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Synopsis

Organic Cultivation of New Medicinal and Aromatic Plants as a Source for Pharmaceutical Industries

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Abstract. Medicinal and aromatic plants continue to be the subject of novel and straight forward applications as a source of active constituents for pharmaceutical industries. Fertilizers are important factor in modern-day agriculture as they increase crops yield and allow crops to be planted in nutrient deficient soils. Although chemical fertilizers are important tool for higher production of different crops, the extensive and intensive use of them resulted in the accumulation of chemicals. Some organic fertilizers as Farmyard manure (FYM) and compost at different rates and different combinations could be used instead of chemical fertilizers to meet the demand of plants from NPK and some micronutrients to improve the quantity and quality of medicinal plants. The present review introduces some researches performed to elaborate the benefits of organic cultivation of some important medicinal and aromatic plants such as *Coleus forskohlii, Satureja hortensis L., Amaranth* species etc.

Key words: organic fertilizers, medicinal plants, microorganisms, phytohormones.

Introduction

Human being has been used medicinal and aromatic plants from ancient time and scientists are constantly brings to light additional information on the relationship between plants and traditional medicines. 80% of global population use medicinal plants to cover all or part of their health care needs (WHO, 2008). Thousands of higher plants have been reported to be of high medicinal value and constitute a major source of raw material for pharmaceuticals, cosmetics, and drug industries. Many of these plants synthesize substances that are useful to the maintenance of health in humans and other animals. These include aromatic substances, most of which are phenols or their oxygen-substituted derivatives such as tannins while others contain alkaloids, glycosides, saponins and many secondary metabolites (Naguib, 2011).

Organic fertilizers are obtained from animal sources such as animal manure or plant sources like green manure. Continuous usage of inorganic fertilizer affects soil structure. Hence, organic manures can serve as alternative to mineral fertilizers for improving soil structure (Dauda *et al.*, 2008) and microbial biomass (Suresh et al., 2004). Composting is a biological process in which organic biodegradable wastes are converted into compost for use as a soil conditioner and an organic fertilizer (Popkin, 1995). Vermicomposting is a simple biotechnological

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process of composting, in which certain species of earthworms are used to enhance the process of waste conversion and produce a better end product (Gandhi *et al*., 1997). These are also used to provide biological control against various plant pathogens (Hoitink & Grebus, 1994). The addition of municipal solid waste compost to agricultural soils has beneficial effects on crop development and yields by improving soil physical and biological properties (Zheljazkov & Warman, 2004).

Biofertilizers are microbial inoculants consisting of living cells of micro-organism like bacteria, algae and fungi alone or combination which may help in increasing crop productivity. Biological activities are markedly enhanced by microbial interactions in the rhizosphere of plants (Tilak & Reddy, 2006). The plant growth promoting rhizobacteria (PGPRs) can influence plant growth directly through the production of phytohormones and indirectly through nitrogen fixation and production of bio-control agents against soil-borne phytopathogens (Glick, 2003). *Azospirillum* species are nitrogen-fixing organisms, capable of forming an associative relationship with the roots of several economically important crops (Vande Broek & Vanderleyden, 1995).

Most of the cultivators of medicinal and aromatic crops have know the importance of cultivation of crop under organic condition and were better equipped to take a more informed decision about expanding its cultivation under organic system of production (Malik, 2014). The decision on area allocation by a cultivator for a given crop, more so for a new crop, is influenced by several factors about some of which the cultivator may have had little or no knowledge when he first started its cultivation. Having once decided to cultivate the crop, the decision on its cultivation under organic farming system is influenced by the experience the cultivator and availability of resources and more deterministic information about the other complementary factors (Afaq et al., 2013).

This review has mainly been focused on some information about organic fertilizer and contemplating and prospecting the work done so far to know the impact of organic farming system on growth and yield of some economical medicinal and aromatic crops.

What are organic fertilizers made of?

Organic fertilizers are made from mined rock minerals as well as natural plant and animal materials. They include ingredients like manure, guano, dried and powdered blood, ground bone, crushed shells, finely pulverized fish, phosphate rock, and wood. While inorganic or synthetic, fertilizers may contain some organic ingredients. The main difference is that they act quickly to simply feed the plant without actually enriching the soil, and may contribute to a toxic build up of salts in the soil when over applied.

What types of organic fertilizers are there?

- *Plant-Based Fertilizers:* Plant-based fertilizers are usually high in nitrogen and sometimes potassium. Some crops are grown specifically to be made into organic fertilizer, while others, such as cottonseed meal, are by-products of another industry.
- *Alfalfa Meal:* This fertilizer is also available in pellets. It has a moderate amount of nitrogen (2 to 3 %) and contains some trace minerals.
- *Corn Gluten:* This by-product of the corn-processing industry contains 10% of nitrogen in a form that's quick to break down. It also has the unique ability to inhibit germination of seeds and is sold as an organic pre-emergent herbicide to control crabgrass in lawns.
- *Cottonseed Meal:* This by-product of the cotton industry is made from the remains of cotton seed after the oil is pressed out. It's a slow-release fertilizer, moderately high in nitrogen (6%) with some phosphorous. It can acidify the soil. Since cotton is such a heavily sprayed crop, there are concerns about pesticides on the seed and in the meal. It's

preferable to use low-residue or pesticide-free cottonseed meal.

• *Seaweed:* Extracts of seaweed and kelp are found in meal and liquid forms. They are good sources of minerals, with some potassium and nitrogen. They also enhance the microbial activity in the soil. Liquid versions of seaweed can be sprayed directly on plants as a foliar fertilizer.

• *Soybean Meal:* This high-nitrogen fertilizer (7%) is similar to alfalfa meal and contains more nitrogen than cottonseed meal.

• *Animal-Based Fertilizers:* By-products from the dairy and meat processing industries produce a bevy of organic fertilizer products.

• *Blood Meal:* A by-product of the slaughtering industry which is a rich source of nitrogen (14%) but the smell may attract dogs and wild animals to the garden.

• *Bonemeal:* Another by-product of the slaughtering industry, bonemeal is a rich source of phosphorous (10%) and calcium (22%) and it supplies some nitrogen. "Steamed" bonemeal has less nitrogen but somewhat faster nutrient availability than "raw" bonemeal.

• *Fish Products:* By-products from fish industry are used in organic fertilizer products such as fish emulsion and fish meal, high in nitrogen (up to 10%) and quickly available to plants.

• *Compost:* Compost is considered the Cadillac of organic fertilizers. It can be made from plant-, animal-, and mineral-based materials. Finished compost has a low but good balance of nutrients while being high in organic matter that helps feed the soil's microorganisms. Composts are available commercially or can be made in field from various kinds of animal manures and lawn and garden wastes. It can be used with other fertilizers. Making compost is a way to deal with yard waste.

