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Evaluation of Two New Acaricides for Use in Integrated Mite Management in Almonds

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Abstract

Three unregistered acaricides (abamectin, MK-239 and EL-436) were evaluated in three almond orchards in the San Joaquin Valley during 1991 to determine whether they can be incorporated in an integrated mite management program. Integrated mite management requires that spider mite and western predatory mite (*Metaseiulus occidentalis*) populations be monitored so that lower-than-label rates of an acaricide can be applied if *M. occidentalis* needs assistance in suppressing spider mite densities.

The rates applied were chosen after conducting preliminary laboratory and greenhouse trials, and were lower than the proposed label rates. In addition to the unregistered acaricides, a low rate of Omite was applied as a standard and a water control also was monitored.

As expected, 0.5 lb ai/100 gal Omite (615 ppm) suppressed spider mites and had minimal impact on *M. occidentalis* populations. Likewise, abamectin (applied at a rate of 0.001 lb ai/100 gal, or 0.75 ppm) also reduced spider mites without having a negative impact on *M. occidentalis* populations. Abamectin is currently unregistered for almonds but should be useful in an integrated mite management program.

The other unregistered materials, EL-436 (Dow Elanco) and MK-239 (American Cyanamid), each were applied at three different rates: 0.001, 0.006 and 0.021 lb ai/100 gallon (or 1.56, 6.25, or 25 ppm). The results indicated that two rates (0.001 and 0.006 lb ai/100 gal) of MK-239 had little impact on *M. occidentalis* populations. However, the rate of 0.006 lb ai/100 gal had a significant impact on spider mite populations, so this rate may be the most effective rate for an integrated mite managment program. The

highest rate, 0.021 lb ai/100 gal, suppressed both spider mite and *M. occidentalis* populations.

The rate of 0.001 lb ai/100 gal EL-436 had little impact on either spider mites or *M. occidentalis*. The rates of 0.006 and 0.021 lb ai/100 gal did not allow adequate numbers of *M. occidentalis* to survive. Thus, this acaricide does not appear promising for use in an integrated mite management program.

Our conclusions are based only on data from two almond orchards because spider mite densities in the third orchard were so low that it was difficult to interpret the data. The same general trends, however, were observed. In all three orchards, spider mite densities were unusually low throughout the growing season, perhaps due to late spring rains and an unseasonably cool summer. Therefore, before incorporating abamectin or MK-239 into an integrated mite management program, these lower-than-label application rates should be confirmed as effective in almond orchards with higher spider mite densities. It is unlikely, however, based on laboratory and greenhouse data, that a full label rate of MK-239 will be appropriate, because it is toxic to *M. occidentalis*. Once registered, both abamectin and MK-239, applied at lower-than-label rates, could be useful products to assist *M. occidentalis* in reducing spider mite densities in California almond orchards.

Introduction

Integrated mite management (IMM) in almonds has used Omite (propargite), Plictran (cyhexatin), and Vendex (fenbutatin-oxide) at lower-than-label rates to adjust predator: prey ratios early in the growing season, in order to enhance biological control of spider mites by the western predatory mite, *Metaseiulus occidentalis* (Nesbitt) (Hoy 1985). Unfortunately, registration of Plictran was lost, and resistance to Omite and Vendex has been documented in spider mites (Dennehy et al. 1987, Grafton-Cardwell et al. 1987, Hoy and Conley 1989, Hoy et al. 1988). The incorporation of new acaricides in almond IMM is highly desirable.

