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Effect of Marigold Organic Liquid Manure for Production of Field Bean (*Lablab purpureus*)

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A B S T R A C T

Marigold organic liquid manure (MOLM) obtained during the processing of marigold flowers was tested in the field with field bean as test crop. Total seven treatments comprising of MOLM mixing with borewell water at different ratios (100:0, 75:25, 50:50 and 25:75 of MOLM: Borewell water) which was compared with the recommended organic liquid manure sources for crop production such as *Jeevamrutha* @ 2000 L ha^{-1} and Biodigester liquid @ 3000 L ha^{-1}. The total quantity of water required to attain the field capacity of soil was estimated and same quantity has been applied to each plot as one time soil application to soil fifteen days before sowing. The results revealed that treatment with MOLM and Borewell water in the ratio of 50: 50 was superior compared to all other treatments with respect to growth and yield parameters throughout the crop growth period. The pod yield was recorded maximum in the 50:50 treatment (10.37 q ha^{-1}) compared to control (5.34 q ha^{-1}). The total microbial count found higher in the post-harvest soils with application of MLOM and found maximum when MOLM applied with borewell water in the ratio of 75:25. The soil fertility with respective to macro and micronutrients content in the soil was also enhanced with application of MOLM. Hence, the MOLM water can be used safely for the crop production as one time application to soil 15 days before sowing mixing with borewell water in the ratio of 50:50.

Introduction

Field crops require enormous amount of fertilizers. However, the environmental pollution caused by excessive use of chemical fertilizers has led to considerable changes in soil leading to environmental degradation. Hence, it is advisable to supply required nutrients to the crops through organic source. One such product is from marigold processing industries. Marigold flowers are used for the extraction of oleoresin which is a colouring agent and used as a nutraceutical in food and pharmaceutical industry to cure many diseases mainly the retina problem. Marigold contains about 90% moisture. In these industries, fresh

marigold flowers are being collected from the farmers and are being dumped in the initial storage tank, where due to natural pressing and fermentation about 10% of the water comes out. In the second stage, these flowers are passed through a shredding and pressing unit, wherein about 30% of water is removed. Finally, it is passed through the dryer to bring down the moisture content to 10% to make pellets. During this entire process about 40% water drains out and it is collected in a storage tank. Omnikan Earth Science, Pvt. Ltd. is one such marigold processing industry located at Hassan, Karnatka, In India, it is estimated that about 10,000 – 15,000 tonnes of marigold is processed per year from such industries and approximately about 4 to 6 Lakh litres of liquid comes out every year. This drained water is a good source of nutrients can be used as organic liquid manure for crop production. Hence, an attempt has been made to study the effect of waste water generated from marigold flower processing industry (generally called as Marigold Organic Liquid Manure -MOLM) on growth and yield of field bean as it is one of the major pulse crop grown in Karnataka and in particular Hassan District.

Materials and Methods

A representative liquid sample of marigold organic liquid manure (MOLM) was collected from the OMNIKAN Marigold flower processing unit located at Hassan, Karnataka State. The sample was characterised for physical and biochemical properties viz., colour, turbidity, pH, Total Suspended Matter, Dissolved Oxygen, Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD) following standard procedures as out lined by KSPCB (Kavitha *et al.,* 2012). It was also characterized for nutrient content such as total Nitrogen, Phosphorous and Potassium. A field experiment was conducted at College of Agriculture, Hassan to evaluate the Marigold Organic Liquid Manure (MOLM) as organic nutrient source using field bean as test crop. The field bean variety used was HA- 4 (Hebbal Avare - 4), developed by UAS, Bangalore. It is a short duration variety of about 90 days. It has synchronized flowering and pod setting with photo thermo insensitive. Hence, it can be grown throughout the year. Pods are half moon shaped with small seeds, good aroma and taste. It can be used for both green vegetable and dal. The experiment was laid out using Completely Randomized Block Design (RCBD) with three replications and seven treatments. The size of the plots was 3.6 m X 3.0 m (10.8 $m^{2)}$ with 45 x 10 cm spacing. The treatment includes onetime application of MOLM mixing with borewell water at different ratios to the soil fifteen days before sowing. Before imposing the treatments the field capacity of the soil was determined by field method. Based on field capacity of the soil (12%) the total quantity of water to be applied to each plot was estimated (2.32 lakh liters per hectare or 250 lts/ plot to attain the field capacity). The treatment details are as follows

