



Influence of organic manures and bio-dynamic preparations on growth, yield and quality of Khasi mandarin (*Citrus reticulata* Blanco) in Mizoram, North-East India

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ABSTRACT

An experiment was conducted during 2015-2017 at Mizoram University, Aizawl, Mizoram, to standardize the organic nutrient management protocol for Khasi mandarin. The experiment was laid out in randomised block design (RBD) with eleven treatments viz T₁: Farm yard manure(FYM), T₂:Vermicompost(VC), T₃:Pig manure (PIM), T₄: Poultry manure (POM), T₅: Neem cake (NC), T₆:(FYM + CPP+ Bio Dynamic (BD)500 + BD 501), T₇: (VC + CPP + BD 500 + BD 501), T₈: (PIM + CPP + BD 500 + BD 501), T₉:(POM + CPP + BD 500 + BD 501), T₁₀:(NC + CPP + BD 500 + BD 501) and T₁₁: Control (RDF). The pooled analysis of two year data indicated that integrated application of FYM + CPP + BD 500 + BD 501 (T₆) resulted in maximum plant height, plant girth, canopy spread and canopy volume. On the other hand, POM + CPP + BD 500 + BD 501 (T₉) recorded maximum yield/ha. With respect to quality parameters, T₇ (VC + CPP + BD 500 + BD 500) recorded the lowest moisture content during both the years of study as well as in pooled analysis, while, T₆ (FYM + CPP + BD 500 + BD 501) recorded highest TSS, Ascorbic acid, TSS: acid ratio and lowest titratable acidity.

Key words: BD 500, BD 501, CPP, FYM, Khasi mandarin, Mizoram, Poultry manure.

INTRODUCTION

Citrus, often regarded as 'golden fruit' or 'queen of all fruits' is commercially an important fruit crop throughout the world (Kour *et al.*, 2009). In India, citrus represents the third most important fruit next to mango and banana and comprises about 12.41 per cent of total fruits produced in the country. Among the various citrus species grown in the country, mandarin orange is one of the most important species covering an area of 4.29 lakh ha with a production of 47.53 lakh tones and a productivity of 11.10 mt/ha (Anonymous, 2017a).

The North eastern region of India is considered as one of the natural home and reservoir of various Citrus species including mandarin orange (Chadha, 1995, Hazarika, 2012). Among various citrus species grown in the region, Khasi mandarin (*Citrus reticulata* Blanco) is the leading citrus species. In Mizoram, out of various fruits grown in the state, Khasi mandarin covers the maximum area and production. The climate in Mizoram is ideal for growing Khasi mandarin. During 2016-17 it was cultivated in an area of about 16,030 ha with a production of 41,430 MT and productivity of 2.58MT/ha (Anonymous, 2017b).

Citrus is a heavy feeder of nutrients and requires all the three major nutrients for their growth, development and yield. The requirements of these nutrients are generally supplied by chemical fertilizers. But, excessive and

unbalanced use of chemical fertilizers may lead to health and ecological hazards, depletion of physico-chemical properties of the soil and ultimately poor crop yields (Singh and Singh 2009). In addition, excess chemical fertilization could be the main cause of pollution in surface and ground water as well as soil and now become diseased and desolate under the influence of indiscriminate and uncontrolled use of inorganic fertilizers (Hazarika *et al.*, 2011).

Consequently, there is renewed interest among the researchers to identify the supplementary/ alternative sources of chemical fertilizers to meet the nutrient demand of the crop in an eco-friendly manner and also to retain the physical, chemical and biological properties of the soil without any loss. As a result, several organic and biological sources have emerged as viable supplementary sources of inorganic fertilizers in crop nutrition programme.

