doubt has paved the way for "Green Revolution", but it has led to the application of heavy doses of chemical fertilizers and pesticides with the sole objective of maximizing the yield. The unbalanced and continuous use of chemical fertilizers in intensive cropping system is causing deterioration of soil health, multi-nutrient deficiencies, low productivity, poor quality and environmental hazards. Poor quality of food and fodder has caused serious health problems and disorders in both animals and human beings. Now, the agriculture research is focused on evolving ecologically sound, biologically sustainable and socio economically viable technologies like organic farming which includes local organic sources of nutrients without using chemical fertilizers and pesticides. Adoption of organic farming minimizes the environmental pollution and maintain long-term soil fertility by improving soil organic matter and essential plant nutrients including secondary and micronutrients. For producing quality food by sustaining the soil productivity and soil health are the challenges before us on one side and minimizing the pressure on non renewable sources or limited available sources on other hand needs immediate attention by all the stakeholders engaged in agriculture. Application of technologies available in organic farming and use of all locally available organic sources particularly on farm biomass which are rich in secondary and micronutrients will meet the twin objective of quality food production and reducing the pressure on non renewable resources.

Article History

Received: 23 March 2019
Accepted: 29 April 2019

Keywords

Organic Farming;
Secondary and Micronutrients;
Soil Health;
Sustainability.

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Doi: http://dx.doi.org/10.12944/CARJ.7.1.02

Introduction

Organic farming is "a production system that sustains soil health, ecosystem and agriculture production, by relaying on ecological processes, biodiversity and natural cycles and adapted to local conditions than use of inputs with adverse effects".[9] FAO suggested that "Organic agriculture is a unique production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity, and this is accomplished by using on-farm agronomic, biological and mechanical methods in exclusion of all synthetic off-farm inputs". Agricultural practices of India date back to more than 4000 years, organic farming is very much native to this country. As mentioned in *Arthashastra*, farmers in the *Vedic* period possessed a fair knowledge of soil fertility, seed selection, plant protection, sowing seasons and sustainability of crops in different lands. The farmers of ancient India adhered to the natural laws and this helped in maintaining the soil fertility over a relatively longer period of time. The organically cultivated food crops have a vast untapped export potential growing at 10 to 15 per cent per annum3. From the past two to three decades organic farming is gaining more importance again and the area under organic farming is increasing day by day. Emerging from 42,000 ha under certified organic farming during 2003-04, the organic agriculture has grown almost 29 fold during the last 5 years. By 2010 India has brought more than 4.48 million ha area under organic certification process.[23]

According to the latest FiBL–IFOAM survey on certified organic agriculture worldwide,[9] data on organic agriculture are available from 162 countries. There are 57 million hectares of organic agricultural land. The countries with the largest areas of organic agricultural land are Australia followed by Argentina and China. India stands in 9th position with 1.49 m ha (0.8 % of total agricultural land) and including wild collections it is 4.2 m ha. India stands in first position with respect to number of producers with 8.35 lakh producers followed by Uganda and Mexico.

There is a good market for organic goods in the world market. Among the different organic products that are exported from the country tea stands in first position with 25% share followed by rice (21%) and fruits and vegetables (15%).[19]

The reason why the organic products are accepted worldwide is due to their superior quality and nutrition than conventional products. For any plant to produce fruit or grain with good quality and nutrition it needs all the essential plant nutrients.

It is known that plant absorbs small amounts of many elements, but 17 elements are known as essential elements based on Arnon and Stout criteria of essentiality.

A. **Primary nutrients:** It includes nitrogen, phosphorus and potassium.

B. **Secondary nutrients**: It includes calcium, magnesium and sulfur. Calcium (Ca): Involved in cell division and plays major role in maintenance of membrane integrity. Magnesium (Mg): Component of chlorophyll, ribosomes and a cofactor for many enzymatic reactions. Sulfur (S): Constituent of amino acids (cystein, methionine), vitamins, lipoic acid and acetyl co-enzyme A[6].

C. **Micronutrients:** Micronutrients (trace elements) are needed in tissue concentrations equal to or less than 100 μg g^{-1} of dry matter. They are referred as micronutrients not because they are less important for plant growth and development, but because they are required in relatively small amounts. They include: Zinc- It is a constituent of several enzymes regulating various metabolic reactions. Iron- An essential component of many hemo and nonhemo Fe enzymes and carriers, including cytochromes and the ferredoxins. Involved in key metabolic functions such as N fixation, photosynthesis and electron transfer. Manganese- Involved in oxygen evolving system of photosynthesis and also influences auxin levels in plants. Copper- It acts as an electron carrier in enzymes and associated with oxidation-reduction reactions. Boron- It is essential for development and growth of new cells in plant meristem. It is associated with translocation of sugars, starch, nitrogen and phosphorus. Molybdenum- It is an essential component of enzyme nitrate reductase in plants. It is also structural component of nitrogenase associated with nitrogen fixation in legumes.

