The Pharma Innovation Journal 2018; 7(10): 590-595

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.03
TPI 2018; 7(10): 590-595

www.thepharmajournal.com
Received: 15-08-2018
Accepted: 20-09-2018

Response of sweet potato to INM and its effect on soil health

Sheth SG, Desai KD, Patil SJ, Navya K and Desai GB

Sheth SG
Department of Vegetable Science, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat, India

Desai KD
Department of Vegetable Science, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat, India

Patil SJ
Department of Fruit Science, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat, India

Navya K
Department of Vegetable Science, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat, India

Desai GB
Department of Vegetable Science, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat, India

Correspondence
Desai KD
Department of Vegetable Science, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat, India

Abstract
A field experiment was laid out at Regional Horticultural Research Station, Navsari Agricultural University, Navsari on sweet potato cv. Collection-71 (C-71) during Rabi 2015. The experiment comprises of four levels of different nutrient sources [T_1: RDF (75 : 50 : 75 NPK kg ha^{-1} + 15 t FYM ha^{-1}); T_2: 50 % RDN + 50 % N from vermicompost along with RDF of P & K; T_3: 50 % RDN + 50 % N from FYM along with RDF of P & K; T_4: 50 % RDN + 50 % N from bio-compost along with RDF of P & K] and two levels of Bio-fertilizers [B_0:without bio-fertilizers and B_1:with bio-fertilizers (combination of Azospirillum, Phosphorus solubilising bacteria (PSB) and Potassium mobilizing bacteria (KMB) @ 5 lit ha^{-1} each)] in FRBD statistical design having three replications. Application of integrated nutrient sources did not showed significant effect on vine length at 30 DATP but at the age of 60 DATP, 90 DATP and at harvest, maximum vine length of 78.98 cm, 120.17 cm and 175.87 cm, respectively was recorded in T_2 treatment. Similarly application of bio-fertilizers did not have any significant results on vine length at 30 DATP. However, treatment B_1 (with bio-fertilizers) found best over treatment B_0 (without bio-fertilizers) and recorded significantly the highest vine length of 76.83 cm at 60 DATP, 117.03 cm at 90 DATP and 170.98 cm at harvest. The highest number of leaves (138.80) per vine at harvest was recorded in T_2 treatment and application of bio-fertilizers (B_1) also produced higher number of leaves (133.06) per vine than B_0 treatment at same stage. Treatment T_2 recorded maximum tuber girth (15.94 cm), tuber length (24.34 cm), highest average tuber weight (129.30 g), maximum number of tuberous roots (5.10), the highest fresh weight of tubers (0.512 kg) per vine, highest total tuber yield (8.27 kg netplot^{-1} and 34.47 t ha^{-1}) and the highest marketable tuber yield (7.84 kg netplot^{-1} and 32.67 t ha^{-1}) with the highest harvest index of 43.52 per cent. Application of bio-fertilizers (B_1) recorded significantly the highest values of tuber girth (15.47 cm), tuber length (23.15 cm), average tuber weight (126.73 g), number of tuberous roots (4.81) per vine, fresh weight of tubers (0.495 kg) per vine, total tuber yield (7.89 kg plot^{-1} and 32.88 t ha^{-1}), marketable tuber yield (7.45 kg plot^{-1} and 31.04 t ha^{-1}) and highest harvest index (41.44%) over the treatment of without bio-fertilizers (B_0) application. Irrespective of different nutrient sources, the difference in starch, total sugar, dry matter and moisture content in tuber was found non-significant. The data pertaining to the soil physical (Bulk density) and chemical (O.C., N, P and K) properties after harvesting the crop as influenced by integrated nutrient management were found to be non-significant except soil organic carbon content which was significantly the highest (0.603 %) in T_2 treatment. The highest gross and net income was obtained in T_2B_1 treatment combination but the highest B:C ratio (2.72) was obtained in T_3B_1 treatment combination.

Keywords: sweet potato, effect on soil health

Introduction
Among different tuber crops, sweet potato [*Ipomoea batatas* (L.) Lam] is an important tuber crop belongs to family Convolvulaceae. Its origin is South America. It is also known as a famine relief crop as it had played a pivotal role in aviating the Bengal famine of 1942. It is an important leafy vegetable in Asia, China, Australia and Africa. Among the tuber crops, sweet potato contains substantial levels of protein in addition of carbohydrates. It is the cheapest source of calories and a chief source of starch. It also provides substantial amounts of vitamins and minerals.