• *Animal Manures:* Manures can be derived from a variety of animals and even insects. Most are available bagged, composted, and sometimes sterilized. The nutrient composition of animal manures varies based on animal, bedding and method of manure storage. Aged manure is better than fresh, and cow is better than horse (high in weed seeds) but any manure will give worthwhile advantages. Cow manure is the manure most commonly found bagged in garden centers while nutrient content is low, the plants can absorb them moderately quickly. On the other hand, manure from sea birds, chickens, and bats is rich in nutrients, especially nitrogen.

Benefits of Organic Fertilizers:

The use of organic fertilizers could open an array of opportunities/ benefits related to the agronomic, economic and social domains;

A) Agronomic benefits:

1. Enhancing soil biological activity through favoring the root colonization by mycorrhizal fungi or by rhizosphere bacteria, these microorganisms can improve N, P and K supply and microelements by mobilization of low-soluble nutrient.

2. Improving the soil physical properties, thus ameliorating soil structure and water holding capacity.

3. Supplying nutrients in a balanced way, which increases plant growth and prolongs the plant health status by suppressing certain soil borne diseases and parasite.

4. The new organic sourced and processed fertilizers (often marketable products) make it possible to be applied according to the nutrient demand of the plant and soil status. This opportunity is mainly relevant to regions with a high soil P content, where P has become the limiting factor of fertilization by organic fertilizers.

5. Environmental benefits due to keeping/ enhancing microbial diversity, reducing soil acidification or alkalization and by reduction of decomposition of toxic substances (Yara, 2010).

B) Economic benefits:

1. Reduces needs in chemical fertilizers and soil management practices.

2. Reduces costs of externalities (i.e. those linked to the whole production and utilization chains).

C) Social benefits:

1. Enhances recycling of organic materials, with benefit for the environment with developing new industries/ production processes.

2. Facilitates the contact between local farms for exchange of organic sources which should allow choosing a product that is the most efficient for a particular crop.

Relationship between organic fertilizers and medicinal & aromatic plants

Medicinal and aromatic plants constitute a major segment of the flora, which provides raw materials for pharmaceuticals, cosmetics and drug industries. Looking into the important role of medicinal plants in different industries, it is great significance to increase production of biomass without using harmful chemical.

The use of organic fertilizers and microbial symbiosis with medicinal and aromatic plants helps in improving the yield and quality. However, the debate on the relative benefits of conventional and organic farming systems has in recent time gained significant interest. Additionally, global agricultural development has focused on increasing productivity rather than on a holistic natural resource management for food security. Thus, developing more sustainable farming practices on a large scale is of utmost importance. Many studies have shown positive results by organic and biofertilization practices. For example, application of rock phosphate and bio-fertilizers produced the maximum herb fresh weight and volatile oil production of *Mentha longifolia* plants (El-Gohary et al., 2013) while fertilizing *Thymus vulgaris* plants with nitropin+compost produced a significant increase in vegetative growth parameters and oil production (Nejatzadeh-Barandozi & Pourmaleknejad, 2014). In addition, using mycorrhiza, azotobacter and vermicompost to fertilize basil plants led to an increase in essential oil yield (Shirzadie et al., 2015).

In the following part we will focus on some new medicinal plants as *Coleus forskohlii, Satureja hortensis L., Amaranth* species etc.

1 - Coleus forskohlii Briq.:

Coleus (*Coleus forskohlii Briq.*), belonging to the family Lamiaceae, is an originated Indian medicinal herb (Valdes et al., 1987). It grows in the subtropical temperate climates of India, Nepal, Burma, Sri Lanka and Thailand. It is also found on the dry and barren hills (Anon, 1950). Apparently, it has been distributed to Egypt, Arabia, Ethiopia, tropical East Africa and Brazil (Willemse, 1985). It is the most important species of genus Coleus popularly known as 'garmar'. It is cultivated for the tuberous roots which are pickled and eaten (Anonymous, 1950). It is also used for the medicinal purposes mentioned in the Hindu and Ayurvedic schools of medicines (Ammon and Muller, 1985) as it is the source of forskolin (De Souza & Shah, 1988).

All plant parts are found to have traces of forskolin while roots are the main source (0.5-1%) and are commercially preferred for its extraction (Valdes et al., 1987). The tuber attachment region contains maximum amount (1-3 times higher forskolin), Yanagihara (1995). Forskolin is used in the treatment of congestive cardiomyopathy, hypertension and glaucoma (Seamon, 1984). The indiscriminate collection of *C. forskohlii* from the wild has made the species vulnerable and it has been included in the list of endangered species (Vishwakarma et al., 1988).

1-1-Influence of organic and inorganic fertilizers on growth and tuber yield of coleus (Coleus forskohlii Briq.) under northern dry zone of Karnataka

The field experiment conducted on sandy loam soil under irrigated conditions in Karnataka, India, showed that the application of 75% of RDF (Recommended dose of fertilizer) with 10t FYM + vermicompost 5 t/hectare significantly increased plant height (66.49cm), number of branches/ plant (85.95), leaf area index (7.49) at harvest, absolute growth rate(3.39g/plant/ day), crop growth rate (0.943 $g/m^2/day$) and relative growth rate (0.046g/g/ week) were recorded at 120-160 days old (Sadashiv et al., 2014).

1-2-Effect of potential bioinoculants and organic manures on root-rot and wilt, growth, yield and quality of organically grown Coleus forskohlii in a semiarid tropical region of Bangalore, India (Table 1).

Another 2-year field experiment was conducted with five bioinoculants and neem cake under organic field conditions (with vermicompost as a nutritional supplement) for evaluation of their potential to control root-rot and wilt (a complex problem involving *Fusarium chlamydosporum* and *Ralstonia solanacearum*) of the medicinal plant *Coleus forskohlii*. Plants treated with *Arbuscular mycorrhizal* fungus, *Glomus fasciculatum*, neem cake or *Pseudomonas fluorescens* showed significant increment in plant height (15- 31%), plant spread (25- 33%), number of branches (63-67%) and dry root yields (129-200%) with reduction of disease incidence (47-50%) compared to controls. Increases in yields were accompanied by increases in N (51- 81%), P (17- 76%) and K (44- 74%) uptake. The forskolin content of the roots was found not to be affected by any of the bioinoculants, but calculated forskolin yield was increased significantly by the treatment of *G .fasciculatum* (227%), neem cake (222%) and *P. fluorescens* (159%), Singh et al. (2012) (see Table 2).

1-3-Effect of organic manures, biofertilizers and inorganic fertilizers on productivity, biochemical parameters and active ingredient of Coleus forskholii.