Organic manures are bulky in nature, but contain all the essential nutrients including micronutrients which are required for the growth and development of crops. Application of organic manures to soil not only improve soil physical properties, pH, water holding capacity but also add important nutrients to the soil, thus increase the nutrient availability and its ultimate absorption by plant (Hazarika *et al.*, 2014). Use of organic manures has been recognized as the most efficient practice for stimulation of various biological transformations in the soil, leading to soil fertility

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and health (Narayanaswamy *et al.*, 2006). Bio-fertilizers such as *Azospirillum*, *Azotobacter*, PSB, VAM have potential practical applications to increase crop productivity through increased biological nitrogen fixation, increased availability or uptake of nutrients through phosphate solubilization or increased absorption, stimulation of plant growth or by rapid decomposition of organic residues. Bio-fertilizers like *Azotobacter* fix atmospheric nitrogen and enhance the production of various field crops (Umar *et al.* 2009). *Azospirillum* also produce growth promoting substances like IAA and GA and their phyto-hormones go a long way in enhancing the crop growth (Govindarajan and Thangaraju, 1998). Inoculation of these N-fixing microorganisms in the soil not only increases the yield but also save 20-40% nitrogen inputs (Hazarika *et al.*, 2014).

In addition to these, bio-dynamics preparations uses no synthetic chemical fertilizers and pesticides, and instead emphasizes building up the soil with compost additions and animal and green manures, controlling pests naturally, rotating crops, and diversifying crops and livestock. In biodynamic preparations eight specific preparations added to their soils, crops, and composts to enhance soil and crop quality and to stimulate the composting process. The eight preparations are made from cow manure, silica, flowers of yarrow, chamomile, dandelion and valerian, oak bark, and the whole plant of stinging nettle. Biodynamic practices show promise in mitigating some of the adverse effects of conventional agriculture on the environment.

Complementary use of organic manures, bio-fertilizers and bio-dynamics not only helps to maintain higher crop productivity but also sustain higher soil fertility. Moreover long term sustainability of productivity could be achieved only through interaction of organic sources of nutrients with bio-fertilizers (Hedge *et al.*, 1992). In view of the factors like increasing demand of organically grown fruits by consumers coupled with unsustainable productivity, organic farming is claimed to be most benign alternative, for which the role of organic manures and bio-fertilizers become important for sustainable production with quality fruits (Singh *et al.*, 2014).

Keeping in view of these points, the present research work has been carried out to evaluate the combined effect of organic manures, bio-dynamic in commercial citrus species Khasi mandarin in Mizoram condition.

MATERIALS AND METHODS

The present experiment was carried out at farmer's field of Khawhai village of Champhai District, Mizoram. The orchard is situated between 24° 05' 03.99" and 23° 00' 03.25" N latitudes and 93° 00' 31.29" and 93° 26' 17.66" E longitudes. It has an average elevation of 1369 meters. The experiment was laid out in randomised block design (RBD) with eleven treatments *viz.* T₁: Farm yard manure (FYM),

T₂: Vermicompost (VC), T₃: Pig manure (PIM), T₄: Poultry manure (POM), T₅: neem cake (NC), T₆: (FYM + CPP + Bio Dynamic (BD) 500 + BD 501), T₇: (VC + CPP + BD 500 + BD 501), T₈: (PIM + CPP + BD 500 + BD 501), T₉: (POM + CPP + BD 500 + BD 501), T₁₀: (NC + CPP + BD 500 + BD 501) and T₁₁ Control (RDF). The organic manures were applied in two split dosages, i.e. February-March and September-October. The quantity of organic manure *i.e.* FYM, VC, PIM, POM and NC applied per plant was calculated based on the 100% of nitrogen requirement of the recommended dose of fertilizers (600g N, 300g P, and 600g K/plant/year). Biodynamic preparations *viz.* CPP was applied @ 250 g/plant, BD 500 (62.5 g was dissolved in 40 L of warm water) was sprinkled as big droplets on soil surface in the evening and BD 501 (2.5 g in 40 L of water) was sprayed to the plants. Vegetative growth parameters *viz.*, plant height, plant girth and canopy spread (N-S) and (E-W) were assessed as per the standard procedures. The canopy volume was calculated by using equation: $CV = 0.524 HD^2$ where H and D stand for height and diameter, respectively (Castle, 1983). Yield per ha was calculated by multiplying the average weight of marketable fruits/plant with the total number of plants per hectare and was expressed in tonnes per hectare. For estimation of fruit quality parameters, standard procedures were adopted. The moisture content of the fruits was determined by oven dry method as described by Rangana (1986). The total soluble solid (°Brix) of fruit pulp was estimated by using of Zeiss Hand Refractometer. Titrable acidity, was estimated by using by adopting the standard methods of AOAC, (1989). Freed's (1966) visual titration method was followed for estimating the ascorbic acid content of the fruit pulp. TSS: acid was determined by dividing the TSS with titratable acidity.

