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EFFECT OF DIFFERENT SOIL AND NUTRIENT MANAGEMENT PRACTICES ON GROWTH OF YOUNG PLANTS OF COORG MANDARIN

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Abstract: The objective is to study effect of different soil and nutrient management modules on growth of Coorg manadarin seedlings and grafted plants. The treatments were: Factor-1: *Plant type*- Seedlings and Grafted; Factor-2: *Cover cropping* -with and without cover crop; and Factor-3: *Nutrients management modules*- T_1: FYM+RDF+citrus special; T_2: T_1+soil application of $MgSO_4$ and $ZnSO_4$+ sunnhemp+Arka microbial consortium+Vesicular arbascular mycorrhiza; T_3: as of T_2 (in place of RDF-50% inorganic+50% organic); and T_4: as of T_2 (in place of RDF-100% organic). Total 16 treatment combinations with three replications maintained. Growth parameters were recorded and leaf nutrient and soil health status were analyzed in two year old orchard. Plant height, girth diameter and number of branches varied from 204-232 cm, 4.43-5.56 cm and 11-15, respectively. Grafted plants with INM (T_3) showed significant improvement in these parameters. Leaf nutrients concentrations did not significantly differ except K and Mn. Leaf K content varied from 1.07-2.09%. The significant improvement was found in INM (T_3). Similarly leaf Mn content varied from 65.8- 86.9 ppm and was significantly enhanced in T_2. There was no significant improvement in soil health parameters; however, long term monitoring can give clear picture of soil health status under different nutrient management modules.

Keywords: Coorg mandarin, growth parameters, leaf nutrient content, nutrient management, soil health

INTRODUCTION

Mandarin (*Citrus reticulata* Blanco) is one of the most important fruits of citrus family and is mainly cultivated in Maharashtra, Madhya Pradesh, West Bengal, Karnataka, Tamil Nadu and North Eastern States. In South India, an ecotype of mandarin known as 'Coorg Mandarin' is quite popular and is being widely cultivated for several decades. It is grown in Kodagu, Hassan, Chikmagalur districts of Karnataka, Wayanad district of Kerala, Shevaroy and Palani hills of Tamil Nadu. This crop is largely grown in rainfed condition as one of the components crop in coffee and pepper plantations. Coorg oranges have greenish-yellow or greenish-orange fruits with tight skin, blend of sweet and sour taste, and longer shelf life compared to other mandarins. Because of this specific taste and nature the Coorg mandarin was given geological indication status during 2006. The total Coorg mandarin production in Karnataka is 46250 tonnes with productivity of 25 t ha^{-1}. Mandarin is planted for more than 150 years with an area of 24,000 ha in Kodagu district and in the recent years, mandarin area has come down to less than 2,000 ha due to citrus decline. Citrus decline is caused by complex biotic and abiotic factors such as improper soils, unavailability of virus free quality planting materials, nutrient deficiencies, mal-practices in nursery, Viral/ mycoplasma/fungal/bacterial diseases and insect pests, improper cultural practices, lack of proper nutrition and plant protection measures, poor drainage, etc. Due to citrus decline, the

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average yield of a plant has come down from 50 kg to 10 kg. These complex issues need to be addressed through interdisciplinary effort. In this context, Central Horticultural Experiment Station, Chettalli has worked out the integrated multidisciplinary approaches like development of disease free quality planting material, proper orchard management, correction of nutrient deficiencies and soil test based optimal nutrient management practices, adaption of various pest and disease control measures, etc. in reviving citrus decline problems in the region [9, 17].

Kotur *et al.* [14] have evaluated long-term cultural practices such as soil-mulch (by hoeing), mulching with dry leaves, non-cultivation, shading (with *Ficus glomerata* Roxb.) and control (slash-weeding and shallow-scuffing) in relation to soil-chemical properties in Coorg mandarin cultivation. Though non-cultivation and soil-mulch reduced pH, organic carbon and exchangeable cations, shading promoted these properties. There are several studies on root systems and leaf nutrient concentration and foliar and soil application of macro and micronutrients [1-8, 10-15]. However, information on integrated nutrient and soil management involving organic and inorganic sources of nutrients, bio-fertilizers, green manuring and cover cropping on growth of Coorg mandarin is lacking. Further, farmers of these regions are claiming that seedlings perform better than grafted plants. However, there is no clear cut scientific information available in this connection. Therefore, in the current investigation, it is aimed to study the effect of different soil and nutrient management practices on growth of both seedling origin and grafted Coorg mandarin plants.

