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Effect of bio-digested liquid manures on soil fertility, productivity and quality of onion (*Allium cepa* L.)

HS Latha, Sharanappa and MV Ravi

Abstract
Present investigation was conducted during 2010-11 and 2011-12 at Gandhi Krishi Vigyana Kendra, University of Agricultural Sciences, Bengaluru to study the effect of Bio-Digested Liquid Manures on Soil Fertility, Productivity and Quality of Onion (*Allium cepa* L.). Application of enriched biodigested liquid organic manure (EBDLM) at 25 kg N equivalent ha^{-1} + 3 sprays of panchagavya (PG) at 3 % produced significantly higher bulb yield (37.78 t ha^{-1}) and was found on par with that of EBDLM @ 125 kg N equi.ha^{-1} + VW spray @ 3 % (36.01 t ha^{-1}) and EBDLM @ 125 kg N equi.ha^{-1} (34.96 t ha^{-1}). The treatment receiving recommended FYM 30 t + 125:50:75 kg N:P_2O_5:K_2O ha^{-1} recorded the lowest bulb yield (25.59 t ha^{-1}) as compared to other treatments. The onion quality parameters like TSS, reducing, non-reducing and total sugar, protein, ascorbic and pyruvic acid content of onion bulb (16.93, 3.66, 8.66, 12.32 1.36 %, 25.27 mg 100^{-1} g & 12.82 µ moles g^{-1}, respectively) were significantly superior with EBDLM @ 125 kg N equi.ha^{-1} + PG spray @ 3 %. Further with respect to soil fertility significantly higher available nitrogen, phosphorus, potassium and sulphur (355.1, 78.3, 190.8 & 36.3 kg ha^{-1}, respectively) was noticed with T_6 as compared to other treatments and it was on par with T_5 (342.6, 75.3, 197.1 & 32.7 kg ha^{-1}, respectively) and T_4 (324.9, 72.1, 185.2 & 32.2 kg ha^{-1}, respectively).

Keywords: Onion, Biodigested liquid manure, Panchagavya, Vermiwash, uptake, protein yield, oil yield

Introduction
Onion (*Allium cepa* L.) is one of the major bulb crops of the world and one of the most important vegetables, as well as spice crops grown for commercial purpose. In the world, onion occupies an area of 3.97 m ha with a production of 75.97 m t with an average productivity is 19.1 t ha^{-1}. India (17.51 m t) stands second in global production after China (24.76 m t) occupying 1.09 m ha with a productivity of 16.10 t ha^{-1}. In Karnataka, it occupies an area of 1.77 lakh ha with a production of 24.51 lakh t and the average productivity is 13.83 t ha^{-1} (NHB, 2012) [2], which is lower compared to the world productivity. Large yellow and small rose red onions are grown in Karnataka for export purpose. The expertise and resources available with the farmer together with breakthrough in varietal improvement may be leveraged for organic onion production to compete in the organic onion export market. Better quality onion bulbs were obtained when FYM and biofertilizers were applied. This clearly indicates the need for organic inputs for better production of onion. It can explore the soil of nutrients. There is a possibility of substituting fertilizers by organic nutrient sources. Onion is the underground economic parts. The physico-chemical and biological properties of the soil determine the production potential. Keeping this in view, large quantity of organic manure is recommended for onion crop. But the use of organic manures has been continuously declining in Indian Agriculture due to several reasons. Decrease in cattle population in recent years and utilization of agricultural wastes into valuable by-products have made the availability of organic manure in agriculture questionable both in time and quantity. Non-availability of sufficient quantity of farmyard manures drawn the attention of researchers and cultivators to utilize the on-farm wastes, green biomass of *Glyricidia maculata, Pongamia pinnata etc*., and ubiquitous weeds *viz.,* parthenium, euphotorium, lantana, calatropis *etc*., for biodigested liquid manure production which can substitute the farmyard manure and compost.