An autumn season experiment was carried out during 2006 in India for determining the effect of *Azotobacter chroococcum* (N fixing) and *Pseudomonas striata* (phosphorus solubilizing bacteria, PSB) along with organic manures farmyard manure (FYM), vermicompost and chemical fertilizers (NPK, 50: 50: 30 kg/ ha) on the productivity, biochemical parameters and active ingredient of *Coleus forskohlii* with nine treatment combinations. The results showed that the maximum dry root yield (16.52 q/ ha) and fresh root yield (168.10 q/ha) were obtained upon treatment with chemical fertilizers (NPK at 50:50:30 kg/ ha) with maximum biochemical changes in roots, N, P, K contents (1.15%, 4.97%, 106.67ppm), protein (7.20%) and fat contents (7.24%) were recorded upon treatment with the chemical fertilizer. Whereas FYM at 5t/ha with vermicompost at 2.5 t/ ha increased carbohydrate (10.28%) and fiber content (13.30%) in roots. finally, Forskolin was maximum (17.29%) with the NPK treatment (Jyoti et al., 2008).

1-4-Organic Cultivation of Medicinal Plants: Influence of Composted Coir Pith on the Growth and Yield of Coleus forskohlii (willd.) Briq

In another study, composted coir pith (CCP) was used as an organic fertilizer and its effect on the growth, primary metabolite and secondary metabolite (forskolin) of *C. forskohlii* were studied. The CCP was amended to the soil in the plots at three rates, 5 t/h (T1), 10 t/ h (T2), and 15 t/ h (T3). It was found that CCP increased the growth and development of *C. forskohlii* in fields amended with 15 t/ h (T3). The activity of the three prime soil enzymes, namely, urease, phosphatase, and dehydrogenase in the rhizosphere soil of *C. forskohlii* also increased with an increase in the quantum of CCP amended to the soil (Padmadevi et al., 2016).

2 - Savory (Satureja hortensis L.)

Satureja species belongs to Lamiaceae family. Summer Savory (*Satureja hortensis L*) is an annual herbaceous plant with small erect hairy stems, grows about 30 cm in height. The branches are pinkish, leaves dark green, petiolate, leathery about 1 cm long. Lilac, pink or white flowers appear in small spikes in the leaf axils, during late summer. In folk medicine, summer savory is currently believed to benefit the entire digestive system. According to its believers, savory acts as a carminative, an anti-flatulent, an appetite stimulant, and works in diarrhea. The herbal tea is considered beneficial as an expectorant and cough remedy. One very interesting use of the tea in Europe is for excessive thirst in diabetics. The tincture can be used in small amounts for alleviating symptoms in cases of rachitic children and for rheumatoid afflictions followed by high fever. Many other therapeutic applications are listed by various herbalists. Savory (*Satureja hortensis L.*) Different forms of dried and processed products of savory (Rezaei et al., 2020).

2-1-Effect of Different levels of Seaweed Fertilizer on Growth Parameters, Yield and Essential Oil Content of Summer Savory (Satureja hortensis L.)

A complete randomized block design experiment was carried out for evaluation of studying the effect of different levels of seaweed fertilizer on the growth characteristics, plant material yield and essential oil percentage. Treatments were foliar application of 0 (control), 2.5, 5 and 10 ml/liter seaweed fertilizer in three times during growing season. It was mentioned that different concentrations of seaweed produced significant increments in all growth and yield parameters. The highest recorded values were those of 10 ml/liter seaweed fertilizer including branches number (35.44), shoot dry weight, root fresh and dry weight (15.17 and 6.42 g), leaf width (8.07 mm), plant height (54.66 cm), shoot fresh and dry weight (181.01 and 37.69 g), essential oil percentage and yield (2.51% and 6.28 g/m^2) (Rezaei et al., 2020).

2-2-Effect of Organic Fertilizers on Nutrients Content and Essential Oil Composition of Savory (Satureja hortensis L.)

Vermicompost as well as washed and unwashed mushroom compost in five levels (10, 20, 30, 40 and 50% v/v) were applied to savory. These produced significant induction of savory growth with macronutrient accumulation. The highest N content (6.3%) and P (0.98%) in savory shoot was obtained with 40% vermicompost application whereas higher potassium (3.19%) and calcium (2.48%) content was found in plants grown in the media containing 30% of vermicompost and 50% of washed spent mushroom compost (SMC) as compared to control plants. The highest essential oil percentage was produced by application of 30 % of vermicompost, the main components of essential oil were carvacrol and gamma-trepenine, while the highest level of carvacrol (62.10%) and gamma-trepenine (32.05%) were obtained in plants in substrates containing 40 and 20% of washed spent mushroom (Behrooz et al., 2018).

3 - Chervil (Anthriscus sylvestris. L) Hoffm.

Chervil (garden chervil, *Anthriscus cerefolium*, *Apiaceae*) is an essential oil bearing plant, related to parsley. It is commonly used to season mild flavored dishes and is a constituent of the French herb mixture fine herbs. It is native to the Caucasus and was spread by the Romans through most of Europe, where it is now naturalized (Vaughan et al., 1997). It is an excellent source of antioxidants that stabilize cell membranes and reduce inflammation associated with headache, sinusitis, peptic ulcer, and infections. Its essential oil contains estragole (as tarragon and basil), plus anethole. Leaves contain a fixed oil, high concentrations of potassium and calcium and apiin-α- glycoside. Flavonoids extract from herb and lignans from root showed strong free radical quenching activity, while the volatile oil obtained from herb was less effective. The identification of the constituents of the extracts indicated that apiin is the main flavonoid, deoxy podophyllo is the major lignan, and methyl chavicol is predominant constituent of essential oil (Feijes et al., 2003).

3-1-Improvement of growth parameters and essential oil productivity of Anthricus cerefolium L. by planting distances and fertilization treatments

Previously, it was established that the main constituents of essential oil of the plant cultivated in Egypt are strongly dependent on the application of nitrogen (N) and/or potassium (K) fertilizers. In order to broaden the possibility to enhance the productivity of the plant in this presented work in 2019, the effect of planting distances (15 cm – 30 cm – 45 cm), NPK feedings (0, 25%, 50%, 75% and 100%) as well as combination treatments between compost (10, 15 and 20 m^3/fed) and NPK were experimented. It was established that the increment of sowing distance from 15 cm to 45 cm increased gradually vegetative growth parameters (see Table 3, 4, 5).

The highest mean values of oil percentage were resulted from sowing distance at 45 cm followed by 30 cm. Compost at 20 t/fed produced the highest values of growth characters and essential oil (%). NPK fertilizer levels caused very noticeable effect on different growth parameters compared with untreated plants. Thus, 100% of NPK gave the maximum values of traits parameters and essential oil (%). The combination treatments between NPK and compost had a great effect on growth traits and essential oil (%). The combination treatment between compost at 20 t/fed and NPK at 100% produced the greatest values of growth characters and essential oil%. Essential oil constituents were identified with GC-MS. The main constituents were methyleugenol and estragole (Amer et al., 2019) (see Table 6 and 7).

