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Organic Management Affects Growth, Yield, Quality and Soil Properties in Elephant Foot Yam

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Abstract

A field experiment was conducted at the Organic Farming Unit, Navsari Agricultural University, Navsari, during 2010-2011 and 2011-2012 to study the growth, yield and quality of elephant foot yam and soil properties as affected by organic manures and biofertilizers under organic farming. Ten treatments were evaluated in this experiment; among them nine were different combinations of organic manures, ash and biofertilizers and one INM treatment. (FYM @ 10 t ha^{-1} + NPK @ 80:60:100 kg ha^{-1}) was studied outside the organic farm. These treatments were tested in randomized block design with three replications. Among the different treatments, the INM treatment, FYM @ 10 t ha^{-1} + NPK @ 80:60:100 kg ha^{-1} resulted in higher crop growth and tuber yield followed by the organic treatment, vermicompost @ 5 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + phosphorus solubilising bacteria (PSB) @ 5 kg ha^{-1} + ash @ 5 t ha^{-1} during all the years. The soil organic C content also increased significantly due to the application of organic manures, whereas soil physical and chemical properties were unaffected. The economic analysis indicated that the INM treatment resulted in the highest net income of ` 2,90,000 ha$^{-1}$ (BCR of 2.9) followed by the organic treatment, vermicompost @ 5 t ha$^{-1}$ + *Azospirillum* @ 5 kg ha$^{-1}$ + PSB @ 5 kg ha$^{-1}$ + ash @ 5 t ha$^{-1}$ (net income of ` 2,56,000 ha^{-1}; BCR of 2.6).

Key words: Elephant foot yam, organic farming, yield, quality, soil properties, B:C ratio

Introduction

The concept of organic farming is not new to Indian farming community. Several forms of organic farming are being successfully practiced in diverse agro-climatic situations, particularly in rainfed, tribal and hilly areas of the country. The Green Revolution in India, undoubtedly, boosted the overall agricultural production. However, there was productivity decline in many intensively cultivated areas, where organic manures were partially or totally excluded. The intensification of land use with increased dependence on agro-chemicals resulted in stagnation of crop yields in many situations, which necessitated a change to a sustainable farming system approach having inbuilt features of equilibrium between farming and nature. This type of farming system, later on, came to be known as organic farming (Alexander, 2009). Tuber crops in general are well adapted to marginal conditions, low input management and drought. They come up well when the rainfall is 1000-1500 mm per year. They can also be cultivated under wide range of soil conditions and their ability to grow under a wide range of agro-climatic situations enhances the scope of extending the cultivation to the non-traditional regions of the country like Maharashtra, Gujarat, Bihar and Karnataka. In general, tuber crops, especially elephant foot yam, respond well to organic manures. Studies conducted at Central Tuber Crops Research Institute for over a decade indicated that organic management improves yield, quality and soil properties in tuber crops (Suja et al., 2009; 2010; 2012a; 2012b). An attempt has been made in this paper to compare yield, quality, economics and soil nutrient status under organic management practices under South Gujarat conditions.

Materials and Methods

The experiment was conducted in randomized block design with three replications at the Certified Organic Farm, Navsari Agricultural University, Navsari, falling under South Gujarat Heavy Rainfall Zone (AES III) during 2010-2011 and 2011-2012 to study the effect of different combinations of organic sources with biofertilizers on elephant foot yam. The site experiences a typical humid climate. The mean annual rainfall was 1643 mm, maximum and minimum temperatures were 32.64 °C and 21.47 °C respectively and relative humidity was 70.17%. In this study, the plot for synthetic fertilizer application was taken outside the organic farm (off-farm). The experimental soil was clayey in texture, slightly alkaline (pH-7.6) and non-saline (EC-0.41 dS m^{-1}) with bulk density of 1.45 g cm^{-3}. Initial nutrient status of the soil during 2010-2011 is presented in Table 1. The treatments were as follows:

T_1 : Vermicompost (VC) @ 5 t ha^{-1} + ash @ 5 t ha^{-1}

T_2 : Farmyard manure (FYM) @ 10 t ha^{-1} + ash @ 5 t ha^{-1}

T_3 : Poultry manure (PM) @ 5 t ha^{-1} + ash @ 5 t ha^{-1}

T_4 : Vermicompost @ 5 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + vesicular arbuscular mycorrhizae (VAM) @ 5 kg ha^{-1} + ash @ 5 t ha^{-1}

