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Navel orange production in relation with replacement of chemical fertilizers by organic manures on sandy soil in Egypt

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Abstract: The possibility of reducing use of mineral fertilizers by partial substitution with organic manure and the effects of them on growth, nutrients status, yield and fruit quality of Washington navel orange planted in Sadat city, El Minufiya governorate, Egypt were studied during two successive seasons. Combination of market residue compost with chemical fertilizers were applied in different ratios. Growth (tree canopy &leaf area),fruit characteristics (number, weight, peel thickness, total soluble solids, total acidity &ascorbic acid "V.C."), yield, crop efficiency, macronutrients (N,P,K); micronutrients (Fe,Zn,Mn,Cu); heavy metals (Pb,Ni,Cd) in the leaves &fruits were determined. Furthermore, all applications led to sufficiency levels of mostly nutrients in orange leaf and maintained the permissible limits in the juice for good health of the human. It can be concluded that fertilizing Navel orange tree grown on sandy soil with combinations of chemical fertilizers + organic manure at ratios 1:1 till 1:3 which led to improve the growth, increase the yield and maintain fruit quality.
Keywords: chemical fertilizers, organic manure, navel orange, growth, nutrients, fruit quality, yield.

Introduction

Organic culture is considering the most benign alternative for citrus farmers use of organic materials such as farmyard manure, cakes of plant origin, vermicompost and also, microbial biofertilizers are important component of the organic citrus cultivation[1]. Acceptable commercial citrus can be achieved using a combination of compost and chemical fertilizers, also, a compost-chemical program is more economical and environmentally beneficial than a alone chemical program[2].The use of organic residues improving soil organic matter and humic substances at higher levels than inorganic fertilizer[3], Thus reducing the need for inorganic fertilizers[4]. Some citrus in Egypt which is grown on reclaimed or sandy lands of low native fertility and low nutrient and water holding capacities, this increase the probability that fertilizer "N" will leach beyond the root zone. The application of organic materials "composts" as fertilizers or soil conditioners to those soils as a source of organic matter are recognized ways of improving their soil physical(water holding capacity), chemical(reduce fertilizer application) and as well as their biological properties such as increasing microbial communities[5,6]. In serial studies using fertilizing with cattle manure with market residue compost on orange[7,8] and also ,banana residue compost or market residue compost on banana[9,10] led to good growth thus, the yield and fruit quality were improvement. Thus, citrus can be cultivated in the sandy soil with only minimum contamination of ground water if best management practices and reduced N application rates are used[11].

The purpose of this study was to reduce significantly the amount of chemical fertilizers applied to Washington navel orange trees without reducing growth and yield with maintain acceptable fruit quality.

Materials and Methods

Fertilizers

A) Organic manure:

Was in compost form (market residue compost "El-Obour") produced from fruits and vegetables waste and by produced from El-Obour market by commercial company and was used as organic source of (N) for each tree in January every year. Its chemical properties were determined before soil application during two successive seasons and were shown in Table (1).

Table (1): Some chemical characteristics of soil and used organic manure (compost) before applying to the trees.

Sample source	Season	(%)			(ppm)							PH (1:2.5)	EC (dsm-1) (1:2.5)	O.M (%)	*Organic Carbon (%)*
		N	P	K	Fe *	Mn*	Zn*	Cu*	Pb*	Ni*	Cd*				
Soil	**1 st season**	0.055	0.017	0.169	2.00	1.66	1.802	0.32	0.25	0.112	0.02	8.1	1.50	0.5	----
Compost	**1 st season**	1.50	0.33	1.25	150	48	150	20	BDL	BDL	BDL	8.4	3.18	40.05	*23*
Compost	***2 nd season***	*1.69*	*0.21*	*1.075*	*84.25*	*70.5*	*116.12*	*10.62*	*0.95*	*0.238*	*0.123*	*7.7*	*4.2*	*39.58*	*22.96*

* were extracted by DPTA BDL: Below detectable limit

B) Chemical fertilizers:

"N" was applied as ammonium sulphate form (20.5%N)in three doses[February, May and August] ;"P" was added as superphosphate(16%P_2O_5)in one dose [Jan.]and mixed with organic compost and 500gm from sulphur(99.5%)/tree."K" was used as potassium sulphate(50%K_2O) in two equal doses;[Feb. and Agu.]; all were broadcast and incorporated into the root zone of tree.