MATERIALS AND METHODS

Experimental location

A new Coorg mandarin orchard was established in Central Horticultural Experiment Station (ICAR-IIHR), Chettalli farm in July 2018 by planting both seedlings and grafted plants. The farm is located in the coordinates of 12.391° N latitude and 75.845° E longitude with an altitude of 609 m above mean sea level. The average annual minimum and maximum temperatures are 32°C and 19°C, respectively. Mean annual rainfall is about 1500 mm mostly distributed during July-August. The soil of experimental field is deep, dark brown, well drained sandy loam texture. The topography of the land is slightly slope. Initial soil properties of experimental fields are depicted in Table 1.

Table 1: Initial soil properties of experimental field

Particulars	*Surface soil (0-15 cm)*		*Subsurface soil (15-30 cm)*	
	Value	*Remarks*	*Value*	*Remarks*
pH	5.76	Acidic	5.70	Acidic
EC (dS/m)	0.18	Safe/Normal	0.16	Safe/Normal
OC (%)	1.76	High	1.63	High
N (kg/ha)	317	Medium	293	Medium
P (kg/ha)	8.23	Low	10.2	Medium
K (kg/ha)	204	Medium	160	Low
Ca (kg/ha)	728	Low	792	Low
Mg (kg/ha)	236	Low	237	Low
S (mg/kg)	14.4	Sufficient	12.4	Sufficient
Fe (mg/kg)	61.6	Sufficient	50.5	Sufficient
Mn (mg/kg)	81.2	Sufficient	52.3	Sufficient
Cu (mg/kg)	6.55	Sufficient	6.76	Sufficient
Zn (mg/kg)	5.57	Sufficient	7.34	Sufficient

Treatment details

There were three different factors in the treatments as below:

Factor 1: Plant type

S - Seedlings and G- Grafted plants

Factor 2: Cover cropping

C_1 -With cover crop and C_0 - Without cover crop

Factor 3: Nutrients

T_1 : 25 kg FYM +100% RDF (inorganic) + citrus special (5 g L^{-1})

T_2 : 25 kg FYM +100% RDF (inorganic) + citrus special (5 g L^{-1})+soil application of $MgSO_4$ (250 g $plant^{-1}$) and $ZnSO_4$ (250 g $plant^{-1}$) + Green manure (sunnhemp)+ AMC (40 g $plant^{-1}$) + VAM (40 g $plant^{-1}$)

T_3 : as of T_2 (in place of RDF= 50% inorganic & 50% organic)

T_4 : as of T_2 (in place of RDF=100% organic)

Total 16 treatment combinations with three replications were maintained in factorial randomized block design. In each replication four plants were maintained. The recommended doses of fertilizer (RDF- 600 g N, 200 g P2O5, and

400 g K2O) are applied in two equal splits in May and in October through di-ammonium phosphate (DAP), urea and muriate of potash (MOP). Farm yard manure (FYM) was applied 15 days before fertilizer application. The citrus special is a micro and secondary nutrient mixture applied as foliar spray (5 g L^{-1}) in two times in monthly interval during August and September. Arka Microbial Consortium (AMC) bio-fertilizer and vesicular Arbascular Mycorrhiza (VAM) were applied along with FYM. Sunnhemp was grown and incorporated as green manure crop during rainy season (July-August) and cowpea was grown as cover crop during summer (February- April). $MgSO_4$ and $ZnSO_4$ were applied in June. Lime (500 g $plant^{-1}$) was applied in all the treatments at the time of planting. During summer season plants were irrigated through drip lines. These treatments were started from May, 2019 and continued for two years.

Measurements, sampling and analysis

The growth parameters such as plant height, girth diameter and number of branches were measured in December, 2020. Plant height was measured using measuring scale from color region to apical stem. The stem girth diameter was measured using Vernier caliper at 15 cm above color region. Total numbers of primary and secondary branches were recorded. Plant leaf samples were collected recently fully matured 4th-5th leaf from top from all the four sides of canopy. Leaf samples were washed with distilled water to remove dust and air dried in shade. Subsequently leaves were dried in hot air oven at 65C. Then oven dried leaves were ground using motorized grinder. Surface soil samples were collected, air dried and processed. Leaf and soil samples were analyzed following the standard procedure.

