Abscission compound screening

Introduction and scope

Olive abscission compound screening trials were conducted at three locations in Central California from mid September to mid November, 2006. The objective of these trials was to determine if compounds, previously shown to loosen mature Florida citrus fruit when applied to canopies (Burns et al, 2006; Burns et al, 2005; Pozo et al, 2004a; Burns et al, 2003a; Hartmond et al, 2000), would accelerate olive fruit abscission. The long-term goal of this project is to adapt table olives to mechanical harvesting. Identification of a suitable abscission agent is viewed as a key to industry adoption of mechanical harvesting, as mechanical harvesting could be performed less aggressively and fruit damage could be minimized. George Martin and others (eg Denney and Martin 1994) have worked extensively in this area and focused primarily on ethylene-releasing compounds.

Conclusions

1. Fifteen abscission compounds or effectors were screened alone or in combination.
2. Compounds releasing ethylene or inducing ethylene biosynthesis loosened olive fruit. However, these compounds also caused moderate defoliation.
3. Components of 'Harvaid' loosened olive fruit but also caused moderate defoliation.
4. Additional work must focus on managing application of these agents to maximize fruit loosening but minimize unwanted leaf loss.

Materials, methods and results

<u>Kearney Agricultural Center trials</u>

Trials were initiated on 4 separate dates in late September to mid October 2006. Three uniform olive trees with adequate fruit load were selected within a block of trees located at the northeast corner of the Kearney Agricultural Center, Parlier, CA. Overall, yield was low in this block, but trees appeared to receive normal horticultural care for the crop load present. For each trial, six replicate branches were selected for each treatment. Each branch contained at least 8 fruit and 25 leaves. Treatments were randomly assigned to the branches, and the number of fruit on each branch was recorded. Abscission compounds were dissolved in water containing 0.05% Kinetic organosilicate adjuvant. A water control containing adjuvant was included in all trials. Treatments were applied between 10:30 am and 2:00 pm with a hand-held 1.5L pressurized sprayer until run-off. Fruit detachment force (FDF) in grams-force was measured 7 or 12 days after application using an Imada DPS-11 digital force gauge. Treatment branches were removed and brought to the laboratory. Olive fruit were clipped from branches to include at least 1 cm pedicel, inserted into the gauge, and the pedicel pulled parallel to the fruit axis until it separated from the fruit. The force necessary to remove fruit from the pedicel was measured in grams-force. Percentage fruit drop was computed by counting the number of

fruit that dropped from the branch, dividing by the total number of fruit at the beginning of the trial, and multiplying by 100. Data were analyzed as a completely randomized design. Analysis of variance and Duncan's mean separation were used to test significance and display means. Percentage data were transformed using arcsin transformation when necessary to stabilize variance.

Trial 1. On September 21, 2006, a trial was initiated using methyl jasmonate (2, 10 and 20 mM) and a Valent BioSciences proprietary compound VBC 20050 (200, 1000 and 2000 ppm). Maximum, minimum and average temperatures on the day of application were 85, 54 and 69 ºF, respectively. On October 3, 2006, FDF and % fruit drop were measured. After 12 days FDF and % fruit drop were no different than the control (table 1). Maximum, minimum and average temperatures for the duration of the trial were 83, 53 and 67 ºF, respectively.

Trial 2. On September 25, 2006, a trial was initiated using MAXCEL (200, 1000 and 2000 ppm), VBC 30069 (500 and 1000 ppm), and coronatine (200 ppm). Maximum, minimum and average temperatures on the day of application were 92, 48 and 69 ºF, respectively. On October 7, 2006, FDF and % fruit drop were measured. After 12 days, FDF in all treatments were no different than the control, but significantly more fruit dropped when VBC 30069 was used (table 2). Maximum, minimum and average temperatures for the duration of the trial were 79, 52 and 65 ºF, respectively.

Trial 3. On September 27, 2006, a trial was initiated using traumatic acid (1000 ppm), Ethrel (500 and 1000 ppm), and traumatic acid + Ethrel (1000 + 1000 ppm). Maximum, minimum and average temperatures on the day of application were 90, 53 and 69 ºF, respectively. On October 9, 2006, FDF and % fruit drop were measured. Ethrel at 1000 ppm significantly reduced FDF compared to the control (table 3). Combining traumatic acid with Ethrel numerically reduced FDF, but loosening was no different than the control. Significantly more fruit dropped in all Ethrel treatments. More fruit dropped when 1000 ppm Ethrel was used alone or in combination with traumatic acid. Excessive leaf drop was noted in Ethrel treatments exceeding 500 ppm. Maximum, minimum and average temperatures for the duration of the trial were 78, 52 and 64 ºF, respectively.