Most of the research on onion was mainly concentrated on the use of FYM, compost, green manure, oil cakes *etc*. There is need to generate efficient organic manurial sources using on-farm available organic substrates in addition to integrated use of vermicompost, panchagavya, dashagavya, jeevamruta, beejambruta, vermiwash, mycorrhizae culture, neem cake/ neem seed extractants in organic farming. Further, there are evidences of enriched biodigested liquid manure use in enhancing the yields of fingermillet, onion, pigeonpea and soybean (Reddy *et al.,* 2011) [5]. There is a need to enhance nitrogen, phosphorus and potassium content of biodigested liquid manure by enriching with neem, pongamia, jatropa cake *etc.* and these enriched sources need to be evaluated for their effect on productivity of onion. Further, there is also need to evaluate the beneficial effects of cow urine, *panchagavya*, vermiwash in conjunction with enriched biodigested liquid manure. Hence the study on yield potential, nutrient uptake and quality as well as their economics is needed in onion on alfisols of southern India.

Material and Methods

A Field experiment on "Development of organic production techniques for groundnut-onion sequence cropping system" was conducted during 2010-11 and 2011-12 at Gandhi Krishi Vigyana Kendra, University of Agricultural Sciences, Bengaluru. The soil of the experimental site was sandy clay in texture and classified as Typic *Oxichaplustalf* having pH 5.6 and electrical conductivity 0.13 dS/m. The available nitrogen, phosphorus and potassium were 244.4, 21.9 and 128.3 kg/ha, respectively. The organic carbon content of the soil was 0.47 %. Total annual rainfall received during 2010 and 2011 was 549.7 and 613.5 mm, respectively. Six irrigations at 5 cm depth were provided during the dry spell of the cropping period. There were ten treatments comprising of three types of organic liquid manures *viz*. biodigested liquid manures (BDLM), enriched biodigested liquid manures (EBDLM) and cow urine (CU) along with foliar spays of 3% panchagavya (PG) and 3% vermiwash (VW) and recommended fertilizers for irrigated onion as detailed below T_1: BDLM @ 25 kg N equivalent ha^{-1}, T_2: BDLM @ 25 kg N equivalent ha^{-1} + VW spray @ 3 %, T_3: BDLM @ 25 kg N equivalent ha^{-1} + PG spray @ 3 %, T_4: EBDLM @ 25 kg N equivalent ha^{-1}, T_5: EBDLM @ 25 kg N equivalent ha^{-1} + VW spray @ 3 %, T_6:EBDLM @ 25 kg N equivalent ha^{-1} + PG spray @ 3 %, T_7: CU@ 25 kg N equivalent ha^{-1}, T_8: CU@ 25 kg N equivalent ha^{-1}+ VW spray @ 3 %, T_9: CU@ 25 kg N equivalent ha^{-1} + PG spray @ 3 %, T_{10}: Rec. FYM 30 t + 125:50:75 kg $N:P_2O_5:K_2O$ ha^{-1}. The treatments were laid out in randomized complete block design with three replications. The gross plot was 3.0 m x 3.3 m. The bio-digested liquid manure was prepared in a 200 litre cement tank by adding 15 kg cow dung, 20 litre cow urine, 30 kg of pongamia green biomass and 100 litre water by frequent stirring. The liquid manure was incubated for 45 days. Then it was enriched with 10% *Pongamia pinnata* cake, biodigested liquid manure contains 0.78, 0.21, 0.27, 0.08, 0.03 and 0.26% N, P, K, Ca, Mg and S, respectively. While, enriched biodigested liquid manure has 1.14, 0.27, 0.47, 0.14, 0.05 and 0.30 % N, P, K, Ca, Mg and S, respectively. The required quantity of liquid manures on nitrogen equivalent was applied to the soil at 20, 60 and 90 days after sowing of onion in the proportion of 33.3 per cent. Panchagavya was prepared by using five products of desi cow *viz*. cow urine, dung, milk, curd and ghee. Vermiwash was prepared by dipping adult earth worms in luke warm water. Three per cent panchagavya and vermiwash solutions were prepared by mixing 30 ml each panchagavya and vermiwash in 1000 ml of water separately. Three sprays of 3% panchagavya /vermiwash was foliar applied at 30, 60 and 75 days after sowing to onion as per treatments. Treatment 1 to 9 were supplied by recommended FYM and vermicompost at 50% each based on N equivalent and treatment T_{10} received FYM at 25 t ha^{-1} two weeks before sowing and recommended dose of fertilizer 125:50:75 kg $N:P_2O_5:K_2O$ ha^{-1} kg ha^{-1} for onion was incorporated in to the soil at the time of sowing. The nutrients were applied in the form of urea, single super phosphate and muriate of potash.