Statistical analysis

Data of plant height, girth diameter and number of branches were used for analysis of variance adopting factorial design for interaction effect. Further soil health and plant nutrient status were analyzed following completely randomized block design following standard statistical procedure [16]. The means of different parameters were compared using critical difference at 5% significance level.

RESULTS AND DISCUSSION

Plant Height

The plant height of two years old Coorg Mandarin varied from 204 cm to 232 cm (Table 2). There was no significant difference in plant height between seedlings and grafted plants, with and without cover cropping and among different nutrient management modules. The interaction of seedlings under cover cropping in nutrient module 2 had recorded the highest significant plant height. However, overall plant health was

Table 2: Effect of plant type, cover cropping and nutrient management modules on plant height (in cm) of Coorg Mandarin

Factor (A)-Plant type	*Factor (B)- Cover cropping*										*Mean (A)*
	No cover crop					*Cowpea cover crop*					
	Factor (C)- Nutrient management										
	T_1	T_2	T_3	T_4	*Mean (AxB)*	T_1	T_2	T_3	T_4	*Mean (AxB)*	
Seedlings	212.3	218.3	211.0	220.0	215.4	230.6	232.0	213.3	203.3	219.8	217.6
Grafted	203.7	216.3	227.0	209.7	214.2	219.3	209.7	214.3	217.7	215.2	214.7
Mean (BxC)	208.0	217.3	219.0	214.8		225.0	220.8	213.8	210.5		
Mean (B)	214.8					217.5					
	Seedlings					Grafted plants					
Mean (AxC)	221.5	225.2	212.2	211.2		211.5	213.0	220.6	213.7		
	T_1		T_2			T_3		T_4			
Mean (C)	216.5		219.1			216.4		212.7			
CD (5%)	8.95		B-8.95		C-12.65	A x B -12.65		A x C-17.89		B x C 17.89	A x B xC 25.31

better in grafted plants. The seedling plants were lanky and infected with bacterial greening. The canopy cover and number of branches were more in grafted plants only. This might be due to enhanced health of plant by AMC and VAM which involves in production of plant growth hormones, nutrient solubility and mobilization and N fixation, etc [19]. Further soil application of Zn and Mg might have supplied sufficient quantity of these nutrients to plants [18].

Stem girth diameter

There was no significant difference in stem girth diameter of Coorg Mandarin between plant type, due to cover cropping and among nutrient management modules. The stem girth diameter varied from 4.43 cm to 5.56 (Table 3). Among the interactive effect grafted plants with INM modules showed significant improvement in plant girth diameter (T_2-T_4). This might be due to sufficient balance supply of secondary and micronutrient, root and plant health enhancement of bio-fertilizers, etc [18, 19].

Number of branches

More numbers of branches were observed in grafted plants under INM treatments when compared to seedling plants. The total numbers of primary and secondary branches varied from 11-15 under different treatment combinations (Table 4). The improvement plant vigour and number of branches in grafted plants could be

Table 3: Effect of plant type, cover cropping and nutrient management modules on stem girth diameter (in cm) of Coorg Mandarin

Factor (A)-Plant type	Factor (B)- Cover cropping										Mean (A)
	No cover crop					Cowpea cover crop					
	Factor (C)- Nutrient management										
	T_1	T_2	T_3	T_4	Mean (AxB)	T_1	T_2	T_3	T_4	Mean (AxB)	
Seedlings	5.10	4.69	4.72	4.97	4.87	5.30	5.56	4.43	4.40	4.92	4.89
Grafted	4.44	4.90	5.34	4.89	4.89	4.67	4.97	4.95	5.04	4.91	4.90
Mean (BxC)	4.77	4.80	5.03	4.93		4.98	5.26	4.69	4.72		
Mean (B)	4.88					4.91					
	Seedlings					Grafted plants					
Mean (AxC)	5.20	5.13	4.58	4.69		4.55	4.93	5.15	4.99		
	T_1		T_2			T_3		T_4			
Mean (C)	4.88		5.03			4.86		4.83			
CD (5%)	0.20		0.20		C-0.29	A x B-0.29		A x C-0.40		B x C 0.40	Ax Bx C 0.57

Table 4: Effect of plant type, cover cropping and nutrient management modules on number of branches of Coorg Mandarin

