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Effect of organic farming on nutritional profile, quality characteristics and toxic parameters of amaranthus

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ABSRACT

Amaranthus crop was grown using organic manures and chemical fertilizers and the effect of organic farming on nutritional profile, quality characteristics, toxic parameters was studied. The experiment was laid out in a randomized block design with 15 treatments consisting of four organic manure treatments of vermicompost (VC), poultry manure (PM), farm yard manure (FYM), rotten cow dung (CD) and recommended dose of chemical fertilizers, *i.e.*, conventional farming as control. Organically and conventionally grown amaranthus were analysed for their nutrient composition. Poultry manure application to amaranthus resulted in significant increase in iron and calcium contents in the edible part of leaves. Application of vermicompost to the crop significantly increased *in vitro* iron availability, total carotenes, crude fibre, vitamin C and zinc contents compared to conventionally grown crop. Both conventionally and organically grown crops were found to contain significantly higher nitrates. Among the organic manures, vermicompost and poultry manure application to amaranthus resulted in significantly higher nitrates. Application of organic manures was found to be significantly influence the nutrient content of these crops compared to conventional fertilizers.

Key words: Amaranth, organic farming, conventional fertilizers, nutritional quality.

INTRODUCTION

The demand for organic food is steadily increasing both in developed and developing countries, with annual average growth rate of 20-25%. Organic farming is gaining wide attention among farmers, entrepreneurs, policy makers and agricultural scientists for varied reasons such as minimum dependence on chemical inputs (fertilizers, pesticides herbicides and other agro-chemicals), thus, safe guarding/ improving quality of resources and environment. In order to deliver enhanced nutrition within a food-based system, it is necessary to increase the nutritional value of the food. By enhancing nutrient dense crops, severe deficiencies can be eliminated in developing countries. Keeping these aspects in view, the present study was undertaken at Post Graduate and Research Centre, Dept. of Foods and Nutrition, ANGRAU, Rajendranagar, Hyderabad. To study the effect of organic farming on nutritional profile, quality characteristics and toxic parameters of amaranthus in two seasons, *i.e. kharif* and *rabi*.

MATERIALS AND METHODS

Amaranthus crop was grown using organic manures and chemical fertilizers and the effect of organic farming on nutritional profile, quality characteristics and toxic parameters was studied. The experiment was laid in an unused forest land. The experimental design used was Randomized Block Design (RBD) with five treatments, and four replications each of organic manures, *i.e.*, vermicompost (VC), farmyard manure (FYM), poultry manure (PM), rotten cow dung (CD) and conventional farming as control. Amaranthus plots (Gross plot 240 m^2 and net plot 210 m^2 (2 m x 1.5 m) were laid in four replications with the following treatments for each crop. Endosulfan was sprayed twice to conventionally grown crops and *Trichoderma viride*, *Pseudomonas fluorescence* and neem oil were used in organically grown crops during the period of growth to control pests. Fresh crop samples and dry powders of amaranthus leaves were analysed for nutrient profile (ash, mineral content, *in vitro* iron availability, crude fibre, vitamin C and total carotenoids, TSS, acidity and total antioxidant activity by standard procedures (AOAC, 1; Ranganna, 10). Nutrient analysis carried out on fresh weight basis.

RESULTS AND DISCUSSION

Among the organic manures tested, poultry manure application to amaranthus resulted in significant increase in iron content (Table 1). Similar results were reported by Uma Reddy (12) in tomato and onion crops with vermicompost application. Worthington (16) reported higher iron content in spinach, tomato, turnip, apple, cabbage, carrots,

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Table 1. Iron and *in vitro* iron availability (%) of amaranthus of both organically and conventionally grown crops.

Treatment	Iron		*In vitro* iron availability
	Kharif	*Rabi*	
Vermicompost	3.76	4.67	12.90
Farm yard manure	3.22	3.80	11.30[b]
Poultry manure	3.87	4.77	11.79
Cow dung	2.90	4.12	10.48[ab]
Control	2.65	3.55	10.26[a]
$CD_{0.01}$	0.02	0.02	1.03
CV(%)	0.30	0.30	NS

