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## Fruit Size Management Strategies for Lemons

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Lemons are suited to Mediterranean-type and sub-tropical climatic conditions, although they can be grown in a wide range of climates. Lemons are grown in almost all the main citrus areas in South Africa, but more extensively in the 'intermediate', 'cool' and 'cold' areas like the Eastern and Western Cape. Small fruit size on lemons has become a concern for growers. Non-controllable factors and controllable factors before planting as well as controllable factors after planting all play a role in lemon fruit size. An individual factor or a combination of factors may be responsible for small fruit size and therefore all the factors influencing fruit size should be considered and managed optimally.

### Non-controllable factors

These factors cannot be changed or manipulated once an orchard has been established. The climate of an area, in particular temperature and therefore effective heat units, plays a major role in lemon fruit growth. Lemon fruit growth follows a sigmoid growth curve similar to that of oranges, with three phases: cell division (phase I), cell enlargement (phase II) and maturation (phase III). Enough heat during phases I and II is essential for fruit growth. Although lemon trees can be planted in areas with a wide range of effective heat units per year (1100 to 1500), some orchards are planted in areas where yearly heat units are lower, or much higher, therefore in sub-optimal growing conditions. Fruit growth is slower in the cooler areas and fruit takes a longer time to reach maturity. The optimum temperature for fruit growth is 30˚C, with 20-30˚C hot enough for satisfactory fruit growth. However, the fruit growth rate decreases at temperatures above 30˚C and below 20˚C, with almost no fruit growth occurring at temperatures above 40˚C and below 13˚C. Therefore, it is advisable to calculate yearly effective heat units using temperatures ≥13˚C and ≤ 35˚C or even 32˚C. However, lemons of adequate size can be produced in hot, humid areas, whereas hot, dry areas can result in smaller fruit. Therefore, the choice of the site of planting is very important and climatic norms for lemon production throughout the season as shown in the table below should be noted. Weather data should be obtained and effective heat units calculated when lemon orchards are established and, especially in seasons giving rise to smaller fruit, to determine if climate played a role.

Broad climatic norms for lemon production in inland and coastal productions areas in Southern Africa (Barry et al., 1996).

| ***Inland production areas*** | | |
|---|---|---|
| Season | Average min. temperature (˚C) | Average max. temperature (˚C) |
| Spring (Aug - Nov) | 10.5 - 15.5 | 25.5 - 30.0 |
| Summer (Dec - Feb) | 16.0 - 21.5 | 27.5 - 33.0 |
| Autumn (Mar - May) | 8.5 - 15.0 | 24.5 - 29.5 |
| Winter (Jun - Jul) | 2.5 - 10.0 | 19.5 - 26.0 |
| ***Coastal production areas*** | | |
| Season | Average min. temperature (˚C) | Average max. temperature (˚C) |
| Spring (Aug - Nov) | 10.0 - 12.5 | 22.5 - 26.0 |
| Summer (Dec - Feb) | 14.5 - 17.0 | 27.0 - 32.0 |
| Autumn (Mar - May) | 10.5 - 13.5 | 21.0 - 25.5 |
| Winter (Jun - Jul) | 6.0 - 9.5 | 17.5 - 22.5 |

### Controllable factors before planting

In addition, controllable factors before planting include the soil type (clay %), soil preparation determining the rooting depth, rootstock choice and cultivar choice. Heavier soils normally result in smaller fruit. Incompatibility between the rootstock and scion can also be a major cause of smaller fruit. Choose your tree spacing wisely when orchards are established, since narrow tree spacing (closer plantings) often results in very dense canopies. Since lemon trees (especially Eureka) tend to be tip-bearers (terminal bearers), pruning to open up trees and to control tree size in this case often removes a lot of bearing wood resulting in a less productive tree.

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**Controllable factors after planting**

**Irrigation:** Cell division and fruit growth are very sensitive to any water stress. Water stress during phases I (cell division) and II (starting ± 60 days after full bloom) of fruit growth results in smaller fruit. Faster and more uniform fruit growth results from more frequent short-cycle irrigation compared to long-cycle irrigation. However, the best irrigation schedule is one that considers the tree's demand and the capacity of the soil. The capacity of the irrigation system should never dictate when and how much water to apply. The design of the system should therefore satisfy the demand of the trees and the capacity of the soil. Maintaining the design specifications of the system is also important to maintain the efficiency. Measuring the delivery rate and operating pressure at least once per annum, should be standard practice. The larger (to some extent) the volume of soil irrigated (reservoir), the smaller the impact of an irrigation error on fruit size. Single line drippers and systems with two drippers per tree, leave no margin for error. A micro-jet system could compensate to some extent for management or system errors. Another important factor that is often neglected is the wetting depth, especially with drip systems. Irrigation scheduling should be based on the effective rooting depth of a specific soil-orchard combination. The most effective instrument to check on irrigation schedules is a profile pit. This is the only direct method and can be done at any part in the orchard. Add to this measuring the delivery rate and operating pressure, and irrigation could effectively be optimized.

