Journal of Root Crops, 2013, Vol. 39 No. 1, pp. 56-61
Indian Society for Root Crops
ISSN 0378-2409

Organic Production of Greater Yam: Yield, Quality, Nutrient Uptake and Soil Fertility

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Received: 25 March 2013; Accepted: 27 June 2013

Abstract

A field experiment was conducted at the Organic Farming Unit, Navsari Agricultural University, Navsari, during 2010-2011 and 2011-2012 to study the effect of different organic manures on yield, quality, nutrient uptake and soil fertility under organic farming in greater yam. Nine treatments were tested in this experiment. Among them, eight treatments were different combinations of organic manures. The control was the INM treatment (FYM @ 10 t ha^{-1} + NPK @ 80:60:80 kg ha^{-1}) which was studied outside the organic farm. These treatments were tested in randomized block design with three replications. The results indicated that tuber and vine yield was higher under INM treatment, which was on par with organic treatments, T_4 (biocompost @ 5.07 t ha^{-1} + neem cake @ 0.51 t ha^{-1}) and T_5 (vermicompost @ 4.72 t ha^{-1} + castor cake @ 1.35 t ha^{-1}). Starch and carbohydrate contents of tuber were significantly enhanced under organic management. Total uptake of N, P and K were, however, significantly higher with INM treatment. Among the organic treatments, the treatment, T_6 (vermicompost @ 7.08 t ha^{-1} + castor cake @ 0.68 t ha^{-1}) resulted in higher total uptake of N, P and K over the other organic treatments during both the years. After harvest of the crop, higher organic C, macro and micro nutrients were observed in the organic treatments. The INM treatment generated higher net income of ` 2,04,959 $ha^{-1}$ and B: C ratio of 2.7 followed by the organic treatment, $T_6$, (vermicompost @ 7.08 t $ha^{-1}$ + castor cake @ 0.68 t $ha^{-1}$) (net income of ` 1,88,643 ha^{-1}; B: C ratio of 2.4).

Key words: Yield, *Dioscorea alata*, organic farming, quality, nutrient uptake, soil properties, B: C ratio

Introduction

The current global scenario firmly emphasizes the need to adopt eco-friendly agricultural practices for sustainable food production. Organic farming protects the environment, provides better food and living conditions to the human beings. Organic farming is not mere the non use of chemicals in agriculture, but it is a system of farming based on integral interrelationship with components of ecosystem (Lampkin, 1990). Organic manures such as farmyard manure, poultry manure, vermicompost, oil cakes, biofertilizers and bio-wastes are some of the important sources to increase the organic matter content, soil microbial population and to sustain agricultural production by reducing and eliminating the adverse effects of synthetic fertilizers, pesticides etc. The tropical root and tuber crops (cassava, sweet potato, yams, aroids and other minor tuber crops) are food and nutritional crops with adaptation to marginal environments. They form important staple food and are major source of energy especially in the developing countries with rapid population expansion. Tuber crops are also medicinally important and preferred as health foods due to the presence of nutraceuticals and antioxidants. In view of the increased awareness about organic farming, safe food production, increased availability of organic inputs, investigation on these aspects become imperative to assess their effect on yield, quality and post-harvest storage of these crops. Earlier studies conducted at Central Tuber Crops Research Institute indicated that organic management improves yield, quality and soil properties in tuber crops (Suja et. al., 2009; 2010; 2012a; 2012b). Hence, the present experiment was conducted to study the effect of organic farming on yield, quality, nutrient uptake and soil fertility in greater yam under South Gujarat conditions.

Materials and Methods

The experiment was laid out in randomized block design, with three replications during 2010-2011 and 2011-2012 at the Organic Farm, Navsari Agricultural University, Navsari, Gujarat, India. The site experiences a typical humid and warm monsoon with heavy rainfall (1500 mm), moderately cold winter and fairly hot and humid summer. Experimental soil was clayey in texture, non-saline (EC-0.35 dS m^{-1}) and slightly alkaline (pH-7.70) in nature. The fertility status of the soil was medium for organic C, low for available N, medium for available P and high for available K (Table 1). There were a total of nine treatments. Different sources of organic manures to supply recommended dose of N on N equivalent basis constituted the eight treatments. One was INM treatment which was taken outside the organic farm (off-farm). The treatments were:

Table 1. Initial properties of the experimental site (0-15 cm depth)