Asia is the largest producer of sweet potato having 92 % of production and 80 % of area in the world. China and India are the leading sweet potato growing countries in the world. In India, the area under sweet potato is 1.08 LHA, with an annual production of 10.87 LT, having productivity of 10.1 t ha-1 (Anon., 2016) [8]. In Gujarat it is commercially cultivated in the districts of Mehsana, Ahmedabad, Kheda, Anand, Surat, Tapi, Dangs, Valsad and Navsari.

In order to obtain good yield, modern varieties of different crops require relatively huge quantity of fertilizers compared to the traditional cultivars. However, it has been repeatedly confirmed that continuous sole and imbalanced use of chemical fertilizers deteriorates soil health and ecological balance which leads to decrease in nutrient uptake efficiency (Saravaiya *et al*., 2010) [24]. Soils that receive plant nutrients only through chemical fertilizers are showing decline in productivity and deficiency in secondary and micronutrients. The physical condition of the soil is also deteriorated with the use of excess chemical fertilizers. Intense cropping is another cause for fast deterioration of land productivity. Thus the organic matter content of most of the soils is declining day by day which have made it necessary to rethink alternatives.

Continued crop production potential of soils has a direct relationship to its organic matter content, and the productivity is positively correlate to the organic matter content of the soil. Crop production potential also relates to soil physical and chemical properties and revolve around the dynamics of organic matter decomposition by soil micro-organisms. Use of bio-fertilizers helps to increase soil micro-flora and fauna, which ultimately increases the decomposition rate, productivity and sustainability of the soils. In future, enhancement and maintenance of soil fertility through microorganisms will be a very significant concern. Organic manures were regarded as important, but it was obvious that they were not available in sufficient quantity to drastically increase food production. Therefore, maximizing the usage of organic waste combining it with chemical and bio-fertilizers in the form of integrated manner found to be the best alternative. There is an ample scope for organic production in tuber crops as they respond well to organic manures (Suja *et al*., 2009) [26].

Thus, the use of inorganic fertilizers in conjunction with organic manures is essential for getting sustainable and profitable yield of sweet potato.

Materials and Methods

A field experiment was laid outat Regional Horticultural Research Station, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsarion sweet potato cv. Collection-71 (C-71) during Rabi 2015.

The experiment comprises of four levels of different nutrient sources [T1: RDF (75 : 50 : 75 NPK kg ha-1 + 15 t FYM ha-1); T2: 50 % RDN + 50 % N from vermicompost along with RDF of P & K; T3: 50 % RDN + 50 % N from FYM along with RDF of P & K; T4: 50 % RDN + 50 % N from bio-compost along with RDF of P & K] and two levels of Bio-fertilizers [B0:Without bio-fertilizers and B1:With bio-fertilizers (combination of Azospirillum, Phosphorus solubilising bacteria (PSB) and Potassium mobilizing bacteria (KMB) @ 5 lit ha-1 each)].50 % nitrogen was substituted on the basis of N content of different manures and was applied at the time of planting along with drenching of bio-fertilizers (600 lit/ha). 50 % potash with 100% phosphorous (in form of CF) were applied 10 DATP. Remaining 50% of nitrogen and potash (in form of CF) were applied in two equal splits i.e. @ 30 and 60 DATP in all treatment combinations.

Transplanting was done on 22nd November, 2015. Before transplanting, cuttings were treated in the solution of chlorpyrifos @ 1 ml/lit. by dipping for 10 minutes. Planting was done at a distance of 60 cm x 20 cm in the plots having 2.4 m width and 2.8 m length. The initial soil samples of the experimental plot was taken and analysed.

Starch and total sugar content were analysed with the procedure given by Padmaja *et al*., 2005 [17] and Rangana *et al*., 1979 [20], respectively. Soil analysis was done with procedure given by Jackson, 1979 [13]. The economic parameters with respect to each treatment combinations were worked out on the bases of prevailing market prices of 2015-16.