Chlorine- Essential for photosynthesis and as an activator of enzymes involved in splitting of water. Associated with osmoregulation of plants growing on saline soils. Nickel- Essential for regulating N metabolism, grain filling and seed viability.[6]

Secondary and Micronutrients Management Practices in Organic Farming

In organic farming chemical fertilizers are not allowed and only organic manures and organic fertilizers are allowed. So whatever might be the nutrient requirement of the crops, it has to be supplied through organic sources only. Generally organic sources are referred as complete plant food as they contain all the essential plant nutrients. Different nutrient management practices followed in organic farming for secondary and micronutrient management are application of FYM, compost, oil cakes, liquid organic manures, biofertilizers, animal manures and organically approved amendments, cropping system management *viz.*, green manures (One season in a year), crop rotation, intercropping, crop residues management as mulch.[3]

Table 1: Secondary and micronutrients range in plant and soil.

Nutrients	Plant	Soil		
		Low	Medium	High
Calcium	0.1-1.0 (%)	<2 meq	-	>2 meq
Magnesium	0.1-0.4 (%)	<1 meq	-	>1 meq
Sulphur	0.1-0.3 (%)	<10 ppm	10-15.6 ppm	>15.6 ppm
Zinc (ppm)	20-100	<0.6	0.6-1.2	>1.2
Iron (ppm)	20-250	<4.5	4.5-9.0	>9.0
Manganese (ppm)	20-300	<3.5	3.5-7.0	>7.0
Copper (ppm)	2-20	<0.2	0.2-0.4	>0.4
Boron (ppm)	10-100	<0.5	0.5-1.0	>1.0
Molybdenum (ppm)	0.1-0.5	<0.2	0.2-0.4	>0.4
Chlorine (ppm)	2000-20000	-	-	-
Nickel (ppm)	0.1-0.2	-	-	-

(Seenappa *et al.*, 2019)

Table 2: Composition of the FYM, green manures, crop residues and mineralized sulfur as percentage of sulfur added to soil through various organic amendments

Organic material	S content (%)	C:N ratio	C:S ratio	Amount of S added (mg kg^{-1} soil^{-1})	% of added S mineralized (16 weeks after incubation)	
					Vertisol	Inceptisol
FYM	0.282	10.5	88.6	28.2	67.3	63.5
Subabul	0.242	12.2	157.0	24.2	55.5	53.6
Gliricidia	0.191	12.1	178.0	19.1	55.1	50.3
Soybean straw	0.097	34.9	371.1	9.7	-39.1	-20.9
Wheat straw	0.072	79.8	598.6	7.2	-109.0	-56.4

(Kotha Sami Reddy *et al.*, 2002)

FYM (Farm Yard Manure) is a well decomposed mixture of dung and urine of farm animals along with other farm wastes. It is the basic organic nutrient source available in most of the farms. The nutrients in manure can vary depending on the animal type, health, age, feed ration, bedding and water content. In addition, the various management practices associated with handling manure, manure storage, duration of storage, application amount, application technique and weather can all dramatically alter the nutrient content in manure and thus the amount of nutrients available in the soil and for future crop use. Understanding and applying the correct amount of manure to your fields can be accomplished by testing your manure prior to application.

The farm yard manure generally has 2.3 % Ca, 0.92 % Mg, 0.44 % S, 803.6 ppm Fe, 1312 ppm Mn, 132.4 ppm Zn and 30.4 ppm Cu along with nitrogen (0.90 %), phosphorus (0.63 %) and potassium (0.98 %).[14]

Table 3: Physico-chemical properties of vermicompost and vermiwash

Parameter	Vermicompost	Vermiwash
pH	6.12	7.11
Calcium (mg kg^{-1})	322.33	192.4
Magnesium (mg kg^{-1})	137.33	102.53
Manganese (mg kg^{-1})	0.69	0.40
Iron (mg kg^{-1})	0.21	0.11
Copper (mg kg^{-1})	0.09	0.05
Zinc (mg kg^{-1})	1.13	0.43

(Abdullah and Kumar, 2010)

The total sulfur mineralized in amended soil varied considerably depending on the type of organic materials incorporated and soil used. Sulfur mineralization expressed as percentage of sulfur added to the soils was highest in FYM treated soils (63.5 to 67.3 %). The percentage of S mineralization from subabul loppings was higher than that from gliricidia loppings. Regression analysis clearly indicated the dependence of S mineralization on the C:S ratio of the organic material added to the soil. Soybean and wheat straw recorded net negative mineralization i.e., immobilization due to wider C:N and C:S ratio.[11]

Compost is an organic matter that has been decomposed in a process called composting. This process recycles various organic materials which otherwise regarded as waste products and produces a soil conditioner. The decomposition process is aided by shredding the plant matter, adding water and ensuring proper aeration by regularly turning. There are different types of compost available like, Vermicompost, Rural compost and Urban compost. Among all, vermicompost is widely used one in which earthworms are used to decompose the organic wastes. The feaces of the earthworms is rich in nutrients and growth promoters.[2]