T1: 100 % BWW (Control)
T2: MOLM: BWW @ 100:0 (250: 0 L)
T3- MOLM: BWW @ 75: 25 (187.5: 62.5 L)
T4: MOLM: BWW @ 50: 50 (125: 125 L)
T5- MOLM: BWW @ 25: 75 (62.5: 187.5 L)
T6- Jeevamrutha @ 2000 L ha^{-1} (2.16 L $plot^{-1}$)
T7- Biodigester liquid @ 3000 L ha^{-1} (3.24 L $plot^{-1}$)

(Note: BWW: Bore Well Water; MOLM: Marigold organic liquid manure)

Plots were prepared by raising the bunds and treatments were imposed 15 days before sowing by flooding the plots with calculated quantities of MOLM mixing with BWW. After fifteen days seeds were dibbled in rows by opening furrows with spacing of 30 cm x 60 cm. All the agronomical practices were carried out as per the recommendation. Growth observations like germination per

cent, plant height, Number of leaves and yield and yield parameters like Number of recems/ plant, Number of pods/ recemes, Number of seeds per pod, Pod yield/ plant, Pod yield/ hectare and test weight (100 seeds) were recorded following standard methods. Growth parameters were recorded at 30 days intervals.

The soil samples were collected at 30, 60 days after sowing and at harvest and were subjected to total microbial load and chemical analysis. Total microbial load was enumerated by using serial dilution plate technique. The technique is based on the principle that complete detachment and dispersion of cells from the effluent will give rise to discrete colonies when incubated on a petri plate containing nutrient media. The soil chemical analysis such as pH, EC, Organic Carbon, available N, P and K and DTPA extractable micronutrients were done using standard protocols as outlined by Jackson, 1973.

Results and Discussion

Characterization of Marigold organic liquid manure (MOLM)

The biochemical properties of both raw and anaerobic treated MOLM are presented in Table 1. The pH of raw MOLM was found acidic (3.60) which has increased to 7.45 after anaerobic treatment. The acidic pH of raw MOLM is due to production of organic acids during fermentation by the lactobacillus and other organisms. The pH has raised to desire level due to addition of caustic soda (NaOH) during anaerobic treatment. The soluble salts content both in treated and raw MOLM was found to be higher (5.9 and 4.1 dS m^{-1}, respectively). Slight increase in soluble salts content in treated effluent compared to raw effluent is due to addition of caustic soda and Alum during treatment. Hence, dilution is must before application to soil. The carbonates and bicarbonates were found absent in raw MOLM due to acidic pH. However, 46.56 me L^{-1} of bicarbonates was found in treated MOLM due to increase in pH. Sodium content in treated MOLM was found higher compared to raw MOLM which is due to addition of caustic soda during anaerobic treatment. This has increased slightly the Sodium Adsorption Ratio (SAR) of treated MOLM (0.138) compared to raw MOLM (0.015). However, SAR in both raw and treated MOLM were found low indicating low alkali hazards to soil when used for irrigation purpose.

The treated MOLM was having appreciable quantity of major nutrients (0.065 % N, 35 mg L^{-1} P and 1612 mg L^{-1} K). The higher potassium content in treated MOLM compared to raw is due to addition of alum [$KAl(SO_4)_2.12H_2O$] during primary sedimentation treatment. Lower P content was recorded in treated compared to raw MOLM. This may be due precipitation of P as Aluminum Phosphate. The micronutrients content viz., Fe, Mn, Cu and Zn in the treated and raw MOLM were also found appreciable quantity.

Field experiment

A field experiment was conducted to know the effect of Marigold organic liquid manure (MOLM) generated by Omnikan Pvt. Ltd. during the processing of Marigold flowers on the growth of Field bean and on soil properties and the results are as follows.