Trial 4. On October 8, 2006, a trial was initiated using VBC 30030 (1000 ppm), VBC 30030 + Ethrel (1000 + 1000 ppm), dikegulac (200, 1000 and 2000 ppm), and 5-chloro-3-methyl-4-nitro-1H-pyrazole (CMNP; 1000 and 2000 ppm). Maximum, minimum and average temperatures on the day of application were 78, 49 and 62 ºF, respectively. On October 15, 2006, FDF and % fruit drop were measured. No differences were seen in FDF or % fruit drop between any treatments (table 4). Increased time from application to analysis may be needed to improve efficacy of these compounds. Maximum, minimum and average temperatures for the duration of the trial were 78, 52 and 64 ºF, respectively.

Lindcove Research and Extension Center trials

A trial was initiated on October 11, 2006 in a block of olive trees located on the north perimeter of the Lindcove Research and Extension Center, Exeter, CA. The purpose of this trial was as stated above, and to provide another geographic location for screening. Three uniform 'Manzanillo' trees with good fruit load were selected, and 4 replicate branches for each treatment were tagged. Fruit number was recorded.

Treatments were randomly assigned to the branches. Abscission compounds were dissolved as indicated and applied between 9:00 am and 12:30 pm. Applications were made as described above. Treatments were Ethrel (750, 1125 and 1500 ppm) with and without 5 mM 1-methylcyclopropene (1-MCP) or 2 mM guanfacine. 1-MCP and guanfacine were selected to mitigate Ethrel-induced leaf loss (Pozo et al, 2004b; Burns et al, 2003b). 1-MCP and guanfacine controls were included. Maximum, minimum and average temperatures on the day of application were 77, 44 and 61 ºF, respectively. On October 18, it was decided that efficacy and leaf drop could not be adequately evaluated because of excessive shrivel in treatment trees. Visual assessment indicated little or no fruit loosening or leaf drop. Maximum, minimum and average temperatures for the duration of the trial were 74, 49 and 61 ºF, respectively.

Tehama trials

A trial was initiated on October 24, 2006, in a commercial olive orchard located in Tehama north of Corning, CA. In two rows, 47 uniform 'Manzanillo' trees were selected and treatments randomly assigned. Fifteen treatments were applied to three trees each, whereas two treatments were applied each to a single tree because of lack of material. All spray treatments included 0.05% Silwet adjuvant. Spray applications were done using a pressurized hand-gun until run-off. Treatments were Ethrel (500, 1000, 1500 and 2000 ppm), Ethrel + 1-MCP (1000 ppm + 5 mM, 1500 ppm + 5 mM, and 2000 ppm + 5 mM), 5 mM 1-MCP, VBC 30069 (500, 1000 and 2000 ppm), 4% MPK with and without 1000 ppm Ethrel, 50 ppm MAXCEL + 500 ppm VBC 30069 (single tree), 500 ppm VBC 30050 + 500 ppm VBC 30069 (single tree), a water control and an untreated control. Maximum, minimum and average temperatures on the day of application were 86, 46 and 63 ºF, respectively. After 3, 6, 10, 13 and 17 days following application, a representative branch from each replicate tree was removed. In the case of single tree applications, three representative branches were removed. Each branch contained at least 8 fruit and numerous leaves. Branches were transported to the Glenn County Cooperative Extension Office in Orland. FDF was determined as described above. Defoliation was evaluated in the orchard using a subjective leaf abscission score of 0 (no defoliation), 1 (light defoliation), 2 (moderate defoliation), and 3 (severe defoliation, greater than 50% canopy volume). Maximum, minimum and average temperatures for the duration of the trial were 74, 49 and 61 ºF, respectively.