The liquid extract obtained through earthworm worked soil is referred to as Vermiwash and it contains all the secondary and micronutrients

Table 4: Soil chemical analysis after harvest and yield of okra

Treatments	Increase in OC %	Increase in Ca (ppm)	Increase in Mg (ppm)	Increase in Zn (ppm)	Fruit yield) (g/plant
Control	-0.07	-2.45	-0.39	-1.50	24.69
Cattle dung @ 100 g/plant	0.27	1.79	0.73	5.12	31.64
Chemical fertilizers	-0.15	1.15	0.35	0.86	75.43
Vermiwash @ 100 ml/plant	0.14	3.40	0.64	6.73	30.36
Vermicompost @ 100 g/plant	0.64	4.07	0.90	10.24	59.04
Vermicompost and Vermiwash	0.73	5.00	1.00	15.62	69.11

(Abdullah and Kumar, 2010)

as that of vermicompost but in lesser quantities comparatively.[2]

Combined application of vermicompost at 100 g/plant at the time of sowing and spraying of Vermiwash at 100 ml/plant recorded higher fruit yield per plant compared to vermicompost and vermiwash alone. The higher yield is mainly due to supply of more amounts of secondary and micronutrients. The vermiwash and vermicompost combination was also found to have a significant influence on the biochemical characteristics of the soil with marked improvement in soil nutrients like calcium, magnesium and zinc.[2]

Oil cakes are the left over solid portion of seed after extraction of oil from the seed. Mostly, edible oil seed cakes are used as poultry and animal feed and non edible oil seed cakes are used as concentrated manure.

Table 5: Composition of different oil cakes

Constituents	Castor cake	Pongamia cake	Jatropa cake
Fe (mg/g)	138.3	53.4	134.4
Mn (mg/g)	102.3	294.0	256.5
Zn (mg/g)	244.8	275.3	378.2
Cu (mg/g)	184.3	127.3	103.3
C:N ratio	9.4:1	10.4:1	12.5:1
OC %	48.84	46.72	50.65

(Anon., 2010)

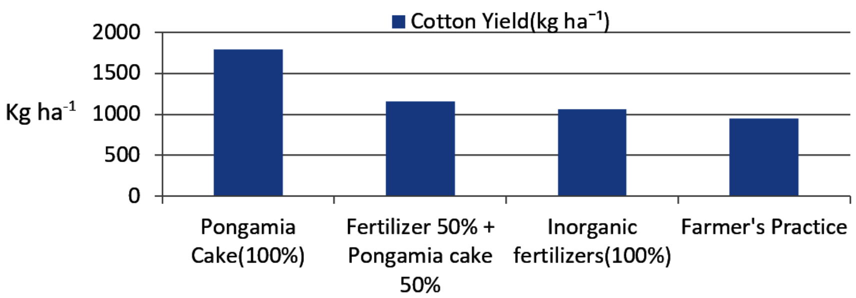
Oil cake obtained from castor is a good source of iron and copper. Whereas oil cake obtained from pongamia is a good source of manganese and jatropa contains more of zinc along with other micronutrients.[5]

Application of pongamia oil cake at 100 % N equivalent dose recorded significantly highest cotton yield (1790 kg/ha) compared to 100 % inorganic fertilizer (1065 kg/ha) and farmers practice (950 kg/ha) which doesn't have any source of secondary and micronutrients. One of the major constraints in cotton production is secondary (magnesium) and micronutrient deficiencies. Pongamia oil cake under the study contains 0.25 % Ca, 0.17 % Mg, 1.89 % S, 59 ppm Zn, 100 ppm Fe, 22 ppm Cu, 74 ppm Mn and 19 ppm B along with primary nutrients N (4.28 %), P2O5 (0.4 %) and K2O (0.74 %). Due to the correction of nutrient deficiencies and balanced supply of all nutrients pongamia treatment recorded highest yield.[16]

Liquid organic manures is organic matter in liquid form, mostly derived from animal feces, which can be used as organic fertilizer in agriculture. The most commonly used liquid organic manures in now a days are,

a. **Jeevamrutha:** It is prepared by mixing cow dung, cow urine, pulse flour, jaggery, and bund soil in a ratio of 10:10:2:2:1 in 200 L of water. It is for soil application.

b. **Panchagavya:** It consists a total of nine products viz. cow dung, cow urine, milk, curd, ghee, jaggery, banana, tender coconut



(Osman *et al.*, 2009)

Fig 1: Cotton yield as influenced by application of pongamia cake

and water. When suitably mixed and used, these have miraculous effects. It is for foliar application.

c. **Beejamrutha:** It is prepared by soaking 5 kg of cow dung bagged in cloth bag in 20 L of water containing 50 g of lime overnight followed by squeezing the cow dung into the solution and adding 5 L of cow urine. Beejamrutha is for seed treatment only.

d. **BDLM (Bio Digested Liquid Manure):** Thirty kilogram green biomass of selected plant biomass, 15 kg cow dung, 20 L cow urine were taken in separate 200 L cylindrical cement tanks, and 100 L water was added to each tank. The contents were incubated for 45 days. During the period the contents were digested by the microorganism present in cow dung.

e. **Vermiwash:** The liquid extract obtained through earthworm worked soil is referred to as Vermiwash. It contains all nutrients as vermicompost but in relatively lesser quantities. Some other liquid organic manures used under organic farming are: Leaf extracts, Amruthjal, Liquid fish and bone meal, Sea weed extract.