Table 1. Fresh and dry tuber yield as influenced by organic manures and inorganic fertilizers in *C. forskohlii*. Data tabulated in this table indicate that T3 (75 per cent RDF + 10 t FYM + vermi compost 5.0 t/ ha) gave the maximum mean values of fresh and dry weight of tuber followed by T2 (75 per cent RDF + 10 t FYM + vermicompost 2.5 t/ha) while T8 (10 t FYM + vermicompost 2.5 t/ ha) resulted in the lowest values.

Treatments	**Fresh tuber yield**			**Dry tuber yield (q/ha)**
	g/plant	**q/ ha**	**g/plant**	
T_1 : 100 per cent RDF + 10 t FYM/ ha (control)	165.46	183.84	21.6	24.08
T_2 : 75 per cent RDF + 10 t FYM + vermicompost 2.5 t/ ha	202.13	224.58	26.47	29.42
T_3 : 75 per cent RDF + 10 t FYM + vermicompost 5.0 t/ ha	225.47	250.52	29.53	32.81
T_4:50 per cent RDF+10t FYM+vermicompost 2.5t/ ha	181.32	201.46	23.75	26.39
T_5:50 per cent RDF+10t FYM+vermicompost5.0t/ha	184.10	204.56	24.11	26.79
T_6:25per cent RDF+10t FYM+vermicompost2.5t/ ha	160.02	177.80	20.96	23.29
T_7:25per cent RDF+10t FYM+vermicompost 5.0t/ha	162.39	180.43	21.27	23.63
T_8: 10 t FYM + vermicompost 2.5 t/ ha	153.70	170.78	20.13	22.37
T_9: 10 t FYM + vermicompost 5.0 t/ ha	160.38	178.20	21.01	23.34
Mean	177.22	196.91	23.21	25.79
S.E.	3.307	6.102	0.719	0.799
C.D. (P=0.05)	9.914	18.29	2.16	2.39

Table 2. Effect of bioinoculants and neem cake on growth and yield parameters of *Coleus forskohlii* at harvesting in field conditions. *Legend:* TV: *Trichoderma viride*; BS: *Bacillus subtilis*; AZ: *Azotobacter chroococcum*; GF: *Glomus fasciculatum*; PF: *Pseudomonas fluorescens*; NC: neem cake; VC: vermicompost.

Treatment	**Plant height (cm)**	**Plant spread (cm)**	**Number of branches**	**Dry shoot yield (t ha^{-1})**	**Dry root yield (t ha^{-1})**	**Forskolin yield (kg ha^{-1})**
TV	41.70ab	43.70ab	20.30a	1.34a	0.18a	1.10a
BS	40.0ab	46.70b	19.30a	1.36a	0.17a	1.02a
AZ	40.20ab	41.30ab	18.30a	1.49a	0.22a	1.32ab
GF	49.60c	49.30b	28.30b	2.58b	0.41c	2.71c
PF	43.60b	47.10b	28.00b	2.01a	0.32bc	2.15bc
NC	48.20c	46.30b	27.70b	2.64b	0.42c	2.67c
VC (Control)	38.00a	37.10a	17.00a	1.33a	0.14a	0.83a
LSD (P< 0.05)	4.10	7.00	6.08	0.80	0.1	0.84

Table 3. Effect of compost on growth characters of chervil plants (mean values of two successive seasons). Means followed by similar letter(s) within the same column are not significantly different at P ≤ 0.05 according to Duncan's multiple range test.

Compost	Plant height		Fresh weight g/plant		Dry weight g/plant	
	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut
10	19.42^{c}	18.41^{b}	142.95^{c}	111.53^{c}	39.06^{c}	30.47^{c}
15	24.85^{b}	18.99^{b}	174.16^{b}	129.84^{b}	47.59^{b}	35.48^{b}
20	33.77^{a}	24.81^{a}	208.54^{a}	142.68^{a}	56.98^{a}	38.98^{a}
LSD at 5%	0.71	0.81	2.45	2.07	0.79	0.71

Table 4. Effect of compost on essential oil percentage and yield (ml/plant) (mean values of two successive seasons). Means followed by similar letter(s) within the same column are not significantly different at P ≤ 0.05 according to Duncan's multiple range test.

Compost	Essential oil %		Essential Oil Yield (ml/plant)	
	1st cut	2nd cut	1st cut	2nd cut
10	0.076^{c}	0.084^{b}	0.110^{c}	0.093^{c}
15	0.090^{b}	0.087^{b}	0.160^{b}	0.118^{b}
20	0.110^{c}	0.110^{a}	0.234^{a}	0.159^{a}
LSD at 5%	0.007	0.006	0.020	0.006

Table 5. Effect of the combination treatments between compost and NPK on growth characters (mean values of two successive seasons). Data are presented as means. Means followed by similar letter(s) within the same column are not significantly different at P ≤ 0.05 according to Duncan's multiple range test.

Compost	NPK	Plant height (cm)		Fresh Weight g/ pot		Dry Weight g/ pot	
		1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut
10 m^3 compost	0 NPK	17.14^{g}	15.06^{e}	96.61^{k}	99.50^{f}	26.40^{j}	27.19^{e}
	25 % NPK	18.55^{g}	17.20^{e}	133.43^{i}	102.20^{f}	36.46^{h}	27.22^{hi}
	50 % NPK	20.20^{ef}	19.96^{d}	145.45^{h}	104.50^{f}	39.74^{g}	28.55^{gh}
	75 % NPK	20.43^{ef}	19.83^{d}	168.44^{g}	120.50^{e}	46.02^{f}	32.92^{f}
	100 % NPK	20.79^{ef}	20.00^{d}	170.84^{g}	130.97^{d}	46.68^{f}	35.78^{e}
15 m^3 compost	0 NPK	20.43^{ef}	16.50^{e}	124.59^{j}	100.93^{f}	34.04^{i}	27.58^{hi}
	25 % NPK	22.20^{de}	16.19^{e}	167.86^{g}	103.87^{f}	45.86^{f}	28.38^{ghi}
	50 % NPK	23.65^{cd}	17.20^{e}	178.18^{f}	132.13^{d}	48.68^{e}	36.10^{e}
	75 % NPK	25.12^{c}	22.03^{cd}	195.02^{e}	149.10^{c}	53.28^{d}	40.74^{d}
	100 % NPK	32.83^{b}	23.05^{bc}	205.17^{d}	163.18^{b}	56.06^{c}	44.58^{c}
20 m^3 compost	0 NPK	32.59^{b}	22.08^{cd}	131.83^{i}	104.07^{f}	36.02^{h}	28.43^{ghi}
	25 % NPK	32.40^{b}	24.70^{ab}	181.29^{f}	107.47^{f}	49.53^{e}	29.36^{g}
	50 % NPK	32.61^{b}	25.06^{ab}	209.35^{c}	151.70^{c}	57.20^{c}	41.45^{d}
	75 % NPK	35.40^{a}	25.23^{ab}	255.02^{b}	166.96^{b}	69.68^{b}	45.62^{b}
	100 % NPK	35.83^{a}	26.99^{a}	265.20^{a}	183.18^{a}	72.46^{a}	50.05^{a}
LSD at 5%		1.59	1.81	3.83	5.30	1.65	0.88

Table 6. Effect of the combination treatments between compost and NPK on essential oil percentage and yield (mean values of two successive seasons). The presented data are means. Means followed by similar letter(s) within the same column are not significantly different at P ≤ 0.05 according to Duncan's multiple range test.

