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GENERAL ARTICLE

INTEGRATED NUTRIENT MANAGEMENT FOR SWEET ORANGE

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ABSTRACT

The experiment was conducted at Regional Agricultural Research Station (RARS), Jamalpur with the objectives to develop suitable and economic fertilizer dose for sweet orange cultivation through integrated nutrient management (INM) and to quantify the change of soil health due to addition of organic manure during 2016-2020.There were seven treatments viz. T_1: 100% RDCF, T_2: Cowdung 5 tha^{-1} + IPNS based inorganic fertilizer, T_3: Cowdung 10 tha^{-1} + IPNS based inorganic fertilizer, T^4: Poultry manure 3 tha^{-1}+IPNS based inorganic fertilizer, T_5: Poultry manure 5 tha^{-1} + IPNS based inorganic fertilizer, T_6: 125% RDCF and T_7: control. The tested variety was BARI Malta-1. The experiment was laid out in Randomized Complete Block design (RCBD) with 7 replications. Results revealed that, T_4 treatment (Poultry manure 3 tha^{-1} + IPNS based inorganic fertilizer produced highest average sweet orange yield (7.23 t ha^{-1}) and the lowest yield (1.85 t ha^{-1}) recorded in the T_7 comprises with control treatment. Soil organic carbon (SOC), total N, available P, K and S contents in post-harvest soil were also highest in T_4 treatment. The overall results indicate that T_4 treatment can help increase fruit yield of sweet orange and carbon accumulation in soil which in turns enriching soil organic matter.

KEYWORDS

Cowdung, poultry manure, inorganic fertilizer, sweet orange, yield and carbon accumulation.

1. INTRODUCTION

Malta or sweet orange *(Citrus sinensis L.)* is a nutritious and popular citrus fruit crops of the world, occupied third position among the sub-tropical fruits. It has a great nutritional role in our daily food requirements, being a rich source of vitamin C. Its popularity is very high due to its sweet and sour taste and pleasant flavor with vitamin C and minerals. In our climatic condition, Malta can easily be grown under the ago-economic edaphic condition of Bangladesh. The popularity and demand of Malta is increasing day by day but farmers do not use balance fertilizer for its cultivation, which cause serious nutritional disorders. Out of many factors, poor nutrient status of the soil as well as malnutrition is considered to be the major factors responsible for declining citrus yield.

Chemical fertilizers are mostly in use for their cultivation, which have some deleterious effects on fruit quality besides adverse effect on soil, water and environmental pollution. Increased chemical fertilizer cost and awareness of environmental pollution have necessitated the use of organic fertilizers for the development of more efficient fertility management program (Bhattarai and Tomar, 2009). Organic fertilizers are apparently environment and farmer friendly renewable source of bulky, low cost organic agricultural inputs for improving soil fertility status. Organic manures are fairly good source of nutrients which has direct influence on plant growth like other commercial fertilizers. A group researcher also reported that application of organic manures with NPK increased the leaf nutrient status of Khasi mandarin, which consequently increased the fruit size, weight and yield (Mukherjee et al., 1991; Prasad and Singhania, 1989). An integrated use of organic manures, biofertilizers and chemical fertilizers could help in achieving the goal of obtaining safer food and environment for the people. Keeping the above facts into consideration, an investigation on integrated nutrient management for sweet orange *(Citrus sinensis)* was carried out to identify the suitable integration of different sources of nutrients with respect to plant growth, yield, quality of sweet orange fruit and to restore soil health.

2. MATERIALS AND METHODS

The experiment on integrated nutrient management for sweet orange was conducted at Regional Agricultural Research Station (RARS), Jamalpur during the year since 2016. Malta variety BARI Malta-1 was used for the study. The initial soil samples of the experimental field were collected and analyzed following standard methods. Soil chemical properties have been presented in Table 1a. Nutrient composition of different organic manure has been presented in Table 1b.