Factor (A)-Plant type	*Factor (B)- Cover cropping*										*Mean (A)*
	No cover crop					*Cowpea cover crop*					
	Factor (C)- Nutrient management										
	T_1	T_2	T_3	T_4	*Mean (AxB)*	T_1	T_2	T_3	T_4	*Mean (AxB)*	
Seedlings	12.3	12.3	11.0	14.7	12.6	13.7	13.7	11.3	11.3	12.5	12.5
Grafted	9.7	15.0	13.3	15.0	13.3	12.7	10.3	13.0	14.0	12.5	12.9
Mean (BxC)	11.0	13.7	12.2	14.8		13.1	12.0	12.2	12.7		
Mean (B)	12.9					12.5					
	Seedlings					Grafted plants					
Mean (AxC)	13.0	13.0	11.2	13.0		11.2	12.7	13.2	14.5		
	T_1		T_2			T_3		T_4			
Mean (C)	12.1		12.8			12.2		13.8			
CD (5%)	Fac. - A 1.81		Fac. - B 1.81		Fac. -C 2.55	A x B 2.55		A x C 3.61		B x C 3.61	Ax Bx C 5.11

supply of plant growth regulators, hormones and balanced nutrient supply through bio-fertilizers, soil application of Mg and Zn, green manuring, and organic manures, etc. [18, 19]

Plant and soil nutrient concentrations

Leaf tissue concentrations of N, P, Ca, Mg, S, Fe, Zn and Cu were not significantly differed due to various treatments. However, K content of leaf tissue was varied from 1.07% to 2.09%. The significant improvement was found in integrated nutrient modules where AMC and VAM were included along with RDF and organic manures. Similarly Mn concentration of leaf was significantly enhanced in these treatments particularly in T_2. The Mn content of leaves varied from 65.8 ppm - 86.9 ppm (Table 5).

There was no significant difference in soil health parameters found due to different nutrient management modules and cover cropping (Table 6).

Table 5: Effect of plant type, cover cropping and nutrient management modules on leaf nutrient concentration of Coorg Mandarin

Treatments	*N (%)*	*P (%)*	*K (%)*	*Ca (%)*	*Mg (%)*	*S (%)*	*Fe (ppm)*	*Zn (ppm)*	*Mn (ppm)*	*Cu (ppm)*
SC_0T_1	1.29	0.199	1.07	1.61	0.244	0.190	317	37.1	75.0	542
SC_0T_2	1.16	0.143	1.54	1.44	0.186	0.215	319	46.1	73.7	674
SC_0T_3	1.16	0.129	1.39	1.31	0.201	0.192	355	46.7	74.9	587
SC_0T_4	1.14	0.173	1.44	2.01	0.276	0.232	373	52.1	75.7	664
SC_1T_1	1.33	0.151	1.20	1.61	0.284	0.212	326	45.0	76.7	593
SC_1T_2	1.10	0.183	1.35	1.76	0.233	0.232	296	51.1	86.9	595
SC_1T_3	1.14	0.165	1.49	1.61	0.200	0.176	285	31.9	65.8	468
SC_1T_4	1.29	0.145	1.36	1.81	0.236	0.244	379	59.5	79.5	579
GC_0T_1	1.23	0.120	1.72	1.66	0.183	0.163	304	30.2	75.9	526
GC_0T_2	1.32	0.231	1.78	1.45	0.184	0.185	311	44.7	78.1	553
GC_0T_3	1.20	0.189	2.09	1.59	0.250	0.184	323	35.7	79.9	530
GC_0T_4	1.16	0.150	1.89	1.64	0.204	0.171	300	32.6	66.8	508
GC_1T_1	1.23	0.145	1.77	1.55	0.158	0.205	394	40.1	83.6	593
GC_1T_2	1.25	0.166	1.85	1.33	0.229	0.201	428	40.3	84.5	566
GC_1T_3	1.14	0.160	1.57	1.88	0.256	0.192	329	32.8	75.5	504
GC_1T_4	1.14	0.179	1.88	1.32	0.258	0.190	266	31.8	65.9	543
CD	NS	NS	0.23	NS	NS	NS	NS	NS	10.1	NS

Note: **S**-seedling plants; **G**- grafted plants; $\mathbf{C_0}$- no cover crop; $\mathbf{C_1}$- cowpea cover crop; $\mathbf{T_1}$:25 kg FYM +100% RDF (inorganic) + citrus special; $\mathbf{T_2}$:25 kg FYM +100% RDF (inorganic) + citrus special +soil application of $MgSO_4$ (250 g) and $ZnSO_4$ (250 g) + lime+ Green manure (sunnhemp)+ AMC + VAM ; $\mathbf{T_3}$:as of T_2 (RDF=50% inorganic & 50% organic); $\mathbf{T_4}$: as of T_2 (RDF-100% organic).

