Floral response of Tahiti lime (*Citrus latifolia* Tan.) to foliar sprays of hydrogen cyanamide

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Floral response of Tahiti lime (*Citrus latifolia* Tan.) to foliar sprays of hydrogen cyanamide.

Abstract — Introduction. In Venezuela, the Tahiti lime production usually concentrates between May and October. However, the international market of lime fruits presents higher demands and prices from November to February. For this reason, new methods of chemical control, aimed at promoting off-season fruiting, were tested. **Materials and methods**. The study was conducted in Venezuela, in an orchard at 180 m of altitude. Six levels (0.5, 1.0, 1.5, 2.0, 2.5 and 3.0%) of hydrogen cyanamide were sprayed on isolated terminal twigs of 3-year-old plants growing under field conditions. The number of vegetative, generative (flowering shoots without leaves), mixed (flowering shoots with leaves) and floral (generative + mixed) shoots and the flower number per twig were determined in order to assess the floral and vegetative activity, shoot flux density, and degree of defoliation. **Results and discussion**. Hydrogen cyanamide sprays had significant effects on floral and total activities, and on generative, mixed and floral shoot flux density, as well as on defoliation of sprayed twigs. Moreover, it did not show any effect on vegetative development during the period of study. Although the triggering effect of hydrogen cyanamide on flower bud break was significant, there was a strong defoliation effect. As this is an evergreen tree, further studies should be performed before recommending its use for flowering control (© Elsevier, Paris).

Citrus latifolia **/ plant physiology / induced flowering**

Induction florale de la lime Tahiti (*Citrus latifolia* Tan.) provoquée par des pulvérisations foliaires de cyanamide d'hydrogène.

Résumé — Introduction. Au Venezuela, la production de lime Tahiti se concentre, habituellement, entre mai et octobre. Cependant, la demande du marché international de la lime se situe entre novembre et février, et les prix sont alors élevés. De nouvelles méthodes de contrôle chimique, visant à promouvoir une production à contre-saison, ont donc été testées. **Matériel et méthodes**. L'étude a eu lieu au Venezuela dans un verger à 180 m d'altitude. Des pulvérisations de cyanamide d'hydrogène (CH), dosé de 0,5 à 3,0 %, ont été appliquées à des rameaux terminaux, isolés, de plants de 3 ans, développés en verger. Le nombre de rameaux végétatifs, génératifs (rameaux florifères sans feuille), mixtes (rameaux florifères avec feuilles) et floraux (rameaux génératifs et mixtes), ainsi que le nombre de fleurs par rameau, a été suivi pour évaluer l'activité florale et végétative, la densité de sortie des tiges et l'intensité de la défoliation. **Résultats et discussion**. Les pulvérisations de CH ont eu un effet significatif sur les activités florale et totale et sur la densité de sortie de rameaux génératifs, mixtes et floraux ; il en a été de même pour la défoliation des rameaux traités. Cependant, pendant la durée de l'expérimentation, le CH n'a pas eu d'effet sur le développement végétatif des rameaux. Bien que le produit ait eu un effet significatif sur l'induction florale, il a occasionné une défoliation sérieuse des arbres. Comme la lime Tahiti est un arbre au feuillage persistant, des études ultérieures devront être menées avant de recommander l'emploi du CH pour le contrôle de la floraison (© Elsevier, Paris).

Citrus latifolia **/ physiologie végétale / floraison induite**

1. introduction

Tahiti lime is a perennial evergreen tree, native to the tropics, which flowers almost every month of the year [1]. Nevertheless, in most areas is of Venezuela, its production is usually concentrated between May and October. On the other hand, the international market of lime fruits presents higher demands and prices from November to February. For the above reasons, it seemed to be important to test new methods of chemical control aimed at promoting off-season fruiting.