Parameters	Organic farm	Off- farm
Texture	Clay	Clay
Bulk density (g cm^{-3})	1.45	1.58
pH	7.70	7.80
EC (dS m^{-1} at 25 °C)	0.35	0.32
Organic C (%)	0.57	0.52
Available N (kg ha^{-1})	238	245
Available P (kg ha^{-1})	36.2	32.8
Available K (kg ha^{-1})	408	412
Fe (mg kg^{-1})	16.1	14.9
Mn (mg kg^{-1})	18.4	18.3
Cu (mg kg^{-1})	2.00	1.92
Zn (mg kg^{-1})	0.61	0.56
Water stable aggregates >1.0 mm	62.3	59.5
Water stable aggregates > 0.5-1.0 mm	18.9	16.8

T_1 : Biocompost (50%) + castor cake (50%) (biocompost @ 3.38 t ha^{-1} + castor cake @ 1.35 t ha^{-1})

T_2 : Biocompost (75%) + castor cake (25%) (biocompost @ 5.07 t ha^{-1} + castor cake @ 0.68 t ha^{-1})

T_3 : Biocompost (50%) + neem cake (50%) (biocompost @ 3.38 t ha^{-1} + neem cake @ 1.02 t ha^{-1})

T_4 : Biocompost (75%) + neem cake (25%) (biocompost @ 5.07 t ha^{-1} + neem cake @ 0.51 t ha^{-1})

T_5 : Vermicompost (50%) + castor cake (50%) (vermicompost @ 4.72 t ha^{-1} + castor cake @ 1.35 t ha^{-1})

T_6 : Vermicompost (75%) + castor cake (25%) (vermicompost @ 7.08 t ha^{-1} + castor cake @ 0.68 t ha^{-1})

T_7 : Vermicompost (50%) + neem cake (50%) (vermicompost @ 4.72 t ha^{-1} + neem cake @ 1.02 t ha^{-1}

T_8 : Vermicompost (75%) + neem cake (25%) (vermicompost @ 7.08 t ha^{-1} + neem cake @ 0.51 t ha^{-1})

T_9 : Farmyard manure (FYM) @ 10 t ha^{-1} + NPK @ 80:60:80 kg ha^{-1}

The organic manures were analyzed for their nutrient contents (Table 2) and quantities of organic manures were applied on N equivalent basis. Before planting, the setts were treated with slurry containing 10% cow dung, 2% cow urine and 0.5% each of *Trichoderma* and *Pseudomonas*. Treated 100 g setts were sown at a distance of 90 cm x 90 cm on the ridges. After planting 50% organic manures were applied as basal and the remaining quantity was applied one month after planting. Off-farm crop was fertilized with recommended dose of nutrients through farmyard manure, Urea, diammonium phosphate and Muriate of potash. The observations on yield and quality were recorded at the time of harvest. The quality parameters of tubers like total sugar, starch and carbohydrate contents were analyzed by standard analytical procedures (Sadasivam and Manickam, 2008). Soil and plant samples were collected at harvest and analyzed by using standard methods for different parameters. After harvest of the crop, soil samples were

Table 2. Nutrient content of organic manures

Manures	N	P	K	Fe	Mn	Zn	Cu
		(%)			(mg kg^{-1})		
Bio-compost	1.82	1.05	1.37	2603	129	42	15
Vermicompost	1.21	0.65	1.00	1550	96	31	12
Neem cake	5.1	1.50	1.40	1022	55	54	28
Castor cake	4.3	1.80	1.30	955	42	49	30

collected at 0-15 cm depth from each plot and analyzed for physical properties, bulk density (BD) and water stable aggregates (WSA); and soil fertility (organic C, major and micro nutrients) during both the years. Total cost of cultivation and gross returns were calculated from average input cost and market price of the produce during the period of investigation. Based on these, the net income and benefit: cost ratios (B: C ratio) were computed. The statistical analysis was carried out as described by Cochran and Cox (1967).

Results and Discussion

Yield and quality

The highest yield of tuber and vine was observed in the INM treatment, T_9, followed by the organic treatments, T_6 (vermicompost @ 7.08 t ha^{-1} + castor cake @ 0.68 t ha^{-1}), T_5 (vermicompost @ 4.72 t ha^{-1} + castor cake @ 1.35 t ha^{-1}) and T_8 (vermicompost @ 7.08 t ha^{-1} + neem cake @ 0.51 t ha^{-1}), which were on par with T_9. Integration of organic manure having high C:N ratio with manure having low C:N ratio increases the mineralization and organic matter build up with efficient microbial activity, which ultimately enhanced the growth and yield of yam. Similar results were reported by Narayan et al. (2004). The treatments had no significant effect on total soluble sugar content in tuber. However, its effect was significant on starch and carbohydrate content in tuber and organic treatments showed their superiority over INM treatment. Organic treatment, T_1 significantly improved the contents of starch and carbohydrate in yam. Starch and carbohydrate content of yam showed significant increase with the application of organic manures as compared to integrated use of organic manure and chemical fertilizers (Table 3). It could be due to balanced nutrition with favorable physico-chemical and biological conditions of the soil. These findings are in accordance with Parthian and Premasekhar (2002) and Azin Ghabelrahmat and Dhumal (2012).