**Fertilization:** Although the N:K ratio in the leaves is an important factor indicating the potential for optimal fruit size, optimal concentrations of all 14 nutrient elements are equally important, especially during the critical stages of phases I and II. Concentrating on, for instance, potassium applications when magnesium is deficient, will not improve fruit size. If any deficiency is present it should be corrected as soon as possible, even during the less efficient period of July to September. The most efficient approach is a balanced one where the purpose of fertilization is to get all nutrients within the optimal range. Potassium is known to improve fruit size, but so are nitrogen, magnesium etc. A potassium stress will reduce fruit size but likewise for a nitrogen or water stress. Before resorting to quick fixes, evaluate the total nutritional status of the trees as well as the irrigation scheduling.

When potassium is lacking and the trees do not respond to soil applications, foliar applications of potassium nitrate or -sulphate at 3% can be used. Depending on several conditions (overall nutritional status, N:K-ratios, actual K and N levels) sprays can be applied in July (nitrate and sulphate), August-September (only sulphate) or November-December (both) to improve fruit size. The earlier the spray, the better will the effect on fruit size be. The optimal N-status is 2.30-2.60%, and 0.70-1.0% for K. When the K-status exceeds 1.25%, K is not the reason for the fruit being too small and additional K will serve no purpose.

**Tree and root health:** Any factor inhibiting water uptake and transport in a plant will have an adverse effect on fruit size. Control of nematodes and *Phytophthora* can improve fruit size. Lemon trees tend to turn yellow relatively quickly after infection with *Phytophthora* and may affect fruit size more than other citrus types. Growers tend to act when signs of collar (foot) rot are noted by applying phosphonate stem paints or foliar sprays. However, when *Phytophthora* feeder root rot or nematodes is present it is normally neglected. Both these organisms cause a nibbling effect on the feeder roots. The results are that the trees need to replace these roots constantly which creates an energy sink. The first sign of such a sink is smaller fruit size. Certain trifoliate hybrid rootstocks such as X639 seldom show problems with collar rot but can develop *Phytophthora* feeder root rot problems. Nematodes can also build up over time on citrange rootstocks to levels as high as and even higher than on the more susceptible rough lemon rootstocks. Regular sampling of roots and soil for testing by the CRI Diagnostic Centre in Nelspruit is recommended. (For more information contact Wilma van der Westhuizen at 013 759 8031 or wb@cri.co.za)

**Delaying harvest and selective harvest:** Although fruit growth is very slow during phase III (maturation) of fruit development just before harvest, delaying harvest and/or selective harvest of larger fruit can result in a fruit size improvement. Make sure fruit are fully expanded before they are harvested. Yearly fruit size measurements throughout the season as done for other citrus types have often been

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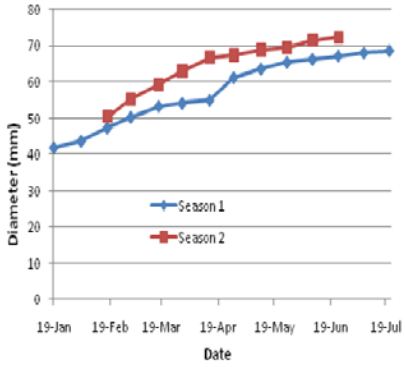
neglected in most lemon orchards. Therefore, monthly, bi-weekly or weekly fruit size measurements from the same tagged fruit from after physiological fruit drop until harvest are very important not only to accurately predict final fruit size at harvest but to make sure what the size of fruit on a tree should be at a specific time to meet export size requirements. If these requirements are not met, certain adjustments to the management program in terms of irrigation or nutrition should be made (see above).