Table 1a: Chemical properties of initial experimental soil at RARS, Jamalpur

Location	pH	OC (%)	OM (%)	Ca	Mg	K	Total N%	P	S	B	Cu	Fe	Mn	Zn
				meq $100g^{-1}$				µg g^{-1}						
RARS, Jamalpur	7.3	0.79	1.35	3.5	1.2	0.11	0.012	5.1	15	0.28	1.4	20	1.1	0.9
Critical Level	-	-		2.0	0.5	0.12	-	10	10	0.20	0.2	4	1	0.6

Table 1b: Nutrient composition of cowdung and poultry manure				
Name of the manure	Moisture (%)	N (%)	P (%)	K (%)
Cowdung	22	1.0	0.40	0.46
Poultry manure	20	1.25	0.70	0.95

The experiment was laid out in Randomized Complete Block (RCB) design. Six months old saplings were planted in 23 October, 2016. Saplings were planted in row system at spacing of 3m x 3m with 5 replications. In fourth year, the plants were fertilized in two splits. The plants were fertilized in 16 November, 2019.Recommended Dose of Chemical fertilizer for the sweet orange plant was $N_{169}P_{79}K_{88}S_{18}Zn_3B_1$ (3 years old tree). Urea, TSP, MoP and Zinc sulphate were used as a source of N, P, K and Zn, respectively. All other chemical fertilizers were applied through IPNS basis. Cowdung and poultry manure were used as organic supplement for Malta cultivation. The above-mentioned fertilizers and manures were applied around the tree excluding 1 m radius from the tree base. Weeding, irrigation and other management practices were done as and when necessary. Imidachloprid (Imitaf @ 0.25 ml/L) was applied to reduce leaf miner infestation when new leaf emerged.

Treatments were as follows:

T_1 = 100% of RDCF ($N_{169}P_{79}K_{88}S_{18}Zn_3B_1$)
T_2 = Cowdung 5 tha^{-1} + IPNS based inorganic fertilizer ($N_{144}P_{72}K_{76}S_{18}Zn_3B_1$)
T_3 = Cowdung 10 tha^{-1} + IPNS based inorganic fertilizer ($N_{119}P_{64}K_{65}S_{18}Zn_3B_1$)
T_4 = Poultry manure 3 tha^{-1} + IPNS based inorganic fertilizer ($N_{151}P_{69}K_{74}S_{18}Zn_3B_1$)
T_5 = Poultry manure 5 tha^{-1} + IPNS based inorganic fertilizer ($N_{139}P_{62}K_{64}S_{18}Zn_3B_1$)
T_6 = 125% of RDCF ($N_{212}P_{99}K_{110}S_{18}Zn_3B_1$)
T_7 = Control.

Table 2: Treatments combinations for sweet orange plant

Treatments	Treatment combinations							
	Chemical fertilizer (g/tree/year)						Organic manure (kg /tree/year)	
	N	P	K	S	Zn	B	Cowdung	Poultry manure
T_1=100%RDCF	169	79	88	18	3	1	0	0
T_2 = 5 t CD + RDCF	144	72	76	18	3	1	4.5	0
T_3 = 10 t CD + RDCF	119	64	65	18	3	1	9	0
T_4 = 3 t PM + RDCF	151	69	74	18	3	1	0	2.7
T_5 = 5 t PM + IPNS	139	62	64	18	3	1	0	4.5
T_6 = 125 % RDCF	212	99	110	18	3	1	0	0
T_7 = Control	0	0	0	0	0	0	0	0

Data on vegetative characters were recorded and analyzed statistically using statistical software STAR which was developed by IRRI. After three years, post harvest soil samples were collected from 0-15cm depth and analyzed following standard procedures. Carbon stock and Carbon accumulation were calculated using following formula.

Carbon stock (t ha^{-1}) = Carbon concentration (%) x bulk density (gcm^{-3}) x depth (cm)

Carbon accumulation (t ha^{-1}) = Final C stock (t ha^{-1}) - Initial C stock (t ha^{-1})

3. Result and Discussion

3.1 Effect of different INM practices on vegetative characters of sweet orange

Integrated nutrient management (INM) practices exhibited significant variation in case of different vegetative characteristics of sweet orange plant. Maximum plant height (3.11 m) was recorded in treatment T_4 (Poultry manure 3 tha^{-1} + IPNS based inorganic fertilizer) followed by T_3 (2.84 m) where (cowdung 10 tha^{-1} + IPNS based inorganic fertilizer) was used and the minimum (1.96 m) under control treatment. T_4 treatment exhibited the highest base girth (30.67 cm) compared to the least in T_7 treatment (15.86 cm). Maximum canopy spread through East-West direction (3.07m) and maximum spread in North-South direction (2.90 m) was observed in treatment T_4 treatment. This value was minimum (2.17m x 2.00 m) under control treatment. No. of branch $plant^{-1}$ and tree volume data showed that, dense branching with good growth condition was found in cowdung and poultry manure treated (T_2, T_3, T_4 andT_5) treatment while, other treatment occupied with sparse branching with good growth condition (Table 3).