Nutrient content and uptake

The content of N, P and K of tuber and vine was not significantly affected during 2010 and 2011 (Tables 4 and 5). However, their total uptake was significantly influenced by various treatments during both the years (Table 6). The INM treatment, T_9 resulted in higher total uptake of N, P_2O_5 and K_2O followed by the organic treatment, T_5 (vermicompost @ 4.72 t ha^{-1} + castor cake @

Table 3. Effect of treatments on tuber yield, vine yield and quality parameters of greater yam (pooled mean)

Treatments	Tuber yield (t ha^{-1})	Vine yield (kg ha^{-1})	Total sugar (%)	Starch (%)	Carbo-hydrate (%)
T_1	12.9	2908	1.90	14.1	15.2
T_2	13.6	2770	1.94	13.2	14.8
T_3	13.2	2815	1.90	12.9	14.6
T_4	13.9	2878	1.91	13.2	14.3
T_5	15.8	3325	1.86	13.9	13.9
T_6	16.3	3319	2.00	13.4	14.9
T_7	14.4	3144	1.92	13.0	14.2
T_8	15.0	3178	1.98	12.4	13.6
T_9	16.4	3472	1.76	12.3	13.3
CD (0.05)	1.5	361	NS	1.0	1.1

Table 4. Effect of treatments on nutrient content of tuber

Treat-ments	Nutrient content (%)					
	N		P		K	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
T_1	0.42	0.46	0.28	0.29	0.82	0.81
T_2	0.42	0.47	0.29	0.29	0.79	0.78
T_3	0.46	0.47	0.30	0.31	0.82	0.85
T_4	0.42	0.47	0.28	0.30	0.80	0.81
T_5	0.47	0.49	0.32	0.33	0.84	0.88
T_6	0.48	0.48	0.32	0.32	0.86	0.82
T_7	0.46	0.49	0.32	0.34	0.83	0.88
T_8	0.45	0.44	0.31	0.32	0.82	0.88
T_9	0.49	0.50	0.33	0.34	0.87	0.89
CD (0.05)	NS	NS	NS	NS	NS	NS

Table 5. Effect of treatments on nutrient content (%) of vine

Treatments	N		P		K	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
T_1	1.00	1.07	0.33	0.36	0.85	0.90
T_2	1.02	1.12	0.32	0.33	0.86	0.95
T_3	1.02	1.01	0.34	0.38	0.87	0.89
T_4	1.05	1.04	0.33	0.36	0.86	0.93
T_5	1.03	1.07	0.35	0.39	0.88	0.86
T_6	1.06	1.07	0.35	0.37	0.89	0.93
T_7	0.92	0.94	0.32	0.32	0.82	0.83
T_8	0.92	0.99	0.30	0.30	0.83	0.90
T_9	1.00	1.09	0.36	0.39	0.87	0.95
CD (0.05)	NS	NS	NS	NS	NS	NS

Table 6. Effect of treatments on nutrient uptake (kg ha^{-1}) by greater yam

Treatments	N			P			K		
	2010-11	2011-12	Pooled mean	2010-11	2011-12	Pooled mean	2010-11	2011-12	Pooled mean
T_1	48.6	48.0	48.3	22.1	21.6	21.8	61.4	57.7	59.6
T_2	46.0	52.4	49.2	21.9	21.5	21.7	59.7	60.0	59.8
T_3	49.7	47.4	48.6	22.7	24.0	23.4	60.2	62.3	61.3
T_4	49.3	50.6	50.0	22.3	23.9	23.1	60.7	63.5	62.1
T_5	59.0	60.2	59.6	28.6	29.1	28.9	73.8	71.9	71.8
T_6	60.2	61.7	60.9	28.5	29.1	28.8	75.7	74.3	75.0
T_7	52.4	50.8	51.6	25.7	25.0	25.4	66.7	65.6	66.2
T_8	52.1	51.9	52.0	25.0	24.4	24.7	67.4	70.4	68.9
T_9	62.0	63.3	62.7	30.6	31.1	30.9	78.6	78.6	78.6
CD (0.05)	8.8	10.0	5.9	4.2	3.1	2.3	8.8	9.4	5.7

Table 7. Effect of different organic manures on organic C and major nutrient status of the soil after harvest

