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Heavy Fruit Load and Late harvest Inhibit Flowering of the 'Nour' Clementine Mandarin

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***Abstract*. The 'Nour' clementine produces easy peeling fruit with adequate size and excellent eating quality. The main problem in the development of this cultivar is its great alternate bearing habit probably due to the fact that fruits are held on the tree until December-January (i.e. during the whole period of flower initiation–differentiation) although they reach minimum internal maturity in early November. Trials conducted in the seasons 2001-02 and 2002-03 indicate that for trees with the same fruit load, early harvest gave rise to greater number of flowers and reduced vegetative shoot abundance the following spring. Subsequently, early harvest increased yield in the following year, mainly through increased fruit number. In addition, the degree of flower inhibition is related to fruit load. In fact, the results indicate that, when fruit load was less than a certain threshold limit in number of fruits per tree, removal of the fruit early increased flowering and reduced vegetative shoot production but when fruit load was significantly greater than that limit flower inhibition was complete and early harvest did not prevent this inhibitory effect.**

Introduction and objectives

The 'Nour' Clementine (*Citrus reticulate* Blanco) is an easy peeling citrus type with fruit of excellent eating quality and adequate size, color and juice content. Within the Clementine group, it is a late-harvested cultivar. This characteristic is mainly due to the fact that its peel stays green whereas its minimum eating quality (sugar/acids ≥ 7.5) is reached by early November. In addition, late harvest procures greater prices to the grower. Fruit is harvested from early December to late January, a period which coincides with the stage of flower initiation-differenciation. Benismail and Bentabet (1988) reported that flower induction in 'Cadoux' Clementine, a mid-season cultivar maturing in Oct.-Nov., occurs in Oct.-Nov. and El-Otmani et al. (1998) indicated that in 'Nour', flower initiation occurs during Nov.-January. Furthermore, 'Nour' is an alternate bearing cultivar and yield of fully grown trees planted at 400 trees per hectare can go from almost zero kilograms to more than 150 kg per tree.

Various authors reported that the presence of fruit on the tree during the period of flower induction to-flower differenciation greatly inhibits floral production of the following cycle which in turn is favourable for greater vegetative shoot production and growth (Plummer et al., 1989; Koshita et al., 1999; Verreyne and Lovatt, 2004; Garcia-Luis et al., 1995). Fruit removal increased generative shoots and decreased the number of vegetative shoots of the following cycle (Garcia-Luis et al., 1995). Monselise and Goldschmidt (1982) reported that heavy crop inhibit summer vegetative.

As a contribution to the understanding of this alternate bearing pattern, this paper reports on research done to investigate effects of tree load and time of harvest on flowering and vegetative growth and its resulting effect on yield.

Materials and methods

Trial 1: The experiment was done on eight-year-old trees of the 'Nour' clementine (*Citrus reticulate* Blanco) grafted on sour orange (*Citrus aurantium* L.). It consisted of totally removing fruit of a set of 10 trees 45 days earlier than when the normal harvest starts and harvesting another set of 10 trees at the 'normal' date. Table 1 summarizes the yield in kg and in fruit number per tree for the 2 dates and shows that the trees in the 2 sets had approximately the same crop load. At harvest yield was recorded for each tree in kg and in fruit counts. The following spring and before flower appearance, 4 shoots per tree, each composed of a spring and a summer growth of the previous year were marked and their number of nodes were counted and recorded. Four replications (i.e.; trees) were used. At flowering, flower development (as number of inflorescences and number of flowers) and vegetative shoot abundance were recorded as numbers per 100 nodes.

Trial 2

The experiment was done on another set of 8-year-old ‘Nour’ trees of the same orchard. Three batches of ten trees (= replications) each were distinguished. Table 2 summarizes the yield characteristics of the three batches of trees and their respective harvest dates. In particular, trees of set 2 had twice the number of fruit that was in the other sets of trees.

Before flowering, 4 shoots per tree, each composed of a spring and a summer growth were tagged and their number of nodes was counted. At flowering flowers and vegetative shoots of the following growth cycle were recorded. At harvest, yield in kg and fruit number were obtained per tree.

For both trials, data were subjected to an analysis of variance using a completely randomized design.

Table 1. Average yield in kg/tree and in fruit number /tree, and weight of individual fruits at the time of harvest (in the year 2001-2002)

Date of harvest	Yield (kg/tree)	Number of fruit/tree	Fruit weight (g/fruit)
Early harvest (29 Oct. 2001)	62	850	73
Normal harvest (13 Dec. 2001 + 2 Jan. 2002)	77	917	85

Table 2. Average yield and fruit number per tree, and individual fruit weight at various dates of harvest (year 2002-2003)

Date of harvest	Yield (kg/tree)	Number of fruit/ tree	Fruit weight (g/fruit)
Early (29 Oct. 2002)			
Trees set 1	42	557	77
Trees set 2	69	1138	62
Normal (24 Dec. 2002 + 29 Jan. 2003): Tree set 3	76	661	116

Results

For Trial 1 Table 3 shows that trees harvested early had twice the number of inflorescences that was recorded for trees that were harvested later. On the contrary to that, vegetative shoots had the opposite trend although the differences were not significant.