The various types of organic solutions prepared from plant and animal origin are effective in the promotion of growth and development in plants. The Panchagavya is an efficient plant growth stimulant that enhances the biological efficiency of crops. It is used to activate biological reactions in the soil and to protect the plants from disease incidence.

Table 6: Nutrient and microbial status of different liquid organic manures

Parameter	Panchagavya	Beejamrutha	Jeevamrutha
pH	6.82	8.20	7.07
EC (dS/m)	1.88	5.50	3.40
Total Zinc (mg kg^{-1})	1.27	2.96	4.29
Total Copper (mg kg^{-1})	0.38	0.52	1.58
Total Iron (mg kg^{-1})	29.71	15.35	282
Total manganese (mg kg^{-1})	1.84	3.32	10.7
Bacteria (cfu/ml)	26.10×10^5	15.40×10^5	19.70×10^5
Fungi (cfu/ml)	18.0×10^3	10.50×10^3	13.40×10^3
Actinomycetes (cfu/ml)	4.20×10^3	6.80×10^3	3.50×10^3

(Nileemas and Sreenivasa, 2011)

Table 7: Effect of liquid organic manures on the yield parameters of tomato

Treatments	No. of fruits/plant	Fruit weight (g/plant)
RDF	11.12	167.23
Panchagavya only	16.12	216.60
Jeevamrutha only	11.87	149.43
Beejamrutha only	8.62	147.51
Beejamrutha + Jeevamrutha + Panchagavya	19.65	271.53
S.Em±	0.55	6.00
C.D.(p=0.05)	1.57	17.00

(Nileemas and Sreenivasa, 2011)

Note: RDF: 150-100-60 kg N-P-K/ha and 25 t FYM/ha, Panchagavya (3%) @ 25, 70 & 100 DAS, Jeevamrutha @ 500 L/ha

Jeevamrutha promotes immense biological activity in soil and enhance nutrient availability to crop. Beejamrutha protect the crop from soil borne and seed borne pathogens and also improves seed germination. All the three organic solutions contain significant amounts of micronutrients as well as microbial population (bacteria, fungi and actinomycetes).[15]

Treatment combination of Beejamrutha+Jeevamr utha+Panchagavya recorded significantly highest number of fruits per plant and fruit weight per plant compared to individual treatments and RDF. All the liquid organic manures contain significant amounts of micronutrients and the combination treatment has supplied higher amount of micronutrients which resulted in higher fruits and fruit weight per plant.

The nutrient content available in the bio-digested liquid manure depends on the source of green biomass used for its preparation. When compared to BDLM, the enriched bio-digested liquid manure

Table 8: Nutrient concentration in bio-digested liquid manures of different green biomass (locally available) and EBDLM

Types of BDLM	pH	EC (dS/m)	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	Fe (ppm)	Zn (ppm)	Cu (ppm)	Mn (ppm)
Parthenium	7.94	0.04	0.76	0.17	0.29	0.13	0.05	0.26	17.4	2.18	1.92	3.6
Lantana	7.23	0.04	0.83	0.20	0.31	0.09	0.06	0.28	14.3	1.91	1.41	2.59
Calatropis	6.41	0.15	0.87	0.23	0.35	0.07	0.03	0.31	22.3	1.99	1.84	4.78
Subabul	7.84	0.05	0.86	0.18	0.33	0.10	0.04	0.23	18.3	1.36	1.16	2.07
Glyricidia	6.45	0.06	0.98	0.22	0.36	0.07	0.05	0.32	19.4	1.92	1.96	3.96
Neem	7.11	0.08	0.61	0.24	0.32	0.08	0.05	0.25	18.5	2.06	2.58	3.98
Pongamia	7.91	0.27	0.81	0.22	0.26	0.09	0.04	0.27	22.4	1.80	2.45	3.83
Jatropha	7.10	0.04	1.04	0.25	0.38	0.08	0.05	0.31	24.5	1.87	1.76	2.19
EBDLM (Pongamia)	8.10	0.26	1.29	0.39	0.57	0.17	0.08	0.35	28.7	3.68	3.66	7.74

(Anand, 2017)

Table 9: Pod yield, haulm yield, oil yield and B:C ratio of groundnut as influenced by the different liquid organic manures