The experiment involved six ratios between chemical fertilizers NPK and organic manure N as 1000 unit of" N" + 100 unit of" P" + 624 unit of "K"/tree/year as recommended doses of National Campaign For Improving Citrus Productivity in Egypt .So, its arranged and illustrated in Table(2) .The other horticultural practices were similar for all trees .The experiment was set in a completely randomized blocks design with three replicates each consisted of three trees.

Table (2): Rates and application dates of fertilizers program in this study

Rate and application date Treatment	**Organic Manure (units) in Jan.**		**Chemical Fertilizers (units)**					
			N			**P_2O_5**	**K_2O**	
	1 st season	**2 nd season**	**Feb.**	**May**	**Aug.**	**Jan.**	**Feb.**	**Aug.**
Chemical Fertilizers only (C.F.)	-	-	400	200	400	100	312	312
Organic manure only (O.M.)	1000	1000	-	-	-	-	-	-
C.F. + O.M. at 1:1 ratio	500	500	200	100	200	50	156	156
C.F. + O.M. at 1:2 ratio	666.7	666.7	133.3	66.6	133.3	33.3	104	104
C.F. + O.M. at 1:3 ratio	750	750	100	50	100	25	78	78
C.F. + O.M. at 1:4 ratio	800	800	80	40	80	20	62.5	62.5

Plant:

The " Washington navel" variety orange (*Citrus sinensis L.Osbeck*), grafted on sour orange rootstock (*C. aurantium, L*), was about twelve years old, planted in a square system of five meters apart, and grown on sandy soil in private farm, Sadat city, El- Minufiya Governorate, on healthy and uniform condition. Some chemical characteristics of the soil at the beginning of the experiment are listed in Table (l).

Analytical methods:

Growth and yields:

Canopy volume of tree was measured in early December which tree shape was considered as a one-half of a probate sphere (volume = 4/6 x π x height x radius^2 "which π = 22/7")[12]. Leaf area was measured in early September using the formula = constant is 0.608(maximum length x maximum breadth)[13]. At commercial harvest (color break) in early December in the two seasons, yield as weight and number of fruit per tree was recorded then cropping efficiency was calculated by dividing the fruit yield weight by the canopy volume[14].

Fruit quality:

Ten fruits were randomly sampled per each tree for estimation of weight, peel thickness, then in the juice, total soluble solids percentage

(T.S.S %) was determined by Carl Zeiss hand refractometer; total acidity as anhydrous citric acid % (T.A.); TSS/TA ratio were calculated and vitamin C. was estimated as mg. ascorbic acid per 100 ml. Juice according to [15]

Leaf and juice mineral composition :

leaf samples were collected in early September and were mature fully expand from non fruiting non flushing spring cycle growth (5 old month) at one miter height of four directions, according to [16] then were washed, dried at 70°c until a constant weight, ground and digested according to [17]. Nitrogen was estimated by semi-micro Kjeldahl method of [18]. Phosphorus was determined by the method outlined by[19]. Potassium, Iron, Manganese, Zinc, Copper, Lead, Nickel and Cadmium were determined using atomic absorption Spectrophotometer "Perkin Elmer 1100 B" after[17]. Also, 10 ml. Juice were digested for nutrient analyses by the same methods.

Statistical analysis:

The data obtained in each season were analyzed by ANOVA according to [20].The means were separated by Duncan's multiple range test using a significant level of $P<0.05$ [21]

Results and discussion

1- Growth and yield:

1.1. Tree canopy and leaf area

Results in Table(3)clearly show that all doses of chemical fertilizers (c.f.) and organic manure (o.m.) gave similar volume of tree canopy in the first season, while in the second one, canopy volumes continued to spread and became more pronounced especially with application of (c.f.) only or (o.m.) only or combining (c.f.+o.f.) in1:1 ratio as comparing with combination its at 1(c.f.):4(o.m.)ratio . Such, increase in tree canopy is important because the largest trees usually used the most water and results in highest fruit yield [11]

Fertilizing with all forms alone or combine not affect leaf area in the first season, while in the second one, combine of(c.f. with o.m.) at rate 1:4 showed the less leaf area comparing with other treatments .This could be attributed to the slow releasing of various nutrients from organic compost in different its ratios ,and also, the ameliorating effect of these on soil properties and its fertilities thus, resulted in the maximum plant expand. These results are in agreement with those obtained by [22,23,24,6].