Compost	NPK	Essential oil %		Essential Oil Yield (ml / plant)	
		1st Cut	2nd Cut	1st Cut	2nd Cut
10 m^{3} compost	0 NPK	0.070^{e}	0.100^{abcd}	0.068^{f}	0.100^{e}
	25 % NPK	0.070^{e}	0.080^{cd}	0.093^{ef}	0.082^{g}
	50 % NPK	0.080^{de}	0.080^{cd}	0.116^{def}	0.084^{fg}
	75 % NPK	0.080^{de}	0.080^{cd}	0.135^{cdef}	0.096^{e}
	100 % NPK	0.080^{de}	0.080^{cd}	0.137^{cdef}	0.105^{e}
15 m^{3} compost	0 NPK	0.070^{e}	0.070^{d}	0.087^{ef}	0.071^{h}
	25 % NPK	0.090^{cd}	0.080^{cd}	0.151^{cde}	0.083^{fg}
	50 % NPK	0.090^{cd}	0.080^{cd}	0.160^{cde}	0.106^{e}
	75 % NPK	0.080^{de}	0.087^{cd}	0.156^{cde}	0.134^{c}
	100 % NPK	0.120^{b}	0.120^{ab}	0.246^{b}	0.196^{a}
20 m^{3} compost	0 NPK	0.100^{c}	0.090^{bcd}	0.132^{cdef}	0.094^{ef}
	25 % NPK	0.100^{c}	0.110^{abc}	0.181^{cd}	0.118^{d}
	50 % NPK	0.100^{c}	0.130^{a}	0.209^{bc}	0.197^{a}
	75 % NPK	0.130^{a}	0.120^{ab}	0.332^{a}	0.200^{a}
	100 % NPK	0.120^{b}	0.100^{abcd}	0.318^{a}	0.183^{b}
LSD at 5%		0.008	0.021	0.051	0.009

Table 7. Effect of Fertilizers on the relative percentage of the main constituents of the essential oil of chervil plant.

No	RT	Constituents	KI*	Compost 10			Compost 15			Compost 20		
				0	50	100	0	50	100	0	50	100
1	3.90	α-Pinene	1109	t	t	t	0.62	0.40	t	0.28	0.2	0.44
2	5.28	(-)-β-Pinene	1190	1.00	0.36	1.12	0.85	0.97	0.21	0.58	0.19	0.77
3	7.38	D-Limonene	1278	1.17	0.92	1.33	1.37	1.23	0.99	0.92	0.36	1.15
4	7.71	Eucalyptol	1291	0.26	t	0.5	2.31	0.97	t	1.14	0.39	1.45
5	8.64	γ-Terpinene	1324	0.21	1.1	0.33	2.24	0.76	t	0.97	0.26	1.25
6	9.43	o-Cymene	1351	t	0.31	t	0.7	0.28	t	0.33	t	0.44
7	12.26	3-Nonanone	1444	0.57	0.29	0.48	0.28	0.52	0.6	0.24	0.3	0.44
8	14.74	1-Nonene	1524	2.71	2.19	2.24	1.49	1.96	2.84	2.18	2.16	2.2
9	15.39	Isomenthone	1544	0.5	0.53	0.48	1.58	0.59	0.35	1.09	0.4	1.22
10	15.81	Copaene	1558	0.19	0.2	t	t	t	0.22	t	0.26	t
11	16.06	Non-3-Enyl Acetate	1566	0.53	0.36	0.35	0.21	0.29	0.54	0.34	0.38	0.42
12	16.34	p-Menthan-3-onecis	1575	0.15	t	0.21	0.90	0.29	t	0.59	t	0.6
13	16.58	3-Nonanol	1582	0.32	0.25	0.35	0.3	0.31	0.25	0.26	0.2	0.28
14	17.03	Pentadecane	1597	0,9	0,66	0,66	0,59	0,67	0,33	0,64	0,97	0,84
15	17.82	2-Nonenal, (E)-	1623	t	0.21	0.35	0.19	0.20	0.15	0.36	0.23	0.25
16	17.90	1-Hexadecanol	1625	0.54	0.42	0.41	0.26	0.46	0.23	0.34	0.62	0.48

17	18.32	1-Nonen-3-ol	1639	1.01	0.51	0.77	0.63	0.79	0.75	0.49	0.49	0.63
18	19.03	Caryophyllene	1663	0.17	0.18	t	t	t	0.24	t	0.24	0.19
19	20.64	3-Octen-2-ol, (Z)-	1716	1.24	0.73	0.69	0.52	0.72	0.32	0.61	0.76	0.67
20	21.05	Pulegone	1731	0.62	1.36	0.55	3.2	1.00	t	1.96	0.43	2.37
21	21.82	Estragole	1757	21.14	19.26	24.29	20.6	25.33	26.43	20.49	23	22.63
22	22.39	Germacrene D	1777	1.54	1.76	1.03	1.04	0.94	1.46	1.32	1.42	1.16
23	22.86	(-)-Zingiberene	1793	3.46	4.32	2.44	2.72	2.73	4.10	3.28	4.36	3.36
24	23.00	β-Bisabolene	1798	0.43	0.55	0.27	0.31	0.29	0.39	0.42	0.53	0.40
25	23.83	α-Farnesene	1827	0.5	0.54	0.34	0.33	0.46	0.17	0.4	0.6	0.47
26	24.21	B-Sesquiphellandrene	1840	0.33	0.34	t	0.21	0.21	0.28	0.27	0.36	0.26
27	24.39	Curcumene	1847	0.42	0.56	0.27	0.3	0.23	0.28	0.44	0.46	0.38
28	28.14	Geranyl propionate	1983	0.72	0.5	0.34	0.35	0.37	0.13	0.4	0.49	0.40
29	28.75	Geranylisovalerate	2006	0.97	0.61	0.44	0.5	0.5	0.26	0.62	0.73	0.59
30	30.33	2-Allyl-1,4-dimethoxybenzene	2068	8.71	7.99	8.43	7.25	7.83	9.48	8.33	8.41	8.34
31	30.87	Methyleugenol	2090	44.67	46.11	44.41	42.39	43.33	43.87	40.37	41.55	40.37
32	31.57	Trans-MethylIso-Eugenol	2115	1.45	0.93	0.96	0.99	0.96	1.35	0.93	1.27	1.11
33	49.18	1-Octadecanol	2546	0.86	1.97	1.62	1.18	1.46	0.70	3.76	2.94	1.45
Oxygenated compounds				83.55	81.57	84.97	83.05	85.25	85.63	82.32	82.85	83.70
Hydrocarbons				12.84	13.79	10.03	12.77	11.13	10.96	11.39	11.14	12.47
Total identified compounds%				96.39	95.36	95.0	95.82	96.38	96.59	93.71	93.99	96.17