RESULTS AND DISCUSSION

Vegetative growth parameters and yield: The integrated effect of bio-dynamic preparations and organic manures influenced the vegetative growth of the Khasi mandarin plants over the control during both the years of study. The results presented in Table 1 revealed that the maximum plant height (5.83 m and 5.66 m) was observed with T₆ (FYM + Cow Pat Pit (CPP) + BD 500 + BD 501) during the second year and in pooled analysis, whereas, during the first year it was recorded (5.49 m) with T₇ (VC + CPP + BD 500 + BD 501). Similarly, T₆ (FYM + Cow Pat Pit (CPP) + BD 500 + BD 501) recorded maximum plant girth in both seasons as well as in pooled analysis (52.78 cm, 56.20 cm and 54.49 cm respectively) and was followed by T₈ (PIM + CPP + BD 500 + BD 501). The improvement in plant growth parameters under T₆ (FYM + Cow Pat Pit (CPP) + BD 500 + BD 501) might be due to the combined impact of FYM and bio dynamic preparations. FYM influenced the physical, chemical and biological properties of soil through supplying macro and micronutrients leading to better plant growth and

Table 1: Effects of organic manures and bio-dynamic preparations on plant growth parameters and yield of Khasi mandarin.

Treatment	Plant height (m)		Plant girth (cm)			Canopy spread (m)						Canopy volume (m³)						Yield (t/ha)	
						N-S			E-W			Pooled			Pooled				
	2015-2016	2016-2017	Pooled	2015-2016	2016-2017	Pooled	2015-2016	2016-2017	Pooled	2015-2016	2016-2017	Pooled	2015-2016	2016-2017	Pooled	2015-2016	2016-2017	Pooled	
T ₁	5.30	5.44	5.37	42.69	44.76	43.73	2.30	2.46	2.38	2.48	2.65	2.56	26.53	29.13	27.83	13.22	13.31	26.53	
T ₂	5.19	5.36	5.27	36.92	39.05	37.99	2.41	2.56	2.49	2.54	2.72	2.63	26.92	29.66	28.29	12.31	12.59	24.90	
T ₃	5.21	5.38	5.29	39.58	41.89	40.73	2.42	2.56	2.49	2.56	2.77	2.67	27.23	30.01	28.62	13.90	14.42	28.32	
T ₄	5.31	5.47	5.39	40.22	42.84	41.53	2.30	2.48	2.39	2.52	2.82	2.67	26.80	30.23	28.52	12.06	12.48	24.54	
T ₅	5.20	5.47	5.34	43.75	46.38	45.07	2.50	2.65	2.58	2.47	2.87	2.67	27.12	31.65	29.38	13.42	13.71	27.13	
T ₆	5.49	5.83	5.66	52.78	56.20	54.49	2.71	2.89	2.80	2.73	3.08	2.91	31.30	36.48	33.89	19.61	20.94	40.54	
T ₇	5.52	5.78	5.65	52.15	56.04	54.09	2.69	2.95	2.82	2.86	3.16	3.01	32.09	36.88	34.48	21.31	21.82	43.13	
T ₈	5.36	5.57	5.47	52.43	56.06	54.25	2.55	2.85	2.70	2.69	2.96	2.82	29.40	33.96	31.68	18.01	18.59	36.59	
T ₉	5.25	5.44	5.35	43.64	46.64	45.14	2.41	2.61	2.51	2.58	2.81	2.70	27.45	30.92	29.19	22.20	23.02	45.22	
T ₁₀	5.43	5.64	5.54	47.77	51.03	49.40	2.49	2.70	2.59	2.66	2.87	2.76	29.32	32.86	31.09	19.39	19.89	39.28	
T ₁₁	5.15	5.26	5.20	35.25	37.27	36.26	2.26	2.40	2.33	2.40	2.54	2.47	25.15	27.20	26.17	11.06	11.68	22.74	
SEm (±)	0.014	0.016	0.013	0.24	0.13	0.15	0.018	0.011	0.011	0.011	0.047	0.024	0.13	0.31	0.17	0.04	0.12	0.07	
CD _{0.05}	0.041	0.047	0.038	0.71	0.39	0.44	0.053	0.032	0.034	0.033	0.140	0.071	0.38	0.91	0.49	0.11	0.36	0.21	