No significant difference was measured between the untreated, adjuvant and 1-MCP control treatments, so these values were pooled (data not shown). Ethrel reduced FDF over the 17 day evaluation period (figure 1). Application of 1500 and 2000 ppm reduced FDF greater than 50% of the control. VBC 30069 was also effective, especially at concentrations of 1000 and 2000 ppm. However, both compounds increased defoliation as time after application increased, especially at the highest concentrations. When 500 and 1000 ppm of Ethrel and VBC 30069 were compared, greater reduction in FDF occurred with VBC 30069 17 days after application (figure 2). At 2000 ppm, however, both compounds reduced FDF similarly. Little difference in leaf abscission score was measured when Ethrel and VBC 30069 were compared at similar concentrations. No change in FDF or leaf abscission score was measured when trees were sprayed with MAXCEL + VBC 30069 or VBC 30050 + VBC 30069 (data not

shown). However, color change likely associated with anthocyanin production was noted where excess spray pooled on the blossom end of fruit.

MPK at 4% had little effect on FDF or defoliation (figure 3). Similar reduction in FDF was measured when 1000 ppm Ethrel was compared with 1000 ppm Ethrel + 4% MPK. However, FDF was lower after 17 days when trees were sprayed with Ethrel + MPK. Ethrel and Ethrel + MPK increased the leaf abscission score in a similar fashion.

1-MCP was used in an attempt to reduce Ethrel-induced defoliation. At 1000 and 1500 ppm Ethrel, combining 1-MCP in the spray tank had little effect on Ethrel-induced reduction in FDF, but defoliation was delayed (figure 4). Although defoliation was delayed and reduced with 2000 ppm Ethrel + 1-MCP compared with 2000 ppm Ethrel alone, Ethrel-induced fruit loosening was negatively impacted. After 17 days, however, FDF was similar in both treatments.

A final evaluation was performed 24 days after application in all treatments. In all cases, FDF either did not change or began to increase (data not shown). This increase is viewed as a re-tightening of a partially loosened abscission zone as a process of wound healing occurs. Maximum, minimum and average temperatures for the duration of the trial were 68, 44 and 55 ºF, respectively. Although we do not know the full impact of temperature in trials reported herein, lower temperatures are expected to reduce efficacy (Yuan and Burns, 2004). Warmer temperatures at the time of application and through the duration of trials may increase efficacy and reduce the time necessary to achieve adequate loosening.

Literature cited

Burns JK, Roka FM, Li KT, Pozo L, Buker RS (2006) Late season 'Valencia' orange mechanical harvesting with an abscission agent and low frequency harvesting. HortSci 41:660-663.

Burns JK, Buker RS, Roka FM (2005) Mechanical harvesting capacity in sweet orange is increased with an abscission agent. HortTechnol 15:758-765.

Burns JK, Pozo LV, Arias CR, Hockema B, Rangaswamy V, Bender C (2003a) Coronatine and abscission in citrus. J Amer Soc Hort Sci 128:309-315.

Burns JK, Pozo LV, Yuan R, Hockema B (2003b) Guanfacine and clonidine reduce defoliation and phytotoxicity associated with abscission agents. J Amer Soc Hort Sci 128:42-47.

Denney JO, Martin GC (1994) Ethephon tissue penetration and harvest effectiveness in olive as a function of application time, and BA or NAA addition. J Amer Soc Hort Sci 119:1185-1192.

Hartmond U, Yuan R, Burns JK, Grant A, Kender WJ (2000) Citrus fruit abscission induced by methyl jasmonate. J Amer Soc Hort Sci 125:547-552.

Pozo L, Redondo A, Hartmond U, Kender WJ, Burns JK (2004a) 'Dikegulac' promotes abscission in citrus. HortSci 39:1655-1658.

Pozo L, Yuan R, Kostenyuk I, Alferez F, Zhong GY, Burns JK (2004b) Differential effects of 1-methylcyclopropene on citrus leaf and mature fruit abscission. J Amer Soc Hort Sci 129:473-478.

Yuan R, Burns JK (2004) Temperature factor affecting the abscission response of mature fruit and leaves to CMN-pyrazole and ethephon in 'Hamlin' oranges. J Amer Soc Hort Sci 129:287-293.