Table 6: Impact of different INM modules on soil properties

Treatments	*pH*	*EC (dS m^{-1})*	*OC (%)*	*N (kg ha^{-1})*	*P (kg ha^{-1})*	*K (kg ha^{-1})*	*Ca (kg ha^{-1})*	*Mg (kg ha^{-1})*	*Fe (mg kg^{-1})*	*Mn (mg kg^{-1})*	*Cu (mg kg^{-1})*	*Zn (mg kg^{-1})*
SC_0T_1	5.21	0.25	1.65	267	3.89	108	670	131	55.8	63.2	7.42	8.02
SC_0T_2	5.08	0.41	2.07	335	5.59	131	721	152	58.6	62.4	8.10	8.93
SC_0T_3	5.38	0.21	2.19	355	3.68	119	751	143	45.9	49.1	6.96	7.22
SC_0T_4	5.51	0.37	2.06	333	3.50	125	744	140	43.5	54.5	7.98	8.71
SC_1T_1	5.27	0.24	1.46	237	5.59	156	746	147	61.5	57.7	9.55	7.24
SC_1T_2	5.72	0.23	2.13	346	5.18	114	851	157	43.5	44.5	6.89	5.83
SC_1T_3	5.49	0.35	2.34	380	6.59	126	826	158	48.1	53.3	7.58	6.61
SC_1T_4	5.91	0.31	2.90	469	4.16	110	730	151	44.5	51.9	6.98	7.67
GC_0T_1	5.10	0.29	2.17	351	3.57	98.4	550	122	83.6	83.3	9.92	8.89
GC_0T_2	5.48	0.32	1.75	283	3.80	127	799	147	55.2	62.4	7.99	7.85
GC_0T_3	5.73	0.28	1.89	307	4.07	131	728	132	49.0	53.8	9.07	7.63
GC_0T_4	5.55	0.25	1.40	226	4.96	89.6	585	119	44.8	52.9	7.94	7.10
GC_1T_1	5.04	0.39	1.34	217	3.43	95.5	589	135	59.4	62.7	7.24	7.35

Treatments	pH	EC (dS m^{-1})	OC (%)	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	Ca (kg ha^{-1})	Mg (kg ha^{-1})	Fe (mg kg^{-1})	Mn (mg kg^{-1})	Cu (mg kg^{-1})	Zn (mg kg^{-1})
GC_1T_2	5.57	0.22	1.78	289	4.89	129	667	140	59.9	68.1	8.53	6.03
GC_1T_3	5.42	0.44	1.99	323	4.78	148	642	138	42.3	56.0	7.08	8.19
GC_1T_4	5.31	0.31	2.11	342	3.25	186	744	138	56.3	65.2	8.09	6.83
CD	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: **S**-seedling plants; **G**- grafted plants; $\mathbf{C_0}$- no cover crop; $\mathbf{C_1}$- cowpea cover crop; $\mathbf{T_1}$:25 kg FYM +100% RDF (inorganic) + citrus special; $\mathbf{T_2}$:25 kg FYM +100% RDF (inorganic) + citrus special +soil application of $MgSO_4$ (250 g) and $ZnSO_4$ (250 g) + lime+ Green manure (sunnhemp)+ AMC + VAM ; $\mathbf{T_3}$:as of T_2 (RDF=50% inorganic & 50% organic); $\mathbf{T_4}$: as of T_2 (RDF-100% organic).

CONCLUSION

To sum-up, the results revealed that health of grafted plants are good compared to seedlings and moreover grafted plants are responded to applied treatments with respect to improvement in stem girth diameter, canopy cover and number of branches. Among the nutrient modules integration and balanced supply of nutrients through organic and inorganic sources, soil application of Mg, S and Zn, plant growth promotion through bio-fertilizers (AMC and VAM) improved the plant growth parameters and plant nutrient. Though there is no much soil health improvement in short term due to various treatments, the long term management particularly integrated management could sustain soil health.

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