In addition, early harvest doubled the yield in kg/tree and in fruit number/tree of the following crop (Table 4). Individual fruit weight was not significantly affected, however.

Table 4. Effect of harvest date on yield (in Kg and number of fruit per tree) and on individual fruit weight of the following crop

Date of harvest	Yield (Kg/tree)	Number of fruits/tree	Fruit weight (g/fruit)
Early (29 Oct. 2001)	91.8± 0.7	740.5±94.4	125.0 ± 3.3
Normal (13 Dec. 2001 + 2 Jan. 2002)	43.0±7.8	372.0±78.8	118.0 ± 2.9
Significance level[z]	**	*	NS

[z]Not significant (NS) or significant at 5% (*) or at 1% (**)

From Trial 2, results in Table 5 indicate that, regardless of the type of mother shoot, fruit number probably has more effect on flower inhibition and vegetative growth than has date of harvest.

In addition, yield of the following crop was reduced as a result of late harvest and of the previous tree fruit (Table 6). However, it appears that fruit number per tree was negatively affected more by number of fruit on the tree in the previous year than by date of harvest of that crop.

Table 6. Effect of harvest date on yield (in Kg and number per tree) and on individual fruit weight of the following crop

Harvest date	Yield (kg/tree)	Number of fruit/ tree	Fruit weight (g/fruit)
Early (29 Oct. 2002)			
Tree set 1	32.0± 10.5	404.2±132.8	78.8 ± 1.0
Tree set 2	6.6 ± 0.7	86.1 ± 9.01	76.8 ± 1.6
Normal (24 Dec. 2002 + 29 Jan. 2003)	13.8 ± 8.1	183.0±106.1	75.5 ± 3.5
Significance level[z]	**	**	NS

[z]Not significant (NS) or significant at 1% (**)

Table 3. Effect of harvest date on the following spring vegetative shoot and inflorescence abundance and on flower counts for the ‘Nour’ clementine (data are for the date of maximum flowering (i.e., 2 April 2002))

Date of harvest	Inflorescences/100 nodes		Number of flowers / 100 nodes		Number of vegetative shoots/100 nodes	
	Spring shoot	Summer shoot	Spring shoot	Summer shoot	Spring shoot	Summer shoot
Early harvest (29 Oct. 2001)	7.3 ± 2.2	13.6 ± 4.8	0.9± 0.9	6.2 ± 3.0	32.9 ± 4.4	18.0 ± 1.8
Normal harvest (13 Dec. 2001 + 2 Jan. 2002)	4.0 ± 2.4	6.5 ± 2.7	2.3± 2.3	3.2 ± 2.1	25.8 ± 5.8	28.4 ± 5.3
Significant level[z]	NS	NS	NS	NS	NS	*

[z]Not significant (NS) or significant at 5% (*)

Table 5. Effect of harvest date and tree fruit load on the vegetative shoot and inflorescence and flower abundance the following spring for the 'Nour' clementine (data are taken at the date of maximum flowering (i.e., 3 April 2003))

Date of harvest	Number of inflorescences/ 100 nodes		Number of flowers/ 100 nodes		Number of vegetative shoots / 100 Nodes	
	Spring shoot	Summer shoot	Spring shoot	Summer shoot	Spring shoot	Summer shoot
Early (29 Oct. 2002)						
Tree set 1	15.7 ± 7.4 a	38.3 ± 13.5	8.9 ± 2.8	32.8 ± 11.7	31.9 ± 9.3	39.4 ± 11.4
Tree set 2	0 b	4.5 ± 4.5	0	4.5 ± 4.5	34.5 ± 4.0	71.4 ± 8.1
Normal (24 Dec. 2002 + 29 Jan. 2003)	13.3 ± 7.8 ab	35.5 ± 11.9	6.1 ± 2.7	31.5 ± 9.1	32.3 ± 9.2	42.3 ± 9.5
Signif. Level[z]	*	**	*	**	NS	**

[z]Not significant (NS) or significant at 5% (*) or at 1% (**)

Discussion

Fruits are strong sinks and Monselise and Goldshmidt (1982) reported that for mandarins, when trees are loaded with fruit, vegetative growth is inhibited and tree reserves are depleted. In addition, maturing citrus fruit are reported to be the source of growth inhibitors such as ABA (Jones et al., 1976).

As result, during the 'ON' year, trees flower profusely and have very few vegetative shoots. The following year, the situation is exactly opposite ('OFF' year) with fewer flowers but many more vegetative shoots which constitute a large surface area where the following year ('NO' year) many flower buds arise leading to heavy flowering and the cycle perpetuates. Our results indicate that this is probably the case for the 'Nour' Clementine. In addition, there is probably a threshold number of fruits per tree beyond which flowering of the following season is completely inhibited. Moreover, the inhibitory effect on flowering is a result of the combination of tree fruit load and harvest time retardation both of which may cause either depletion of tree reserves or production of growth inhibitors in amounts that effect the tree hormonal balance leading to imbalanced growth and development. Similar situations were reported by Goldshmidt and Golomb (1982), Monselise and Goldschmidt (1982), Golomb and Goldschmidt (1987), Monselise et al. (1983), and Verreyne and Lovatt (2004) for various citrus cultivars.

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