Table 3: Vegetative characteristics of sweet orange plant as influence by INM practices, 2019-2020

Treatments	Plant height (m)	Base girth (cm)	Canopy spreading (m)		No. of branch /plant	Tree volume (m^3)
			EW	NS		
T_1	2.57 b	25.37 d	2.65 cd	2.56 c	20.67 d	9.10 c
T_2	2.65 b	27.48 bc	2.84 bc	2.77 b	25.56 c	10.89 bc
T_3	2.84 ab	28.68 b	3.02 ab	2.91 a	28.36 b	13.04 a
T_4	3.11 a	30.67 a	3.07 a	2.90 a	30.14 a	14.47 a
T_5	2.76 ab	27.02 c	2.88 ab	2.76 b	24.76 c	11.48 b
T_6	2.19 c	20.58 e	2.58 d	2.61 c	18.67 e	7.70 d
T_7	1.96 c	15.86 f	2.17 e	2.00 d	10.65 f	4.44 e
CV (%)	4.77	5.96	3.70	3.49	5.41	4.56
LSD(0.05)	0.352	1.46	0.211	0.113	0.913	1.12

Means in a column followed by same letter(s) do not differ significantly at 5% level by LSD

Note: T_1:100% RDCF, T_2: CD 5 tha^{-1} + inorganic fertilizer, T_3: CD 10 tha^{-1} + inorganic fertilize,

T_4: PM 3 tha^{-1} + inorganic fertilizer, T_5: PM 5 tha^{-1} + inorganic fertilizer, T_6:125% RDCF and T_7: control

3.2 Effect of different INM practices on fruit characters and yield of sweet orange

Data on fruit characteristics of sweet orange are presented in table 4. Fruit characters and yield of sweet orange were significantly affected by different INM practices. Maximum fruit no. plant^{-1} (49.55), fruit length (6.40 cm), fruit breadth (5.95 cm) were recorded from T_4 treatment and the minimum were found in T_7 treatment. Individual fruit wt. of the treatments varied from 141.53 g to 190.27 g. In 2019-2020, the highest sweet orange yield (7.10 t ha^{-1}) was recorded in the T_4 (poultry manure 3 tha^{-1} + inorganic fertilizer) treatment followed by T_3 (cowdung 10 tha^{-1} + inorganic fertilizer). The lowest sweet orange yield (1.94 t ha^{-1}) was recorded from T_7 (control) treatment. Application of poultry manure with NPK fertilizers improved the soil texture and porosity due to bulkiness in nature, which might have helped the plant root development and enhanced the uptake of available nutrients. These observations were corroborated with the findings in guava (Villasurda, 1990; Yadav et al., 2012). TSS ranged from 8.5% to 9.5% in different treatments.

Table 4: Fruit characteristics of sweet orange plant as influence by INM practices, 2019-2020

Treatment	Fruit No. Plant^{-1}	Fruit length (cm)	Fruit diameter (cm)	Individual fruit wt. (g)	Fruit Yield (t ha^{-1}) 2018-2019	Fruit Yield (t ha^{-1}) 2019-2020	Average yield (t ha^{-1})	TSS (%)
T_1	32.56 d	5.80 e	5.22	156.44 d	5.10 c	4.80 d	4.95	8.7 b
T_2	37.35 c	6.00 d	5.76	168.71 c	5.93 b	5.69 c	5.81	8.9 b
T_3	43.58 b	6.10 c	5.93	182.08 b	6.73 b	6.31 b	6.52	9.5 a
T_4	49.55 a	6.40 a	5.95	190.27 a	7.37 a	7.10 a	7.23	9.5 a
T_5	43.28 b	6.33 b	5.82	177.58 b	6.20 b	6.34 b	6.27	9.4 a
T_6	30.38 de	5.72 f	5.21	153.56 d	4.83 c	4.73 d	4.78	8.7 b
T_7	18.59 e	5.66 g	5.01	121.53 e	1.77 d	1.94 e	1.85	8.5 b
CV (%)	3.57	2.64	1.37	5.32	6.63	5.60	-	2.44
LSD(0.05)	3.89	0.062	NS	6.9	0.55	0.39	-	0.51