Table 3 : Tree canopy, leaf area ,fruit number and fruit weight in Washington navel orange trees grown in sandy soil as affected by chemical fertilizers and organic manure ratios during two seasons.

Rate and application date Treatment	Tree canopy (m^3)		Leaf area (cm^2)		Fruit number/tree		Fruit weight (gm.)	
	1 st season	2 nd season	1 st season	2 nd season	1 st season	2 nd season	1 st season	2 nd season
Chemical Fertilizers only (C.F.)	13.333a	38.515a	21.86a	22.41a	164b	203a	352.29a	301.38a
Organic manure only (O.M.)	12.63a	36.819a	20.76a	21.58ab	178ab	204a	330.83a	294.78a
C.F. + O.M. at 1:1 ratio	10.728a	31.356ab	21.17a	24.07a	182a	181ab	330.2a	361.67a
C.F. + O.M. at 1:2 ratio	8.468a	35.092ab	18.01a	18.94bc	162b	191ab	306.87a	304.85a
C.F. + O.M. at 1:3 ratio	11.35a	34.947ab	20.44a	22.2a	163b	190ab	338.75a	320.83a
C.F. + O.M. at 1:4 ratio	11.086a	21.371b	19.57a	18.34c	162b	165b	319.02a	321.87a

Means with the same letter are not significantly at 5% level

1.2. Fruit number, weight and yield

Table(3) noted that the fertilized trees by compost only o.m. in the two seasons and those combine of c.f. with o.m. at 1:1 rate in the first season or c.f. only in the second one, produced the highest fruit number compared with other treatments.

Fertilizing by all forms and ratios had light and no significant effect on fruit weight. This was true in the two seasons.

Table(4)show that the use of c.f. or o.m. each alone or combine at different ratios gave similar yield in the first season, wherever in the second one, combine of c.f. with o.m. at 1:1 ratio significantly increased the yield compared with combine c.f. + o.m. at 1:4 ratio but this increase was non significantly compared with other ratios. Also, there were increases in yield per tree in the second season proportional to the increases in tree canopy. These results were in line with those reported with use of different organic forms on lemon [26] on mandarin[27] and on orange [4,7,8,28] .

1.3. Crop efficiency (fruit production per unit of canopy volume)

The results in Table(4) show that there were no significant differences between all applications on crop efficiency in the first season, while in the second one the more crop efficiency was induced by applications of combine either c.f. + o.m. at 1:4 rate then at 1:1 rate. As well as, that crop efficiency declined as trees grew older. This is in accordance with those recorded by[7,8,25,29].

2- Fruit quality:

Results in Table(4) noted that applications of o.m. combined with c.f. at 2:1 ; 3:1 and 4:1 ratios produced fruits had the biggest peel thickness in the first season, while in the second one, there were no significant differences between various applications.

Fruits from trees received c.f. only or combined with o.m. at 1:1 or 1:2 ratios were the highest in total soluble solids(TSS%)in the first season, while in the second one, there were no significant differences various treatments.

Results presented in Table(5) indicate that applying c.f. only resulted in an increase of total acidity content (T.A.) in the juice in the two seasons.

Applying c.f. combined with o.m. at 1:1 ratio in the first season and at 1:4 ratio in the second season markedly increased total soluble solids/total acidity(TSS/TA) ratio in the juice.

The trees fertilized by o.m. only in the first season or o.m. combined with c.f. at 1:1 ratio in the second one, produced fruits contained the highest ascorbic acid in juice.

So, release nutrients resulting from biodegradation of manures by soil microorganisms as well as in activating both cell division and cell enlargement could explain those results [30]. This result agrees with those obtained by [4,7,8,25,31,32] who found that application of the organic amendments did not adversely affect quality.

Table 4:Yield,crop efficiency, peel thickness and total soluble solids percent(T.S.S.) in Washington navel orange trees grown in sandy soil as affected by chemical fertilizers and organic manure ratios during two seasons.