During the last two years we conducted laboratory bioassays to evaluate unregistered acaricides for their impact on the two-spotted spider mite *Tetranychus urticae* Koch, the Pacific spider mite *T. pacificus* (McGregor), and their predator *M. occidentalis*. Laboratory tests suggested that EL-436 (4-[2-[4-(1,1-dimethylethyl)phenyl]ethoxy]quinazoline) (Dow

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MK-239 (N-(4-t-butylbenzyl)-4-chloro-3-ethyl-1-methyl-pyrazole-5-carboxamide; proposed trade name is Fenpyrad) (American Cyanamid) is a contact acaricide that is toxic to all stages of spider mites and *M. occidentalis* at rates less than the recommended field rate of 50-100 ppm (M. H. C. and M. A. H.,unpublished data). The impact of MK-239 on all mites tested varies between and within species but it is less toxic to *M. occidentalis* than to *T. urticae* and *T. pacificus.*

Abamectin (Merck Sharp and Dohme) is more toxic to *T. pacificus* than to *M. occidentalis* at concentrations lower than the proposed field rates (Grafton-Cardwell and Hoy 1983). Exposure to fresh abamectin at field rates is toxic to both *T. pacificus* and *M. occidentalis.* The toxicity of abamectin to *M. occidentalis* at field rates declines rapidly with time but remains high for spider mites (Hoy and Cave 1985). Omite (Uniroyal Chemical) has little effect on *M. occidentalis* at 0.5 lb ai/100gal but is toxic to spider mites (although resistant strains do exist).

Both Dow Elanco and American Cyanamid have indicated an interest in registering their acaricides for use in almonds. Information on abamectin will be submitted to the EPA in 1991 for registration in almonds.

Laboratory bioassays provide a simple and inexpensive way to compare toxicity of pesticides to different life stages of prey and predator. We have had success in correlating the results of laboratory bioassays with field mortality when mortality is either high or very low in the laboratory (Hoy and Conley 1987). The impact of an acaricide is sometimes equivocal in laboratory tests with regard to predicting what will happen in the field. Sometimes it is either only slightly more toxic to spider mites than to *M. occidentalis* or some life stages of *M. occidentalis* are more sensitive than those of its prey. This is the situation with EL-436 and MK-239. In these situations, it is unclear whether laboratory assays are useful in predicting whether they can be used in an IMM program. It will probably be necessary to apply these acaricides at lower-than label-rates to be compatible with good biological control by *M. occidentalis*, but the actual rates need to be confirmed in the field.

We performed these field trials in three almond orchards during 1991 to ascertain whether low rates of abamectin, MK-239 or EL-436 would be useful in an integrated mite management program. The goal of such a program is to reduce spider mite populations while allowing *M. occidentalis* to persist. We attempted to apply rates that would exhibit low toxicity to *M. occidentalis* but not reduce spider mite densities to a point where these obligatory predators would not have prey. *M. occidentalis* that lack prey will starve or disperse from the trees and this can cause a secondary outbreak of spider mites later in the season.

MATERIALS and METHODS

Three rates, 1.56, 6.25, and 25.00 ppm (0.001, 0.006, and 0.021 lbs ai/100 gal) of 1.8 EC EL-436 and of 2.0 EC MK-239, one rate of abamectin (0.75 ppm or 0.001 lb ai/100 gal) and one rate of propargite (615 ppm or 0.05 lbs ai Omite/100 gal), as well as a water check were applied in each of three almond orchards. These rates were selected based on prior laboratory and greenhouse evaluations of toxicity to *Tetranychus* spp. and *M. occidentalis*. The first site (West Side Field Station near Five Points, CA) was composed of randomly-assigned rows of fifteen-year-old Nonpareil, Carmel, and Jeffrey almond varieties onto which treatments were equally assigned. The second (Dow Elanco Experimental Farm, Fresno, CA) consisted of alternating rows of four-year-old Nonpareil and Carmel varieties. The third location (a commercial orchard near Kerman, CA) consisted of four-year-old Nonpareils. Six replicates of each treatment were assigned in a randomized complete block design with each row containing one replicate of each treatment, except at the West Side Field Station, where two rows were used. Each of the six replicates consisted of one treated tree surrounded by one buffer tree. Treatments were blocked to account for a possible gradient in spider mite densities due to the prevailing wind pattern. Each plot was surrounded by two rows of untreated trees to serve as a buffer.