4-Amaranthus

Amaranthus genus, belonging to *Amaranthaceae* family, includes more than 60 species (Pisarikova et al., 2006). It is a worldwide distributed although most species are found in the warm temperate and tropical regions of the world (Sauer, 1993). Amaranth was cultivated by early civilizations over 2000 years ago, and continues to be used essentially worldwide, even to the present day (Liu & Stützel, 2004). Amaranth can be considered a multipurpose crop. Several *Amaranthus* species are cultivated as ornamentals, pseudo-cereals with high nutritive value (amaranth grain), leaf-vegetables, potherbs and for fodder (Sauer, 1967 & Mallory et al., 2008).

Amaranthus species are classified into three subgenera; the most economically important one is the subgenus *Amaranthus proper*, which includes the three species domesticated for grain production; *Amaranthus hypochondriacus* L., *Amaranthus cruentus* L, and *Amaranthus caudatus* L. (Trucco & Tranel, 2011). The high nutritional value of both seeds and leaves as well as recent interest of crop may be regarding its high-quality protein ، unsaturated oil, and various other valuable constituents - support the use of species from this genus as oilseed crops for oils production, all over the world (Kauffman, 1992; Venskutonis & Kraujalis, 2013).

4-1-Effect of organic root plus (bio-stimulant) on the growth, nutrient content and yield of Amaranthus

The effectiveness of organic root plus (bio-stimulant) was compared with conventional fertilizer on the growth and yield of Amaranthus in a glass house study. The treatments consisted of control, full rate each of bio-stimulant and fertilizer, and combination of fertilizer with bio-stimulant at full and half rates. The urea, single super-phosphate and potash were applied at 100kg N, 60kg P_2O_5 and 30kg K/ ha (fertilizer full rate). Results showed that the use of organic bio-stimulant alone was not as effective as that of fertilizer alone in most determined increases of number of leaves, plant height and leaf area in the first cycle and regeneration. Complimentary application of bio-stimulant with mineral fertilizer promoted the vegetative growth, nutrient composition, root development and yield of *Amaranthus*. When full rate of bio-stimulant was combined with full rate of mineral fertilizers, the number of leaves, plant height, leaf area and shoot yield were increased over the mineral fertilizer. In conclusion, the combinations of the two materials at various ratios were also effective (Akande, 2006).

4-2-Effect of Inorganic and Organic Fertilizers on the Performance and Profitability of Grain Amaranth (Amaranthus caudatus L.) in Western Kenya

Protein malnutrition is a major cause of morbidity and mortality in developing countries where the cost and availability of animal protein remain prohibitive. Grain amaranth (*Amaranthus caudatus L*) has the potential to substitute expensive animal protein. Nitrogen is a key limiting element in grain amaranth production. A study investigated the effects of different rates of inorganic nitrogen and cattle manure on the growth and yield of grain amaranth over a period of two years. Inorganic fertilizer at the rate of 100 kg N/ha significantly delayed flowering. Grain yield showed a linear response to inorganic and organic N application. Regression analysis projected the optimum inorganic fertilizer and manure application rates (87.5 kg N/ha and 9 t/ha, respectively) with yield of 1.84 t/ha as shown in Table 9. The highest profitability was achieved at the optimum manure and fertilizer rates (Richard et al., 2012). Moreover, Dry matter yield increased gradually as inorganic or organic fertilizer increased.

4-3-Influence of organic, mineral and organo-mineral fertilizers on growth, yield, and soil properties in grain amaranth (Amaranthus cruentus. L)(see Table 8)

A pot trial was conducted in the screen-house, Nigeria, during 2014 to examine the influence of organic, mineral and organo-mineral fertilizers on growth, yield, and soil properties in grain amaranth (*Amaranthus cruentus*) as well as residual effects. The treatments comprised of Aleshinloye Grade A (Organo-mineral fertilizer), Aleshinloye Grade B (Un-amended compost), Sunshine Grade A (Organo-mineral fertilizer), Sunshine Grade B (Un-amended compost), NPK and control. The experiment was a completely randomized design (CRD) with four replicates. All the treatments (except the control of no soil additive) were applied at the rate of 90 kg N ha^{-1}. Pre and post cropping analysis of soils used in screen house were done.

The treatments were:

1. Aleshinloye Grade A (compost amended with mineral fertilizer)2. Aleshinloye Grade B (un-amended compost)

3. Sunshine Grade A (compost amended with mineral fertilizer).

4. Sunshine Grade B (un-amended compost).

5. Mineral fertilizer (NPK at rate of 15:15:15).

6. Control.

The results show that the assessed parameters were significantly influenced (P≤0.05) by the applied fertilizer types. Dry shoot weight values were 2.3 and 2.1g, respectively, with Sunshine Grade A and Aleshinloye Grade A and these were significantly higher than that of NPK treatment after the first cropping. Residual effect of Amaranth fresh shoot weight values obtained from Sunshine Grade A and Aleshinloye Grade A were also significantly higher than that of the NPK treatment. Sunshine Grade A and Aleshinloye Grade A had a significant and additive effect on soil nutrients after harvesting of *Amaranthus cruentus* when compared with NPK in the first and second cropping. Thus organic fertilizers fortified with mineral fertilizer have great potential in the production of amaranth and could also be used effectively in increasing soil fertility for amaranth production (Olowoake, 2014).

4-4-Effect of Organic and Inorganic Fertilizer on Growth and Yield of Amaranthus Caudatus L. in Northern Guinea Savanna of Nigeria

Two field trials were conducted during the wet seasons of 2009 and 2010 in the northern Guinea savanna ecological zone to study the effect of organic and inorganic fertilizer on the growth and edible yield of *Amaranthus caudatus L.* The treatments consisted of three levels of farmyard manure organic fertilizer (FYM) 0, 5 and 10 t ha-1 and four levels of inorganic fertilizer (Compound fertilizer NPK 20:10:10) 0, 150, 300 and 450 Kg ha^{-1} arranged in a randomized complete block design. Most of the crop parameters were maximized with the application of 300 kg NPK ha^{-1}. The regression of edible yield per hectare to NPK level indicates a strong linear response up to 450kg NPK ha^{-1} and the difference between this rate and 30 kg ha^{-1} was not significant. The rate of 5 t ha^{-1} FYM also significantly increased all the growth attributes. No significant interaction was observed between NPK and FYM, on almost all the characters accessed. Application of 300 kg ha^{-1} NPK and 5 t ha^{-1} FYM gave the best edible yield of vegetable amaranth (Joseph et al., 2012) (see Table 10).