Rate and application date Treatment	Yield (Kg/tree)		Crop efficiency Kg/m^3		Peel thickness (cm)		T.S.S. (%)	
	1 st season	2 nd season	1 st season	2 nd season	1 st season	2 nd season	1 st season	2 nd season
Chemical Fertilizers only (C.F.)	57.775a	61.18ab	4.333a	1.588b	0.43b	0.46a	11a	10.8a
Organic manure only (O.M.)	58.887a	60.135ab	4.662a	1.549b	0.50ab	0.43a	10b	10a
C.F. + O.M. at 1:1 ratio	60.096a	65.462a	5.601a	2.087ab	0.50ab	0.46a	11a	10a
C.F. + O.M. at 1:2 ratio	49.712a	58.226ab	5.87a	1.659ab	0.60a	0.50a	10.8a	10.9a
C.F. + O.M. at 1:3 ratio	55.216a	60.957ab	4.864a	1.744b	0.60a	0.36a	10b	10.8a
C.F. + O.M. at 1:4 ratio	51.681a	53.108b	4.661a	2.485a	0.56a	0.43a	9.8b	10.2a

Means with the same letter are not significantly at 5% level

Table 5:Total acidity percent(T.A.), total soluble solids percent(T.S.S.)/ Total acidity percent(T.A.)ratio and ascorbic acid content of Washington navel orange fruit grown in sandy soil as affected by chemical fertilizers and organic manure ratios during two seasons.

Rate and application date Treatment	T.A. (%)		T.S.S. / T.A. ratio		Ascorbic acid (mg/100 gm. juice)	
	1 st season	2 nd season	1 st season	2 nd season	1 st season	2 nd season
Chemical Fertilizers only (C.F.)	1.241a	0.928a	8.863d	11.637b	37.44cd	46.96b
Organic manure only (O.M.)	0.988b	0.737b	10.121c	13.568ab	46.8a	39.78d
C.F. + O.M. at 1:1 ratio	0.825c	0.783ab	13.333a	12.771ab	39.0bc	51.48a
C.F. + O.M. at 1:2 ratio	0.978b	0.806ab	11.042b	13.523ab	37.44cd	43.94c
C.F. + O.M. at 1:3 ratio	0.864c	0.783ab	11.574b	13.793ab	40.56b	48.36b
C.F. + O.M. at 1:4 ratio	0.960b	0.667b	10.208c	15.292a	35.1d	42.12c

Means with the same letter are not significantly at 5% level

3- Leaf nutrients status:

Results presented in Tables(6 &7)indicated that macronutrients (N,P,K%)of leaf were near or in the 0ptimum ranges for mature citrus trees[33].

Also, addition c.f. alone increased "N" in leaf orange than the other treatments .This was true in the two seasons .Combining of c.f. with o.m. at 1:1 ratio increased leaf "P"in the two seasons .While combined them at 1:4 ratio increased leaf "K" in the two seasons. Those values are in accordance with [7,8].

Tables(6&7)showed that micronutrients (Fe,Zn,Mn,Cu, "ppm")levels for the first season were low but it increased in the second one to near or in the current leaf standards according to [34]with some variation among "Mn" levels under addition of o.m. alone and c.f. + o.m. at 1:3 ratio and also, "Cu level under addition of c.f. alone. Such, in the first season supplying the trees with c.f. only produced leaves contain a high "Fe" & "Cu" while "Mn" was high with supplying o.m. only, wherever, no different values of "Zn" was between all applications. Wherever, in the second season supplying the trees with c.f. +o.m. at 1:1 ratio produced leaves contain a high "Fe,Zn,Cu" while "Mn" was high with c.f. +o.m. at 1:4 ratio. Those values are in accordance with [7,8].

Tables (6&7)noted that heavy metals take the same aforementioned trend between the two seasons .In the first season, leaf "Pb" content increased due to addition of c.f. + o.m. at 1:1 ratio, the level of "Ni" increased in o.m. only application ,while, level of "Cd" increased with addition of c.f. + o.m. at 1:4 ratio. But, in the second season, leaf "Pb,Ni &Cd" levels increased due to addition c.f. + o.m. at 1:2 ratio.

Table 6: Nutrients leaf content in Washington navel orange trees grown in sandy soil as affected by chemical fertilizers and organic manure ratios during first season.