We began monitoring prey and predator levels beginning in April 1991. We released a strain of *M. occidentalis* that is resistant to carbaryl, organophosphates and sulfur (COS) in the Dow Elanco orchard on 12 June 1991 and in the commercial orchard in Kerman on 10 July 1991. Fifty and 100 mites of all stages of the COS strain of *M. occidentalis* /tree were released in the Dow Elanco and Kerman orchards, respectively, to supplement the low levels of indigenous *M. occidentalis*. No predators were released at the West Side Field Station. The COS strain was mass-reared on a mixed population of *Tetranychus* spp. on bean flats in a greenhouse at the University of California at Berkeley.

Leaf samples were collected the day before acaricides were applied. A single application of acaricides was made at West Side Field Station on 28 June 1991, at the Dow Elanco Experimental Farm on 10 July 1991, and at the commercial orchard in Kerman on 17 July 1991 using an air blast sprayer (FMC Mist Blower) at a rate of 0.9-1.0 gal/tree. Samples of 30 leaves/tree were collected once a week for 4-5 weeks to monitor spider mite and *M. occidentalis* densities. Leaves from each tree were isolated in individual paper bags, cooled, transported to the laboratory, and brushed with a mite brushing machine. Eggs and actives of both predators and spider mites were counted. The mean number of mites/leaf and cumulative spider-mite-days (SMD) were analyzed using the Mann-Whitney U test and the Wilcoxon signed rank test (P=0.05) (Conover 1971, Marascuilo and Serlin 1988).

Results and Discussion

The principal tetranychid species in all orchards was *T. pacificus* but because it is difficult to distinguish between *T. urticae, T. pacificus* and *T. turkestani* under a dissecting microscope, the data are presented as *Tetranychus* spp. (Hoy 1985). *Panonychus ulmi* (Koch) (European red mite) was present in all orchards. *M. occidentalis* was the only predatory mite detected. Spider mite densities in all three orchards during 1991 were exceptionally low, perhaps due to late rains in March and unusually low temperatures throughout the season. The six-spotted thrips, *Scolothrips sexmaculatus* (Pergande), appeared in all three orchards during the last two sample dates at levels of approximately one per thirty leaves and could have reduced mite densities.

Dow Elanco Farm

Mite population densities are shown in Fig. 1. European red mite levels were very low throughout the season (cumulative SMD for water check barely exceeded 3, Fig 2B), and therefore were not considered further. *Tetranychus* populations were significantly decreased one week postspray due to abamectin and Omite treatments but quickly rebounded in subsequent weeks compared to the water check (Figs 1B, C). The cumulative SMD for the season were significantly lower for abamectin- and Omite-treated trees compared to the check (116 and 123 SMD, respectively, compared to 163 SMD) (Fig. 2A). *M. occidentalis* levels were not significantly lower than the water check at any time, suggesting that both Omite and abamectin are selective.

The lowest rate of EL-436 (1.56 ppm) did not significantly reduce spider mite or *M. occidentalis* populations compared to the check except for decreased levels of spider mites on 7 August (Fig. 1D). In the 1.56 ppm-treated trees, there were statistically more predators three weeks after treatment (31 July) than at the prespray sample date (10 July). The rates of 6.25 and 25.00 ppm EL-436 significantly reduced cumulative SMD compared to the check by 40.5 and 41.1%, respectively (Fig. 2A). These rates, however, also reduced the *M. occidentalis* populations on all sample dates subsequent to treatment (Figs. 1E, F). Densities of *M.*

occidentalis were lower than the check at three (31 July) and four weeks (7 August) postspray. Therefore, any reduction in cumulative SMD was primarily due to the effect of EL-436, and not to biological control by *M. occidentalis*.