Table 2: Effects of organic manures and bio-dynamic preparations on quality parameters of Khasi mandarin.

Treatment	Moisture (%)		Ascorbic acid (mg/100 g)			TSS (°Brix)			Titratable acidity (%)			TSS / acid ratio		
	2015-2016	2016-2017	Pooled	2015-2016	2016-2017	Pooled	2015-2016	2016-2017	Pooled	2015-2016	2016-2017	Pooled	2015-2016	2016-2017
T ₁	84.22	83.45	83.84	48.23	49.50	48.87	9.54	10.34	9.94	0.84	0.86	0.85	11.31	11.98
T ₂	84.57	83.48	84.03	46.14	46.58	46.36	10.15	10.22	10.19	0.83	0.87	0.85	12.20	11.79
T ₃	83.33	83.64	83.49	45.61	49.44	47.52	9.64	10.80	10.22	0.85	0.86	0.86	11.28	12.49
T ₄	83.26	84.23	83.75	42.56	41.30	41.93	10.15	10.22	10.19	0.84	0.84	0.84	12.04	12.18
T ₅	85.35	84.13	84.74	50.14	49.27	49.71	11.05	11.11	11.08	0.85	0.83	0.84	12.96	13.44
T ₆	81.02	81.34	81.18	57.23	56.24	56.74	11.92	11.84	11.88	0.73	0.71	0.72	16.23	16.70
T ₇	80.15	80.24	80.20	51.52	53.24	52.38	11.66	11.75	11.70	0.75	0.75	0.75	15.59	15.63
T ₈	84.20	82.47	83.34	51.28	52.23	51.75	11.26	11.43	11.34	0.77	0.82	0.79	14.63	14.02
T ₉	81.94	82.14	82.04	55.65	54.76	55.21	11.45	11.54	11.50	0.76	0.77	0.77	15.03	14.92
T ₁₀	82.14	83.11	82.63	52.14	50.24	51.19	11.16	11.14	11.15	0.76	0.77	0.77	14.59	14.52
T ₁₁	85.83	85.20	85.52	41.68	40.45	41.07	9.44	10.14	9.79	0.90	0.91	0.90	10.53	11.19
SEm (±)	0.24	0.26	0.19	0.12	0.15	0.10	0.028	0.030	0.028	0.013	0.019	0.013	0.18	0.33
CD _{0.05}	0.72	0.77	0.56	0.35	0.46	0.28	0.083	0.087	0.081	0.037	0.055	0.040	0.52	0.98

development (Singh *et al.*, (2009). Lloyd (2005) reported that BD 500 increases health fertility and life of soils by stimulating humus formation, increasing microbial life, earth warm activity; and promoting root growth. Carpenter *et al.*, (2000) recorded that biodynamic formulations like BD-500-508 and Cow Pat Pit showed remarkable effect on crop growth. The findings are in conformity with Dudi *et al.*, (2003), Kaul and Bhatanagar (2006) in Kinnow mandarin and Garg *et al.* (2004) in guava.