Fruit size measurements on Eureka lemon should be done for both the main crop from the spring flower/set and for the smaller crops since the time of set in the year may play a role in fruit size at harvest. A database of long-term mean fruit growth rates can be used to compare growth rates between seasons and orchards and identify problem areas. Not only would fruit growth rates differ between different orchards and seasons, but the growth curve may flatten off earlier, especially in poor orchards and orchards with very heavy crop loads. Once a below-average growth rate is identified, the abovementioned adjustments can be made. Note the differences in fruit growth rates in the graph below between two consecutive seasons for the same Eureka lemon orchard in Citrusdal in the Western Cape.




**Pruning:** Pruning in the winter after harvest and before bud break improves the light distribution inside the tree and improves the quality of the bearing wood by rejuvenating it. Pruning can also be used as a thinning technique. In very dense trees and especially older, larger trees light levels drop to below 30% in the inside of the tree and adversely affect fruit size. Reducing the tree volume of these larger trees by reducing tree height often improves light distribution in the tree and reduces the within-row and between-row tree shading which may result in larger fruit. Strong, vigorous and upright water shoots should be removed as early as possible.

**Crop load:** Although there are a lot of controllable and non-controllable factors that play a role in fruit size, fruit load (number of fruit) is normally the major contributing factor. The more fruit on a tree, the smaller the fruit are. With thinning we change the leaf:fruit ratio resulting in more leaves contributing to the growth of a single fruit. Crop reduction, especially in heavy crop years with the aim of reducing fruit-to-fruit competition and therefore improving fruit size can be accomplished through blossom thinning by pruning during bloom and hand thinning. Unfortunately chemical thinning using synthetic auxins is not an option for lemons since there is no product registered for this use.

**Hand thinning:** Selective removal of fruit from heavily bearing trees (the small and blemished fruit as well as fruit in clusters are removed) as soon as possible after the November/December fruit drop (physiological fruit drop) period can improve fruit size and the earlier this can be done the greater the effect would be. This is, however, a time-consuming practice.

**Summer girdling:** Summer girdling in combination with some of the other control measures can have a positive effect on fruit size of most citrus types, but only if all the other factors that have an adverse effect on fruit size are managed optimally and neutralised. It is, however, a time-consuming and unpopular option and not commonly used on lemons.

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## Vruggrootte Bestuur Strategieë vir Suurlemoene

deur
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Suurlemoene is aangepas by Mediterreense en subtropiese klimaatstoestande, alhoewel dit in 'n wye reeks klimate verbou kan word. Suurlemoene word byna in al die belangrikste sitrusareas in Suid-Afrika verbou, maar meer in die 'intermediëre', 'koel' en 'koue' areas soos die Oos- and Weskaap. Klein vrugte by suurlemoene het 'n probleem geword vir produsente.
Nie–beheerbare faktore en beheerbare faktore voor plant sowel as beheerbare faktore na plant speel 'n rol in die vruggrootte van suurlemoene. 'n Enkele faktor of 'n kombinasie van faktore mag verantwoordelik wees vir klein vrugte en dus moet al die faktore wat vruggrootte beïnvloed egter in ag geneem word en optimaal bestuur word.

### Nie-beheerbare faktore

Hierdie faktore kan nie verander word of gemanipuleer word nadat 'n boord reeds gevestig is nie. Die klimaat van 'n area, meer spesifiek temperatuur en dus effektiewe hitte eenhede, speel 'n belangrike rol in suurlemoen vruggroei. Suurlemoen vruggroei volg 'n sigmoïdale groeikurwe soortgelyk aan die van lemoene, met drie fases: selverdeling (fase I), selvergroting (fase II) en rypwording (fase III).

Genoeg hitte tydens fases I en II is belangrik vir vruggroei. Alhoewel suurlemoenbome in areas met 'n wye reeks van effektiewe hitte eenhede per jaar (1100 tot 1500) geplant kan word, word sommige boorde geplant in areas waar die jaarlikse hitte eenhede laer is, of baie hoër, dus in sub-optimale verbouingstoestande. Vruggroei is stadiger in die koeler areas en vrugte neem langer om oesrypheid te bereik. Die optimum temperatuur vir vruggroei is 30˚C, met 20-30˚C warm genoeg vir voldoende vruggroei. Vruggroeitempo neem af by temperature bo 30˚C en onder 20˚C, met bykans geen vruggroei by temperature bo 40˚C en onder 13˚C. Daarom word dit aanbeveel om jaarlikse effektiewe hitte eenhede te bepaal deur temperature ≥13˚C en ≤ 35˚C of selfs 32˚C te gebruik. Suurlemoene met 'n voldoende vruggrootte kan in warm, humiede areas geproduseer word, terwyl warm, droë areas kan lei tot kleiner vrugte. Dus die keuse van die area waar suurlemoen aanplantings gedoen word, is baie belangrik en die klimaatsnorme vir suurlemoenproduksie deur die seisoen soos aangedui in die tabel hieronder, moet in ag geneem word. Weerdata moet verkry word en die effektiewe hitte eenhede moet bepaal word wanneer suurlemoenboorde gevestig word en, veral in seisoene waar klein vrugte 'n probleem is, om te bepaal of klimaat 'n rol gespeel het.
Breë klimaatsnorme vir suurlemoenproduksie in die binnelandse- en kus produksieareas in Suidelike Afrika (Barry et al., 1996)