Means in a column followed by same letter(s) do not differ significantly at 5% level by LSD

Note: T_1:100% RDCF, T_2: CD 5 tha^{-1} + inorganic fertilizer, T_3: CD 10 tha^{-1} + inorganic fertilize,

T_4: PM 3 tha^{-1} + inorganic fertilizer, T_5: PM 5 tha^{-1} + inorganic fertilizer, T_6:125% RDCF and T_7: control

3.3 Nutrient status of post-harvest soil

Integrated nutrient management package had a positive influenced on post harvest soil nutrient status. The pH of post harvest soil was affected by different treatments and ranged from 7.1 to 7.8 (Table 5). Maximum value of soil pH (7.8) was found from combined application of PM 3 tha^{-1} + inorganic fertilizer and minimum value of soil pH (7.1) was obtained in 100%RDCF treatment. The pH of post harvest soil was lowest in the 100% RDCF treatment might be due to the application of acid forming fertilizer (eg. Urea). Soil Organic carbon varies from 0.75% to 0.87%. Maximum organic carbon (0.87%) was found from poultry manure 3 t ha^{-1} + inorganic fertilizer treatment and minimum (0.75%) in control treatment. On the other hand, treatments where organic manure was applied resulted in higher organic carbon. The combined application of organic manure and chemical fertilizers increased organic matter content in soil (Zhang et al., 2009). Under T_4 (poultry manure 3 tha^{-1} + inorganic fertilizer) treatment, about 44.73% increases was observed in the available N content of the soil compared to control. Combine application of cowdung and inorganic fertilizer also increased the available N. Likewise; remarkable increases of about 117.64% and 50% were recorded for P and K respectively in the T_4 in comparison to the control. Other soil nutrient status was higher in the treatments where organic fertilizers were applied for slow released pattern of nutrients. On the other hand, in control treatment no organic and chemical fertilizers were applied resulted lower nutrient status.

Table 5: Effect of INM practices on nutrient status of post harvest soil, 2018-19

Treatments	pH	SOM (%)	SOC (%)	Total N %	K meq 100g^{-1}	P µg g^{-1}	S µg g^{-1}	B µg g^{-1}	Zn µg g^{-1}
T_1	7.1	1.34	0.78	0.041	0.15	9.7	17.1	0.35	1.4
T_2	7.4	1.39	0.81	0.048	0.17	12.1	17.4	0.43	1.9
T_3	7.4	1.47	0.86	0.051	0.19	13.5	20.73	0.49	2.1
T_4	7.8	1.49	0.87	0.055	0.21	14.8	22.81	0.51	2.3
T_5	7.7	1.46	0.85	0.053	0.17	14.1	19.3	0.44	1.9
T_6	7.2	1.32	0.77	0.040	0.15	7.4	16.2	0.38	1.6
T_7	7.3	1.29	0.75	0.038	0.14	6.8	15.9	0.32	1.1
Initial soil	7.3	1.35	0.79	0.012	0.11	5.1	15	0.28	0.9

Note: T_1:100% RDCF, T_2: CD 5 tha^{-1} + inorganic fertilizer, T_3: CD 10 tha^{-1} + inorganic fertilize,

T_4: PM 3 tha^{-1} + inorganic fertilizer, T_5: PM 5 tha^{-1} + inorganic fertilizer, T_6:125% RDCF and T_7: control

3.4 Soil carbon accumulation under INM practices under sweet orange plant

The quality parameters of soil were markedly improved by integrated application of inorganic fertilizers and organic manures after two years experiment. The initial soil organic carbon, bulk density and carbon stock in soil were 0.79 %, 1.49 gcm^{-3} and 17.65 tha^{-1}, respectively. After two years, bulk density varied from 1.44-1.49 gcm^{-3}. The soil organic carbon stock and carbon accumulation values are higher recorded in poultry manure 3 tha^{-1} + IPNS based inorganic fertilizer (18.79, 1.14) followed by cowdung 10 tha^{-1} + IPNS based inorganic fertilize (18.70, 1.05) and the lower values were recorded in control (16.76, -0.89) treatments. Result revealed that, highest carbon accumulation was observed in integrated application of inorganic fertilizers and organic manures treatments. West and six reported that the duration of carbon sequestration varies between ecosystem, climate regimes and fertilization management (e.g. soil organic amendment inputs) (West and Six, 2007).