Treatments	Organic C (%)		Available N		Available P (kg ha^{-1})		Available K	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
T_1	0.62	0.65	258	253	35.2	38.2	417	488
T_2	0.68	0.64	250	265	40.7	47.6	451	466
T_3	0.65	0.61	269	280	37.8	41.0	429	472
T_4	0.62	0.67	263	275	36.2	39.3	430	475
T_5	0.58	0.62	260	295	34.2	38.8	408	410
T_6	0.69	0.73	253	292	38.8	43.3	462	397
T_7	0.59	0.72	271	232	36.6	39.5	436	445
T_8	0.66	0.66	260	241	42.7	47.6	467	415
T_9	0.60	0.55	262	249	37.8	43.3	447	475
CD (0.05)	NS	0.10	NS	41	NS	NS	NS	NS

Table 8. Effect of different organic manures on DTPA extractable micro nutrient content of the soil after harvest

Treatments	Fe		Mn		Zn		Cu	
	(mg kg^{-1})							
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
T_1	17.6	22.7	20.5	21.6	0.67	0.65	2.20	2.32
T_2	16.4	24.7	19.8	22.7	0.68	0.67	2.17	2.37
T_3	17.3	22.0	20.5	21.1	0.66	0.68	2.19	2.39
T_4	18.1	22.0	20.4	18.8	0.60	0.70	2.28	2.40
T_5	19.1	21.0	18.4	19.2	0.63	0.72	2.18	2.41
T_6	18.3	20.9	19.4	19.7	0.61	0.67	1.99	2.37
T_7	18.1	20.8	21.4	19.5	0.65	0.61	2.03	2.31
T_8	17.8	22.0	19.9	18.9	0.62	0.62	1.99	2.27
T_9	14.8	18.6	18.3	18.3	0.57	0.56	1.93	2.09
CD (0.05)	1.9	NS	NS	NS	NS	NS	NS	NS

1.35 t ha^{-1}) and T_6 (vermicompost @ 7.08 t ha^{-1} + castor cake @ 0.68 t ha^{-1}), respectively. The uptake of nutrients is a function of nutrient content and dry matter production. These treatments produced higher total biomass yield, which resulted in higher uptake of nutrients. Similar observations were made by other workers (Chatoo et al., 2010; Partha Sarthi Patra et al., 2011) in different crops.

Soil properties

Among the soil properties, organic C and available N in 2011-2012 and Fe in 2010-2011 were significant (Tables 7 and 8). The remaining parameters were not affected significantly, but improved due to application of organic manures compared to INM (Table 9). Similar results were also observed in the case of major and micro nutrients after harvest (Tables 7 and 8). These findings were in agreement with those reported in other crops under Indian conditions (Mahapatra et al., 2006; Srivastava et al., 2006; Suja et al., 2010; 2012a; 2012b).

Economics

Among the different treatments, T_9 (FYM @ 10 t ha^{-1} + NPK @ 80:60:80 kg ha^{-1}) generated higher net income of ` 2, 04,959 ha^{-1} and B: C ratio of 2.7 followed

Table 9. Effect of different organic manures on bulk density and water stable aggregates of the soil after harvest

Treat-ments	Bulk density (g cm^{-3})		Water stable aggregates (%)	
	2010-11	2011-12	>1.0 mm	0.5-1.0 mm
T_1	1.55	1.53	66.1	21.0
T_2	1.48	1.43	67.7	22.2
T_3	1.54	1.49	64.6	21.2
T_4	1.51	1.42	67.4	21.2
T_5	1.43	1.52	63.0	19.9
T_6	1.45	1.39	69.7	22.8
T_7	1.50	1.51	67.9	20.8
T_8	1.44	1.46	68.1	22.0
T_9	1.59	1.62	60.1	17.9
CD (0.05)	NS	NS	NS	NS

Table 10. Economic analysis

Treatments	Yield (t ha^{-1})	Cost of cultivation (` ha^{-1})	Gross income (` ha^{-1})	Net income (` ha^{-1})	B: C ratio
T_1	12.9	121467	258000	136533	2.1
T_2	13.6	118600	272000	153400	2.3
T_3	13.2	125900	264000	138100	2.1
T_4	13.9	117950	278000	160050	2.4
T_5	15.7	133972	314000	180028	2.3
T_6	16.3	137357	326000	188643	2.4
T_7	14.4	132672	288000	155328	2.2
T_8	15.0	136707	300000	163293	2.2
T_9	16.4	123041	328000	204959	2.7

Cultivation cost (excluding input cost): ` 1,12,400; Market rate: ` 20 kg^{-1}

by T_6 (vermicompost @ 7.08 t ha^{-1} + castor cake @ 0.68 t ha^{-1}), which fetched net income of ` 1,88,643 ha^{-1} and B:C ratio of 2.4 (Table 10).

Conclusion

Organic farming produced yield almost equivalent to that of chemical based farming besides improving the quality of crop as well as soil properties. However, organic farming if done on equivalent nutrient basis and if premium price is not obtained, it becomes less profitable than chemical farming.

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