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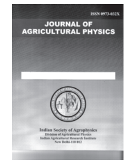

Research Article

Effect of Different Management Practices on Variations in Soil Physico-Chemical Properties and Guava Yield

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ABSTRACT

Field experiment was conducted to assess the impact of different soil management system on the response of tree crops to the added inputs. Guava cultivated under subtropical climatic condition of Rehmankhera, Lucknow was subjected to different organic and inorganic nutrient management system yielded highest of 72.5 kg fruits per tree. Differential responses of soil physico-chemical properties to different soil nutrient management modules were also recorded. Highest water holding capacity and porosity of 22.07 and 46.28% was estimated across treatments. Among the soil micronutrients, particularly Zn and Cu significantly improved guava yield. Soil organic carbon, available N, P and K contents were also influenced as a function of different nutrient management in guava orchard soil. The recent study focused on proper care should be given on priority basis for developing robust orchard ground floor management system. This is essential for increasing the guava productivity in guava growing region of Uttar Pradesh.

Key words: Guava, Soil management, Productivity, Soil physico-chemical properties

Introduction

Fruit crops are responsive to the externally supplied inputs for their growth and development. Productivity of fruit crops is a function of soil management system; most often differential response is recorded even under similar climatic condition. Guava which is hardy in nature when treated with different substrates; it yielded differently based on the amount and type of nutrition sources. Shukla *et al.* (2014) recorded guava growth and development along with the nutrient contents impacted across treatments and seasons under different substrate treated soils. Even, restoring optimum nutrient regimes for soil resources is essential for better nutrient flow for fruit productivity (Adak *et al*., 2014). Further, Adak *et al.* (2017) are of the opinion of having better soil management as a function of different substrate treated guava soil for better soil health. In fact, organic and inorganic sources are needed to sustain the orchard soil health and fruit productivity. Based on experimentation in a Brazilian soil during 2012-13, Rocha *et al*. (2016) recorded higher Paluma guava fruit with better quality in soil treated with humic substances (Humitec) @20mL L^{-1} $tree^{-1}$; and soil organic mulching responded well than no mulching system. Addition of micronutrients many a times improves the quality of guava fruits. Kumar *et al.* (2016) reported that guava fruit yield was increased by different rates of foliar application of Zn micronutrient.

Guava orchard productivity in Lucknow region having mostly sandy loam to sandy soils

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is lower due to several reasons. Constrains in soil properties could be one of the reasons for which better soil management is needed (Adak *et al*., 2018). Soils with high compaction and low water holding capacity, restricted infiltration rate deprived the nutrients to flow to the root zone. Sometimes, low nutrient availability also contributes to the lower guava production. Thus, evaluation of soil based on short or long-term orchard management is the need of the hour; obviously for restoring good soil quality and enhancing input use efficiency (Sharma *et al*., 2008). Although, Berry *et al*. (2003) expressed that organic modules may sustain guava production; yet integrated approach is required as nutrient availability may vary with the type of soil. Nutrient budgeting of other key nutrient elements was also required for sustaining the production system. Montes *et al*. (2016) found improvement in 'Paluma' guava fruit yield (>40 Mg ha^{-1} per cycle; 2009-2012) through application of 0.5 kg N per tree in the form of Urea and 0.55 kg K_2O/tree/cycle K fertilizers in Ultisol in Brazil. Similarly, Cavalcante *et al*. (2019) recorded highest productivity when K fertilizers were applied @101 and 143 g K_2O $tree^{-1}$ $year^{-1}$ in guava tree. Therefore, integration of both organic and inorganic fertilizers could improve the physical, chemical and biological soil health; which improves the retention capacity and nutrient transformations (Bulluck *et al*., 2002). Hence the present experiment was conducted with the aim of studying the guava yield and variations in soil properties as a function of nutrient management practices under Lucknow condition.