The onion cultivar Agrifound light red seeds of onion were sown with a recommended seed rate of 20 kg ha^{-1}. The furrows were opened at a row spacing of 20 cm and seeds were placed at 10 cm distance within the rows to a depth of 3 cm and later soil was covered. Sowing was done on November 15th 2010 and November 3rd 2011.Thrips and aphids were controlled by spraying 4 per cent neem seed kernel extract twice during crop growth period of onion.

The yield of onion crop was recorded at harvest. Further, TSS, reducing, non-reducing, total sugar, protein, ascorbic and pyruvic acid content of onion bulb and economics of onion were computed. The soil samples (0-15 cm depth) were collected at the end of onion crop and analyzed for organic carbon, available N, P, K and S by adopting standard methods.

Results and Discussion

Soil chemical fertility

Organic carbon content (SOC) and nutrient status increased in the soil over the years in onion cultivation. Significantly higher SOC, available nitrogen, phosphorus, potassium and sulphur (0.63 %, 355.1, 78.3, 190.8 and 36.3 kg ha^{-1}, respectively) was noticed with T_6 and it was followed by T_5 (0.61 %, 342.6, 75.3, 187.1 & 32.7 kg ha^{-1}, respectively) and T_4 (0.60 %, 324.9, 72.1, 185.2 and 32.2 kg ha^{-1}, respectively) (Table 4). Significantly higher SOC with T_6 was attributed to the contribution of carbon to soil through EBDLM. Rajnish and Subhash (2011) [4] observed that SOC was 13 per cent higher with organic nutrient management (0.91 %) than with synthetic fertilizer use (0.80 %). Further, significantly higher available nutrients with T_6 was attributed to slow release of nitrogen from organics might have reduced the N loss from soil since organic carbon in the soil is higher than that from inorganic fertilizer application. High available soil phosphorus could be attributed to increased solubility of native P by means of organic acids produced during the course of decomposition. The increase in available potassium might be related to release of K from EBDLM and also to the solubilisation of mineral bound K or native K. Application of different bio-digested liquid organic manures significantly increased the soil available nutrients indicating their build up in treated soil. The increase in available nutrients may due to the effect of enrichment of bio-digested liquid manure with *pongamia* cake that was more pronounced in increasing the post-harvest soil available nutrients.

Yield and Bulb Quality

In general the productivity of onion was more in the second year (2011-12) than during first year (2010-11) but response to different treatments was similar in both the years of experimentation hence, pooled data is discussed. On an average application of EBDLM at 125 kg N equivalent ha^{-1} + 3 sprays of PG at 3 % produced significantly higher total dry matter production and bulb yield of onion (7.95 and 37.78 t

ha$^{-1,}$ respectively) followed by EBDLM at 125 kg N equivalent ha^{-1} + 3 sprays of VW at 3 % (7.52 and 36.01 t ha^{-1}, respectively) and EBDLM at 125 kg N equivalent ha^{-1} (6.78 and 34.96 t ha^{-1}, respectively) than all other treatments. Significantly lower total dry matter production and bulb yield of onion (3.29 and 25.59 t ha^{-1}, respectively) was observed with recommended practice (Table 1). The increase in yield in BDLM and EBDLM along with three sprays of panchagavya and vermiwash at 3 per cent may be due to biodigested liquid manures and its enrichment with *pongamia* cake which contributed secondary and micronutrients along with major nutrients besides improving the soil condition, which enhanced the root proliferation and source to sink relationship. Foliar application of panchagavya and vermiwash readily supplied nutrients and growth hormones *viz.* IAA and GA present in panchagavya might have stimulated the production of growth regulators in cell system (Somasundaram, 2003) [6]. The significant effect of panchagavya was mainly attributed to its nutrient content, higher biological activity and presence of plant growth promoting substances, which was confirmed by Hazarika *et al.* (2006) [1].