*Significant at 0.01 level; Values with similar superscripts are not significant in column

celery, leek, lentil, lettuce, pepper, potato, apple and pears in organically grown crops, compared to conventionally grown ones. Vermicompost application to amaranthus crop significantly increased *in vitro* iron availability compared to conventionally grown crop. Among the organic manures applied to amaranthus, cow dung application registered in significantly lower *in vitro* iron availability (Table 1). Among the various organic manures tested in both the seasons, vermicompost application resulted in significantly higher zinc content in amaranthus. Uma Reddy (12) reported similar increase in zinc content of organically grown vegetables. Among the organic manures tested, application of poultry manure to amaranthus registered significantly higher calcium content in both the seasons (Table 2). Similar increase in calcium content in organically cultivated vegetables was reported in spinach, cabbage, carrot, beans, tomato, turnip, apple, carrot, celery, leek, lentil, lettuce, pepper, potato, apple and pears by Worthington (16). Organically grown amaranthus was observed to contain significantly higher magnesium levels compared to conventionally grown crops. However application of vermicompost in amaranthus resulted in significantly higher magnesium content in both the seasonal crops. The absorption of micronutrients such as iron and zinc from the soil was significantly influenced by the application of organic manures, *i.e.*, vermicompost, poultry manure, farm yard manure and cow dung (Table 2). Soil that has been managed organically has more microorganisms, which produce many compounds that influence the plant to absorb more micronutrients from soil. It is also reported that substances such as citrate and lactate combine with the soil minerals and make them more available to plant roots. For iron, in particular, this is especially important because many soils contain adequate iron but in an unavailable form. The presence of these microorganisms explains the trend showing a higher mineral content of organic food crops (McClintock, 7).

Crude fibre content of organically grown amaranthus was found to be significantly higher compared to conventionally cultivated vegetables of both seasons. Crude fibre content was significantly higher in amaranthus (*rabi*) grown with vermicompost application. However, *kharif* grown amaranthus followed no significant trend among all the treatments applied. Vitamin C content of amaranthus was found to be significantly higher compared to conventionally grown vegetables in both the seasons (Table 3). Similar increase in vitamin C was reported in organically grown vegetables compared to conventionally cultivated crops by Worthington (16), Asami *et al*. (2), Venkat Rao (14), Lumpkin (6), and Uma Reddy *et al.* (13). Among all the organic manures tested, vermicompost application to amaranthus crop in both the seasons registered significantly higher vitamin C contents. Vermicompost application to amaranthus crop resulted in significantly higher total carotenes in *rabi* season compared to other organically cultivated crops. However, a non significant trend was

Table 2. Micronutrient content (g/100 g) of organically and conventionally grown amaranthus leaves.

Treatment	Ash		Zinc		Calcium		Magnesium	
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
Vermicompost	2.69	2.79	0.23	0.26	223.00	224.55	223.00	224.55
Farmyard manure	2.49	2.59	0.17	0.20	185.50	187.05	185.50	187.05
Poultry manure	2.54	2.64	0.21	0.23	155.03	156.80	155.03	156.80
Cow dung	2.48	2.63	0.14	0.16	172.48	173.98	172.48	173.98
Control	2.20	2.30	0.10	0.12	122.85	124.40	122.85	124.40
$CD_{0.01}$	NS	NS	0.01*	0.01*	0.81*	0.81*	0.81*	0.81*
CV(%)	4.80	5.00	3.20	2.80	0.30	0.30	0.30	0.30

*Significant at P<0.01 level

Table 3. Crude fibre content (g/100 g) of organically and conventionally grown amaranthus leaves.

Treatment	Crude fibre		Vitamin C		Total carotenoids	
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
Vermicompost	13.30	15.25	129.17	144.49	1.15	1.45
Farm yard manure	11.25	11.85	125.36	126.53 [a]	1.11[a]	1.23
Poultry manure	12.90	12.95	128.13	129.95[a]	1.11[a]	1.36
Cow dung	11.40	12.35	124.97	118.14[b]	1.03	1.14
Control	10.25	10.25	120.64	117.19[b]	0.99	1.19
$CD_{0.01}$	NS	2.32*	NS	17.07*	0.05*	0.17*
CV (%)	12.30	6.70	6.40	4.80	1.80	4.80

*Significant at P = 0.01 level; Values with similar superscript are not significant in column

observed with amaranthus cultivated in *kharif* season. Significantly lower total carotenes were found in all crops cultivated with chemical fertilizers compared to organically grown vegetables (Table 3). Organically grown amaranthus in *rabi* of both the seasons were found to have significantly higher total soluble solids compared to conventionally cultivated amaranthus crop. Vermicompost application to the crop cultivated in *rabi* season registered significantly higher total soluble solids compared to conventionally grown vegetables and other organically cultivated crops. A non significant trend was observed with amaranthus cultivated in *rabi* crop grown in both *kharif* and *rabi* season (Table 4). Increase in total soluble solids in onion was reported with vermicompost application compared to chemically fertilized crop (Uma Reddy *et al.*, 12). Prabakharan and Pitchai (9), and Lumpkin (6) also reported increase in total soluble solids in organically grown crops. However, non significant trend was observed in acidity of amaranthus of both organically and conventionally cultivated crops of both the seasons. Vermicompost application to amaranthus crops registered significantly higher total antioxidant activity in both the seasons. Conventionally grown crops contained significantly lower total antioxidant activity in both seasons (Table 4). Similar increase in antioxidant activity in organically cultivated crops was reported by Asami *et al.* (2). Organic production methods which are limited in the use of insecticides, herbicides and fungicides compared to conventionally cultivated plants may need to synthesize their own chemical defense mechanisms, and the increase in antioxidant activity has been attributed to this need.