Kerman orchard

European red mite and *Tetranychus* spp. served as prey for *M. occidentalis* in this orchard. Compared with the check, 0.75 ppm abamectin and 1.56 ppm MK-239 had little negative impact on either spider mite species or on *M. occidentalis* densities (Fig 3A, B and D). The cumulative SMD totals were moderately, but not significantly, reduced (approximately 77%) compared to the check (Figs. 4A, B). Compared to the check, 6.25 and 25.00 ppm MK-239 caused a significant decrease in cumulative SMD for*Tetranychus* spp. (17% and 20% of the SMD for the check, respectively) (Fig 4A). The 25.00 ppm rate caused a moderate (63% of check), but significant, lowering of *P. ulmi* SMD (Fig. 4B). Both 6.25 and 25.00 ppm reduced *M. occidentalis* populations one week postspray (Figs. 3E, F). *M. occidentalis* populations treated with 6.25 ppm rebounded within one week whereas those treated with 25.00 ppm did not. Therefore, it is likely that *M. occidentalis* had an impact on spider mite populations in trees treated with 6.25 ppm, but not in trees treated with 25.00 ppm MK-329.

West Side Field Station

The densities of spider mites in all treatments were very low throughout the experiment; cumulative SMD did not exceed 15 for either *Tetranychus* spp. or *P. ulmi.* While statistical differences between treatments exist, such low densities make further discussion of results of minimal biological importance. However, the data are presented in order to show interactions between spider mites and *M. occidentalis* (Figs. 5, 6). In general, these results support the conclusions observed in the other orchards.

Conclusions

At the rates tested, Omite and abamectin are selective because *M. occidentalis* densities were not reduced while, at least in some orchards, spider mite densities were. The lowest rate of EL-436 tested, 1.56 ppm, had little impact on either spider mite or *M. occidentalis*; population levels were similar to those of the check throughout the sampling dates. Both 6.25 and 25.00 ppm of EL-436 reduced *M. occidentalis* and spider mite densities. Thus, while 6.25 and 25.00 ppm controlled spider mite populations, they eliminated this important biological control agent and therefore were not selective for *M. occidentalis*. Thus, this acaricide does not appear promising for use in an integrated mite management program. The 1.56 rate of MK-239 had no significant impact on either spider mites or *M. occidentalis*, while 25.00 ppm was equally toxic to both. The 6.25 ppm rate, which allowed *M. occidentalis* to persist while reducing spider mite densities, may be selective and therefore useful in an IMM program.

Due to the low levels of spider mites in all orchards during 1991, these results require further field validation, particularly in orchards with larger populations of spider mites. Nevertheless, the field data are consistent with our laboratory toxicity data that indicate that EL-436 may not be suitable as a selective agent but MK-239 may be. In a laboratory leaf spray bioassay, the LC_{50} ratio for adult female *Tetranychus* spp. compared to *M. occidentalis* is around 2.0, which means that the acaricide is more toxic to spider mites than to *M. occidentalis*. The ratio for MK-436 is approximately 0.5 (Chapman & Hoy, unpublished data).

Field experiments to evaluate the selectivity of pesticides to biological control agents are time consuming and expensive. Thus, we plan to incorporate these field data into a model combining data obtained from laboratory and greenhouse tests to predict toxicity in the field. Such a model may allow us to determine which new acaricides (and at what rates) are compatible with IMM in California almond orchards. Because resistance to acaricides is a critical issue, addition of new acaricides into an almond IMM program would allow resistance management to be continued. Knowledge of selective rates will enable growers to maintain control of spider mites by *M. occidentalis*, will reduce acaricide rates applied, and thus reduce spider mite populations.