5- Foliar application of selenium and humic acid changes yield, essential oil, and chemical composition of Plectranthus amboinicus (Lour.) plant and its antimicrobial effects

Plectranthus amboinicus is an indigenous vegetable that can be freshly eaten. This plant is used for medicine to cure common illnesses such as cough, stomachache, headache, and skin infection. This study was conducted to study the effect of both selenium (2, 4, 8, 12, and 16 g/ l) and humic acid (1.5 and 3.00 g/ l), in addition to control, which was sprayed with water. Generally, mass production of P. amboinicus (Lour.) plants has significantly increased as a result of application of different levels of selenium and humic acid treatments, compared with the control treatment. Essential oil percentage and yield (ml/plant) increased significantly as a result of selenium and humic acid treatments compared with control (S0H0). For essential oil constituents, the results clear that carvacrol (5.96–15.45%) is the first main compound followed by γ-Terpinene (6.74–11.80 %). The third main component is Limonene (3.23–11.32%), whereas the fourth one is α-Muurolene. Moreover, these treatments had a positive effect on selenium, total carbohydrates, photosynthetic pigments, and total phenolic content. Based on scavenging the stable ATBS [2, 2′-azino-bis (3-ethylbenzothiazoline-6-sulphonic acid)] radical, all treatments increased significantly inhibition % especially S4H2 compared with untreated plants. Antibacterial and antifungal activities of *P. amboinicus* were studied. The results indicated that *P. amboinicus* had a great antifungal and antibacterial effect (El-Gohary et al., 2020) (see Table 11).

6- Effect of Rock Phosphate vs. Biofertilizer on Growth, Yield, and Essential Oil Content of Mentha longifolia subsp schimperi Grey

This study was conducted during two successive seasons 2012 and 2013 to determine the influence of phosphate fertilizer namely rock phosphate at the rates of 150, 300, 450 and 600 Kg/ Fed, bio-fertilizer (*Azotobacter chroococcun and Bacillus megaterium var. phosphaticum*) and their interaction on growth characters, essential oil content and essential oil composition (EL Gohary et al., 2013). The obtained data cleared that plant height, branches number/ plant, herb fresh weight (g/ plant), essential oil percentage and essential oil yield (ml/ plant) were augmented due to phosphate fertilizer treatment. The highest values of these previous parameters were observed when receiving the plants rock phosphate at the highest rate.

In regard to bio-fertilizer treatment, this treatment led to increase the growth and essential oil. The best results in terms of these characters were obtained as a result of rock phosphate at 600 Kg / Fed + bio-fertilizer. The main essential oil constituent were carvon, menthone and 1, 8-cineol. All fertilizers treatments had a pronounced effect on essential oil composition.

7- Comparative Effect of Organic Fertilizers on Growth and Chemical Constituents of Plantago Ovata Plant

This study was conducted in Experimental Farm of National Research Centre, during two successive seasons to evaluate the influence of different kinds and levels of organic fertilization (compost, compost tea and humic acid) on the growth, production and chemical constituents of *Plantago Ovata* plant (Hussein et al., 2012). Generally, all fertilizer treatments produced a pronounce increment in all growth parameters of *Plantago ovate.* The maximum mean values of fixed oil content (%) was recorded as a result of foliar application with humic acid at level of 0.06%. The superior stimulation for mucilage accumulation was observed with the highest level of compost tea followed with the highest humic acid level. The uptake of the nutrients N, P, K, Fe, Zn and Mn, in general, was significantly increased in response to supplying various sources of organic fertilizers. The highest mean value of total carbohydrate content (%) was observed with the highest humic acid level.

In conclusion, the highest level of humic acid and compost tea caused the maximum values of soluble and non-soluble sugars.

8- Influence of fertilization on growth, yield and chemical constituents of Lallemantia iberica plant

This investigation was carried out to study the influence of fertilizers on growth, yield and chemical constituents of *Lallemantia iberica* (Bieb) (El-Sherbeny et al., 2015). The field experiments were carried out during two successive seasons 2010/2011 and 2011/2012 at Sekem farm (50 km from Cairo North East Governorate, Egypt) to study the effect of mineral nitrogen fertilizer (140 and 200kg N/ ha) or compost as organic fertilizer (12 and 18 tons/ha) alone or in combination with bio fertilizer (rhizobacterin). Growth characters, nutrients content, total carbohydrates (%), mucilage (%), fixed and essential oil were estimated.

The data revealed that various fertilizer levels improved the different growth characteristics as well as the amount of studied chemical constituent's content. The highest values regarding plant height, number of branches, total fresh and dry weights, nutrients content, as well as total carbohydrates and mucilage were recorded as a result of application of combined fertilizer of compost at 7.5 Ton + 90 Kg N/ Fed and rhizobacterin. The accumulation of fixed and essential oils were also promoted by the various fertilizer treatments.

9- Effect of Foliar Organic Fertilization on the Growth, Yield and Oil Content of Mentha piperita var. citrata

This study was carried out to evaluate the response of *Mentha piperita var. citrata* (Eau de Cologne mint) to foliar fertilization under Egyptian conditions. *Mentha piperita var. citrata* was cultivated at Sekem Experimental farm (Hendawy et al., 2015). Fresh, healthy, insect and disease free suckers were transplanted in furrow at a depth of 4-5 cm as per the treatments. Three weeks later after transplanting, the plants were sprayed with aqueous solution of the test nutrient compounds humic acid (0. 2.5 and 5 g/L) and amino spot (0, 1 and 1.5 mL/L). The crop was harvested in mid-May (First cutting) and mid-August (Second cut). Growth and yield characters were measured. The essential oil percentage was determined in both cuts from fresh herb and was analyzed by GC/Mass. It was evident from results that, humic acid and/or amino spot fertilizer (Algae extract) had a significant effect on growth characters during both cuts. Increasing amino spot doses increased growth characters (plant height, herb fresh and dry weight) at all doses in the two cuts. The interaction effect was significant in both cuts, the highest values of plant height, herb fresh and dry weight (g/plant) were produced from the treatment sprayed with humic acid at 5 g/L+amino spot at 1.5 mL/L.

The second effective level was the treatment sprayed with 2.5 g/ L humic acid+1.5 mL/ L amino spot at the two cuts. During the 1st cut, humic acid or amino spot fertilizer had a significant effect on essential oil percentage and yield (mL/plant). All treatments produced significant effect on oil percentage and oil yield (mL/plant) except the interaction treatments, which had no significant effect on essential oil percentage during second cut. Linalool and linalyl acetate were the main constituents of essential oil of this plant. All treatments or cuttings had a pronounced effect on essential oil constituents. Based on the experimental results it is recommended to treat *Mentha piperita* var. citrata (Eau de Cologne mint) plants with humic acid at 5 g/L+ amino spot at 1.5 mL/L to produce high mass production and oil yield.