Effect on growth parameters

The height of the field bean and number of leaves per plant at 30 Days After Sowing (DAS) was lowest in the plots where only borewell water was given for irrigation (Table 2). Significantly higher plant height and number of leaves per plant were observed in the plots irrigated with MOLM and borewell water in the ratio of 50:50. The same trend

was observed at 60 DAS and at harvest. During the harvesting stage there was a drastic reduction in number of leaves in all the treatments due to withering effect. At harvest, the number of leaves pre plant was 4.89 in the treatment with MOLM and BW water applied in the ratio of 50:50 and in the control plot it was 2.67 numbers.

Effect on yield and yield parameters

Application of MOLM to the field bean 15 days before sowing as a source of organic liquid manure significantly influenced the yield and yield parameters. The data are presented in Table 3. The number of recemes per plant and number of pods per recemes were recorded more in the treatment T4 (6.17 and 29, respectively), where MOLM and BW water applied in the ratio of 50:50 compared to all other treatments. The lowest recemes per plant was observed in plots treated with MOLM and BW water in the ratio of 25:75. The number of seeds per pod was almost similar in all the treatments. However, the higher seeds per pod was observed in treatment T4 (3.89 seeds/ pod) and lower in control (3.56 seeds/pod).

The yield per plot was significantly highest in the treatment T4 where the plots were irrigated with MOLM and borewell water in the ratio of 50:50 (1.62 kg plot^{-1}) and it was on par with the treatment received MOLM and BW water in the ratio of 75:25 (1.57 kg plot^{-1}). The lowest yield per plot was observed in the control plots (0.89 kg/ plot). Similarly, significantly higher pod yield per hectare was obtained in treatment with MOLM and borewell water in the ratio of 50:50 (1037 kg ha^{-1}) and the lowest yield per hectare was in control, where only borewell water was given (534 kg ha^{-1}). The higher pod yield in MOLM treatments may be due to better growth parameters, viz., plant height and number of leaves, this growth parameters in turn increased the rate of photosynthesis, inturn resulted in higher yield parameters, viz., number of recemes per plant, number of pods per recemes, number of pods per plant, number of seeds per pod and test weight. Which in turn contributed for 51.49% additional yield when compared with application of 100% borewell water alone. Further, this yield resulted in obtaining higher net returns (Rs 50669 ha^{-1}) with additional cost of cultivation of Rs 1250 ha^{-1} as compared to 100 % bore well water treatment. This accounts to a saving of inorganic fertilizers besides improving the environment as MOLM water is eco friendly organic liquid. These results are in agreement with the findings of Savitha and Srinivasamurthy (2015) in tomato with the application of diluted distillery spent wash which recorded higher yield. Similarly higher growth and yield parameters were reported in wheat treated with distillery effluent (Jolley *et al*., 2012); in maize and wheat due to application of paper mill effluent (Chhonkar *et al.,* 2000) and in rice and wheat treated with dyeing industry effluent (Pattak *et al.,* 1999). Similar results were also obtained by Asha (2016) in different crops by treating with organic liquid manure.

Effect on microbial population

Total microbial population present in the in the soil before and after imposing the treatment (30 and 60 DAS) was analyzed and presented in Table 4. Since, the soil in the experimental plot was uniform there was no much difference in bacterial and fungal populations before imposing the treatments. At 30 days after sowing, the maximum bacterial population was observed in T3, where MOLM and BWW water (75:25) was given (39.90 x 10^6 cfu/100 g of soil) and it was on par with T4, where MOLM and BWW water (50:50) was given (39 x 10^6 cfu/ 100g of soil). The lowest was observed in the T_1

control, where only BWW (100%) water was given (23 x 10^6 cfu/100 g of soil). The same trend was observed in fungal population in all the treatments. The same trend was observed at 60 Days after sowing.