Treatment	Pod yield (kg/ha)	Haulm yield (kg/ha)	Oil yield (kg/ha)	B:C ratio
BDLM @ 25 kg N equivalent per ha + 3 sprays of Panchagavya at 3%	1783	2767	554	2.3
BDLM @ 25 kg N equivalent per ha + 3 sprays of vermiwash at 3 %	1752	2589	538	2.2
EBDLM @ 25 kg N equivalent per ha + 3 sprays of Panchagavya at 3 %	2023	3090	668	2.7
EBDLM @ 25 kg N equivalent per ha + 3 sprays of vermiwash at 3 %	1879	2794	596	2.4
Control (25-50-25 Kg N-P2O5-K2O/ha)	1625	2518	482	1.8
C. D. at 5 %	186	303	61	-

(Shashidara, 2014)

contains more amounts of all the nutrients. This is because enriching is usually done with oil cakes which are very good sources of plant nutrients and moreover they are concentrated organic manures.[3]

All the organic treatments recorded significantly higher yields and B:C ratio compared to control i.e., RDF which doesn't have any secondary and micronutrients. Application of enriched bio digested liquid manure at 25 kg N equivalent per ha + 3 sprays of Panchagavya at 3 % recorded highest pod yield, haulm yield, oil yield and B:C ratio compared to other treatments. This is mainly because EBDLM (Enriched Bio Digested Liquid Manure) and Panchagavya contains more secondary and micronutrients than BDLM and vermiwash.[21]

Table 10: Secondary nutrient content in different sources

Source of nutrient	Ca (%)	Mg (%)
Neem leaf extract	0.77	0.75
Poultry manure	0.32	0.41
Wood ash extract	15.00	1.00
Modified neem leaf extract	15.66	1.53

(Emmanuel, 2012)

Leaf Extracts

Modified neem leaf extract (1200 L/ha) gave significantly higher yields in both maize and watermelon (sole and intercrop) compared to NPK. The modified neem leaf extract also improved soil parameters like pH, organic matter, calcium and magnesium after the harvest. NPK treatment recorded lower yields as well as poor soil parameters like pH, organic matter, calcium and magnesium after the harvest as chemical fertilizers contains no source of other nutrients.[8]

Biofertilizers is a substance which contains living microorganisms which, when applied to seeds, plant surfaces, or soil, colonize the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of nutrients to the host plant.[23]

Though many biofertilizers are identified and used regularly, most of them are specific for primary nutrients. The work on secondary and micronutrient solubilizing or mobilizing microorganisms is meager. Some of the microorganisms identified in increasing the availability of secondary and micronutrients are: S- *Thiobacillus sulfoxidans, Beggiota*, Fe- *Thiobacillus ferroxidans, Ferrobacillus ferroxidans*, Zn- *Bacillus spp*.

Table 11: Yield and soil chemical composition after harvesting of maize + watermelon intercropping under different fertilizer treatments

Treatments	Yield (kg/plot)		Soil status after harvesting of crop			
	Maize	Watermelon	pH	OM %	Ca (mmol/kg)	Mg (mmol/kg)
Neem leaf extract @3 L/25 m^2	1.65b	20.3bc	6.25d	1.44b	1.00b	1.00b
Poultry manure @ 15 kg /25m^2	1.70b	16.75b	6.10c	1.66e	1.25c	0.84d
Wood ash extract @3 L/25 m^2	3.00d	10.4a	6.80f	1.51bd	1.29d	0.78c
Modified neem leaf extract @ 3 L/25 m^2	3.85e	28.8d	6.34d	1.74f	1.31e	0.88e
NPK 15-15-15 @ 300g/25m^2	2.15c	23.8c	5.38ab	0.38b	0.06a	0.06a
Control	1.20a	7.8a	5.2a	0.28a	0.03a	0.07a

(Emmanuel, 2012)

Note: Initial- pH: 5.45; OM: 0.69; Ca: 0.11; Mg: 0.09

Azolla, a floating fern which is commonly used in rice fields along with fixing atmospheric nitrogen also supplies secondary and micronutrients like Ca, Fe, Zn, Mn, Cu, B, Co and Ni[4].

Initial soil status: P- 3.9%; Fe- 3.72; Mn -0.66; Zn - 0.29; Cu- 0.21

Higher values of P, Fe, Mn, Zn and Cu uptake, were observed by inoculation with VAM + PDB, while inoculation by VAM or PDB solely recorded relatively lesser values. Due to higher availability of micronutrients in VAM + PDB, it recorded highest yield as well as highest per cent increase over control (16.6 %). VAM is more efficient in increasing the nutrient availability than PSB. VAM (Vesicular Arbuscular Mycorrhizae) is associated with the rots of plants and increases the total volume of roots which in turn increases the volume of soil in contact with roots. As a result the micronutrients which are less mobile in the soil is made available to plant by these vesicular extensions.[17]

Table 12: Mineral profile of Azolla pinnata

Minerals	Content	Minerals	Content
Copper (ppm)	9.1	Calcium (%)	1.64
Boron (ppm)	31	Iron (ppm)	1569
Cobalt (ppm)	8.11	Zinc (ppm)	325
Nickel (ppm)	5.33	Manganese (ppm)	2418

(Anitha *et al.,* 2016)

Animal manures

The most commonly used animal manures are poultry manure and goat manure in India. Horse manure and swine manure are also in use in foreign countries.