It is known that the drought-rehydration sequence induces flowering on citrus trees [2–5]. Lovatt et al. [6] stated that low-biuret urea also stimulates floral bud-break in citrus. Nevertheless, Pire and Rojas [5] did not show flowering response of Tahiti lime to foliar sprays of urea under warm climates. Various authors showed that applications of 2-chlorethyl phosphonic acid can stimulate flower bud-break on citrus under warm conditions [7, 8].

In potato seedlings, Amberger [9] found that hydrogen cyanamide quickly penetrated into the foliar tissue and it was transported by the vascular system of the plant. Hydrogen cyanamide seems to be directly involved in nitrogen metabolism and in protein synthesis [9]. On the other hand, Miller and Hall [10] demonstrated that the degradation of cyanamide occurred through urea via other compounds and the final product of amino acids. He proved also that cyanamide is a specific inhibitor of catalase activity. The inhibition of catalase activity leads to the accumulation of hydrogen peroxide, higher peroxidase activity and glutathione concentration in sugar beet seedlings [9]. This effect may be explained by favouring a shift from the Endem-Mayerhoff Parmas cycle to the oxidative pentose pathway with the concomitant increased production of reduced nucleotides. When cyanamide is applied in adequate levels it triggers dormancy breaking effects in seeds and buds [9].

Hydrogen cyanamide has been proven to enhance flower bud-break in apple, almond, actinidia, fig, grapevine, peach, persimon and plum [11, 12], as well as in red raspberry [13] and in kiwifruit [14].

2. materials and methods

A trial was carried out on a 3-year-old Tahiti lime orchard (*Citrus latifolia* Tan.) grafted on *C. volkameriana* Pasq. and located at La Suareña, Aragua State, Venezuela (lat. 9° 43' N, long. 66° 43' W, 180 m MSL). Trees were planted at a distance of 6 × 3 m on a clay soil. Six hydrogen cyanamide treatments (0.5, 1.0, 1.5, 2.0, 2.5 and 3.0%) and a control without hydrogen cyanamide were tested on a completely randomized experimental design with eight replicates and one plant per plot.

At the beginning of the experiment, 12 twigs per plant were tagged in order to receive the hydrogen cyanamide spray treatments, and to monitor the floral and vegetative activity, shoot flux density, and degree of defoliation. Hydrogen cyanamide solutions were sprayed on the leaves of the terminal flux of the tagged twigs on July 29, 1994. At the moment of the spray, these twigs were isolated by covering the foliage surrounding them with a flexible plastic sheet.

The number of vegetative, generative (flowering shoots without leaves), mixed (flowering shoots with leaves) and floral (generative + mixed) shoots and of flowers per twig were determined. The ratio of the number of twigs carrying floral or vegetative shoots to the number of tagged twigs per plant, expressed as percentage, was used to determine the plant developmental activity. Total activity was expressed as percent of twigs carrying floral and/or vegetative shoots. On the other hand, the ratio of the number of generative, mixed or vegetative shoots to the number of tagged twigs per plant was used to determine the number of shoots per twig or shoot flux density.

3. results and discussion

3.1. floral activity and shoot flux density

In July 1994, there was a light floral activity in the test treatment (13.73% twigs with floral shoots) (*table I*). The sprays with various hydrogen cyanamide concentration showed a significant effect on floral activity ($P = 0.0003$): the percentage of twigs with floral shoots increased as hydrogen cyanamide levels increased, up to the 2.5% concentration. Sprays with 1.5, 2.0, 2.5 and 3.0% hydrogen cyanamide significantly increased floral activity in relation to the control. Treatments in the range between 2.0 and 3.0% concentration presented a flowering response in more than 60% of the twigs. This effect is also illustrated in *figure 1*, in which the regression analysis of floral activity as a function of hydrogen cyanamide concentration is represented ($r^2 = 0.824$).

Increasing hydrogen cyanamide levels caused a significant effect on generative shoot flux density, but, under these experimental conditions, they were rather low (*table II*). However, 1.5, 2.0 and 2.5% hydrogen cyanamide produced significant increases of generative flux densities in relation to the test treatment, with the 2.5% hydrogen cyanamide causing the maximum response (0.73 generative shoots per twig), although lower than expected.