Rate and application date Treatment	(%)			(ppm)						
	N	P	K	Fe	Zn	Mn	Cu	Pb	Ni	Cd
Chemical Fertilizers only(C.F.)	2.76a	0.11d	1.248c	14a	5.5a	14b	4a	2.9c	4bc	1c
Organic manure only (O.M.)	2.41d	0.165b	1.44b	9.5b	5a	20a	2.5b	2.9c	7a	5ab
C.F. + O.M. at 1:1 ratio	2.56c	0.19a	1.152c	4c	5a	15b	1.5c	4.5a	5b	4b
C.F. + O.M. at 1:2 ratio	2.6b	0.120cd	1.248c	8.5b	5a	15b	2bc	1.8d	4bc	4b
C.F. + O.M. at 1:3 ratio	2.3e	0.135c	1.584b	4c	5a	15b	2bc	3.9b	3c	5ab
C.F. + O.M. at 1:4 ratio	2.2f	o.18ab	1.776a	4c	5.5a	15b	2bc	2d	3c	6a

Means with the same letter are not significantly at 5% level

Adequate ranges for citrus leaf were :2.4-3.5 (N), 0.15-0.3 (P), 1.2-2.0 (K)[33]. 35-135 (Fe), 19-50 (Zn), 19-100 (Mn), 5-15 (Cu)[34]. satisfactory levels for leaf barley plants were:<35(Pb),<26(Ni),<15(Cd)[33].

Moreover, there is reduction of some nutrients in response to some additions may be due to the increase in growth which depletes more amounts of those nutrients, besides, there are an increase in some other elements due to the availability of elements which slow release matches uptake by plant roots and prevents it from leaching [36].Also, this difference in the uptake of nutrients may be attributed to variation in the breakdown of applied organic compost rate and the changes from compost soil interaction with time which may alter metal availability for crops [37].

These results are in agreement with those reported by[7,8, 38-41].

Table 7: Nutrients leaf content in Washington navel orange trees grown in sandy soil as affected by chemical fertilizers and organic manure ratios during second season.

Rate and application date Treatment	(%)			(ppm)						
	N	P	K	Fe	Zn	Mn	Cu	Pb	Ni	Cd
Chemical Fertilizers only C .F.)	2.91a	0.19d	1.63ab	71.5e	14cd	8d	3.5bc	5.5cd	10.5c	14d
Organic manure only (O.M.)	2.54c	0.25b	1.64ab	104b	17b	18c	4ab	7.5b	12b	15.5b
C.F. + O.M. at 1:1 ratio	2.67b	0.33a	1.65ab	149a	19a	21b	4.5a	5.5cd	10c	14.5c
C.F. + O.M. at 1:2 ratio	2.65b	0.21cd	1.6b	92c	14cd	18c	3c	9.5a	14.5a	17.5a
C.F. + O.M. at 1:3 ratio	2.28d	0.21cd	1.68ab	62f	13d	4e	3c	6c	7.5d	14.5c
C.F. + O.M. at 1:4 ratio	2.24d	0.22c	1.7a	75d	15c	22.5a	3.5bc	5d	7.5d	12.5e

Means with the same letter are not significantly at 5% level

Adequate ranges for citrus leaf were :2.4-3.5 (N), 0.15-0.3 (P), 1.2-2.0 (K).[33]. 35-135 (Fe), 19-50 (Zn), 19-100 (Mn), 5-15 (Cu)[34]. satisfactory levels for leaf barley plants were:<35(Pb),<26(Ni),<15(Cd) [33].

4- Fruit nutrients status

Results recorded in Tables (8&9) show that all macro and micro nutrients and heavy metal in the orange juice were low in the concentration comparing with those in the orange leaf, this could be due to deplete amount from the leaf nutrients as source and transfer to the fruit as sink and used it in fulfill maturity. This is in agreement with [42,43] who found that Fe, Cu, Zn, Mn and heavy metals content in orange trees were in the order : root > leaves > peel > pulp (juice).On the other hands, the concentration of each element greatly varied among the all applications and control approximately 0.282-1.14 % of" N"; 0.151- 0.20 % of" P"; 0.445 -1.08 % of "K"; 1.439 -5.55 ppm of" Fe"; 0.113 – 1.58 ppm of" Zn"; 0.039 - 0.5 ppm of" Mn"; 0.064 - 0.48 ppm of "Cu"; 0.150 - 0.505 ppm of "Pb"; 0.032 – 0.187 ppm of" Ni" and 0.0102 - 0.0428 ppm of" Cd". For the two studied seasons, but remained within the permissible limits for human consumption according to GDR legislation [33]. Such, the concentration of [K,Fe,Zn,Cu &Cd] in the fruits juice produced from trees received c.f. + o.m. at 1:3 ratio were lower than the other ratios through two seasons, while "N","P" were low in the juice from trees received c.f. + o.m. at 1:4 ratio. This is in accordance with those recorded by[7,8,9,39,41,44-46].