| ***Binnelandse produksieareas*** | | |
|---|---|---|
| Seisoen | Gemiddelde min. temperatuur (˚C) | Gemiddelde maks. temperatuur (˚C) |
| Lente (Aug - Nov) | 10.5 - 15.5 | 25.5 - 30.0 |
| Somer (Des - Feb) | 16.0 - 21.5 | 27.5 - 33.0 |
| Herfs (Mrt - Mei) | 8.5 - 15.0 | 24.5 - 29.5 |
| Winter (Jun - Jul) | 2.5 - 10.0 | 19.5 - 26.0 |
| ***Kus produksieareas*** | | |
| Seisoen | Gemiddelde min. temperatuur (˚C) | Gemiddelde maks. temperatuur (˚C) |
| Lente (Aug - Nov) | 10.0 - 12.5 | 22.5 - 26.0 |
| Somer (Des - Feb) | 14.5 - 17.0 | 27.0 - 32.0 |
| Herfs (Mrt - May) | 10.5 - 13.5 | 21.0 - 25.5 |
| Winter (Jun - Jul) | 6.0 - 9.5 | 17.5 - 22.5 |

Breë klimaatsnorme vir suurlemoenproduksie in die binnelandse- en kus produksieareas in Suidelike Afrika (Barry et al., 1996)

### Beheerbare faktore voor plant

Beheerbare faktore voor plant sluit die grondtipe in (klei %), grondvoorbereiding wat die worteldiepte bepaal, onderstamkeuse en die keuse van die kultivar. Swaar gronde lei gewoonlik tot kleiner vrugte. Onverenigbaarheid tussen die onderstam en bostam kan ook

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aanleiding gee tot kleiner vrugte. Kies jou boomspasiëring versigtig wanneer boorde gevestig word, omdat nou boomspasiëring (digte aanplantings) soms aanleiding gee tot baie digte bome. Omdat suurlemoenbome (spesifiek Eureka) neig om terminaal (op punte van lote) te dra, kan snoei om bome oop te maak en om boomgrootte te beheer baie drahout verwyder wat die bome minder produktief maak.

**Beheerbare faktore na plant**

**Besproeiing:** Seldeling en vruggroei is baie sensitief vir enige waterstres. Waterstres tydens fases I (seldeling) en II (begin ± 60 dae na volblom) van vruggroei lei tot kleiner vrugte. Vinniger en meer uniforme vruggroei word verkry met meer gereelde kortsiklus besproeiing in vergelyking met langsiklus besproeiing. Die beste besproeiingskedule is egter een wat die boom se behoefte en die kapasiteit van die grond in ag neem. Die kapasiteit van die besproeiingsisteem moet nooit dikteer wanneer en hoeveel water toegedien moet word nie. Die ontwerp van die sisteem moet dus aan die behoefte van die bome en die kapasiteit van die grond voldoen. Die handhawing van die ontwerp spesifikasies van die sisteem is belangrik om effektiwiteit van die sisteem te behou. Meting van die leweringstempo en druk ten minste een keer per jaar moet ‘n standard praktyk wees. Hoe groter (tot ‘n sekere mate) die grondvolume besproei (reservoir), hoe kleiner is die impak van ‘n besproeiingsfout op vruggrootte. Enkellyn druppers en sisteme met twee druppers per boom, los geen ruimte vir ‘n fout. ‘n Mikrospuitsisteem kan tot ‘n mate kompenseer vir bestuurs- of sisteemfoute. Nog ‘n belangrike factor wat dikwels nagelaat word is die benattingsdiepte, veral met drupsisteme. Besproeiingskedulering moet gebaseer wees op die effektiewe worteldiepte van ‘n spesifieke grond-boord kombinasie. Die mees effektiewe instrument om besproeiingskedules to monitor is ‘n profielgat. Dit is die enigste direkte metode en kan in enige deel van die boord gedoen word. As dit saam met die meting van die leweringstempo en druk gedoen word kan besproeiing optimaal uitgevoer word.