Result and Discussion

Among the data on growth and yield parameters given in table-1, growth parameters like vine length and number of leaves per vine were significantly influenced by application of organics, inorganics and bio-fertilizers. Application of integrated nutrient sources did not showed significant effect on vine length at 30 DATP but had significant effect on later growth stages i.e. 60 DATP, 90 DATP and at harvest. At the age of 60 DATP the maximum vine length (78.98 cm) was recorded in treatment T2 (50 % RDN + 50 % N from vermicompost along with RDF of P & K) which was statistically remained at par with treatment T3 (50 % RDN + 50 % N from FYM along with RDF of P & K) and T4 (50 % RDN + 50 % N from bio-compost along with RDF of P & K) which recorded 73.50 cm and 72.83 cm vine length, respectively. Similar trend was observed at 90 DATP where treatment T2 recorded maximum vine length (120.17 cm) and statistically remained at par with treatment T3 and T4 with 116.00 cm and 110.73 cm vine length, respectively. While at harvest the maximum vine length (175.87 cm) was recorded in same treatment T2, which was statistically remained at par with treatment T3 having 165.97 cm vine length. The above results are in conformity with Halavatau *et al*. (1998) [11], Venkatesan *et al*. (2013) [28], Annepu, 2011 [2] and Panwar and Wani (2014) [18] in different tuber crops. This was mainly because added organic sources not only acted as nutrient sources but also might have influenced of their availability to the plants for a longer period. After 60 DATP, the grand growth period involving high physiological activities synchronized with maximum nutrient uptake, which may have aided to increase the vine length (Ravindrababu, 1999) [21].

Similarly application of bio-fertilizers did not have any significant results on vine length at 30 DATP. However, treatment B1 (with bio-fertilizers) found best over treatment B0 (without bio-fertilizers) at 60 DATP, 90 DATP and at harvest and recorded significantly the highest vine length of 76.83 cm, 117.03 cm and 170.98 cm, respectively. Isfahani and Besharati (2012) [12] are also in accordance with the above results by reporting maximum vine length with application of PSB in cucumber. It is very well known that bio-fertilizers had played an important role in fixing the atmospheric nitrogen and making them available to the plants, which is a major nutrient for vegetative growth.

At harvest, number of leaves per vine showed significant results due to the application of different nutrient sources. The highest number of leaves 138.80 per vine was recorded in treatment T2 but this was statistically remained at par with treatment T3 having 129.80 leaves. The findings are similar with the research findings of Thirumdasu *et al*. (2015) [27] who obtained higher number of leaflets in EFY at harvest. Probable reason behind this may be that vermicompost improved the physical, chemical and biological characteristics of soil that resulted in the easy absorption of water and nutritional elements in order to produce higher number of leaves and to use them for other vital processes (Yourtchi *et al*., 2013) [29].

Application of bio-fertilizers (B1) recorded significantly the highest number of leaves (133.06) per vine as against the treatment without bio-fertilizers (B0). This could be attributed to the better formation of micro-flora in the soil and had increased the growth and development of the plants (Saravaiya *et al*., 2010) [24].