Materials and Methods

The present study was laid out on 8-9 yrs old Guava cv Shewta in the research farm of ICAR-CISH, Rehmankhera, Lucknow, UP with nine treatments tabulated in Table 1. Soil organic mulching in the form of guava leaf litter and paddy straw (1:1) was used @ 5 kg per plant and 100 g $tree^{-1}$ biofertilizers were applied. For micronutrients, 200 g Zinc sulphate, 150 g Copper sulphate, 150 g Manganese sulphate and 50 g Borax $tree^{-1}$ were applied. Foliar spray of micronutrients was done at fruit setting and developmental stages three times. The treatments were replicated thrice (with two trees per each treatments was selected) in a RBD with guava planted at a spacing of 5×5 m (Row to row× Plant to plant) during 2013-15. The site is designated as subtropical region with dry hot summer and moderate rainfall with Sandy loam soil. Soil samples were collected each year from the guava tree basin for analysis of both physical and chemical properties. Soils were processed and analysis was done following standard protocols proposed by Walkley and Black (1934) for soil organic carbon estimation, Subbiah and Asija (1956) for available N, Olsen *et al*. (1954) for available P, and neutral normal acetate method for K, and Lindsay and Norvell (1978) for available Zn, Cu, Mn and Fe contents. Guava yield was recorded every year from all the treatments; guava fruits were collected randomly from replicated trees and used for biochemical analysis following standard procedure underlined by Ranganna (2001). All data were subjected to statistical analysis at 5% level of significance; standard error of means was computed. Variations in soil physical properties across nine treatments were presented graphically.

Results and Discussion

Improvement in guava yield in different nutrient management system was observed as compared to control plots; highest yield being recorded as 63.65 kg $tree^{-1}$ (T4) and second highest of 62.04 kg $tree^{-1}$ (T2). The fruit yield in the next season also increased significantly upto 72.5 kg $tree^{-1}$ (Table 2). Control plots were having lowest yield of 37.82 and 41.2 kg $tree^{-1}$ (T9) during 2013-14 and 2014-15 respectively. Addition or deletion of one of the components like FYM, NPK or reducing the doses by half also reduced the fruit yield. Soil or foliar micronutrients application (T4 & T5) improved the yield than T1. Yield in T2 Vs T7 was statistically significant which indicated that inclusion of inorganic fertilizers like NPK is essentially required for the tree nutrition or even reducing the doses by half significantly reduced fruit yield. Therefore, integrated nutrient management consisting of organic + inorganic

Table 1. Treatment details applied for assessing the response in Guava cv Shewta

Sl. No.	Details
T_1	10 kg FYM+120, 60, 50 g N, P, K/ tree /year of age (Recommended dose)
T_2	10 kg FYM + 120, 60, 50 g N, P, K/tree/year of age + *Azotobacter* + Phosphate solubilizing microorganisms (PSM) + *Trichoderma harzianum* + Organic mulching (10 cm thick)
T_3	120, 60, 50 g N, P, K /tree /year of age + *Azotobacter* + PSM + *Trichoderma harzianum* + Organic mulching (10 cm thick)
T_4	120, 60, 50 g N, P, K/tree/year of age + Foliar application of Zn, B, Mn and Cu
T_5	120, 60, 50 g N, P, K/tree/year of age + Soil application of Zn, B, Mn and Cu
T_6	5 kg FYM+120, 60, 50 g N, P, K/tree /year of age + *Azotobacter* + PSM + *Trichoderma harzianum* + Organic mulching (10 cm thick)
T_7	10 kg FYM + *Azotobacter* + PSM + *Trichoderma harzianum* + Organic mulching (10 cm thick)
T_8	10 kg FYM + 60 g N + 30 g P + 25 g K / tree/year of age + *Azotobacter* + PSM + *Trichoderma harzianum* + Organic mulching (10 cm thick)
T_9	Control

Table 2. Response of guava to different soil nutrient management system at Lucknow, India

Treatments	Fruit yield (kg/tree)		TSS (p Brix)		Acidity (%)		Ascorbic acid (mg/100 g)	
	I^{st} yr	II^{nd} yr	I^{st} yr	II^{nd} yr	I^{st} yr	II^{nd} yr	I^{st} yr	II^{nd} yr
T1	52.41	65.8	11.90	11.2	0.36	0.26	221.8	213.0
T2	62.04	72.5	12.30	10.4	0.26	0.25	224.2	208.7
T3	42.53	58.7	11.10	10.2	0.36	0.31	201.1	217.4
T4	63.65	58.1	12.70	11.4	0.29	0.28	228.2	221.7
T5	57.52	62.3	11.53	10.4	0.36	0.32	216.2	216.4
T6	51.43	63.4	11.67	12.2	0.32	0.31	218.03	212.0
T7	38.38	48.8	11.57	10.2	0.29	0.27	204.7	213.0
T8	52.35	55.5	11.90	11.4	0.38	0.32	218.0	204.3
T9	37.82	41.2	10.77	10.6	0.36	0.34	201.1	208.7
CD $_{(0.05)}$	11.75	14.4	0.91	NS	NS	NS	NS	NS
SEm ±	3.92	4.12	0.30	0.32	0.02	0.02	14.87	13.46