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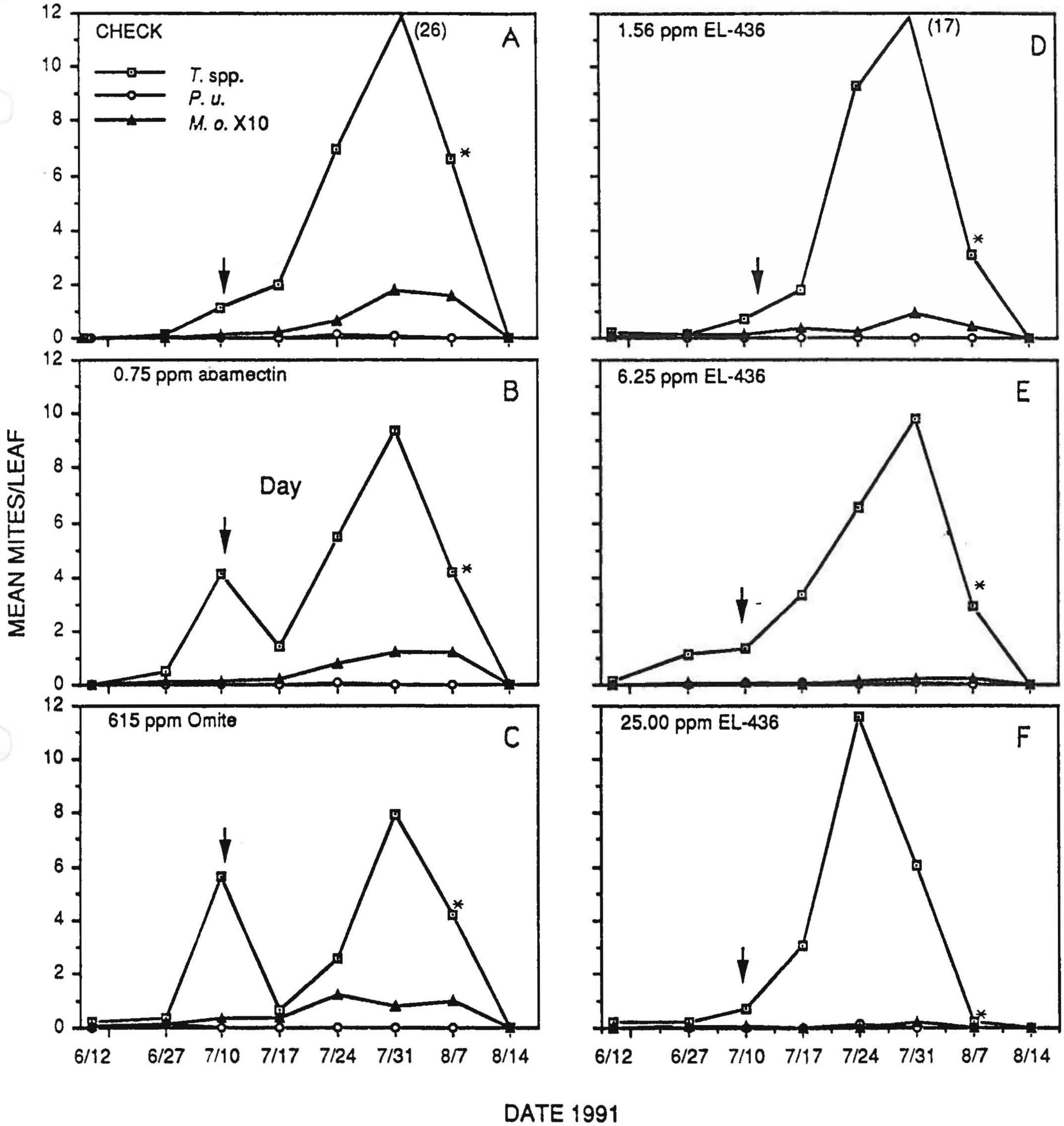


Fig. 1. Dow Elanco orchard, Fresno CA. Arrow indicates application of acaricides. *T.* spp.=all stages of *Tetranychus* spp. (predominantly Pacific spider mite), *P. u.*=active stages of European red mite (*Panonychus ulmi*), *M. o.* x10= *Metaseiulus occidentalis* (all instars multiplied by ten). *= generalist predators detected (western flower thrips).