Conventionally grown amaranthus was found to contain significantly higher nitrates compared to organically grown crops. Among the organic manures, vermicompost and poultry manure application to amaranthus resulted in significantly higher nitrates (Table 5). Increase in nitrate levels were reported in conventionally grown crops potatoes, lettuce, leeks and spinach by Finesilver *et al.* (3) and Woese *et al.* (16). The nitrates are commonly developed by the application of nitrogen through chemical fertilizers and as well as by organic manures. Nitrate level in plants is determined by a number of factors, such as variety, light intensity, climate and soil and specifically nitrogen supply. Nitrogen application depends on the amount of the fertilizer applied, availability of nitrogen

Table 4. Quality parameters (g/100 g) of organically and conventionally grown amaranthus leaves.

Treatment	TSS (%)		Acidity (%)		Total antioxidant activity		Nitrate content (mg/ kg)	
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
Vermicompost	20.25	20.25	1.26	1.26	343.21	359.38	2302.53	2178.16
Farm yard manure	18.25	19.13[a]	1.02	1.02	323.81	318.75	2008.80	2389.87
Poultry manure	19.25	19.88[a]	1.26	1.26	328.57	340.63	2225.55	2680.39
Cowdung	18.75	18.25[a]	1.26	1.26	307.14	312.50	2258.40	2442.05
Control	15.50	15.13	1.02	1.02	292.85	309.38	2467.30	3327.73
$CD_{0.01}$	NS	2.33*	NS	NS	16.68*	31.75*	83.48*	355.67*
CV(%)	10.20	8.20	24.40	24.40	1.90	3.50	1.30	4.90

*Significant at P<0.01 level; Values with similar superscript are not significant in column during the period of growth and time of application to the plant, has been considered as the source of nitrate variability in many studies compared to organically versus conventionally grown produce. In many organic fertilizers, the organically bound nitrogen is relatively insoluble and easily not available to the plant. In contrast, the nitrogen in mineral fertilizers is soluble and is readily available to the plant (Finesilver *et al*., 3). In general, extensive use of chemical fertilizers and organic manures with high nitrogen increase nitrate content in vegetables regardless of the kind of fertilizers or organic manures. There is also a higher risk of contamination of ground water with nitrates when over fertilization takes place (Sohn and Yoneyama, 11).

Endosulfan residues were not detected in organically cultivated amaranthus, as no endosulfan was sprayed to control pests in organically grown crops and pest management was done by spraying neem oil. In conventionally grown crops, the residues of endosulfan were 0.116 and 0.382 mg/kg in amaranthus, in *kharif* and *rabi* seasons, respectively. The concentration of endosulfan residues in all conventional crops was with in maximum residue limit (MRL), *i.e.*, 2 mg/kg (Narasimha Rao, 8). Higher levels of pesticide residues were reported in conventional foods, *viz*., fruits, vegetables, meats, dairy and processed foods especially in conventionally produced foods (Gour and Sreenivasa Rao, 4). All pesticides after their use in agro ecosystem invariably leave their residues in various quantities and the hazards depend on chemical nature of the compound. Since most pesticides are toxic in nature, their continuous ingestion even in minute quantities can result in accumulation in body tissues, which may lead to adverse effects on health. Undoubtedly, many of these pesticides used today may cause cancer, mutations and other problems (Gour and Sreenivasa Rao, 4). The indiscriminate application of chemical fertilizers and pesticides not only pose health risk but also leads to the degradation of soil and water and therefore cause damage to the ecological foundation essential for sustainable advances in productivity which have led to the on set of a fatigue in the green revolution (Kesavan and Swaminathan, 5).

Organic farming is a reliable way to increase nutrients, *i.e.*, micronutrients, decrease nitrate levels and also reduce exposure to pesticides through foods. It seems to offer a low-residue alternative to conventionally grown produce, where exposure to pesticides is minimized and one major reason why consumers now prefer to buy organic foods.

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