I^{st} yr: 2013-14 II^{nd} yr: 2014-15

sources including micronutrients application along with mineral fertilizers may suffice the fruit yield in guava in this region. Fruit biochemical parameters like TSS, acidity and ascorbic acid also varied across the treatments; however significant effect on these parameters was not recorded. Highest values were estimated as 12.70 & 12.20^0 Brix, 0.38 & 0.34% and 228.2 & 221.7 mg/100g of TSS, acidity and ascorbic acid, respectively (Table 2). Fruit yield stability is important for orchardists/farmers/commercial growers for not only increasing the income but also for orchard sustainability (Roussos and Gasparatos, 2009). Organic and inorganic sources of nutrition are included in many parts of the world for maintaining a healthy orchard soils (Canali *et al.*, 2009). Even, micronutrient application either foliar spray or soil application enhanced quality fruit production to a number of tree crops (Shukla *et al.*, 2018). Hernandes *et al.* (2012) reported the response of Guava cv. Paluma @7 year liming and 3-year fertilization in an Oxisol in terms of fruit yield improvement with liming and nutrient balances. Kumar *et al.* (2017)

obtained positive results of micronutrient spray of Zn @0.01%, B (0.03%) and 0.5% K at two-week interval after fruit sets during 2013-14 on 8 yrs old Guava grown in silty clay loam soil Under Mollisol in India. Based on soil nutrient index, Adak *et al.* (2019) alloted fertility ratings in orchard soils for future soil nutrient management requirement. Soil parameters like SOC, available N, P and K were determined across different treatments and significant differences were observed in some parameters (Table 3). SOC varied between 0.31 to 0.42 and 0.341 to 0.380% in year I and II across treatments. Highest available N of 103.9 and 76.77 mg kg^{-1} was recorded in these two years. Similarly, available P and K of 26.68 & 27.98 and 193.0 & 173.55 mg kg^{-1} were noted for the two years, respectively. Lowest values were of course recorded in control. In case of micronutrients, there was significant increase in DTPA extractable Zn and Cu across eight treatments (Table 4). A range of 0.58 to 1.02 & 0.66 to 1.14 mg kg^{-1} of Zn and 0.29 to 0.85 & 0.46 to 0.88 mg kg^{-1} of Cu was recorded during two fruiting seasons, respectively. Impact of different treatments on Fe content did not vary significantly

Table 3. Changes in soil properties under different nutrient management system in guava grown at Lucknow, India

Treatments	SOC (%)		Available N (mg/ kg)		Available P (mg/kg)		Available K (mg/kg)	
	Ist yr	IInd yr	Ist yr	IInd yr	Ist yr	IInd yr	Ist yr	IInd yr
T1	0.38	0.367	96.3	74.20	26.68	25.10	172.6	138.88
T2	0.42	0.380	103.9	75.43	24.30	27.98	193.0	173.55
T3	0.35	0.351	85.4	76.77	23.97	24.58	136.1	128.53
T4	0.32	0.364	68.3	65.57	20.77	24.42	158.3	143.63
T5	0.31	0.373	71.6	70.83	21.88	24.12	152.2	141.12
T6	0.35	0.357	102.9	73.97	25.38	26.28	140.9	136.77
T7	0.42	0.344	90.5	66.97	12.28	23.37	139.0	120.02
T8	0.43	0.360	103.7	75.60	26.73	26.53	151.2	137.31
T9	0.34	0.341	77.2	61.83	11.40	20.33	116.7	101.61
CD $_{(0.05)}$	0.055	NS	13.94	NS	5.81	NS	NS	30.58
SEm ±	0.018	0.021	4.50	5.96	1.93	1.70	17.52	10.20