The onion quality parameters like TSS, reducing, non-reducing and total sugar, protein, ascorbic and pyruvic acid content of onion bulb (16.93, 3.66, 8.66, 12.32 1.36 %, 25.27 mg 100-1 g & 12.82 µ moles g^{-1}, respectively) were significantly superior with EBDLM @ 125 kg N equi.ha^{-1} + PG spray @ 3 % (Table 2 & 3). This may be attributed to higher and balanced nutrition including micronutrients in enriched biodigested liquid manure; the results are in conformity with the findings of Naveen Kumar (2009) [3].

Table 1: Dry matter accumulation in leaves per plant at different growth stages of onion as influenced by different liquid organic manures

	Dry matter accumulation in leaves (g plant^{-1})			Dry matter accumulation in bulbs (g plant^{-1})			Total dry matter accumulation per plant (g plant^{-1})			Bulb yield (t ha^{-1})		
Treatments	**2010**	**2011**	**Pooled**	**2010**	**2011**	**Pooled**	**2010**	**2011**	**Pooled**	**2010**	**2011**	**Pooled**
T_1	1.20	1.25	1.22	4.09	4.2	4.15	5.29	5.45	5.37	30.17	30.77	30.47
T_2	1.32	1.37	1.34	4.1	4.26	4.18	5.42	5.63	5.52	32.31	32.95	32.63
T_3	1.36	1.42	1.39	4.38	4.55	4.46	5.74	5.97	5.85	32.67	33.32	32.99
T_4	1.43	1.49	1.46	5.22	5.43	5.32	6.65	6.92	6.78	34.62	35.31	34.96
T_5	1.54	1.60	1.57	5.83	6.07	5.95	7.37	7.67	7.52	35.67	36.35	36.01
T_6	1.65	1.72	1.68	6.15	6.4	6.27	7.80	8.12	7.95	36.91	38.65	37.78
T_7	1.01	1.05	1.03	2.88	3	2.94	3.89	4.05	3.97	26.33	26.86	26.60
T_8	1.06	1.10	1.08	3.2	3.33	3.26	4.26	4.43	4.34	28.83	29.41	29.12
T_9	1.11	1.15	1.13	3.82	3.97	3.89	4.93	5.12	5.02	30.00	30.60	30.30
T_{10}	0.90	0.87	0.88	2.36	2.45	2.41	3.26	3.32	3.29	25.33	25.84	25.59
S. Em±	0.07	0.08	0.06	0.29	0.3	0.21	0.29	0.29	0.21	2.16	2.25	1.56
C. D. at 5 %	0.22	0.24	0.16	0.86	0.9	0.64	0.85	0.88	0.59	6.41	6.67	4.46

Table 2: Total soluble solids, reducing sugar, Non-reducing sugar and total sugar of onion at harvest as influenced by different liquid organic manures