The increase in population in soil after imposing treatment is mainly because the MOLM is purely organic source and it contains diverse microbial population, this may added to the soil microbial population. Another important aspect here is, when MOLM was given by diluting it with borewel water in the ratio of 50:50 and 75:25, the microbial load has been increased in rhizosphere. This is due to roots exudates that will help in increasing microbial population. These microbial inoculants not only promote plant growth but also control the diseases efficiently (Umashankar *et al.,* 2011; Umashankar *et al.,* 2010), this is indirectly increasing growth of the plant. Many rhizosphere bacteria that enhance plant growth can also act as a biocontrol agent against pathogen by controlling deleterious microorganisms (Muthuraju *et al.,* 2006), the same trend was also observed by Pakale and Alagawadi, 1993 and Prathiba *et al.,* 1994.

Effect on Soil Biochemical properties and Nutrient status

The effect of one time application of marigold organic liquid manure on soil biochemical properties and nutrient status are presented in Table 5, 6 and 7.

Soil pH

There is no significant effect of MOLM on soil pH at 30 and 60 days after sowing of field bean but significant variation was observed at harvest. At harvest a significant increase in soil pH was observed due application of biodegester liquid and Jeevmbruth compared to control. Highest was recorded in T6 and lowest was recorded in T4 treatment. Pathak *et al.,* (1999) also observed that there was no change in pH of soil after harvest of wheat and rice due to application of distillery effluent.

Electrical conductivity

Significant variation in soil electrical conductivity was observed at 30 and 60 days after sowing of field bean but non significant was observed at harvest. Highest EC was recorded in treatment receiving MOLM @ 100 % (0.32 and 0.2 dS m^{-1}, respectively at 30 and 60 DAS) and lowest was recorded in T7 treatment with Jeevambrutha. With increase in dosage of MOLM the EC of soil also increased but present within the permissible limit. This may be due to higher salt content in MOLM water. Similarly, Pathak *et al.,* (1999) reported that the EC of soil increased when distillery effluent was used for rice and wheat cultivation.

Organic carbon

There was no significant variation in soil organic carbon content due to application of MOLM. There is no much addition of organic materials through MOLM as the content of organic carbon is very negligible in the MOLM.

Available Nitrogen

Significant variation in available nitrogen content in soil was observed due to application of MOLM in all growth stages of filed bean. Highest available nitrogen content was recorded in T2 treatment with MOLM @ 100 % (302.27, 245.86 and 252.96 kg ha^{-1}, at 30, 60 DAS and at harvest, respectively) followed by T4 which was significantly higher than control and T6 and T7 treatments. Higher content in available nitrogen in MOLM treated plots compared to control may be due to presence of high amounts of immediately

plant available N, in the form of NH_4^+ in the MOLM water as it is shown in Table 1. Similarly, Bechini and Marino (2009) and Sorensen (2004) found higher levels of immediately plant available NH_4-N content in the Liquid Cattle Manure which ranged from 33 to 55 % and 50 to 60 % of the total N, respectively.

Table.1 Characterization of Marigold Organic Liquid Manure (MOLM) generated during process of marigold flowers before and after treatment

Sl. No.	Parameters	Marigold organic liquid manure (MOLM)	
		Untreated	After Anaerobic treatment
1.	pH	3.6	7.45
2.	Electrical Conductivity (dS m^{-1})	5.9	6.4
3.	Na (me L^{-1})	0.09	0.451
4.	Ca + Mg (me L^{-1})	70.0	21.2
5.	Carbonates (me L^{-1})	Absent	Absent
6.	Bicarbonates (me L^{-1})	Absent	46.56
7.	SAR (Sodium Adsorption Ratio)	0.015	0.138
8.	Nitrogen (%)	0.033	0.065
9.	Phosphorous (mg L^{-1})	68	35
10.	Potassium (mg L^{-1})	896	1612
11.	Zn (mg L^{-1})	1.89	0.044
12.	Cu (mg L^{-1})	0.268	0.037
13.	Mn (mg L^{-1})	2.068	0.029
14.	Fe (mg L^{-1})	10.10	0.296
15	*Chemical Oxygen Demand (mg L^{-1})	37600	196
16	*Biological Oxygen Demand 3 Days @ 27^o C (mg L^{-1})	25588	45