Table 1. Abscission compound screening trial applied on 9-21-06 at the Kearney Agricultural Center, Parlier, CA. Compounds were applied to six replicate branches. Fruit detachment force (FDF in grams-force) and % fruit drop were evaluated 12 days after application. Compounds evaluated were methyl jasmonate and VBC 30050 at the concentrations indicated, and a water control. All treatments contained 0.05% Kinetic. No significant differences in FDF or % fruit drop were found between treatments.

treatment	FDF (g-force)	% fruit drop
control	466	4.6
methyl jasmonate		
2 mM	461	3.4
10 mM	437	4.8
20 mM	488	4.0
VBC 30050		
200 ppm	439	3.1
1000 ppm	453	4.8
2000 ppm	427	3.3

Table 2. Abscission compound screening trial applied on 9-25-06 at the Kearney Agricultural Center, Parlier, CA. Compounds were applied to six replicate branches. Fruit detachment force (FDF in grams-force) and % fruit drop were evaluated 12 days after application. Compounds evaluated were MAXCEL, VBC 30069 and coronatine at the concentrations indicated, and a water control. All treatments contained 0.05% Kinetic.

treatment	FDF (g-force)	% fruit drop *
control	555	3.5 c
MAXCEL		
200 ppm	515	3.2 c
1000 ppm	512	0.0 c
2000 ppm	525	3.2 c
VBC 30069		
500 ppm	515	28.4 b
1000 ppm	561	54.3 a
Coronatine		
200 ppm	538	1.5 c

* Means followed by the same letter are not significantly different, $P \leq 0.05$.

Table 3. Abscission compound screening trial applied on 9-27-06 at the Kearney Agricultural Center, Parlier, CA. Compounds were applied to six replicate branches. Fruit detachment force (FDF in grams-force) and % fruit drop were evaluated 12 days after application. Compounds evaluated were traumatic acid, Ethrel and traumatic acid + Ethrel at the concentrations indicated, and a water control. All treatments contained 0.05% Kinetic.

treatment	FDF (g-force) *	% fruit drop *
control	490 a	2.5 c
Traumatic acid (TA)		
1000 ppm	431 a	0.0 c
Ethrel		
500 ppm	436 a	12.9 b
1000 ppm	342 b	46.4 a
TA + Ethrel		
1000 + 1000 ppm	394 ab	44.9 a

* Means followed by the same letter are not significantly different, $P \leq 0.05$.

Table 4. Abscission compound screening trial applied on 10-8-06 at the Kearney Agricultural Center, Parlier, CA. Compounds were applied to six replicate branches. Fruit detachment force (FDF in grams-force) and % fruit drop were evaluated 7 days after application. Compounds evaluated were VBC 30030, VBC 30030 + Ethrel, dikegulac and 5-chloro-3-methyl-4-nitro-1*H*-pyrazole (CMNP) at the concentrations indicated, and a water control. All treatments contained 0.05% Kinetic. No significant differences in FDF or % fruit drop were found between treatments.

treatment	FDF (g-force)	% fruit drop
control	525	2.8
VBC 30030		
1000 ppm	524	3.7
VBC 30030 + Ethrel		
1000 + 500 ppm	483	4.2
Dikegulac		
200 ppm	468	0.0
1000 ppm	506	1.3
2000 ppm	439	2.6
CMNP		
1000 ppm	469	0.0
2000 ppm	487	0.0