Table 8: Nutrients juice content in Washington navel orange fruit grown in sandy soil as affected by chemical fertilizers and organic manure ratios during first season.

Rate and application date Treatment	(%)			(ppm)						
	N	**P**	**K**	**Fe**	**Zn**	**Mn**	**Cu**	**Pb**	**Ni**	**Cd**
Chemical Fertilizers only (C.F.)	0562a	0.17b	0.751b	2.441c	0.153ab	0.27c	0.089b	0.194ab	0.187a	0.0353b
Organic manure only (O.M.)	0.560a	0.18b	0.792a	1.702d	0.135b	0.28c	0.071bc	0.155b	0.032f	0.0135c
C.F. + O.M. at 1:1 ratio	0.392b	0.17b	0.465e	4.862a	0.169a	0.23d	0.079bc	0.244a	0.117c	0.0116de
C.F. + O.M. at 1:2 ratio	0.360c	0.17b	0.527d	3.557b	0.136b	0.50a	0.066c	0.150b	0.175b	0.0123cd
C.F. + O.M. at 1:3 ratio	0.322d	0.20a	0.445f	1.439e	0.113c	0.25cd	0.064c	0.175ab	0.078e	0.0102e
C.F. + O.M. at 1:4 ratio	0.282e	0.17b	0.608c	2.605c	0.142b	0.33b	0.168a	0.194ab	0.108d	0.0428a

Means with the same letter are not significantly at 5% level

Acceptable maximum levels for human consumption as(mg/100g) were: 15 (Fe&Mn), 1.9(Cu),0.39(Ni)[35]. 5.0 (Zn),0.05 (Cd) and 0.5 (Pb) according to GDR legislation [33]

Table 9: Nutrients juice content in Washington navel orange fruit grown in sandy soil as affected by chemical fertilizers and organic manure ratios during second season

Rate and application date Treatment	(%)			(ppm)						
	N	**P**	**K**	**Fe**	**Zn**	**Mn**	**Cu**	**Pb**	**Ni**	**Cd**
Chemical Fertilizers only (C.F.)	1.14a	0.160c	1.04a	5.1b	0.43cd	0.064b	0.12d	0.505a	0.165a	0.0120a
Organic manure only (O.M.)	1.10a	0.187a	1.05a	5.03b	0.33de	0.106a	0.11d	0.450c	0.155a	0.0122a
C.F. + O.M. at 1:1 ratio	0.99cb	0.180ab	0.75b	5.03b	0.53c	0.057bc	0.38b	0.475b	0.160a	0.0120a
C.F. + O.M. at 1:2 ratio	0.97c	0.164bc	1.08a	5.55a	1.58a	0.046cd	0.48a	0.475b	0.152a	0.0117a
C.F. + O.M. at 1:3 ratio	1.03b	0.190a	1.00a	2.48c	0.23e	0.039d	0.28c	0.500a	0.160a	0.0122a
C.F. + O.M. at 1:4 ratio	1.02bc	0.151c	0.75b	2.55c	0.78b	0.110a	0.13d	0.500a	0.155a	0.0120a

Means with the same letter are not significantly at 5% level

Acceptable maximum levels for human consumption as(mg/100g) were: 15 (Fe&Mn), 1.9(Cu) ,0.39 (Ni) [35]. 5.0 (Zn),0.05 (Cd) and 0.5 (Pb) according to GDR legislation[33].

Conclusion

It can be concluded that fertilizing Navel orange trees grown on sandy soil with combinations of chemical fertilizers + organic manure at ratios 1:1 till 1:3 which led to improve the growth, increase the yield and maintain fruit quality

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