The effect of integrated nutrient sources and bio-fertilizerswas found significanton all yield parameters except dry matter content of vine and fibrous roots (table-1). Among different integrated nutrient sources applied, treatment T2 recorded the maximumtuber girth (15.94 cm) and tuber length (24.34 cm) but both these parameters were statistically remained at par with treatment T3 having 15.02 cm tuber girth and 22.59 cm tuber length. Treatment T2 also found best in gaining highest average tuber weight (129.30 g) but it was statistically remained at par with treatments T3 and T4 with 123.99 g and 118.66 g average tuber weight, respectively. This treatment (T2) also found best and significantly recorded the maximum number of tuberous roots (5.10) per vine. The data on fresh weight of tubers also reflect that the highest fresh weight of tubers (0.512 kg) per vine was recorded in treatment T2 but statistically remained at par with treatment T3 that recorded 0.485 kg fresh tuber weight per vine. Among all the treatments on different nutrient sources, treatment T2 produced highest total tuber yield (8.27 kg netplot-1 and 34.47 t ha-1) which was statistically remained at par with treatment T3 which recorded 7.55 kg netplot-1 and 31.44 t ha-1 total tuber yield. Exactly the same trend was observed for marketable tuber yield and treatment T2 recorded the highest marketable tuber yield (7.84 kg netplot-1 and 32.67 t ha-1) and statistically remained at par with treatment T3 having marketable yield of 7.10 kg netplot-1 and 29.57 t ha-1. The data on harvest index showed that treatment T2 recorded the highest harvest index of 43.52 % which was statistically remained at par with treatment T3, recorded 39.90 % harvest index. George and Mittra (2001) [10], Anonymous (2010 a) [5], Rahul *et al*. (2011) [19], Laxminarayana (2013) [14], Panwar and Wani (2014) [18] reported higher yield of sweet potato by application of organic sources which are similar to the findings of present investigation. Application of vermicompost (replaced as 50 % N- T2) along with 50 % RDN and RD of P & K on yield and yield attributes reveal that it exerted significant influence but statistically remained at par with T3 treatment in which FYM was replaced as 50 % N along with 50 % RDN and RD of P & K. The reasons may be that, the application of vermicompost and FYM had favoured the activity of soil micro flora, besides supplementing the nutrients (Saravaiya *et al*., 2010) [24]. Incorporation of organic manures provide conducive physical environment mainly by improving the bulk density of soil (Arriage and Lowery, 2003) [9] which helps in better root extension, tuber bulking and absorption of nutrients from the soil as well as from nutrient sources. The highest yield in INM treatments may also due to strong positive association of the growth and yield attributes (Amanullahkhan, 1997) [1].

Application of bio-fertilizers (B1) recorded significantly the highest values of tuber girth (15.47 cm), tuber length (23.15 cm), average tuber weight (126.73 g), number of tuberous roots (4.81) per vine, fresh weight of tubers (0.495 kg) per vine, total tuber yield (7.89 kg plot-1 and 32.88 tha-1), marketable tuber yield (7.45 kg plot-1 and 31.04 tha-1) and highest harvest index (41.44 %) over the treatment of without bio-fertilizers (B0) application. The findings are in conformity with Anonymous (1998) [3], Saad *et al*. (1999) [22], Anonymous (2005) [4], Anonymous (2010b) [6] and Anonymous (2010c) [7] in same crop. The possible reason behind this may be the bio-fertilizers containing Azospirrillum, a free living nitrogen fixing bacteria have increased soil available N content by fixing atmospheric N throughout the growing period and helped in producing higher yields. Nedunchezhiyan and Reddy (2002) [15], Saikia and Borah (2007) [23] reported that Azospirrillum can replace one-third N requirements of the crop. PSB and KMB have the ability to solubilize insoluble phosphorus and potassium, respectively. These bacteria secrete organic and inorganic acids such as malic acid, citric acid, formic acid and acetic acid etc. and they lower the pH of soil and bring about the dissolution of bound from nutrients and make them available to plants (Singh *et al*., 2002) [25]. The interaction effect between integrated nutrient sources and bio-fertilizers was found to be non-significant of all the parameters on growth and yield.

As evident from the data (table-2) it was observed that there was non-significant difference in starch, total sugar, dry matter and moisture content of tuber, irrespective of different nutrient sources. However, higher starch content (14.43 %) and total sugar content (2.97 %) was obtained in treatment T2 while, higher dry matter content (31.33 %) and lower moisture content (68.67 %) was obtained in T3 treatment. The application of bio-fertilizers had also shown non-significant effect on all quality parameters of tubers.

The data pertaining to the soil physical (Bulk density) and chemical (O.C., N, P and K) properties (table-2) after harvesting the crop as influenced by integrated nutrient management were found to be non-significant except soil organic carbon content. Among all the treatments, treatment T2 recorded significantly the highest soil organic carbon content (0.603 %). This was statistically remained at par with treatment T3 having 0.595 % soil organic carbon. The results are similar with that the results obtained by Nedunchezhiyan and Srinivasalu Reddy (2004) [16] and George and Mittra (2001) [10]. Replacing 50 % N with various organic nutrient sources, added larger amount of organic carbon to the soil, thus the obtained results are significant with respect to the soil organic carbon content.