There was a significant effect of hydrogen cyanamide on the mixed shoot flux density. In all cases, the values were higher than those of the generative ones. This response seems to be important, since, in citrus species,

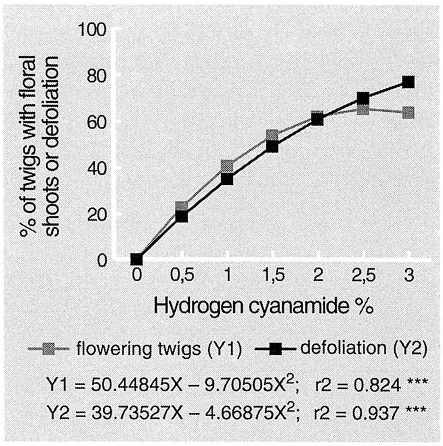

Figure 1.
Floral activity and defoliation in Tahiti lime as function of hydrogen cyanamide concentration.

Table I.
Effects of hydrogen cyanamide sprays on floral and vegetative activity of Tahiti lime, 42 d after the spray.

Hydrogen cyanamide (%)	% of twigs with bud break			Defoliation (%)
	Floral	Vegetative	Total	
0	13.73 c	6.25	19.78 c	4.93 d
0.5	23.96 bc	2.08	23.96 bc	10.43 d
1.0	40.84 abc	4.17	41.88 abc	38.53 c
1.5	48.75 ab	11.46	58.12 ab	49.00 bc
2.0	64.58 a	12.50	68.75 a	61.13 ab
2.5	69.29 a	12.50	70.33 a	72.55 a
3.0	61.46 a	23.97	67.71 a	75.25 a
Duncan test	***	ns	***	***

*** Duncan multiple range test significant at 1‰; ns = non significant.
a, b, c, d: homogeneous groups according the Duncan multiple range test.

Table II.
Effects of hydrogen cyanamide sprays on floral flux density of Tahiti lime, 42 d after the spray.

Hydrogen cyanamide (%)	Shoot number per twig			Flower number per twig
	Generative	Mixed	Floral	
0	0.08 c	0.26 b	0.34 c	0.80 c
0.5	0.07 c	0.29 b	0.37 c	1.49 c
1.0	0.33 bc	0.50 ab	0.84 bc	3.89 abc
1.5	0.51 ab	0.66 ab	1.17 ab	4.58 ab
2.0	0.37 ab	1.06 a	1.43 ab	5.54 ab
2.5	0.73 a	1.05 a	1.78 a	7.50 a
3.0	0.15 c	1.00 a	1.15 ab	4.19 ab
Duncan test	*	**	***	***

*, **, *** Duncan multiple range test significant at 5%, 1%, 1‰.
a, b, c: homogeneous groups according the Duncan multiple range test.

mixed shoots tend to set more fruits than generative ones. In fact, the production of mixed shoot increased with the 0.5 to 2.5% level of hydrogen cyanamide, and from the 2% level, there was a significant effect on the mixed shoot flux density (*table II*).

Hydrogen cyanamide had an effect on the floral shoot flux density too, because, from the 1.5% level, the floral shoot flux density increased significantly in relation to the control. The peak response was shown at the 2.5% level (*table II*).

Several authors showed increases of floral bud break in grapevines with the spray of hydrogen cyanamide, between the 1 to 4% concentration range [11, 12]. This product also stimulated floral bud break in red raspberry [13], kiwifruit [14], pecan [15] and apple [16]. Nevertheless, some authors reported a reduction of production due to an increased fruit abscision caused by hydrogen cyanamide in table grapes [12], nectarines [17], and red raspberry [13].

3.2. density of flowers

The number of flowers per twig also increased with the hydrogen cyanamide concentration, and all levels caused significantly higher densities of flowers than the control. Maximum floral density was reached at the 2.5% concentration (*table II*).