Table 8. Effect of bio-stimulant and/or fertilizer treatments on root development and yield of *Amaranthus*. The presented data are means. Means having the same letter within a column are not significantly different (P=0.05) according to DMRT.NK: N and K fertilizer.

Treatments	Root length (cm)	Root fineness (cm/ g)	Fresh root Weight (g)	Dry root weight (g)	Fresh shoot yield (g)	
					1st cycle	Regeneration
Control	21.6c	0.53d	27.7c	5.43d	355d	64d
Bio-stimulant (BS)	32.1ab	1.19ab	35.0b	11.07c	463cd	95c
Fertilizer (Fert)	33.3a	1.07b	46.7a	18.79a	780b	260ab
BS + ½ Fert	31.6ab	0.96bc	36.0b	11.86c	798b	288a
½ BS + Fert	33.9a	0.97bc	46.7a	15.49b	650c	153bc
½ BS + ½ Fert	32.5ab	1.76a	36.3b	18.18a	711bc	300a
BS + Fert	34.9a	0.85c	43.0ab	15.99b	899a	158bc
BS+NK	28.8b	1.03b	32.3bc	17.05ab	845a	208b

Table 9. Effect of inorganic fertilizer and manure on yield and harvest index of grain amaranth in Western Kenya in 2008 and 2009 growing seasons. *Legend:* NS: Non significant.

Treatments		2008 season			2009 season		
		Grain yield (t/ ha)	Dry matter yield (t/ ha)	Harvest index	Grain yield (t/ ha)	Dry matter yield (t/ ha)	Harvest index
Inorganic fertilizer	0 kg N/ha	0.29	0.74	0.28	0.23	0.65	0.26
	30 kg N/ha	0.90	2.31	0.28	0.76	2.10	0.27
	60 kg N/ha	1.55	3.61	0.30	1.47	3.71	0.28
	100 kg N/ha	2.10	5.14	0.29	1.94	4.98	0.28
LSD (5%)		0.573	1.220	NS	0.347	1.012	0.059
Manure	0 t/ha	0.01	0.024	0.29	0.01	0.025	0.29
	0.5 t/ha	0.05	0.120	0.29	0.05	0.122	0.29
	1 t/ha	0.11	0.280	0.28	0.13	0.300	0.30
	2 t/ha	0.25	0.560	0.31	0.39	0.890	0.30
	3 t/ha	0.67	1.560	0.30	0.79	1.810	0.30
LSD (5%)		0.093	0.179	0.051	0.210	0.531	NS

Table 10. Effect of mineral and organic fertilizers on yield of *Amaranthus Caudatus L.*

Treatments	Shoot dry wt g/plant			Days to 50% anthesis	Edible yield kg ha^{-1}
	20	30	40		
NPK-Fertilizer, Kg ha^{-1}					
0	2.4b	5.8b	10.5c	40.3	37c
150	3.2ab	9.2b	17.1b	38.3	59b
300	3.6a	9.9b	22.2a	39.3	78a
450	3.1ab	15.3a	19.8ab	39.3	86a
±SE	0.33	1.77	1.47	0.91	4.33
FYM t ha^{-1}					
0	2.6b	6.5b	12.2c	41.0a	49b
5	2.9ab	10.4ab	17.9b	38.8a	69a
10	3.7a	13.6a	22.2a	38.2b	78a
±SE	0.28	1.53	1.27	0.79	3.76
Interaction					
N×F	NS	NS	NS		NS

Table 11. Herb fresh and dry weights of *Plectranthus amboinicus* (Lour.) at different levels of selenium and humic acid (mean values of two successive seasons). *Legend:* CV%, coefficient of variation %. Means with the same letters in each column indicate no significant difference between treatments at 5% level of probability.

Treatments	First cut		Second cut		Total herb weight	
	Herb fresh weight (g/ plant)	Herb dry weight (g/ plant)	Herb fresh weight (g/ plant)	Herb dry weight (g/ plant)	Fresh weight (g/ plant)	Dry weight (g/ plant)
S0H0	553.00^{f}	55.54^{d}	514.68^{h}	54.04^{h}	1067.68^{j}	109.58^{h}
S1H1	709.25^{e}	72.34^{c}	612.05^{g}	62.43^{g}	1321.3^{i}	134.77^{g}
S1H2	793.55^{c}	79.67^{b}	712.33^{d}	80.49^{c}	1505.88^{f}	160.16^{d}
S2H1	784.40^{d}	78.44^{b}	638.63^{f}	63.86^{g}	1423.03^{h}	142.3^{f}
S2H2	796.80^{c}	79.68^{b}	733.08^{c}	73.31^{e}	1529.88^{e}	152.99^{e}
S3H1	797.70^{c}	81.98^{b}	679.75^{e}	69.86^{f}	1477.45^{g}	151.51^{e}
S3H2	826.50^{a}	87.32^{a}	790.00^{b}	83.97^{a}	1616.5^{b}	176.29^{a}
S4H1	822.00^{b}	87.95^{a}	719.20^{d}	76.95^{d}	1541.2^{d}	164.90^{c}
S4H2	829.40^{a}	88.05^{a}	803.00^{a}	88.33^{a}	1632.4^{a}	176.38^{a}
S5H1	821.80^{b}	89.24^{a}	738.00^{c}	81.18^{c}	1559.8^{c}	170.42^{b}
S5H2	818.75^{b}	88.98^{a}	809.00^{a}	84.91^{b}	1627.75^{a}	173.88^{b}
CV%	0.268	3.127	0.978	2.487	0.44	1.61

Summary

- Medicinal and aromatic plants continue to be the subject of novel and straight forward applications as a source of active constituents for pharmaceutical industries.
- Fertilizers are an important factor in modern-day agriculture as they increase crops yield and allow crops to be planted in nutrient deficient soils. Although chemical fertilizers are important tool for higher production of different crops, the extensive

and intensive use of them resulted in accumulation of chemicals.

• Some organic fertilizers as Farmyard manure (FYM) and compost at different rates and different combination could be used instead of chemical fertilizers to meet the demand of plants from NPK and some micronutrients to improve the quantity and quality of medicinal plants.

• The present review introduces some researches performed to elaborate the benefits of organic cultivation of some important medicinal and aromatic plants such as *Coleus forskohlii, Satureja hortensis L., Amaranth* species, etc.

Conclusions

• The review of literature has clearly revealed that medicinal and aromatic crops respond positively to organic cultivation practices.

• It is possible to move in the direction of integrated nutrient and pest management practices from the current chemical cultivation techniques.

• Medicinal and aromatic plants can be shift totally to organic farming in a phased manner to keep plants free from any chemical residues and save our ecosystem.

• However, lots of research work needs to be carried out for this transformation to take place and to scientifically validate some of the current practices.

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