*Source: Analysed at Karnataka State Pollution Board, Hassan

Table.2 Effect of marigold flower pressed juice on the plant height and number of leaves per plant of field bean

Treatments	Plant Height (cm)			Number of leaves $plant^{-1}$		
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
T1:100%BWW (Control)	22.73	58.22	63.67	11.97	11.05	2.67
T2: MOLM:BWW @ 100:0	28.93	79.78	79.89	14.10	14.39	3.78
T3- MOLM:BWW @ 75 : 25	32.33	85.22	84.67	15.63	17.58	4.89
T4: MOLM:BWW @ 50 : 50	32.20	80.56	83.00	14.97	15.15	3.89
T5: MOLM:BWW @ 25 : 75	28.77	73.67	70.67	12.30	11.81	3.33
T6: Jeevamrutha@ 2000 L ha^{-1}	23.93	74.55	77.56	13.50	12.47	3.55
T7: Biodigester liquid @ 3000 L ha^{-1}	23.30	61.56	66.22	12.10	11.52	3.20
SEm±	1.73	4.24	4.98	0.85	0.37	0.70
CD (p=0.05)	5.26	12.86	15.09	2.58	1.12	2.13

BWW- Borewell water; MOLM - Marigold organic liquid manure

Table.3 Effect of marigold organic liquid manure on yield and yield parameters of field bean

Treatments	No. of recemes/ plant	No. of pods per recemes	No. of seeds per pod	Yield per plot	Yield per ha (kg)	Test weight (100 seed weight (g))
T1:100% BWW (Control)	5.09	19.67	3.56	0.89	534	18.80
T2: MOLM:BWW @ 100:0	5.19	26.00	3.89	1.54	975	19.81
T3- MOLM:BWW @ 75 : 25	5.50	28.33	3.89	1.57	1004	19.88
T4: MOLM:BWW @ 50 : 50	6.17	29.00	3.89	1.62	1037	19.95
T5: MOLM:BWW @ 25 : 75	3.63	20.33	3.56	1.20	715	18.55
T6: Jeevamrutha@ 2000 L ha^{-1}	5.17	26.00	3.89	1.51	953	19.36
T7: Biodigester liquid @ 3000 L ha^{-1}	4.50	23.33	3.89	1.10	642	18.81
SEm±	0.32	1.02	0.10	0.07	056	0.22
CD (p=0.05)	0.96	3.08	0.30	0.22	170	0.67

BWW- Borewell water; MOLM - Marigold organic liquid manure

Table.4 Effect of marigold organic liquid manure on the bacteria (Cfu x 106/ 100 g of soil) and Fungus (Cfu x 104/ 100 g of soil) populations in the soil

Treatments	Before Imposing Treatments		30 DAS		60 DAS	
	Bacteria	Fungus	Bacteria	Fungus	Bacteria	Fungus
T1:100% BWW (Control)	15.67	4.43	23.00	10.57	33.87	14.00
T2: MOLM:BWW @ 100:0	16.33	5.13	35.57	13.23	38.80	14.90
T3- MOLM:BWW @ 75:25	15.43	5.77	39.90	21.23	43.77	21.90
T4: MOLM:BWW @ 50:50	16.23	5.77	39.00	19.33	44.00	21.00
T5: MOLM:BWW @ 25:75	16.10	6.13	34.90	17.00	39.90	19.77
T6: Jeevamrutha@ 2000 L ha^{-1}	16.23	5.63	28.43	16.10	38.57	20.90
T7: Biodigester liquid @ 3000 L ha^{-1}	15.13	6.20	30.23	16.33	36.23	19.10
SEm±	0.30	0.43	0.81	0.66	1.09	0.68
CD (p=0.05)	NS	NS	2.45	2.01	3.31	2.06

BWW- Borewell water; MOLM - Marigold organic liquid manure; Cfu- Colony forming units

Table.5 Effect of marigold organic liquid manure on soil pH, EC and per cent organic carbon content at different growth period of filed bean