T_5 : Vermicompost @ 5 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + phosphorus solublizing bacteria (PSB) @ 5 kg ha^{-1} + ash @ 5 t ha^{-1}

T_6 : Farmyard manure @ 10 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + vesicular arbuscular mycorrhizae @ 5 kg ha^{-1} + ash @ 5 t ha^{-1}

T_7 : Farmyard manure @ 10 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + phosphorus solublizing bacteria @ 5 kg ha^{-1} + ash @ 5 t ha^{-1}

T_8 : Poultry manure @ 5 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + vesicular arbuscular mycorrhizae @ 5 kg ha^{-1} + ash @ 5 t ha^{-1}

T_9 : Poultry manure @ 5 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + phosphorus solublizing bacteria @ 5 kg ha^{-1} + ash @ 5 t ha^{-1}

T_{10} : Farmyard manure @ 10 t ha^{-1} + NPK @ 80: 60: 100 kg ha^{-1} (RDF) (as a control outside the organic farm).

The organic manures, vermicompost, FYM and poultry manure used in the experiment contained N, P and K of 1.21, 0.65, 1.00; 0.5, 0.2, 0.5 and 1.5, 1.2, 0.8%, respectively. Potassium content in rice-mill ash was 0.8%. The seed corm was planted at 90 x 90 cm spacing on the ridges. In the organic practices, the seed corms were treated with cow dung (10%) + cow urine (2%) + *Trichoderma harzianum* (0.5%) slurry and dried under shade before planting. Fifty per cent organic manures were applied at the time of planting and the remaining quantity was applied one month after planting. Biofertilizers were applied along with organic manures at the time of sowing. A green manure crop of sunhemp (seed rate of 25-30 kg ha^{-1}) was raised to produce sufficient quantity of green biomass (about 20 t ha^{-1}) in the organic plots. Off-farm crop was fertilized with FYM, Urea, diammonium phosphate (DAP) and Muriate of potash (MOP) as per recommendation. The data on important growth parameters were recorded at the time of harvest. Soil samples were collected at 0-15 cm depth from each plot after harvest of the crop and the soil chemical properties such as organic C, available N, P and K contents of the soil were determined by standard analytical procedures. Protein content of the tuber at harvest was analyzed by Kjeldhal method (Jackson, 1967). Total cost of cultivation and gross returns were calculated

Table 1. Initial soil properties of organic farm and off-farm

Parameters	On-farm	Off-farm	Parameters	On-farm	Off-farm
Bulk density (g cm^{-3})	1.45	1.66	Organic C (%)	0.52	0.51
Water stable aggregates (0.5-1.0 mm)	61.0	18.6	Available N (kg ha^{-1})	246	238
Water stable aggregates (> 1.0 mm)	56.2	17.0	Available P (kg ha^{-1})	31.5	42.5
			Available K (kg ha^{-1})	389	408

from average input cost and average market price of the produce during the period of investigation. Based on these the net income and benefit: cost ratio (B: C ratio) were computed. All the data were subjected to analysis of variance (ANOVA) as per the standard procedure.