**Bemesting:** Alhoewel die N:K verhouding in die blare ‘n belangrike faktor is wat die potensiaal vir optimale vruggrootte aandui, is optimale konsentrasies van al 14 voedingselemente ewe belangrik, veral tydens die kritiese periodes van fases I en II. Deur te konsentreer op byvoorbeeld kalium toedienings terwyl magnesiumtekorte voorkom, sal nie vruggrootte verbeter nie. Indien enige tekort voorkom, moet dit so gou as moontlik reggestel word, selfs tydens die minder effektiewe periode van Julie tot September. Die mees effektiewe benadering is ‘n gebalanseerde een waar die doel van bemesting moet wees om alle voedingselemente binne optimale vlakke te verkry. Kalium is bekend om vruggrootte te verbeter, so ook stikstof, magnesium ens. ‘n Kaliumtekort sal vruggrootte benadeel, net so ook ‘n stikstoftekort en waterstres. Evalueer eers die totale voedingstatus van die boom en die besproeiingskedulering voor daar na kitsoplossings gekyk word.

Wanneer daar ‘n kaliumtekort is en die bome reageer nie op grondtoedienings nie, kan blaartoedienings van kaliumnitraat of -sulfaat teen 3% gedoen word. Afhangende van ‘n paar kondisies (algehele voedingstatus, N:K verhoudings, K en N vlakke) kan toedienings in Julie (nitraat en sulfaat), Augustus tot September (slegs sulfaat) of November tot Desember (beide) gedoen word om vruggrootte te verbeter. Hoe vroeër die toedienings gemaak word, hoe groter is die effek op vruggrootte. Die optimale N-status is 2.30-2.60%, en 0.70-1.0% vir K. Wanneer die K-status 1.25% oorskry, is K nie die rede vir te klein vrugte nie en addisionele K sal geen doel dien nie.

**Boom- en wortelgesondheid:** Enige faktor wat wateropname en vervoer in ‘n plant belemmer, sal vruggrootte nadelig beïnvloed. Beheer van aalwurms (nematodes) en *Phytophthora* kan vruggrootte verbeter. Suurlemoenbome word baie vinnig geel na infeksie met *Phytophthora* en vruggrootte kan moontlik meer geaffekteer word as by ander sitrustipes. Produsente reageer wanneer simptome van kraagvrot sigbaar word deur fosfonaat stamverwe of blaarbespuitings toe te dien, maar wanneer *Phytophthora* wortelvrot of aalwurms teenwoordig is, word geen beheer gewoonlik toegepas nie. Beide hierdie organisms het ‘n knaageffek op die voedingswortels. Gevolglik moet die bome hierdie wortels aanhoudend vervang wat dan ‘n energie sink veroorsaak. Die eerste teken van so ‘n sink is kleiner vrugte. Sekere onderstamme (trifoliaat kruisings) soos X639 toon selde kraagvrot probleme maar ontwikkel *Phytophthora* wortelvrot. Aalwurms

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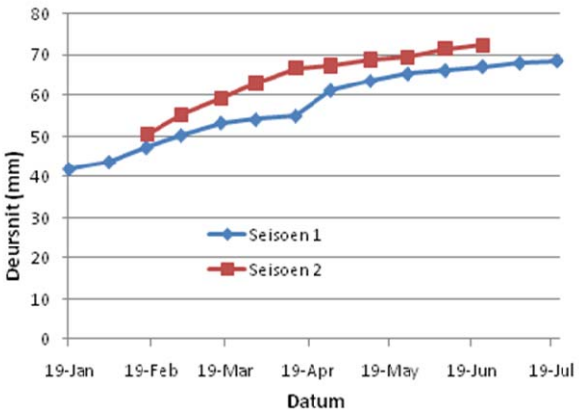
kan ook oor tyd op 'citrange' onderstamme akkumuleer tot op vlakke so hoog as en hoër as op meer vatbare growweskil suurlemoen onderstamme. Gereelde monsterneming van wortels en grond vir toetsing by die CRI Diagnostiese sentrum in Nelspuit word aanbeveel. (Vir meer inligting kontak Wilma van der Westhuizen by 013 759 8031 of wb@cri.co.za).