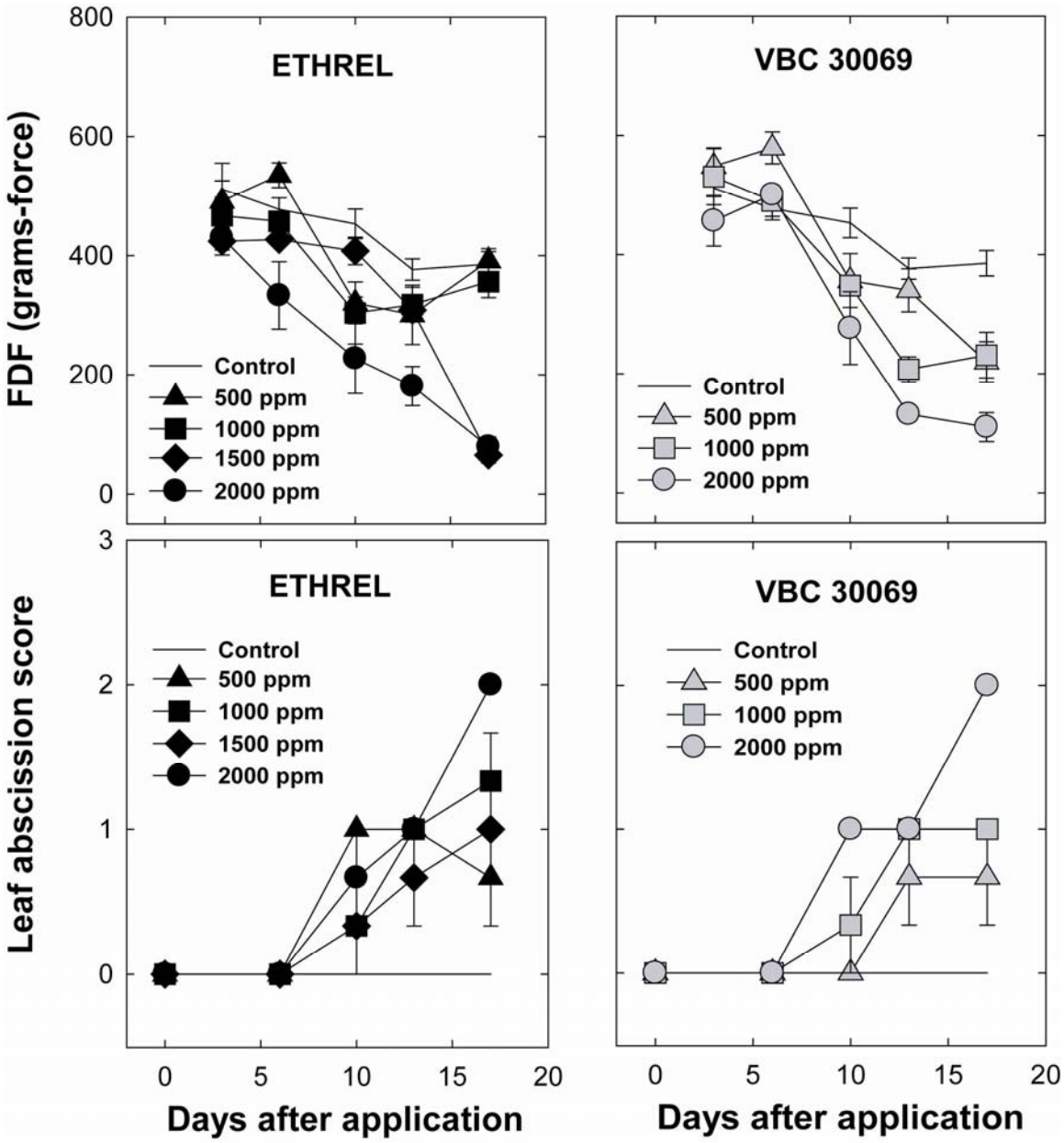

Figure 1. The effect of various concentrations of Ethrel and VBC 30069 on fruit detachment force (FDF in grams-force, upper panels) and leaf abscission score (0, no abscission; 3, severe abscission, lower panels) in olive. Trial was initiated on October 24, 2006 in Tehama, CA. Data plotted are the means $\pm$ SE.