Table 4. Response of different soil nutrient management system on soil micronutrients in guava grown at Lucknow, India

Treatments	Fe(mg/ kg)		Mn(mg/ kg)		Zn(mg/ kg)		Cu(mg/ kg)	
	Ist yr	IInd yr	Ist yr	IInd yr	Ist yr	IInd yr	Ist yr	IInd yr
T1	3.80	3.50	3.96	4.28	0.62	0.77	0.37	0.57
T2	3.53	3.23	2.85	4.30	0.66	0.78	0.34	0.58
T3	3.90	3.38	2.91	3.41	0.70	0.74	0.37	0.59
T4	2.94	3.85	2.65	5.24	0.60	1.14	0.43	0.71
T5	3.36	3.76	5.06	5.37	1.02	1.04	0.85	0.88
T6	3.12	3.93	4.23	4.35	0.64	0.81	0.45	0.53
T7	3.73	3.37	3.02	3.57	0.60	0.79	0.29	0.63
T8	3.39	3.79	3.13	4.16	0.64	0.88	0.53	0.66
T9	2.72	3.12	3.32	3.52	0.58	0.66	0.33	0.46
CD $_{(0.05)}$	NS	NS	NS	1.20	0.15	0.18	0.20	0.15
SEm ±	0.43	0.36	0.76	0.39	0.05	0.06	0.06	0.05

but for Mn significantly different range of 3.41 to 5.37 mg kg^{-1} was recorded. Soil physical properties were also varied across these treatments; highest water holding capacity was recorded as 22.07 percent. It was also noted that soil porosity varied between 43.40 to 46.28% across treatments (Fig. 1). Impact of different treatments on soil bulk density and particle density was estimated and it was found that these densities varied marginally across soil management systems ranging from 1.35 to 1.41 g/cc (BD) and 2.41 to 2.54 g/cc (PD) across the treatments (Fig. 2).

Emphasis on maintaining soil quality is important for long-term orchard productivity. Monitoring of soil quality parameters is essential for soil properties improvement (Sparling *et al.*, 2004). Inclusion of organic with the mineral fertilization programmes makes the soil-plant system robust in terms of availability of soil solution nutrients (Herencia *et al.*, 2008). Soil organic carbon plays sensitive role in the bioavailability of nutrients; its amount and type renders to the development of carbon management for productive soils (Blair *et al.*, 1995). Addition of organic sources and/or soil mulching improves the soil condition; water holding capacity and porosity in soil. In our study also positive changes in soil properties were recorded in organic + inorganic or organic treated soil than control or only inorganic plots. In fact, soil management practices tend to influence the physico-chemical and even biological properties in fruit orchard soils (Walsh *et al.*, 1996; Castellini *et al.*, 2013; Paltineanu *et al.*, 2016). Such changes may not be registered in a single season but the impact

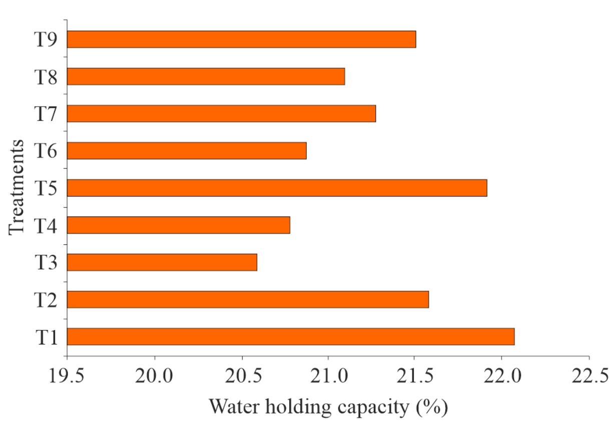

Fig. 1. Variations in water holding capacity and porosity in guava orchard under different soil nutrient management system