**Uitstel van oes en selektiewe oes:** Alhoewel vrugte baie stadig groei tydens fase III (rypwording) van vrugontwikkeling net voor oestyd, kan die uitstel van die oes en/of selektiewe oes van groter vrugte, vruggrootte verbeter. Maak seker dat vrugte hul maksimum grootte bereik het voor dit geoes word. Jaarlikse vruggrootte metings deur die seisoen soos gedoen word vir ander sitrustipes word gewoonlik nagelaat in die meeste suurlemoenboorde.
Dus, maandelikse, twee-weeklikse of weeklikse vruggrootte metings van dieselfde gemerkte vrugte vanaf na fisiologiese vrugval tot met oestyd is belangrik nie net om finale vruggrootte by oestyd te skat nie, maar ook om seker te maak hoe groot vrugte op 'n boom behoort te wees op 'n bepaalde tyd om aan die uitvoer vruggrootte standaarde te voldoen. Indien vrugte nie aan hierdie standaarde voldoen nie, moet sekere aanpassings aan die besproeiing- en bemesting bestuursprogram gedoen word (sien hierbo). Vruggroootte metings op Eureka suurlemoen moet gedoen word vir die hoofoes vanaf die lente blom/set en vir die kleiner oeste omdat die tyd van set in die jaar 'n rol mag speel by vruggrootte by oestyd. 'n Databasis van langtermyn gemiddelde vruggroeitempos kan gebruik word om groeitempos tussen seisoene en boorde te vergelyk en om probleemareas te identifiseer. Vruggroeitempos sal nie net verskil tussen seisoene en boorde nie, maar die groeikurwe kan vroeër afplat, veral in swak boorde en boorde met 'n baie swaar oeslading. Sodra 'n onder gemiddelde groeitempo geïdentifiseer is, kan die bogenoemde aanpassings gemaak word. Let op die verskil in vruggroeitempos in die grafiek hieronder tussen twee agtereenvolgende seisoene vir dieselfde Eureka suurlemoenboord in Citrusdal in die Weskaap.




**Snoei:** Snoei in die winter na oestyd en voor knopbreek verbeter ligverspreiding binne-in die boom en verbeter die kwaliteit van die drahout deur dit te verjonk. Snoei kan ook as 'n uitduntegniek gebruik word. In baie digte bome en veral ouer, groter bome daal ligvlakke tot onder 30% in die binnekant van die boom en word vruggrootte benadeel. Vermindering van die boomvolume van hierdie groot bome deur boomhoogte te verminder kan ligverspreiding binne die boom verbeter en die binnery of tussenry boom oorskaduïng verminder wat kan lei tot groter vrugte. Sterk, groeikragtige en regop waterlote moet verwyder word so gou as moontlik.

**Vruglading:** Alhoewel daar verskeie beheerbare en nie-beheerbare faktore is wat 'n rol speel in vruggrootte, is vruglading (aantal vrugte) normaalweg die grootste bydraende faktor. Hoe meer vrugte op 'n boom, hoe kleiner is die vrugte. Met uitdun, verander ons die blaar:vrug verhouding sodat ons meer blare het in die boom wat bydra tot die groei van 'n enkele

vrug. Oesverlaging veral in jare met ‘n swaar oes, met die oog om vrug-tot-vrug kompetisie te verminder en sodoende vruggrootte te verbeter, kan gedoen word met blomuitdun deur te snoei in die blomtyd en met handuitdun. Ongelukkig is chemiese uitdun met sintetiese ouksiene nie ‘n opsie op suurlemoene nie, omdat geen produkte vir die doel geregistreer is nie.

**Handuitdun:** Selektiewe verwydering van vrugte op bome met ‘n swaar drag (die kleinste en beskadigde vruggies en vrugte in trosse word verwyder) so gou as moontlik na die November/Desember vrugval (fisiologiese vrugval) kan vruggrootte verbeter en hoe vroeër dit gedoen kan word hoe groter is die effek. Dit is egter ‘n tydrowende praktyk.

**Somer ringelering:** Somer ringelering in kombinasie met van die ander beheerstrategieë kan ‘n positiewe effek op vruggrootte van die meeste sitrustipes hê, indien die ander faktore wat vruggrootte benadeel optimaal bestuur word. Dit is egter ‘n baie arbeidsintensiewe en ongewilde opsie en word nie algemeen op suurlemoene gebruik nie.

Die outeurs wil graag die bydraes van Ballie Wahl, Graham Barry, Hennie Le Roux, Hannes Bester, Paul Cronje, Steve Turner, Mark Fry en Piet van Rensburg erken.

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