Treatments	pH			EC (dSm-1)			OC (%)		
	30 DAS	60 DAS	At Harvest	30 DAS	60 DAS	At Harvest	30 DAS	60 DAS	At Harvest
T1:100% BWW (Control)	7.52	7.49	7.27	0.15	0.13	0.15	0.62	0.64	0.63
T2: MOLM:BWW @ 100:0	7.50	7.15	7.36	0.32	0.28	0.19	0.63	0.68	0.71
T3- MOLM:BWW @ 75 : 25	7.28	7.16	7.23	0.24	0.25	0.19	0.62	0.68	0.72
T4: MOLM:BWW @ 50 : 50	7.28	7.26	7.19	0.22	0.23	0.18	0.66	0.72	0.66
T5: MOLM:BWW @ 25 : 75	7.37	7.36	7.20	0.19	0.19	0.17	0.67	0.68	0.68
T6: Jeevamrutha@ 2000 L ha^{-1}	7.62	7.63	7.50	0.15	0.13	0.13	0.61	0.66	0.63
T7: Biodigester liquid @ 3000 L ha^{-1}	7.62	7.55	7.44	0.13	0.13	0.14	0.61	0.63	0.63
SEm±	0.12	0.15	0.05	0.01	0.02	0.02	0.02	0.02	0.02
CD (p=0.05)	NS	NS	0.16	0.04	0.05	NS	NS	NS	NS

BWW- Borewell water; MOLM - Marigold organic liquid manure

Table.6 Effect of marigold organic liquid manure on available NPK content in soil (kg ha^{-1}) at different growth period of filed bean

Treatments	N			P			K		
	30 DAS	60 DAS	At Harvest	30 DAS	60 DAS	At Harvest	30 DAS	60 DAS	At Harvest
T1:100% BWW (Control)	211.67	219.69	223.42	42.74	25.64	42.74	364.97	347.70	399.07
T2: MOLM:BWW @ 100:0	302.27	245.86	252.96	172.00	128.17	136.75	945.20	963.10	758.20
T3- MOLM:BWW @ 75 : 25	273.02	227.56	242.93	136.73	111.07	107.17	874.77	835.07	663.63
T4: MOLM:BWW @ 50 : 50	225.41	225.55	237.99	128.18	102.55	95.88	624.30	748.23	622.80
T5: MOLM:BWW @ 25 : 75	213.13	207.89	225.95	85.45	68.36	85.43	551.97	648.30	550.23
T6: Jeevamrutha@ 2000 L ha^{-1}	200.26	217.52	223.14	42.74	34.19	54.19	375.97	373.10	444.00
T7: Biodigester liquid @ 3000 L ha^{-1}	196.65	240.80	236.79	34.52	34.19	46.07	344.97	350.60	377.83
SEm±	14.29	6.80	3.36	10.23	10.47	10.97	25.06	32.90	30.24
CD (p=0.05)	44.02	20.94	10.35	31.54	32.25	33.81	77.22	101.37	93.17

BWW- Borewell water; MOLM - Marigold organic liquid manure

Table.7 Effect of marigold organic liquid manure on DTPA extractable micronutrient content in soil (mg kg-1) at different growth period of filed bean

Treatments	Zn			Fe			Cu			Mn		
	30 DAS	60 DAS	At Harvest	30 DAS	60 DAS	At Harvest	30 DAS	60 DAS	At Harvest	30 DAS	60 DAS	At Harvest
T1:100% BWW (Control)	1.29	1.05	0.90	5.23	5.13	6.80	0.86	0.89	0.90	14.16	9.90	8.89
T2: MOLM:BWW @ 100:0	1.57	1.38	1.32	9.56	10.76	10.50	0.96	0.97	0.97	32.54	26.28	23.75
T3- MOLM:BWW @ 75 : 25	1.38	3.05	1.16	8.42	8.29	9.31	0.91	1.00	0.91	25.18	21.39	19.83
T4: MOLM:BWW @ 50 : 50	1.28	1.22	1.08	7.31	7.93	8.21	0.89	0.99	0.90	19.88	19.05	17.71
T5: MOLM:BWW @ 25 : 75	1.35	1.08	1.15	6.12	6.29	7.53	0.87	0.91	0.96	17.07	14.68	12.86
T6: Jeevamrutha@ 2000 L ha^{-1}	1.03	2.07	0.78	4.87	4.82	5.75	0.83	0.84	0.84	14.96	13.97	12.86
T7: Biodigester liquid @ 3000 L ha^{-1}	2.11	0.78	0.79	3.70	5.44	5.16	0.70	0.81	0.80	11.45	10.22	8.01
SEm±	0.52	0.85	0.06	0.65	0.45	0.37	0.06	0.03	0.05	5.20	4.37	3.71
CD (p=0.05)	NS	NS	0.18	1.99	1.39	1.14	NS	0.10	NS	NS	NS	NS