Results and Discussion

Growth and yield

The results of pooled analysis of two years' data pertaining to growth parameters, pseudostem girth, canopy spread and plant height and yield are presented in Table 2. The pooled data indicated that pseudostem girth was not affected significantly due to the chemical or organic treatments. Higher pseudostem girth was observed in the chemical treatment, T_{10} (FYM @ 10 t ha^{-1} + NPK @ 80:60:100 kg ha^{-1}) followed by the organic treatments, T_6 (FYM @ 10 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + VAM @ 5 kg ha^{-1} + ash @ 5 t ha^{-1}) and T_7 (FYM @ 10 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1} + ash @ 5 t ha^{-1}). Chemical treatment (T_{10}) resulted in the highest canopy spread (84.9 cm), plant height (92.0 cm) and corm yield (22.2 t ha^{-1}). The organic treatments, T_5 and T_6, were on par with chemical based farming for the growth parameters, canopy spread and plant height. Corm yield under organic treatment, T_5 (21.1 t ha^{-1}) was on par with the chemical treatment, T_{10} (22.2 t ha^{-1}). It may be due to the overall improvemt in soil physico-chemical properties under the influence of continuous application of organic manures. Application of organic manures continuously from 2005 to 2011 lowered the soil bulk density. The lowering of bulk density coupled with greater mineralization of organic matter was found to be beneficial for a tuber crop like elephant foot yam (Tables 1 and 4). Suja et al. (2010) also reported that organic farming proved significantly superior in elephant foot yam at all the on farm sites tested due to the overall improvement in soil physico-chemical properties under the influence of organic manures. The growth and yield of tannia was also found to be higher under organic farming due to the favourable effects on soil properties (Suja et al., 2009). Similar results were reported by Mahapatra et al. (2006a) in basmati rice and Mahapatra et al. (2006b) in lentil, chick pea and wheat.

Table 2. Effect of treatments on pseudostem girth, canopy spread, plant height and tuber yield (mean of two years)

Treat-ments	Pseudostem girth (cm)	Canopy spread (cm)	Plant height (cm)	Tuber yield (t ha^{-1})
T_1	13.7	71.8	71.4	17.1
T_2	13.7	73.9	75.8	15.8
T_3	13.6	74.9	76.6	14.8
T_4	14.3	63.2	64.6	16.8
T_5	13.1	81.7	89.4	21.1
T_6	14.6	79.6	84.7	17.6
T_7	14.6	78.2	84.1	19.2
T_8	14.1	72.4	79.8	16.8
T_9	14.0	70.2	79.6	18.3
T_{10}	14.8	84.9	92.0	22.2
CD (0.05)	NS	10.8	9.3	1.9

Quality

Biochemical constituents of corms, total sugar and starch were significantly affected by the different organic and inorganic treatments. The total sugar and starch contents were significantly higher for the organic treatment, T_5 (VC @ 5 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1} + ash @ 5 t ha^{-1}) than the INM treatment, T_{10}. Though the protein content was not significantly affected, the organic treatments resulted in higher protein content than the chemical treatment (Table 3). In this study, organic farming improved the quality of elephant foot yam similar to the reports of Suja et al. (2012a) and Suja et al. (2012b). Rembialkowska (2007) also stated that organically grown crops contain more biochemical elements than conventionally grown crops.

Soil properties

The soil physical properties, bulk density (BD) and water stable aggregates (WSA); and chemical properties, organic C, available N, P and K contents after harvest of the crops as affected by different treatments are presented in Table 4. The results indicated that the bulk density, water stable aggregates, available N and K were not significantly affected due to the different treatments though these were slightly higher than the initial content. Among the chemical parameters, organic C and available P contents were significantly affected due to the different treatments. Organic treatments had higher organic C contents, whereas organic C content in chemical based farming was the least. This may be due to the addition of organic manures, especially green biomass @ 20 t

Table 3. Effect of treatments on bio-chemical constituents of corm (mean of two years)

Treatments	Protein content	Total sugar (% FW basis)	Starch
T_1	2.91	1.20	17.2
T_2	2.90	1.19	16.8
T_3	3.01	1.22	16.9
T_4	2.78	1.17	17.2
T_5	2.97	1.24	17.9
T_6	2.77	1.13	17.2
T_7	2.82	1.14	15.7
T_8	2.63	1.07	16.1
T_9	2.80	1.11	15.6
T_{10}	2.64	1.06	15.3
CD (0.05)	NS	0.10	1.2

ha^{-1} through green manuring since 2005 in this Organic Farm. Suja et al. (2012b) also observed higher organic C status under organic management in elephant foot yam. After two years of experimentation, available P was appreciably higher in the chemical plot. This may be due to the addition of both synthetic fertilizers and FYM, which could reduce the P fixation. Among the organic treatments, higher status of P was observed in T_8, which was on par with most of the organic treatments, except T_1 and T_2. Thus organic farming envisages a comprehensive management approach to improve the soil health, underlying the productivity of a soil (Palaniappan and Annadurai, 1999). Increase in soil organic matter and available P have been measured in some organic systems by Scow et al. (1994), Clark et al. (1998) and Suja et al. (2010). Similar results have been also reported in other crops under Indian conditions (Srivastava et al., 2006; Mahapatra et al., 2006b).

