between 0.1 and 0.2% for the 6-month storage period. Oxygen concn fluctuated slightly around 5% in the CA treatments during the first 4 months storage and decreased to 3% in the last 2 months as fruit respiration increased. Ethylene levels varied with time for all storage treatments, generally increasing with time (Table 1).

Color. The change in color index was greatest with plain air storage (A) and least with the CA low ethylene atm (D) during the first 13 weeks (Table 2). Both CA treatments (C and D) were significantly greener than the control (A), while lowering of ethylene levels with air storage (B) reduced rate of green color loss, so that it was equivalent to that of plain CA (C). Both CA treatments (C and D) were better by the 21st week than either of the air treatments (A and B) and this trend continued up to a storage time of 27 weeks.

Mold. Mold decay (Table 2) was slight after 13 weeks with no significant differences being recorded between the treatments. Mold decay in the CA treatment (C) was significantly greater ($P<1\%$), however, than the other 3 treatments (A, B and D) by the 21st week. This difference still existed after 27 weeks. Statistical analysis also showed that the overall effects of CA atm (C and D) after 27 weeks increased mold, while low ethylene treatments (B and D) reduced mold overall.

The results show that the reduction of ethylene levels in storage environments greatly reduces mold, while the use of CA storage reduces the rate of color change. It seems feasible, therefore, that further reduction of ethylene levels in CA storage to those levels obtained in treatment B would result in very low mold development and added color retention in stored lemons.

Table 1. Changes in ethylene levels during storage.

	Ethylene level change (ppm)					
	Length of storage (months)					
Treatments[z]	1	2	3	4	5	6
A	0.10	0.30	0.40	0.30	0.40	0.50
B	0.05	0.10	0.05	0.10	0.07	0.10
C	1.50	1.60	40.00	90.00	130.00	300.00
D	0.20	0.50	0.40	0.60	2.00	1.20

[z]See text for explanation of treatments.

Table 2. Color index values and percentage mold decay after storage up to 27 wk.[z]

	13 wk		21 wk		27 wk	
Treatment	Color index	Mold (%)	Color index	Mold (%)	Color index	Mold (%)
A	2.3a	3.0	1.9a	6.4a	1.7a	13.3a
B	2.8ac	1.3	2.0a	1.4a	1.8a	3.2a
C	3.3bc	2.9	3.1b	35.2b	2.0b	41.2b
D	3.8b	1.5	3.3b	3.3a	2.3b	9.9a

[z]Means in the same column followed by the same letter do not differ significantly, 5% level.

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Inhibition Effects of Localized Growth Regulator Sprays on Mature Lemon Trees[1]

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Additional index words. lemon rid thickness, *Citrus limon,* ammonium ethyl carbamoylphosphonate, ethyl hydrogen 1-propylphosphonate

Abstract. **Sprays of a plant growth regulator ammonium ethyl carbamoylphosphonoate (Krenite), applied to top regrowth of mature Lisbon lemon trees [*Citrus limon* (L.) Burmann] resulted in significant inhibition of growth for over 1 year. At concentrations above 0.2% there was excessive foliar and small branch damage.**

Mechanically pruning the tops of lemon trees has been a commercial practice in California for many years (11). The increasing expense of top pruning brush shredding makes the use of a growth inhibitor more attractive (2).

Spraying young regrowth shoots of mechanically topped lemon and avocado trees with certain growth inhibitors resulted in a significant retardation of growth (1, 6, 10). No chemical has been registered for this use on citrus and avocado for various reasons. This study was initiated with hope that the effectiveness of Krenite might be demonstrated and eventually could be approved for commercial use.