BWW- Borewell water; MOLM - Marigold organic liquid manure

Available phosphorus

Significant variation in available P content in soil was observed due to application of MOLM in all growth stages of filed bean. Highest available P content was recorded in T2 treatment with MOLM @ 100 % (172, 12.17 and 136.75 kg ha^{-1}, at 30, 60 DAS and at harvest, respectively) followed by T3 which is significantly higher than control and T6 and T7 treatments. Higher content in available P in MOLM treated plots compared to control may be due to higher P content in the MOLM. It may also due to higher mobility of P in soils treated with MOLM. Siddique and Robinson (2003) and Tarkalson and Leytem (2009) reported that P availability and mobility in Liquid Cattle Manure treated soils were higher than in soils treated with potassium di-hydrogen phosphate or mono-ammonium phosphate, respectively.

Available potassium

Significant variation in available K content in soil was observed due to application of marigold organic liquid manure in all growth stages of filed bean. Highest available K content was recorded in T2 treatment with MOLM @ 100 % (945, 963 and 758 kg ha^{-1}, at 30, 60 DAS and at harvest, respectively) followed by T3 which is significantly higher than control and T6 and T7 treatments. The potassium content in soil decreased with the

decrease dose of MOLM application. Higher content in available K in soils treated with MOLM compared to control which may be due to significant contribution from the MOLM.

Micronutrients

Apart from macronutrients, MOLM also contains micronutrients, essential for plant growth. Therefore, it can serve directly as a source of micronutrients, upon its use as basal dressing for crops, increasing micronutrients plant uptake and probably concentration (Brock *et al.*, 2006; Nikoli and Matsi, 2011). In addition, an indirect effect of MOLM on the availability of the soil native micronutrients cannot be excluded. Application of the MOLM to soil for a long period and/or at high rates can increase the soil organic matter especially the dissolved fraction (Antil *et al.,* 2005; Culley *et al.*, 1981; Nikoli and Matsi, 2011). Consequently, soil application of MOLM can enhance solubilization of metal micronutrients through their complexation with the dissolved organic matter and consequently increase availability to plants (Japenga *et al.*, 1992). The concentration of soil available micronutrients is likely to be increased after long-term repeated applications of MOLM (Brock *et al.*, 2006; Nikoli and Matsi, 2011). In the present study, though there was no significant variation in Zn content in soil due application of marigold liquid manure at 30 and 60 DAS of field bean but, significant variations were recorded at harvest. At harvest, highest being recorded in treatment T2 (1.32 mg kg^{-1}) followed by T3 (1.16 mg kg^{-1}) which is significantly higher than control. Significant variation in Fe content in soil was observed due application of marigold liquid manure throughout the crop growth stage of field bean. Highest iron content in soil was recorded in T2 followed by T3 which were significantly higher than control and T6 and T7 treatments. Higher content of iron in MOLM treated plots is due to higher iron content in MOLM. No significant variation in Cu and Mn content in soil was observed due application of marigold liquid manure. However, slightly higher content of Cu and Mn were observed in MOLM treated plots compared to control.

In conclusions, marigold organic liquid manure (MOLM) is a natural organic liquid manure and it can be used as good source of nutrients. In the present study, one time application of MOLM along with bore well water in the ratio of 50: 50 gave higher yield of field bean without deteriorating the soil biochemical properties and soil fertility status. Hence, it can be used for sustainable agricultural production.

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