Application of farmyard manure at 10 t/ha, poultry manure at 5 t/ha and gypsum at 250 kg/ha increased total uptake of all secondary nutrients and there by pod and haulm yield of groundnut compared to control. The increase in uptake of nutrients and yield is mainly due to supply of nutrients by the organic manures and gypsum. Poultry manure at 5 t/ha is as effective as that of farm yard manure at 10 t/ ha. Irrespective of the time of application, gypsum significantly increased the nutrient uptake and yield of groundnut and there is no significant difference whether gypsum is applied at the time of sowing or half at the time of sowing and half at 35 DAS.[18]

Utilization of poultry manure has been a common practice in India. Poultry manure is rich organic manure since solid and liquid excreta are excreted together resulting in no urine loss. In deep litter manure, the litter absorbs moisture and helps keep the manure friable. Litter is not used when the birds are reared in cages so the manure obtained in cage system is more concentrated. Lower C:N ratio,

Table 13: Effect of microbial inoculation on the availability of P, micronutrients and yield of faba bean

Treatments	Soil nutrient content after harvest					Yield (t/fed)	% increase over control
	P	Fe	Mn	Zn	Cu		
Control	3.71	3.55	0.67	0.28	0.24	2.62	-
VAM	8.44	4.22	0.84	0.61	0.30	2.97	12.03
PDB	6.15	3.75	0.70	0.39	0.28	2.85	7.14
VAM+PDB	8.93	5.43	1.00	0.79	0.53	3.09	16.16
L.S.D. at 0.05	1.30	0.30	0.29	0.09	0.20	0.30	-

(Raafat and Tharwat, 2006)

Note: VAM: Vascular Arbuscular Mycorrhizae PDB: Phosphorus Dissolving Bacteria 1 fed = 0.42 ha higher nutrients like sulfur, iron, zinc, copper and manganese were recorded in cage poultry manure.[20]

Application of cage system poultry manure (CS-PM) at 10 t/ha recorded higher protein content and oil content in mustard and is on par with cage system and deep litter system poultry manure (DLS-PM) at higher rates *i.e.*, at 20 t/ha. Higher protein and oil content is mainly due to supply of secondary and micronutrients. Lowest protein and oil content was recorded in control due to no supply of nutrients.[13]

Even though there is a strict restriction in the use of fertilizers in organic farming, IFOAM, Germany has allowed the use of some of the chemical fertilizers as amendments (which are mostly of natural occurring substances) and they were shown in the above table with their respective secondary and micronutrient contents.[23]

Organically Approved Amendments

Some of the substances are allowed with some restrictions like the substances should be free from heavy metals and other pollutants.

Table 14: Effect of organic manure and gypsum on yield and nutrient uptake of groundnut

Treatment	Groundnut yield (q/ha)		Nutrient uptake (kg/ha)		
	Pod	Haulm	Ca	Mg	S
Organic manure					
Control	16.2	29.5	44.2	27.2	12.2
FYM 10 t/ha	18.5	32.2	51.2	30.9	14.0
Poultry manure(PM) 5 t/ha	18.1	32.0	51.5	30.5	13.7
CD (P=0.05)	0.73	1.17	1.78	1.13	0.42
Gypsum (250 kg/ha)					
Control	16.6	30.5	45.8	28.1	12.5
Full at sowing	18.1	31.6	50.1	30.2	13.6
Half at sowing + half at 35 DAS	18.1	31.6	50.9	30.4	13.8
CD (P=0.05)	0.51	0.78	1.27	0.82	0.30

(Rao and Shaktawat, 2005)

Note: FYM: Ca-0.24%; S-0.06% PM: Ca-1.1 %;S-0.1% Gypsum:Ca-18%;S-14%

Table 15: Effect of different poultry manures on protein and oil content of mustard

Treatments	Protein content (%)	Increase over content (%)	Oil content (%)	Increase over control (%)
Control	21.25	-	40.25	-
DLS-PM @10 t/ha	22.42	5.22	41.41	2.80
DLS-PM @20 t/ha	23.78	10.64	42.35	4.96
CS-PM @10 t/ha	23.75	10.53	43.71	7.92
CS-PM @20 t/ha	24.31	12.59	44.11	8.75
LSD (0.05)	1.43	-	2.69	-

(Mohamed *et al.,* 2010)

Cropping System Management

Crop rotation is the back bone of organic farming practices and is a must to keep the soil healthy and to allow the natural microbial systems working. Crop rotation is the succession of different crops cultivated on same land. Follow 3-4 years rotation plan. All high nutrient demanding crops should precede and follow legume dominated crop combination and returned back to soil. Rotation of pest host and non pest host crops helps in controlling soil borne diseases and pest. It also helps in controlling weeds. It is better for improving productivity and fertility of soil. Crop rotations help in improving soil structure through different types of root system. Legumes should be used frequently in rotation with cereal and vegetable crops. Green manure crops should also find place in planning rotations. Some important benefits of crop rotations are: a). Not all plants have same nutritive