Maleic hydrazide (MH) is a chemical growth inhibitor that has been found to reduce or inhibit growth on a number of plants including lemons (10, 12). Growth inhibitors such as succinic acid-2,2-dimethylhydrazide (SADH) and the potassium salt of 6-hydroxy-3-(2H)-pyridacinone (KMH) have been tested as growth inhibitors for lemon top regrowth (6). KMH sprayed lemon showed a significant reduction in top growth 8 months after application. Growth was not reduced significantly and measurements taken 1 year after spraying showed no significant inhibition of top regrowth either KMH or SADH. Two experimental plant growth retar-

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[2]Cooperative Extension Service, Ventura, California.

dants, ethyl hydrogen 1-propylphosphonate (EHPP, NIA-10637) and 1-propylphosphonic acid (NIA-10656) inhibited avocado and lemon top regrowth (1, 6) and also controlled sprouts on trunks and stumps of citrus (3, 4). EHPP retards shoot growth of wild cherry, ash, beech, poplar trees and eucalyptus seedlings (5, 9). Krenite prevents spring bud break or provides growth suppression of species such as oak, maple, ash, sweet gum, sycamore and yellow poplar (7).

A field trial to evaluate the effectiveness of Krenite for retarding lemon top growth was initiated in May, 1974 near Camarillo in Ventura County. Trees were 11-year-old 'Frost Lisbon' on Troyer rootstock. Trees were mechanically topped to a height of 2.74 m in Oct., 1973 and the sprays were applied using a power sprayer with pressure of 7 kg/sq. cm (100 psi) on May, 1974 when regrowth obtained a length of 30 cm. Top growth was sprayed at low volume to minimize runoff using 0.2, 0.25, 0.3 or 0.4% Krenite or 0.25% EHPP in water with 0.02% X-77[3] as a wetting agent. Control trees received no spray. A randomized block design was used with 5 single tree replications. Tree height was measured prior to treatment on May 22 then 4, 7 and 13 months following applications.

Seventy fruit samples were picked from a zone adjacent to the area of 0.4% Krenite and 0.25% EHPP application, and same no. of fruit was picked from untreated control trees 13 months following trial initiated. Rind thickness was measured on half the fruit when picked, while the other half was held in cold storage at 10°C and measured 4 months after picked.

No visual symptoms of tree abnormality were observed from any treatment 2 weeks after application. All concn of Krenite showed some degree of die-back 2 months after treatment while those sprayed with EHPP showed shriveled, twisted and narrow leaves in the area of new growth that was sprayed. Trees sprayed with Krenite showed dead shoot tips and chlorotic leaves and no new growth in tree tops 4 months after treatment, while those sprayed with EHPP showed twisted leaves and rosetted new growth (Fig. 1). There were significant differences in growth inhibition between the first measurement after treatment and final measurement (Table 1). Responses to the

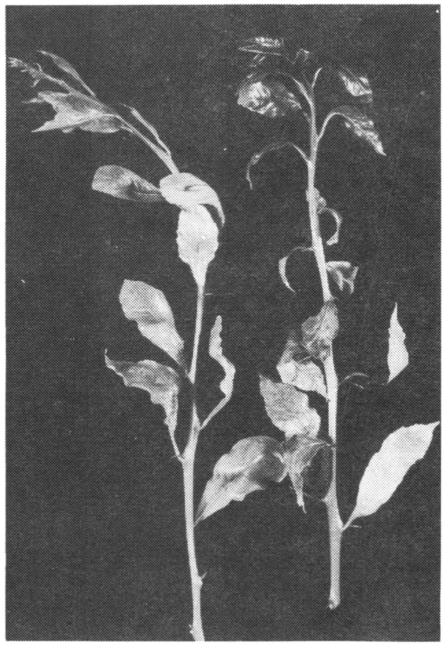

Fig. 1. Narrow twisted leaves of mature lemon trees sprayed with 0.25% EHPP 4 months after treatment.

chemicals were observed only in the area of application. All concn of Krenite with the exception of the 0.2% rate showed die-back 7 months after treatment. The trees sprayed with EHPP continued to grow but at a slower rate than the controls.

Final tree height measurements (Fig. 2) were made about 13 months after treatment. Die-back had ceased in all Krenite treatments at that time and normal regrowth resumed. Krenite at 0.3% and 0.4% caused dieback of from 30 to 45 cm on shoots about 9 mm in diam, and some twig die-back occurred on trees treated with 0.2 and 0.25% Krenite. EHPP-treated trees grew normally, but new growth that had been sprayed retained the malformed leaves. Total average height increase varied for 13 months from −0.03 to 1.73 m (Table 1). Both Krenite and EHPP treatments resulted in significant top regrowth inhibition. There were no significant differences between the Krenite treatments, however, they all showed greater growth reduction than the EHPP treatments and the control.