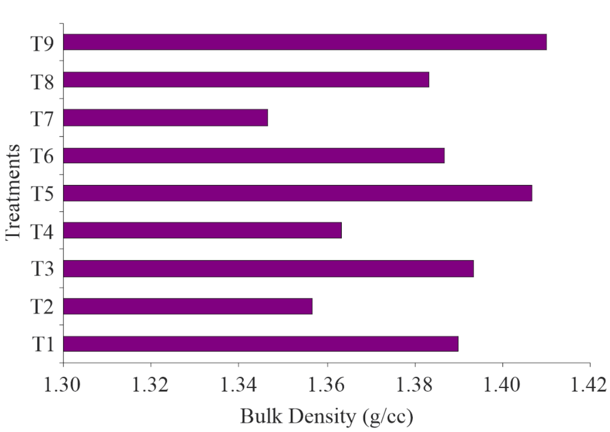

Fig. 2. Variations in bulk and particle densities in guava orchard under different soil nutrient management practices

may be recoded over the years of cultivation (de Herrera *et al*., 2016; Namaghi *et al*., 2018). Kiczorowski *et al.* (2018) studied effect of organic mulches on growth and yield of Šampion apple trees in Poland and concluded that they have positive impact on apple fruit number, growth and mineral contents. Compaction of the fruit orchard particularly in basin area over years has tremendous impact on the soil physical properties. It was reported by researchers across globe on the variations of soil physical properties on different types of soil (Becerra *et al*., 2010; Medeiros *et al*., 2013; Montanaro *et al*., 2017). Rafaela *et al.* (2017) described the degree of compactness and compression index under irrigated conditions in banana field soils in Brazil. Not only physical attributes but also penetration cum soil strength also significantly affects on root and tree development (Adak *et al.,* 2020). Moreover, tillage or tillage with orchard floor management system used to impact on the soil physical properties as evidenced from Atucha *et al*. (2011), Cho *et al*. (2013) and Souza *et al*. (2018). Soil fertility *vis-a-vis* guava yield was also studied; based on field study on quantity-intensity relationships of potassium in soils under some guava orchards on marginal lands. Sharma *et al*. (2012) concluded for better management of K in these soils as these soils have higher affinity for K. Similarly, Cavalcante *et al*. (2018) inferred from a study (2015-16) that for maintaining the soil fertility level in guava orchards, K application @ 90 - 135 g plant^{-1} year^{-1} and without application of Ca is to be practiced. In this experiment, it was noted that inclusion of organic + inorganic sources (T2) improved the bioavailability of soil nutrients apart from improvement in soil organic carbon. Adak *et al.* (2016) observed variations in soil physical properties in guava orchard ecosystem having different planting densities maintained over a period of time. Even different substrates could enhance the functional relationship among the physical, chemical and biological properties in guava orchard soil (Adak *et al*., 2017). All these variations ultimately indicated the behavior of soils and its associated contribution towards other properties over a period of time; needs for orchard ground floor management to improve the condition of soil. Sometimes texture also plays as one of the key indicators for nutrient availability. It decides the amount and types of chemical fertilizers to be incorporated towards better nutrition of fruit crops (Shahandeh *et al*., 2011). Vignozzi *et al.* (2019) confirmed the role of soil conservation practices on ecosystem services in Olive orchard. Thus, investigation of variations in soil physico-chemical properties as a function of soil nutrient management system in guava orchard soil under subtropical climatic conditions is called for.

Conclusions

The study was laid out with the aim of estimating the guava yield as a function of different soil management practices and obtained better guava fruit yield as compared to control plots. Addition of foliar spray or soil application of micronutrients along with NPK could yield considerably. Yield improvement was recorded from 37.82 to 63.65 and 41.20 to 72.5 kg tree^{-1} during 2013-14 and 2014-15 respectively; however further efforts should be made to improve the yield harvesting beyond 72.5 kg tree^{-1}. This is only possible when integrated nutrient management module is well adapted. Moreover, variations in soil properties under these management systems were also noted; some are influenced positively. The study thus inferred that for maximizing guava fruit yield in sandy loam soil, proper tree nutrition involving combination of organic sources like 10 kg FYM, *Azotobacter,* PSM, *Trichoderma harzianum,* organic mulching along with mineral fertilizers (120, 60, 50 g N, P, K/tree/year of age) should be adopted by the farmers of this region. The future study should also focus on the root biology aspect in guava; its volume length and pattern of distribution under different soil management practices for nutrient uptake *vis-à-vis* productivity.

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