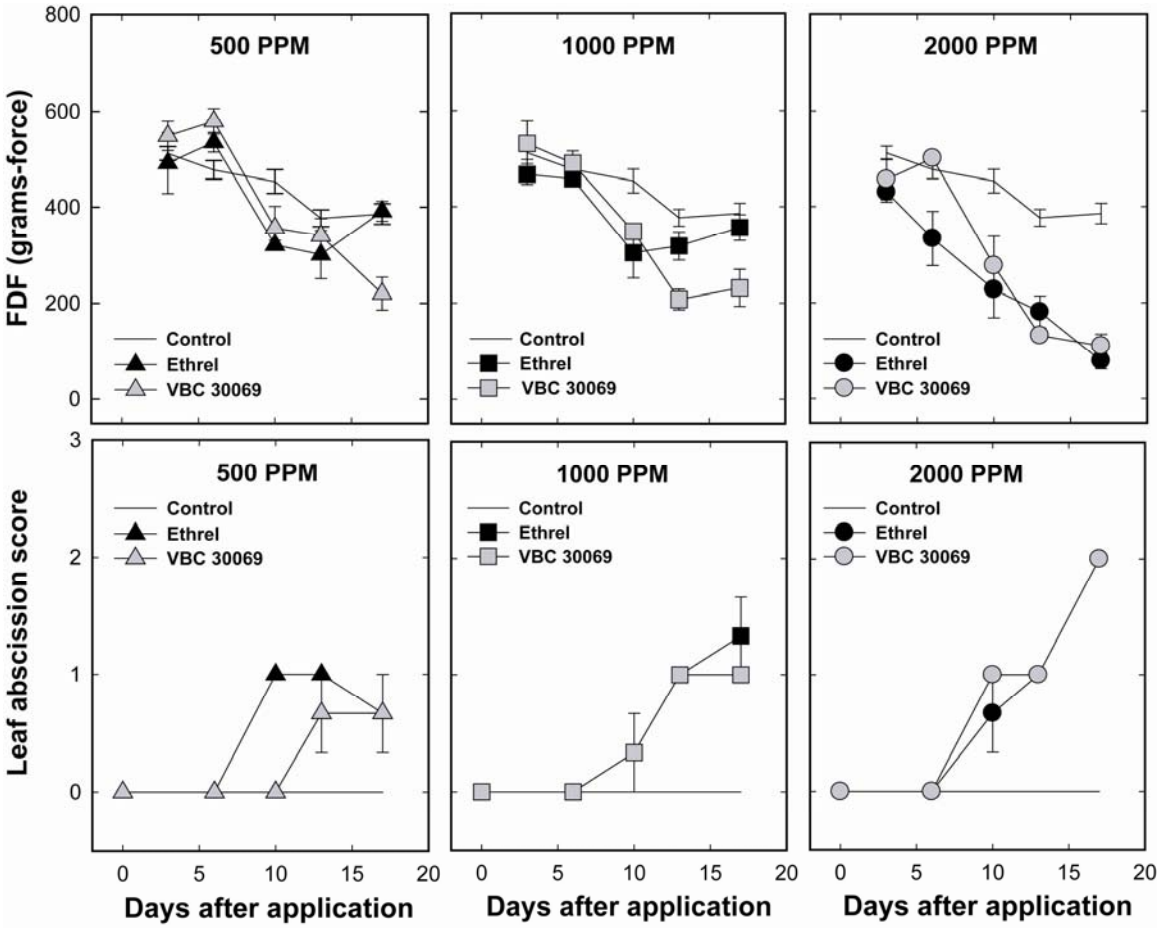

Figure 2. A comparison of equivalent concentrations of Ethrel and VBC 30069 on fruit detachment force (FDF in grams-force, upper panels) and leaf abscission score (0, no abscission; 3, severe abscission, lower panels) in olive. Trial was initiated on October 24, 2006 in Tehama, CA. Data plotted are the means $\pm$ SE.

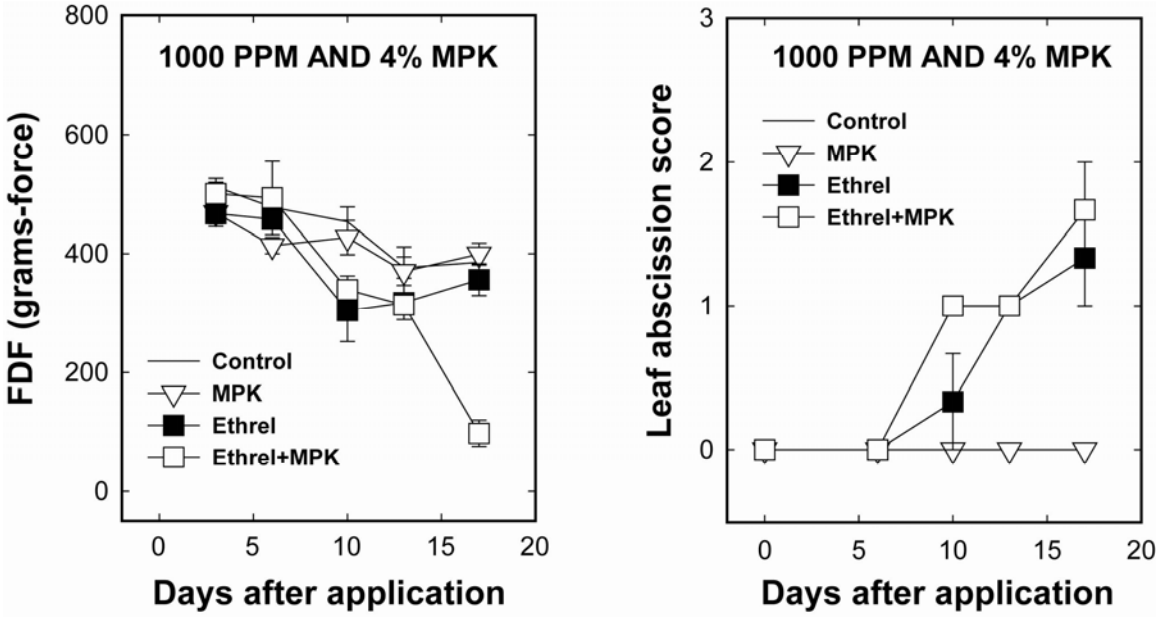

Figure 3. The effect of 4% MPK 1000ppm Ethrel, and 4% MPK + 1000 ppm Ethrel on fruit detachment force (FDF in grams-force, left panel) and leaf abscission score (0, no abscission; 3, severe abscission, right panel) in olive. Trial was initiated on October 24, 2006 in Tehama, CA. Data plotted are the means $\pm$ SE.