Treatments	TSS (%)			Reducing sugar (%)			Non-reducing sugar (%)			Total sugar (%)		
	2010	**2011**	**Pooled**	**2010**	**2011**	**Pooled**	**2010**	**2011**	**Pooled**	**2010**	**2011**	**Pooled**
T_1	14.85	15.29	15.07	3.55	3.47	3.51	8.11	7.99	8.05	11.66	11.46	11.56
T_2	14.87	15.31	15.09	3.53	3.53	3.53	8.05	8.07	8.06	11.58	11.6	11.59
T_3	15.00	15.45	15.23	3.58	3.53	3.55	8.13	8.02	8.07	11.71	11.55	11.62
T_4	15.19	15.65	15.42	3.63	3.63	3.63	8.32	8.18	8.25	11.95	11.81	11.88
T_5	15.54	16.01	15.78	3.64	3.63	3.64	8.57	8.52	8.55	12.21	12.15	12.19
T_6	16.68	17.18	16.93	3.65	3.67	3.66	8.59	8.74	8.66	12.24	12.41	12.32
T_7	12.70	12.75	12.72	3.36	3.29	3.32	7.37	7.25	7.31	10.73	10.54	10.63
T_8	13.75	14.16	13.96	3.46	3.48	3.47	7.92	7.79	7.85	11.38	11.27	11.32
T_9	14.17	14.59	14.38	3.45	3.47	3.46	8.09	7.96	8.02	11.54	11.43	11.48
T_{10}	12.34	12.38	12.36	3.19	3.16	3.18	6.99	6.89	6.94	11.66	11.46	11.54
S. Em±	0.79	0.88	0.64	0.08	0.10	0.07	0.30	0.30	0.21	0.27	0.35	0.22
C. D. at 5 %	2.34	2.62	1.88	0.23	0.29	0.19	0.88	0.89	0.61	0.79	1.04	0.63

Table 3: Protein, ascorbic and pyruvic acid content of onion after harvest as influenced by different liquid organic manures

Treatments	Protein (%)			Ascorbic acid (mg 100^{-1}g)			Pyruvic acid (µ moles g^{-1})		
	2010	**2011**	**Pooled**	**2010**	**2011**	**Pooled**	**2010**	**2011**	**Pooled**
T_1	1.30	1.26	1.28	22.76	23.89	23.33	12.29	12.41	12.35
T_2	1.30	1.30	1.30	23.22	24.71	23.96	12.30	12.42	12.36
T_3	1.30	1.31	1.31	23.52	24.70	24.11	12.33	12.46	12.40
T_4	1.31	1.32	1.31	23.68	24.87	24.28	12.37	12.50	12.44
T_5	1.33	1.35	1.34	24.11	25.32	24.71	12.41	12.53	12.47
T_6	1.35	1.38	1.36	24.65	25.89	25.27	12.77	12.86	12.82
T_7	1.20	1.22	1.21	22.62	23.75	23.19	11.31	11.42	11.37
T_8	1.23	1.25	1.24	22.74	23.88	23.31	12.25	12.37	12.31
T_9	1.26	1.27	1.26	22.75	23.89	23.32	12.27	12.39	12.33
T_{10}	1.22	1.23	1.22	20.33	21.02	20.68	11.27	11.38	11.32
S. Em±	0.08	0.08	0.06	0.56	0.51	0.66	0.30	0.27	0.16
C. D. at 5 %	NS	NS	NS	1.65	1.53	1.94	0.89	0.82	0.45

Table 4: Soil fertility status after harvest of onion as influenced by different liquid organic manures

Treatments	Organic carbon (%)			N (kg ha^{-1})			P_2O_5 (kg ha^{-1})			K_2O (kg ha^{-1})			S (kg ha^{-1})		
	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled	2010	2011	Pooled
T_1	0.55	0.56	0.56	302.6	317.3	309.9	66.4	72.1	69.2	152.5	174.0	163.3	28.1	30.8	29.4
T_2	0.56	0.59	0.57	304.4	321.4	312.9	66.9	72.8	69.8	164.6	183.9	174.3	29.3	32.4	30.9
T_3	0.56	0.60	0.58	304.4	323.6	314.0	66.9	74.2	70.5	167.0	187.3	177.1	29.8	32.9	31.3
T_4	0.57	0.62	0.60	313.7	336.1	324.9	68.7	75.8	72.1	174.3	196.1	185.2	30.6	33.9	32.2
T_5	0.60	0.62	0.61	326.7	358.5	342.6	71.7	79.0	75.3	175.4	198.9	187.1	31.0	34.4	32.7
T_6	0.62	0.64	0.63	343.8	366.5	355.1	74.4	82.2	78.3	178.3	203.2	190.8	34.3	38.2	36.3
T_7	0.48	0.52	0.50	261.7	287.0	274.4	57.5	61.6	59.5	147.4	162.9	155.1	26.7	29.5	28.1
T_8	0.51	0.51	0.51	276.6	294.0	285.3	60.7	65.5	63.0	149.4	165.6	157.5	27.5	30.1	28.8
T_9	0.51	0.53	0.52	280.3	298.5	289.4	61.4	66.6	64.1	150.4	169.1	159.7	27.9	30.5	29.2
T_{10}	0.48	0.50	0.49	261.7	275.0	268.4	57.5	61.4	59.5	149.3	162.2	155.8	22.5	24.5	23.5
S. Em±	0.03	0.03	0.01	13.9	16.8	10.88	1.2	2.0	1.14	7.0	5.6	4.54	1.7	2.1	1.32
C. D. at 5 %	0.09	0.10	0.04	41.2	48.1	31.19	3.5	5.8	3.28	20.9	25.5	13.50	5.0	6.1	4.05