Previous work with oranges, grapefruit and lemons showed that the most undesirable fruit quality effect of MH was associated with rind thickness (8, 10). Rind thickness measured made on fruit from the 0.4 Krenite and 0.25% EHPP treatments and untreated trees showed no significant differences on both dates measured, however the rind

Table 1. Effect of Krenite and EHPP on growth of mature lemon trees.

Treatment[y]	Concn (%)	Linear top growth (m) — Months after treatment 0	4	7	13	Total mean increase
Krenite	0.4	2.90	2.90	2.87	2.87	−0.03a[z]
Krenite	0.3	2.90	2.90	2.90	2.98	0.08a
Krenite	0.25	2.90	2.90	2.90	3.02	0.12a
Krenite	0.2	2.90	2.93	2.90	3.29	0.39a
EHPP	0.25	2.90	3.35	3.84	4.21	1.31b
Control	–	2.90	3.72	4.48	4.63	1.73c

[z]Mean separation by Duncan's multiple range test, 1% level.
[y]Applied May 22, 1975.

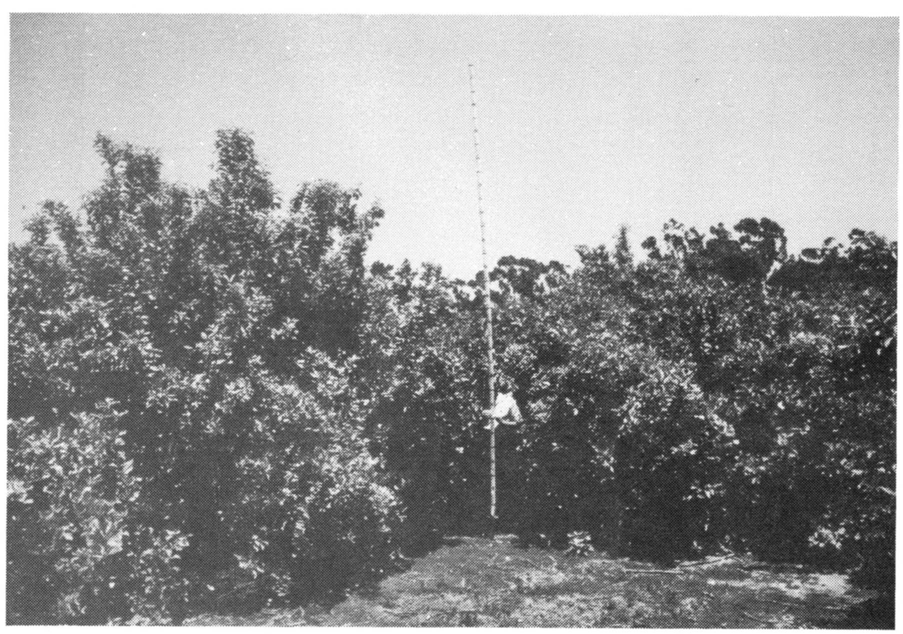

Fig. 2. Inhibitory effects of Krenite sprays to top regrowth. Right tree sprayed with 0.2% Krenite. Left unsprayed tree. Photographed 13 months after treatment.

[3]Colloidal Products of Sausalito, California produces X-77. The principal functioning agent of X-77 are alkylarylpolyoxyethylene glycols, free fatty acids and isopropanol.

[4]Research involved the use of chemicals that require registration for label usage under the Federal Government Pesticide Control Act (FEPCA). This report does not contain recommendations for use of such chemicals, nor does it imply that they are registered for use.

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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Additional index words. Citrus reticulata, Citrus sinensis, mandarin, citrange, leaf nutrient concentration

Abstract. **Three-year-old seedlings of Cleopatra mandarin (*Citrus reticulata* Blanco) and Troyer citrang [*Citrus sinensis* (L.) Osbeck × *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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[2]Cooperative Extension.