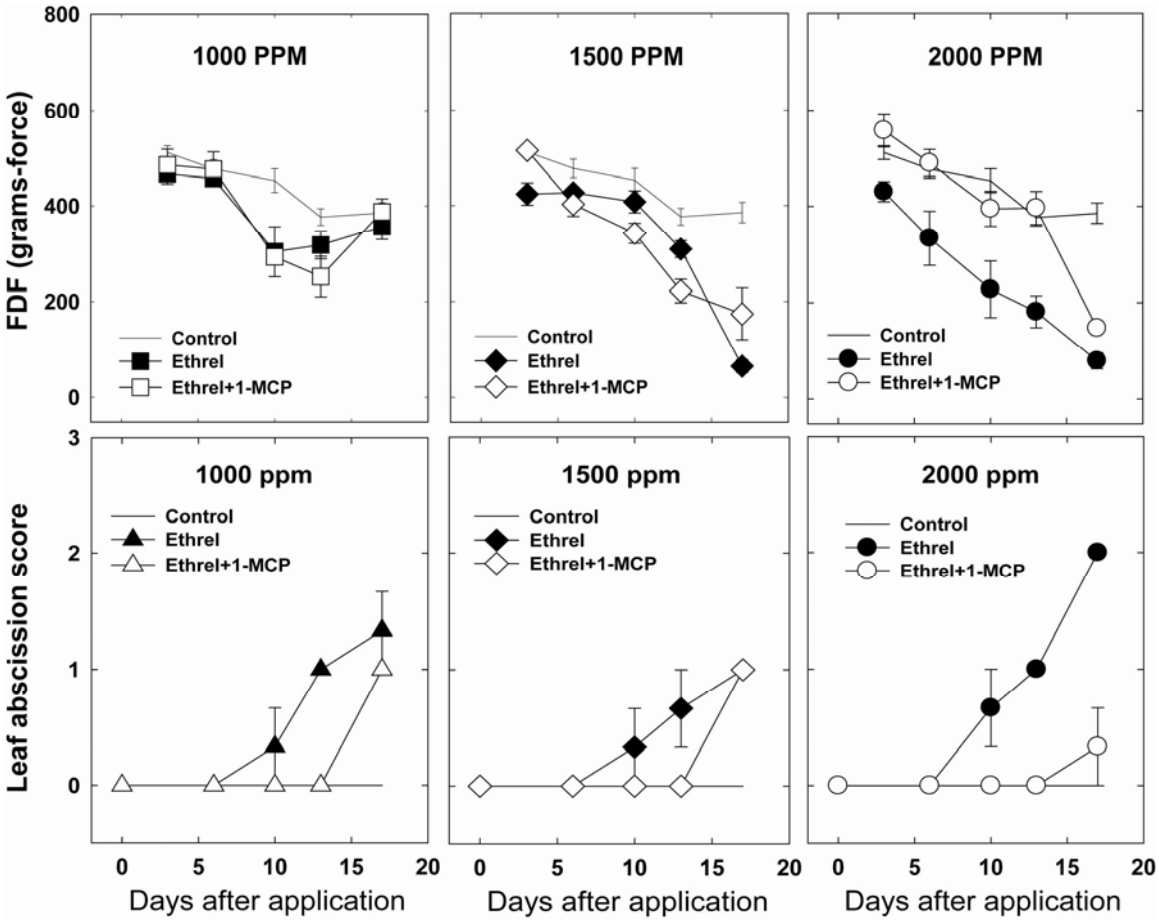

Figure 4. The effect of various concentrations of Ethrel and Ethrel + 5 mM 1-MCP on fruit detachment force (FDF in grams-force, left panel) and leaf abscission score (0, no abscission; 3, severe abscission, right panel) in olive. Trial was initiated on October 24, 2006 in Tehama, CA. Data plotted are the means $\pm$ SE.