Table 6: Soil fertility attributes under INM practices under sweet orange plant, 2018-19

Treatments	Initial soil			Post harvest soil			Carbon accumulation (t ha^{-1})
	SOC (%)	BD (gcm^{-3})	C Stock (t ha^{-1})	SOC (%)	BD (gcm^{-3})	C Stock (t ha^{-1})	
T_1	0.79	1.49	17.65	0.78	1.49	17.43	0
T_2	0.79	1.49	17.65	0.81	1.47	17.86	0.21
T_3	0.79	1.49	17.65	0.86	1.45	18.70	1.05
T_4	0.79	1.49	17.65	0.87	1.44	18.79	1.14
T_5	0.79	1.49	17.65	0.85	1.45	18.48	0.83
T_6	0.79	1.49	17.65	0.77	1.49	17.20	0
T_7	0.79	1.49	17.65	0.75	1.49	16.76	0

Note: T_1:100% RDCF, T_2: CD 5 tha^{-1} + inorganic fertilizer, T_3: CD 10 tha^{-1} + inorganic fertilize,

T_4: PM 3 tha^{-1} + inorganic fertilizer, T_5: PM 5 tha^{-1} + inorganic fertilizer, T_6:125% RDCF and T_7: control

3.5 Cost and return analysis

Table 7 showed the economic performance of sweet orange as influenced by integrated application of inorganic fertilizers and organic manures. The highest gross return (TK 1084500 ha^{-1}), gross margin (TK 786500 ha^{-1}) and BCR (3.63) were recorded from T_4 (poultry manure 3 tha^{-1} + inorganic fertilizer) treatment. T_3 (cowdung 10 tha^{-1} + inorganic fertilizer) gave the second highest values for the said parameters. Among the treatment, the lowest gross return (TK 277500 ha^{-1}), gross margin (TK 131000 ha^{-1}) and BCR (1.89) were recorded from control treatment.

Table 7: Cost and return analysis of sweet orange as influenced by INM practices, 2019-2020

Treatments	Average sweet orange yield (t ha^{-1})	Gross return (TK ha^{-1})	Total variable cost (TK ha^{-1})	Gross margin (TK ha^{-1})	BCR
T_1	4.95	742500	260000	482500	2.85
T_2	5.81	871500	275000	596500	3.16
T_3	6.52	978000	290000	688000	3.37
T_4	7.23	1084500	298000	786500	3.63
T_5	6.27	940500	312000	628500	3.01
T_6	4.78	717000	271500	445500	2.64
T_7	1.85	277500	146500	131000	1.89

Note: T_1:100% RDCF, T_2: CD 5 tha^{-1} + inorganic fertilizer, T_3: CD 10 tha^{-1} + inorganic fertilize,

T_4: PM 3 tha^{-1} + inorganic fertilizer, T_5: PM 5 tha^{-1} + inorganic fertilizer, T_6:125% RDCF and T_7: control

Input: Unit price **(**Tk.Kg^{-1}**):** Urea=16, TSP= 22, MoP = 15, Gypsum = 12, Zinc sulphate = 200, Boric acid = 250, Cowdung= 2 , Poultry manure: 10

Output: Price of sweet orange: 150 Tk Kg^{-1}

4. Conclusion

From four years experimental results, it can be concluded that T_4 treatment (integrated use of 3 tha^{-1} poultry manure with inorganic fertilizer) was found to be the most effective in increasing sweet orange yield and improved carbon accumulation in soil. Overall results indicating the superiority of poultry manure treated treatment over cowdung treated treatment in different integrated nutrient management practice in sweet orange.

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