The different integrated nutrient treatment combinations, studied in present investigation were observed to influence profoundly on gross income, net income and benefit: cost ratio. The highest gross income (Rs. 4,21,875/-) and the highest net income (Rs. 3,00,640/-) was obtained with the application of 50 % RDN + 50 % N replaced by vermicompost along with RD on P & K and bio-fertilizers. This is mainly due to the highest marketable yield (33.75 t ha-1) obtained in this treatment combination. Though, the highest gross and net income was obtained in T2B1 treatment combination, the highest B:C ratio (2.72) was obtained in T3B1 treatment combination. This was mainly due to lower input cost and higher tuber yield (29.86 t ha-1), next to T2B1 treatment combination.

Conclusion

Table 1: Impact of organic sources, bio-fertilizers and their interaction on growth and yield parameters of sweet potato.

Treatments	Vine length (cm)				No. of leaves /vine	Tuber girth (cm)	Tuber length (cm)	Av. tuber weight (g)	No. of tuberous roots/vine	Fresh weight of tubers/ vine (kg)	Total tuber yield/net plot (kg)	Marketable tuber yield/net plot (kg)	Total tuber yield t/ha	Marketable tuber yield t/ha	HI (%)	Dry matter content of vine (%)	Dry matter content of fibrous roots (%)
	30 DATP	60 DATP	90 DATP	At harvest	At harvest												
T_1	34.73	68.50	105.67	157.13	119.05	14.08	21.09	114.13	4.30	0.451	6.87	6.44	28.62	26.82	36.35	17.30	87.48
T_2	39.17	78.98	120.17	175.87	138.80	15.94	24.34	129.30	5.10	0.512	8.27	7.84	34.47	32.67	43.52	18.09	87.51
T_3	38.97	73.50	116.00	165.97	129.80	15.02	22.59	123.99	4.60	0.485	7.55	7.10	31.44	29.57	39.90	18.55	86.57
T_4	38.03	72.83	110.73	160.10	125.78	14.49	21.37	118.66	4.37	0.466	7.22	6.79	30.10	28.29	38.08	18.71	86.84
SEm ±	1.150	2.325	3.307	4.516	3.720	0.431	0.648	3.568	0.162	0.011	0.279	0.278	1.161	1.160	1.572	0.573	1.448
C. D. (@ 5 %)	NS	7.051	10.030	13.697	11.283	1.307	1.966	10.821	0.49	0.034	0.845	0.844	3.521	3.518	4.768	NS	NS
B_0	36.55	70.08	109.25	158.55	123.66	14.30	21.55	116.31	4.38	0.462	7.07	6.63	29.44	27.63	37.49	17.69	86.09
B_1	38.90	76.83	117.03	170.98	133.06	15.47	23.15	126.73	4.81	0.495	7.89	7.45	32.88	31.04	41.44	18.63	88.11
SEm ±	0.813	1.644	2.338	3.193	2.630	0.305	0.458	2.523	0.115	0.008	0.197	0.197	0.821	0.820	1.112	0.405	1.024
C. D. (@ 5 %)	NS	4.986	7.092	9.685	7.979	0.924	1.390	7.652	0.35	0.024	0.598	0.597	2.490	2.488	3.372	NS	NS
T×B	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
SEm ±	1.626	3.288	4.677	6.386	5.261	0.609	0.917	5.045	0.229	0.016	0.394	0.394	1.642	1.640	2.223	0.810	2.048
C. D. (@ 5 %)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. (%)	7.460	7.750	7.160	6.710	7.100	7.090	7.110	7.190	8.640	5.750	9.120	9.690	9.130	9.690	9.760	7.720	4.070

Table 2: Impact of organic sources, bio-fertilizers and their interaction on quality parameters of sweet potato tubers and soil status

