thickness of the lemons from all treatments, including the control were reduced about 2 mm after storage. The rind thickness reduction was due to storage.

The data suggest that 0.2% Krenite would provide a commercially acceptable degree of retardation of shoot growth for 1 year following top-pruning without excessive foliage and twig damage or increased rind thickness but yield effects must be determined.

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Influence of Budding Height on Performance of 'Valencia' Sweet Orange on Two Rootstocks[1]

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Abstract. **Three-year-old seedlings of Cleopatra mandarin (*Citrus reticulata* Blanco) and Troyer citrang [*Citrus sinensis* (L.) Osbeck x *Poncirus trifoliata* (L.) Raf] were budded to 'Valencia' orange (*Citrus sinensis* (L.) Osbeck) at 5, 15, 30, 45, 60, and 90 cm above the ground level. Fruit yield was highest from trees budded at 15 cm height above the ground and tended to decrease as budding height increased. Nutrient concentrations in the leaves of trees were affected by the height of budding, but remained in an optimum range for maximum fruit production. The different rootstocks affected the nutrient concentrations in the leaves dramatically, but they still remained in an optimum range for maximum production of oranges.**

According to Bitters et al. (1) high budding of citrus lessened the incidence of gum disease and prevented malformation of typical unions by flaring of the crown roots. Generally, high-budded trees tend to have relatively smoother unions. Commercial lemon growers bud high (7) to delay and minimize the expression of shell bark. Murray (6) found that 'Marsh' grapefruit scions budded on sour orange rootstock at 5, 13, 25, 38, 51 and 63 cm above the ground in Trinidad gave smoothest bud union at 38 cm; no difference in bud-union reaction was experienced with 'Jaffa' sweet orange. The stock overgrew 'Marsh' grapefruit, however, when budding height was 25 cm or less, whereas above 25 cm, the scion overgrew the stock. The no. of fruit per tree decreased with height of budding, and the size of individual fruits increased as budding height was increased up to and including 38 cm. Blondel (2) reported that optimum budding height of 'Clementine' mandarin on trifoliate rootstock was 10 cm above the ground for smooth bud union, fruit production, and tree size.

The critical height for budding 'Valencia' sweet orange scion on Cleopatra mandarin or Troyer citrange rootstocks for best bud union formation and the greatest possible production is unknown. This study was designed to determine optimum budding height and the influence of budding height on nutritional status of the scion.

Three-year-old Cleopatra mandarin and Troyer citrange seedlings were budded to 'Valencia' orange at 5, 15, 30, 45, 60, and 90 cm above the ground level on the same date. Budlings were planted at the South Coastal Field Station, Orange County, California in a coastal environment, in 1966, and grown under normal field conditions. There were 7 randomized blocks with 1 tree per block. The entire experiment was sprayed each spring with a combination of 454 g of $ZnSO_4$ (36% Zn) and 454 g of $MnSO_4$ per 378 liters of water.

Fifty fully-expanded spring-cycle leaves from non-fruiting terminals were sampled in Sept. 1973 and 1974 for chemical analysis and yield records were obtained for these 2 years. Leaves were prepared as previously described (4) and analyzed for nutrient content (5).

Effect of budding height. The bud union was found to be smooth and no visual overgrowing of either the scion or rootstock was noted irrespective of the height of budding or rootstock. These combinations formed a good bud union at all budding heights, but the yield of fruit decreased as budding height was increased above 15 cm. The largest yield was obtained from trees budded at 15 cm (Table 1). The negative linear coefficient of correlation between the height of budding and yield of fruit was highly significant, r = −.803** (Table 1). This is in agreement with values reported by Murray (6) in Trinidad and by Blondel (2) in Algeria.

The data (Table 1) show that the nutrient concn in leaves were in an optimum range for maximum production of oranges (3), nevertheless, yields decreased with an increase in the height of budding. Nitrogen was statistically but irregularly affected by budding height. P concn showed a curvilinear relationship, R = .931**. The highest P concn was found when the seedlings were budded at 30 and 45 cm (Table 1). P concn at all budding heights was in an adequate range for optimal citrus production and was not a limiting factor. K concn increased with an increasing height of budding, r = .749** (Table 1) but in all cases were in range for optimal yield production (3). Leaf Mg concn was correlated with budding height, r = .719**. Leaf Cl concn decreased with an increase in height of budding, r = −.818**. Zinc concn in the leaves increased with an increased height of budding, r = .947***.