Significantly maximum N-S spread was observed in T₆ (FYM+CPP+ BD500+BD501) during first year (2.71 m) whereas it was recorded maximum in T₇ (VC + CPP + BD 500 + BD 501) during second year as well as in pooled analysis (2.95 m and 2.82 m). Similarly, maximum E-W spread (2.86m, 3.16 and 3.01 m) and canopy volume (32.09 m³, 36.88 m³ and 34.48 m³) were observed in treatment T₇(VC+ CPP + BD 500 + BD 501) during the first year and second year as well as in pooled analysis. The maximum spread and volume with VC and bio-dynamic preparations might be due to the increase in shoot length and number of leaves which might have occurred due to higher nutrient availability supporting higher accumulation of photosynthates in the plant body and physical properties of soil. Plants sprayed with Biodynamic compost invariably produce bigger leaves and develop denser canopy, the photosynthetic system is activated for enhanced biological efficiency, enabling synthesis of maximum metabolites and photosynthesis (Somasundaram *et al.*, 2007).

The highest yield was observed under treatment T₉ (POM + CPP + BD 500 + BD 501) during both seasons as well as in pooled analysis. It was followed by T₇ (VC + CPP + BD 500 + BD 501). The increased nutrient elements in the soil enhanced uptake of nutrients and water caused to higher photosynthesis leading to an increase of the assimilation rates which ultimately increased the yield of the plant. Brown *et al.*, (1993) reported that among various organic sources, poultry manure had the most important role followed by farm yard manure that is in agreement with the result of the present study. Dadashpour *et al.*, (2012) and

Yadav *et al.*, (2012) also revealed that maximum fruit yield was obtained from poultry manures in strawberry and guava. Sharma *et al.*, (2017) observed that yield of cumin increased significantly with application of poultry manure along with biodynamic manure 500 + BD 501.

Quality parameters of the fruits: The results of the present investigation revealed that the quality parameters of the mandarin fruits were significantly influenced by combined application of organic manures with bio-dynamic preparations during both the years as well as in pooled analysis (Table 2). The present studies indicated that moisture content was minimum in T₇ (VC + CPP + BD 500 + BD 500) in both the years of study as well as in pooled analysis (80.15, 80.24 and 80.20 % respectively), while it was highest in control (T₁₁). Similarly, among all the treatments, the significantly highest TSS (11.92, 11.84 and 11.88 °Brix respectively) was recorded in T₆(FYM + Cow Pat Pit (CPP) + Bio Dynamic (BD) 500 + BD 501) during first year, second year and pooled analysis. The same treatments also recorded the highest value of ascorbic acid (57.23, 56.24 and 56.74 mg/100 g respectively). The same treatments also recorded lowest titratable acidity (0.73, 0.71 and 0.72 % respectively) and highest TSS: acid ratio (16.23, 16.70 and 16.46 respectively). Interestingly, plants receiving organic manures have produced better fruit quality attributes which might be due to better growth of plants which favoured the higher TSS, less acidity and better ascorbic acid content. These results are inconformity with the findings of Amarante *et al.*, (2008) who noted that fruits from the organic orchard had lower titratable acidity and higher soluble solids content in apple cv. 'Royal Gala' than fruits from conventional orchard. Similar results were also reported by Peck *et al.*, (2009) who recorded that fruits from organic production system had higher TSS and TSS: acid ratio than fruits from integrated fruit production system. Higher TSS with incorporation of FYM and BD-500 had also been reported by Ram and Pathak (2007) in guava. Jayasree and George (2006) also reported that application of biodynamic preparations (BD 500 and BD 501) increased fruit quality in chilli.

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