Treatments	Quality parameters of tuber				Soil status after harvest				
	Starch content (%)	Total sugar content (%)	Dry matter content (%)	Moisture content (%)	Bulk density (g/cm^3)	Soil organic carbon (%)	Available N content (kg ha^{-1})	Available P_2O_5 content (kg ha^{-1})	Available K_2O content (kg ha^{-1})
T_1	13.70	2.61	31.23	68.77	1.15	0.563	262	27.68	232
T_2	14.43	2.97	29.77	70.23	1.10	0.603	260	29.09	238
T_3	13.99	2.58	31.33	68.67	1.12	0.595	265	29.84	239
T_4	13.58	2.70	28.80	71.20	1.07	0.555	259	27.32	234
SEm ±	0.413	0.099	0.950	0.950	0.025	0.010	6.330	1.065	5.652
C. D. (@ 5 %)	NS	NS	NS	NS	NS	0.031	NS	NS	NS
B_0	13.52	2.81	29.68	70.32	1.10	0.564	262	28.34	233
B_1	14.33	2.62	30.88	69.12	1.11	0.594	261	28.63	238
SEm ±	0.292	0.070	0.672	0.672	0.017	0.007	4.476	0.753	3.997
C. D. (@ 5 %)	NS	NS	NS	NS	NS	0.022	NS	NS	NS
T×B	NS	NS	NS	NS	NS	NS	NS	NS	NS
SEm ±	0.584	0.139	1.343	1.343	0.035	0.014	8.952	1.505	7.993
C. D. (@ 5 %)	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. (%)	7.270	8.890	7.680	3.340	5.430	4.310	5.930	9.150	5.870

Table 3: Effect of integrated nutrient sources and bio-fertilizers on economics.

Sr. No.	Treatments	Fixed cost (Rs.)	Variable cost (Rs.)	Total cost (Rs.)	Marketable Yield (t ha^{-1})	Gross income (Rs.)	Net income (Rs.)	B:C ratio
1.	T_1B_0	97,011	00	97,011	24.72	3,09,000	2,11,989	2.19
2.	T_1B_1	95990	2,820	98,810	27.17	3,39,625	2,40,815	2.44
3.	T_2B_0	95990	23,445	1,19,435	32.92	4,11,500	2,92,065	2.45
4.	T_2B_1	95990	25,245	1,21,235	33.75	4,21,875	3,00,640	2.48
5.	T_3B_0	95990	2,448	98,438	27.23	3,40,375	2,41,937	2.46
6.	T_3B_1	95990	4248	1,00,238	29.86	3,73,250	2,73,012	2.72
7.	T_4B_0	95990	2190	98,180	25.14	3,14,250	2,16,070	2.20
8.	T_4B_1	95990	3990	99,980	28.60	3,57,500	2,57,520	2.58

Input cost

Urea-313/50 kg	SSP-390/50 kg	MOP-575/50 kg
FYM - Rs.570/t	Vermicompost - Rs.5500/t	Biocompost - 400/t
Irrigation charges- Rs.30/hr	Labour cost- 178/day (8 hours)	Planting material– Rs. 40 paisa / cutting
Bio-fertilizers – Rs 120 / litre each	Chlorpyrifos – Rs.475 /litre	Carbofuran 3G – Rs.350 /5 kg
Pendimethalin – Rs.349 /litre	Selling price of tubers: Rs. 12.50 /-	