Nitrogen, Ca, Na, Cu, and B concn in the scion leaves were statistically significant, but did not fit linear or curvilinear curves (Table 1). All of these nutrients were in a range for optimal citrus production. Mn and Fe leaf concn

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Table 1. Effect of height of budding on yield and nutrient concn in scion leaves of orange grown on Cleopatra mandarin and Troyer citrange rootstocks.[z]

Budding ht (cm)	Yield (kg/tree)	Nutrient concn in oven-dried leaves N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Na (%)	Cl (%)	Zn (ppm)	Mn (ppm)	Cu (ppm)	B (ppm)	Fe (ppm)
5	69.5ab	2.44b	0.131BC	0.90C	5.39bc	0.297C	0.042bc	0.070b	181C	90	5.2b	68BC	78
15	73.6a	2.40c	0.132BC	0.93BC	5.32c	0.292C	0.039bc	0.068bc	186BC	89	4.8bc	68BC	81
30	70.8ab	2.41bc	0.133BC	0.89C	5.61b	0.305BC	0.038c	0.064c	183BC	88	4.7c	68C	82
45	60.2abc	2.43bc	0.136B	0.99B	5.45bc	0.297C	0.042bc	0.063c	191BC	91	4.9bc	71C	83
60	54.3c	2.40bc	0.132BC	0.99B	5.45bc	0.296C	0.043b	0.063c	206BC	93	5.1bc	66B	85
90	58.8bc	2.43bc	0.127C	0.98BC	5.54b	0.318B	0.041bc	0.063c	213B	94	5.2bc	71C	82
Coef. of correlation (r)	−.803**	NS	0.931**[y]	0.749**	NS	0.719**	NS	−0.818**	0.947**	NS	NS	NS	NS
CV	53%	2%	5%	11%	7%	8%	17%	18%	17%	17%	17%	9%	15%

[z]Each value is a mean of 28 individual determinations. Mean separation 5% level (lower case) or 1% level (upper case).
[y]This value is expressed as R.

Table 2. Main effects of rootstock and sampling dates on yield and on the nutrient concentrations in 'Valencia' orange scion leaves.[z]

Variable	Yield (kg/tree)	Nutrient concn in oven-dried leaves N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Na (%)	Cl (%)	Zn (ppm)	Mn (ppm)	Cu (ppm)	B (ppm)	Fe (ppm)
Rootstocks													
Cleopatra mandarin	68.1	2.38B	0.129B	0.93b	5.42	0.290B	0.042A	0.054B	199	93a	4.9b	73A	79B
Troyer citrange	60.8	2.46A	0.135A	0.97a	5.50	0.311A	0.039B	0.075A	187	89b	5.1a	64B	85A
Sampling date													
Sept. 1973	82.4A	2.45A	0.127B	0.99A	4.95B	0.288B	0.034B	0.054B	204A	110A	4.6B	69	83
Sept. 1974	46.3B	2.38B	0.136A	0.91B	5.96A	0.313A	0.047A	0.075A	183B	72B	5.4A	68	81
Interactions													
Budding ht. X rootstock	NS	NS	NS	NS	NS	NS	NS	NS	**	NS	NS	NS	**	NS

[z]Each value is a mean of 84 individual determinations. Mean separation in columns, within variables at 5% level (lower case) or 1% level (upper case).
NS = not significant.
** = significant at 1% level.

were not influenced statistically by budding height. Thus, reduction in yield of fruit due to increased heights of budding can not be attributed to nutrient deficiencies or toxicities.

Main effects of rootstocks. Leaves from trees growing on Troyer citrange rootstocks contained substantially higher N, P, K, Mg, Cl, Cu, and Fe and lower Na, Mn, and B, than those from trees growing on Cleopatra mandarin rootstock (Table 2). Ca and Zn concn were not influenced measurably by the 2 rootstocks. These increases in nutrient concn in the leaves from trees growing on Troyer citrange rootstock can be attributed in part to the lower yields of fruit produced on that rootstock. This is not in agreement with the previous finding (3) where higher nutrient concn in scion leaves were found with Troyer citrange rootstock. Nutrient concn in the leaves of the 'Valencia' orange trees growing either on Cleopatra mandarin or Troyer citrange rootstocks were in an adequate range for optimum yield production (3).

Sampling date effects. Nutrient concn in 'Valencia' leaves and the yield varied during the 2 experimental years, when samples were taken (Table 2). This is a common phenomenon in fruit trees. Factors causing these variations are beyond experimental control.

Interactions. Concn of Cl in the leaves of trees growing on Troyer citrange rootstock was significantly affected by the height of budding, but not on Cleopatra mandarin rootstock (Table 3). Leaf B concn was significantly influenced by budding height on Cleopatra mandarin but not on Troyer rootstock.

Table 3. Interaction effects of height of budding and rootstocks on the concn of Cl and B in 'Valencia' scion leaves.[z]

Budding ht (cm)	Cl in oven-dried scion leaves (%) Cleopatra mandarin	Troyer citrange	B in oven-dried leaves (ppm) Cleopatra mandarin	Troyer citrange
5	0.059	0.081A	75AB	62
15	0.053	0.083A	70B	67
30	0.052	0.075AB	71B	64
45	0.057	0.068B	76AB	65
60	0.052	0.073AB	69B	62
90	0.054	0.071B	79A	63

[z]Each value is a mean of 14 individual determinations. Mean separation in columns at 1% level.

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