Economics

Among the different treatments, T_{10} (FYM @ 10 t ha^{-1} + NPK @ 80 : 60 : 100 kg ha^{-1}) fetched higher net return of ` 2,81,434 ha$^{-1}$ and benefit: cost ratio (B: C ratio) of 2.7 as against the organic treatment, $T_5$ (vermicompost @ 5 t ha$^{-1}$ + *Azospirillum* @ 5 kg ha$^{-1}$ + phosphorus solublizing bacteria @ 5 kg ha$^{-1}$ + ash @ 5 t ha$^{-1}$), which generated net income of ` 2,55,500 ha^{-1} and B: C ratio of 2.5 (Table 5). Under premium price, the same trend was observed, however B: C ratio was higher compared to that computed using market price. The B : C ratio in all the organic treatments can be further raised if organic manures would be on farm generated. One of the important aspect in organic farming is that each field/farm or region has inherent fertility. Therefore, care should be taken that only a small amount of nutrients actually leave the system so that “import” of nutrients can be restricted. This can be achieved only by recycling the on farm wastes, which reduces the input cost (Yadav, 2011).

Conclusion

Organic farming produced comparable yield of quality corms and returns to that of conventional practice. Organically produced corms had significantly higher total sugar and starch contents. The chemical properties of

Table 4. Effect of treatments on physico-chemical properties of soil after harvest (mean of two years)

Treatments	Bulk density (g cm^{-3})	Water stable aggregates (%)		Organic C (%)	Available N	Available P (kg ha^{-1})	Available K
		0.5-1.0 mm	>1.0 mm				
T_1	1.45	20.1	66.3	0.60	264	33.8	408
T_2	1.39	21.6	70.6	0.63	266	35.5	411
T_3	1.48	18.5	64.2	0.58	267	38.4	395
T_4	1.46	19.4	63.9	0.59	263	43.8	425
T_5	1.46	20.7	69.3	0.61	270	41.4	427
T_6	1.39	21.7	69.8	0.63	266	39.2	422
T_7	1.36	21.9	71.4	0.64	274	39.7	417
T_8	1.49	18.6	62.1	0.57	269	44.3	416
T_9	1.44	19.5	62.6	0.60	271	43.8	412
T_{10}	1.62	17.2	59.9	0.54	283	47.9	443
CD (0.05)	NS	NS	NS	0.04	NS	7.7	NS

Table 5. Economic analysis of organic vs chemical management

Treatments	Yield (t ha^{-1})	Cost of cultivation (` ha^{-1})	Gross income (` ha^{-1})		Net income (` ha^{-1})		B:C ratio	
			Market price	Premium price	Market price	Premium price	Market price	Premium price
T_1	17.1	165500	342000	376200	176500	210700	2.1	2.3
T_2	15.8	156900	316000	347600	159100	190700	2.0	2.2
T_3	14.8	158000	296000	325600	138000	167600	1.9	2.1
T_4	16.8	166500	336000	369600	169500	203100	2.0	2.2
T_5	21.1	166500	422000	464200	255500	297700	2.5	2.8
T_6	17.6	157900	352000	387200	194100	229300	2.2	2.5
T_7	19.2	157900	384000	422400	226100	264500	2.4	2.7
T_8	16.8	159000	336000	369600	177000	210600	2.1	2.3
T_9	18.3	159000	366000	402600	207000	243600	2.3	2.5
T_{10}	22.2	162566	444000	488400	281434	325834	2.7	3.0

Cultivation cost (excluding input cost): ` 1,50,000 ha$^{-1}$; Market rate: ` 20 kg^{-1}; Premium rate: ` 22 kg^{-1}

soil were also improved under organic farming. If premium price is obtained, production of elephant foot yam with the application of vermicompost @ 5 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + phosphorus solublizing bacteria @ 5 kg ha^{-1} + ash @ 5 t ha^{-1} would become more profitable than chemical based farming.

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