References

1. Amanullahkhan M. Influence of fertilizer levels, intercropping and organic manures on the growth and yield of cassava. *Thesis Ph.D.*, submitted to Tamil Nadu Agricultural University, Coimbatore, India, 1997.
2. Annepu SK. Effect of integrated nutrient management on growth, yield and quality of elephant foot yam [*Amorphophallus paeonifolius* (Dennst.) var. Gajendra]. *Thesis M.Sc.*, submitted to Acharya N. G. Ranga Agricultural University, Hyderabad, 2011.
3. Anonymous. *Annual Report*, AICRP on Tuber Crops, Thiruvananthapuram, 1998, 21-22.
4. Anonymous. *Annual Report*, AICRP on Tuber Crops, Thiruvananthapuram, 2005, 52.
5. Anonymous. *Annual Report*, AICRP on Tuber Crops, Thiruvananthapuram, 2010a, 50.
6. Anonymous. *Annual Report*, AICRP on Tuber Crops, Thiruvananthapuram, 2010b, 51.
7. Anonymous. *Annual Report*, AICRP on Tuber Crops, Thiruvananthapuram, 2010c, 52.
8. Anonymous. www.nhb.gov.in, NHB Database, 2016.
9. Arriage JF, Lowery B. Soil physical properties and crop productivity of an eroded soil amended with cattle manure. J Soil Sci. 2003; 168:888-899.
10. George J, Mittra BN. Integrated nutrient management in sweet potato production. J Root Crop. 2001; 27(1):169-175.
11. Halavatau SM, Sullivan O, Asher CJ, Blamey FPC. Better nutrition for the improvement of sweet potato and taro yields in the south pacific. Trop. Agric. 1998; 75:6-12.
12. Isfahani MF, Besharati H. Effect of bio-fertilizers on yield and yield components of cucumber. J Biol. Earth Sci. 2012; 2(2):83-92.
13. Jackson ML. Soil Chemical Analysis, Prentice Hall of India Pvt., New Delhi, 1979.
14. Laxminarayana K. Impact of INM on soil quality, yield, proximate composition and nutrient uptake of sweet potato in Alfisols. J Root Crops. 2013; 39(1):48-55.
15. Nedunchezhiyan M, Reddy SD. Nitrogen management in sweet potato (*Ipomoea batatus* L.) under rainfed conditions. Indian J Agron. 2002; 47(3):449-454.
16. Nedunchezhiyan M, Srinivasalu Reddy D. Growth, yield and soil productivity as influenced by integrated nutrient management in rainfed sweet potato. J Root Crops. 2004; 30(1):41-45.
17. Padmaja G, Moorthy SN, Bala N, Lila Babu, Sundaresan S, Sanjeev MS *et al*. Analytical methodologies for tropical tuber crops, CTCRI, Trivandrum. 2005; 9-12:26-27.
18. Panwar S, Wani AM. Effect of organic production on growth and productivity of sweet potato under Poplar based agro-forestry system. Int. J Adv. Res. 2014; 2(12):229-232.
19. Rahul KY, Bijaya Devi AK, Sinam SD. The yield and economics of sweet potato cv. Sree Bhadra as influenced by the organic base plant nutrients. CTCRI Proceedings, 2011, 303-306.
20. Rangana SC. Manual of Analysis of Fruit and Vegetable Products. Tata McGraw Hill Publishing Company Limited, New Delhi, 1979, 105-118.
21. Ravindrababu M. Studies on integrated nutrient management with vermicompost and inorganic fertilizer in carrot. *Thesis*, *M.Sc.*, submitted to Acharya N. G. Ranga Agricultural Univeristy, Hyderabad, 1999.
22. Saad MS, Ali Sabuddin AS, Yunus AG, Zulkifli H. Effects of *Azospirillum* inoculation on sweet potato grown on sandy tin-tailing soil. Commun. Soil Sci. Plant Anal. 1999; 30(11-12):1583-1592.
23. Saikia J, Borah P. *Azospirillum* biofertilizer in sweet potato: growth, yield and economics. J Root Crops. 2007; 33(1):38-42.
24. Saravaiya SN, Chaudhary PP, Patel DA, Patel NB, Aahir MP, Patel VI. Influence of integrated nutrient management (INM) on growth and yield parameters of elephant foot yam under south Gujrat condition. The Asian J Hort. 2010; 5(1):58-60.
25. Singh SB, Singh AP, Kumar N. Bio-fertilizers: Natural cheap source of nutrients. Indian Farmers Digest, 2002, 53-56.
26. Suja G, Susan Jhon K, Sundaresan S. Potential of tannia (*Xanthosoma sagittifolium* L.) for organic production. J Root Crops. 2009; 35:36-40.
27. Thirumdasu R, Devi BAK, Thokchom M. Analysis of growth, physical aspects and yield of elephant foot yam, *Amorphophallus campanulatus* Roxb. Blume cv. Gajendra in spice intercropping system under sloppy foothills of Imphal East. Inter. J Farm Sci. 2015; 5(4):118-126.
28. Venkatesan K, Jansirani P, Kamalkumar R, Sujatha R.

Effect of organic management on the growth and yield of elephant foot yam. J Root Crops. 2013; 39(2):260-262.

29. Yourtchi MS, Hadi MHS, Darzi MT. Effect of nitrogen fertilizer and vermi-compost on vegetative growth, yield and NPK uptake by tuber of potato (Agria cv.). Inter. J Agri. Crop Sci. 2013; 18(5):2033-2040.