Table 16: Organically approved and permitted sources as secondary and micronutrient

Source
Matter produced on an organic farm unit
Farmyard and poultry manure, slurry, urine, Composts, Vermicompost, Crop residues, green manure, Straw and other mulches
Traps, barriers and repellants
Physical methods (e.g. chromatic traps, mechanical traps), Mulches, nets, Pheromones – in traps and dispensers only
Mineral Origin
Clay (bentonite, perlite, vermiculite, zeolite) and Diatomaceous earth, Calcified sea weed, Basic slag, Lime, Limestone, Gypsum and Calcium chloride, Kieserite, Epsum salt, Natural phosphates (like rock phosphate), Sulphur (elemental) and Boudreaux mixture
Plant, Animal and Microbiological origin
Bacterial preparations (biofertilizers), Biodynamic preparations, Plant preparations and botanical extracts, Plant based repellents (Neem preparations from *Azadirachta indica*), Algal preparations (gelatin), Casein, Extracts from mushroom, chlorella, fermented products from Aspergillus, Beeswax, Natural acids (vinegar), plant oils, Quassia.
Others
Carbon dioxide, nitrogen gas, Soft soap, soda, sulphur dioxide, Homeopathic, ayurvedic preparations, Herbal and biodynamic preparations, Sea salt and salty water

(Yadav, 2011)

Table 17: Mineral composition of eupatorium on dry weight basis

Constituent (unit)	Value	Constituent (unit)	Value
Organic carbon (%)	1.87	Sulphur (mg/kg)	390.4
Nitrogen (%)	1.05	Iron (ppm)	500.3
Phosphorus (%)	0.11	Copper (ppm)	19.3
Potassium (%)	1.50	Zinc (ppm)	330.5
Calcium (mg/kg)	470.3	Manganese (ppm)	115.6
Magnesium (mg/kg)	320.0	Boron (ppm)	4.00

(De *et al.*, 2008)

needs. b). Soil structure is improved through different types of roots and addition of organic matter. c). Rotations help against the buildup of weeds, insects and pathogens.

Green manuring is the growing of a crop for the specific purpose of incorporating it into soil while green, or soon after maturity with a view to improving the soil and benefiting subsequent crops. Green manuring helps in increasing organic matter and nutrient content of soil, maintain and improve soil structure, reduce the loss of nutrients and soil loss by erosion. There are two types of green manuring: I. Green manuring in situ: In this system, green manure crops are grown and buried in the same field which is to be green-manured, either as a pure crop or as intercrop with the main crop. This is most common green manure crops grown under this system are sunhemp (*Crotalaria juncea*), dhaincha (*Sesbania aculeata*), pillipesera (*Phaseolus trilobus*) and guar (*Cyamopsis tetragonaloba*) II. Green leaf manuring: refers to turning into the soil green leaves and tender twigs collected from shrubs and trees grown on bunds, waste lands and nearby forest areas. The common shrubs and trees used are Glyricidia, Sesbania, Karanj etc.

Table 18: Effect of eupatorium on grain, straw yield and B:C ratio of rice

Treatment	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	B:C ratio
No eupatorium	5707	4650	2.8
Eupatorium @5t/ha	6120	5227	2.9
Eupatorium @10t/ha	6735	6206	3.18
Eupatorium @15t/ha	6915	6130	3.13
Eupatorium @20t/ha	6929	6862	3.08
C.D. at 5%	315	505	-

(Manjappa, 2014)

Eupatorium (*Chromoleana odorata*) an obnoxious weed found in abundance in the India has become a menace in younger plantations, waste lands and along road sides. This weed is also known to cause diseases in animals and human beings. Considering its adverse impact on the environment, several attempts have been made to control this weed by adopting various methods. But, none of the methods showed great promise in controlling this weed. Under this juncture, few efforts were made to find out alternate ways for controlling/minimizing this weed menace. One of the environmentally friendly ways to eradicate this weed would be its utilization for productive purposes in agriculture. One of the ways of using eupatorium is as green leaf manure before its seed setting. Further, the nutrient (secondary and micronutrient) content of eupatorium is quite comparable to other conventional green manure crops like sunnhemp and Glyricidia.[7]

Green leaf manuring with eupatorium, an alien obnoxious weed at 10 t/ha recorded significantly higher rice grain (6735 kg/ha) and straw yield (6206 kg/ha) along with highest B:C ratio (3.18) due to supply of all plant nutrients including secondary and micronutrients compared to control (5707 kg/ha, 4650 kg/ha & 2.8, respectively).[12]