Intial soil status: N=244.4 kg ha^{-1}; P_2O_5=50.86 kg ha^{-1}; K_2O= 154 kg ha^{-1}

Economics

Economic analysis is one of the major criteria for evaluating efficient and economically viable nutrient management practices. In the present study, comparative economics of production of organic onion indicated that gross return per hectare could be improved to a significant extent (Table 5). Higher discounted gross returns (Rs. 7,85, 713 ha^{-1}) were obtained with application of EBDLM @ 125 kg N equivalent ha^{-1} + PG spray @ 3 % which was followed by application of EBDLM @ 125 kg N equivalent ha^{-1} + VW spray @ 3 % (Rs. 7,49,390 ha^{-1}) and EBDLM @ 125 kg N equivalent ha^{-1} (Rs. 7,27,628 ha^{-1}). The higher discounted net returns and maximum B:C ratio (Rs. 605546 ha^{-1} and 4.36, respectively) were recorded with application of EBDLM @ 125 kg N equivalent ha^{-1} + PG spray @ 3 % followed by EBDLM @ 125 kg N equivalent ha^{-1} + VW spray @ 3 % (Rs. 573504 ha^{-1} and 4.26, respectively) and EBDLM @ 125 kg N equivalent ha^{-1} (Rs. 554551 ha^{-1} and 4.20, respectively). This was attributed to bulb yield of onion with these treatments. The higher B: C ratio might be due to higher net returns. Similar results of higher gross return and net return were obtained with application of Panchagavya by Yadav and Lourduraj (2006) [8] in rice and Somasundaram (2003) [6] in green gram.

It can be concluded from the study that the application of enriched liquid organic manure at equivalent to 100 per cent recommended dose of nitrogen with foliar spray of panchagavya or vermiwash at 3% on 30, 60 and 75 DAS is the best option for higher productivity of onion, beside improving protein, ascorbic acid and pyruvic acid as well as soil fertility, total nutrient uptake and also higher economic returns.

Table 5: Economics of onion as influenced by different liquid organic manures

Treatments	Cost of Cultivation (Rs. ha^{-1})			Gross Returns (Rs. ha^{-1})			Net Returns (Rs.ha^{-1})			B:C Ratio
	2010	2011	Dis. CoC	2010	2011	Dis.GR	2010	2011	Dis.NR	
T_1	93459	94239	162796	362040	369240	634087	268581	275001	471291	3.89
T_2	96501	97333	168116	387720	395400	679038	291219	298067	510921	4.04
T_3	97169	98014	169286	392040	399840	686632	294871	301826	517346	4.06
T_4	99329	100226	173077	415440	423720	727628	316111	323494	554551	4.20
T_5	100954	101838	175885	428040	436200	749390	327086	334362	573504	4.26
T_6	102766	105028	180167	442920	463800	785713	340154	358772	605546	4.36
T_7	90070	90759	156841	315960	322320	553444	225890	231561	396603	3.53
T_8	93580	94334	162984	345960	352920	605990	252380	258586	443005	3.72
T_9	95301	96081	165992	360000	367200	630547	264699	271119	464556	3.80
T_{10}	94938	95601	165265	303960	310080	532426	209022	214479	367161	3.22

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