3.3. vegetative activity

The natural vegetative activity was low, because, in the control treatment, only 6.25% twigs carried vegetative shoots (*table I*). During the period of the study, there was no significant effect of hydrogen cyanamide on the vegetative activity of Tahiti lime. Nevertheless, there was a slight increase of vegetative activity from the 1.5% level of hydrogen cyanamide. Vegetative shoots are important, because floral shoots of the next flowering season develop mostly from apical buds of vegetative shoots.

3.4. total activity

Hydrogen cyanamide sprays had a significant effect on the total activity which increased significantly with the hydrogen cyanamide levels up to the 2.5% level (*table I*). Treatments in the range of 1.5 to 3.0% levels stimulated bud break in more than 68% of the twigs, while in the control the total activity was less than 20%.

3.5. defoliation

Hydrogen cyanamide produced increasing defoliation with increasing concentrations tested (*table I; figure 1*). It is possible that Tahiti lime flower bud-break is related to the defoliation caused by hydrogen cyanamide. The *figure 2* shows a linear relationship between the flowering twig percentage and the defoliation percentage ($r^2 = 0.819$). Defoliation ranged from 38.53% at the 1% hydrogen cyanamide level to 75.25% at the 3.0% level and their differences with the control were significant (*table I*).

Furthermore, in Taiwan, Lin [18] showed that a 2.45% hydrogen cyanamide concentration produced a marked defoliation in grapevines which occurred in the 6-day period following the spray. George and Nissen [17] found a notorious defoliation effect of hydrogen cyanamide on nectarines in Queensland, Australia.

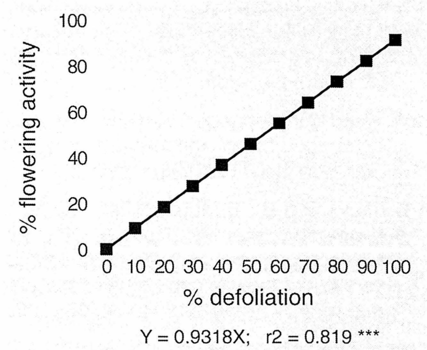

Figure 2.
Floral activity in Tahiti lime as a function of the defoliation caused by hydrogen cyanamide sprays.

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Floración inducida de la lima persa (*Citrus latifolia* Tanaka) provocada por pulverizaciones foliares de cianamida de hidrógeno.

Resumen — Introducción. En Venezuela, la producción de lima persa se concentra, habitualmente, entre mayo y octubre. Sin embargo, la demanda del mercado internacional de la lima se produce entre noviembre y febrero, y los precios son altos en este periodo. Siguiendo esta lógica, se probaron nuevos métodos de control químico para originar una producción fuera de la época. **Material y métodos**. El estudio se realizó en un huerto a 180 m de altitud. Se aplicaron pulverizaciones de cianamida de hidrógeno (CH), dosificado de 0,5 a 3,0 %, en ramas terminales, aisladas, de plantas de 3 años desarrolladas en huertos. Se efectuó un seguimiento del número de ramas vegetativas, generativas (ramas floríferas sin hojas), mixtas (ramas floríferas con hojas) y florales (ramas generativas y mixtas) y del número de flores por rama, para evaluar la actividad floral y vegetativa, la densidad de brote de tallos y la intensidad de la defoliación. **Resultados y discusión**. Las pulverizaciones de CH tuvieron un efecto significativo en la actividad floral y total (sexual y asexual) y en la densidad del brote de ramas generativas, mixtas y florales; igualmente significativo fue su efecto en la defoliación de ramas tratadas. No obstante, durante el experimento el CH no afectó al desarrollo vegetativo de las ramas. Aunque el producto tuvo un importante efecto en la floración inducida también produjo una grave defoliación de los árboles. Al ser la lima persa un árbol con hojas perennes habrán de realizarse otros estudios antes de aconsejar el empleo del CH para el control de la floración (© Elsevier, Paris).

***Citrus latifolia* / fisiología vegetal / floración inducida**