Table 19: Chemical properties of rice straw

Constituent (unit)	Value	Constituent (unit)	Value
Organic carbon (%)	1.87	Sulphur (mg/ha)	390.4
Nitrogen (%)	1.05	Iron (ppm)	500.3
Phosphorus (%)	0.11	Copper (ppm)	19.3
Potassium (%)	1.50	Zinc (ppm)	330.5
Calcium (mg/ha)	470.3	Manganese (ppm)	115.6
Magnesium (mg/ha)	320.0	Boron (ppm)	4.0

(Abdul *et al.*, 2016)

Crop residues is the portion of a plant or crop left in the field after harvest, or that part of the crop that is not used domestically or sold commercially. Total amount of residue produced in India – 350 m t/yr. Crop residue management: It is the use of the non-commercial portion of the plant or crop for protection or improvement of the soil. Management of crop residues as a source of nutrients in organic farming is done by Residue incorporation, Surface retention and mulching, Composting.

Rice straw organic carbon concentration (1.87%) was moderate. Straw was rich in phosphorus, calcium, magnesium and sulphur (1170, 470, 320 and 390 mg/ha, respectively), as well as iron and zinc (500 and 330.5 ppm, respectively). Other mineral elements such as boron, manganese, copper and sodium are in relatively lower concentrations.[1]

Application of rice straw at 1.25 t/ha after grounding into small pieces of 2-5 cm recorded significantly higher yield along with improving the organic matter, secondary and micronutrient content of the soil. The decrease in the growth traits at higher application of rice straw might be due to the high dose of rice straw, which apparently takes more time to decompose for release of nutrients. The results suggest that the use of rice straw at lower application rates could be considered as optimum for groundnut production. Its use could also limit environmental pollution arising from burning of rice straw.[1]

Table 20: Groundnut yield as influenced by ground rice straw(GRS)

			Nutrient content of soil after harvest (ppm)									
Treatment	**Seed yield (kg/ha)**	**OM (%)**	**Ca (meq)**	**Mg (meq)**	**S**	**Fe**	**Mn**	**Cu**	**B**	**Mo**	**Zn**
Control	650 c	5.2 b	2.5	1.2	10	4.3	6.0	0.13	0.24	0.23	0.15
GRS @1.25 t/ha	1278 a	5.8 a	2.4	1.0	15.5	8.2	8.0	0.19	0.34	0.12	0.50
GRS @2.5 t/ha	976 b	6.0 a	2.6	1.1	16.7	7.4	7.6	0.18	0.28	0.13	0.31

(Abdul et al., 2016)

Table 21: Secondary and micronutrient content in different crops

Crop	Ca (%)	Mg (%)	S (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)	Mo (ppm)
Rice	1.2-1.4	0.2-0.3	0.2-0.4	70-150	150-500	18-50	8-25	6-7	-
Wheat	0.2-0.1	0.16-1.0	0.1-0.3	10-300	16-200	21-70	5-50	-	-
Maize	0.3-0.7	0.15-0.45	0.15-0.5	50-250	20-300	20-60	5-20	5-25	-
Sorghum	0.3-0.6	0.1-0.2	0.1-0.3	65-100	10-190	15-30	2-7	1-10	-
Barley	0.3-1.2	0.15-0.5	0.15-0.4	40-250	25-100	15-70	5-25	-	0.1-0.2
Sugarcane	0.2-0.5	0.1-0.35	0.1-0.3	40-250	25-400	20-100	5-15	4-30	0.05-0.4
Soybean	0.36-2.0	0.26-1.0	0.21-0.4	51-350	21-100	21-50	10-30	21-55	0.1-0.5
Mustard	1.0-2.5	0.25-0.75	0.3-0.75	70-300	25-200	34-200	5-15	30-100	0.1-0.4

(Tandon, 2013)

Plants differ in their ability to uptake and accumulate nutrients in their plant tissues. Legume plants have a capability to accumulate more amounts of molybdenum than other plants as molybdenum is a component of nitrogenase enzyme which is responsible for nitrogen fixation. Similarly, oil seed crops will accumulate more amounts of sulphur than other crop plants as sulphur is essential for oil synthesis.[21]

Conclusion

The birthright of all living things is good health. This law is true for soil, plant, animal and man: the health of these four is one connected chain. Any weakness or defect in the health of any earlier link is passed onto the next and succeeding link, until it reaches the last, namely, the man. Therefore, to produce quality food and to sustain the environment organic agriculture plays a crucial role and organic management practices like application of FYM, compost, oil cakes, liquid organic manures, biofertilizers, vermicompost, organically approved amendments, cropping system management *viz*., green manuring, crop rotation, intercropping, crop residues management found beneficial for sustaining soil health in terms of build-up of secondary and micronutrients and safeguarding the environmental degradation. Effective management and recycling of available on-farm wastes helps to reduce the dependency on external chemical inputs and limits the environmental pollution arising out of burning of farm wastes.

Acknowledgement

The authors are thankful to the University of Agricultural Sciences, GKVK, Bengaluru for carrying research on organic farming during the Ph. D program and supporting for the project.

Conflict of Interest

Authors declare no conflict of interest.

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