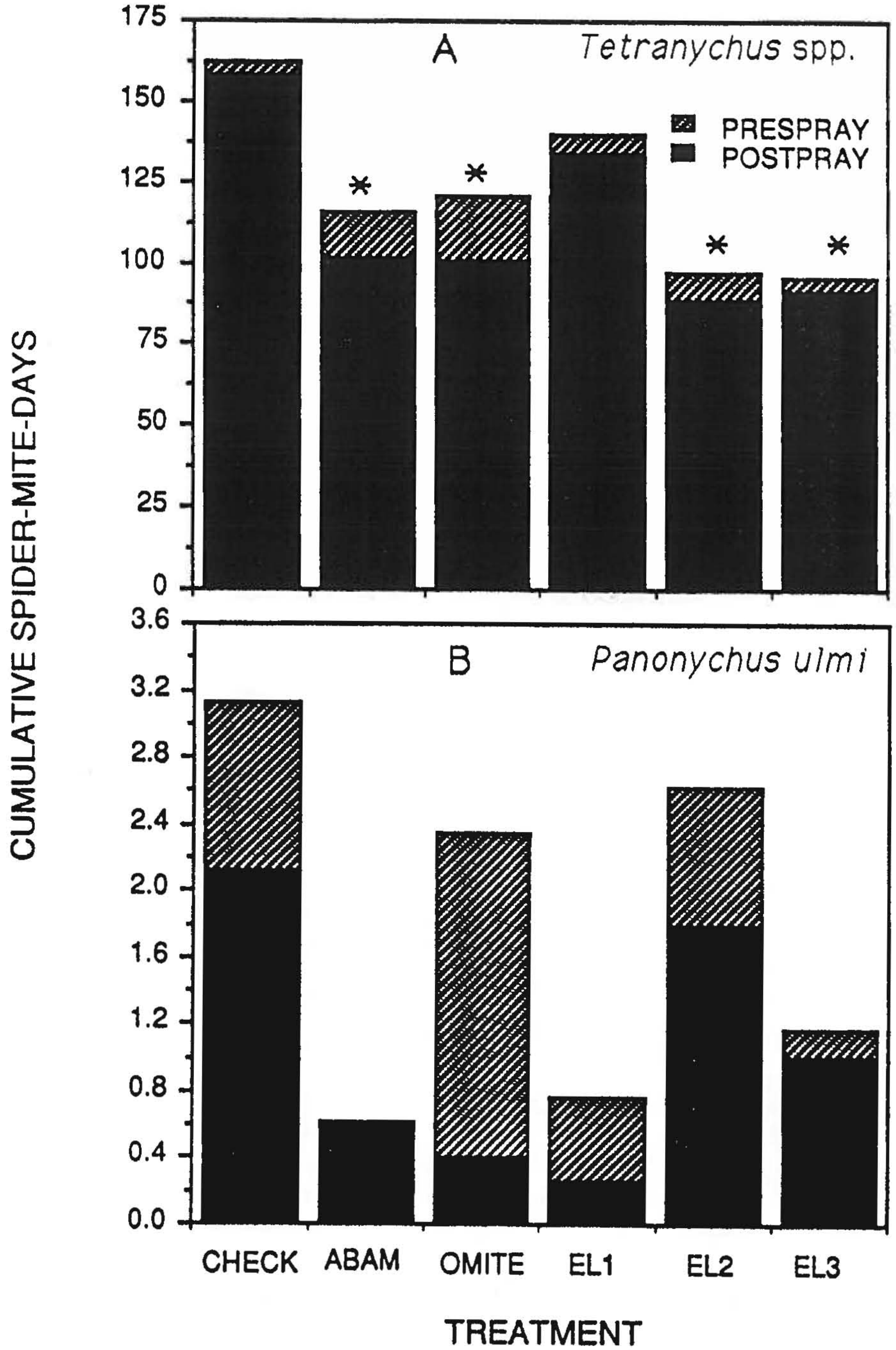


Fig. 2. Cumulative spider-mite-days for A) *Tetranychus* spp. and B) *Panonychus ulmi* in the Dow Elanco orchard for 1991. CHECK= water only, ABAM= 0.75 ppm abarmectin, OMITE= 615 ppm Omite, EL1=1.56 , EL2=6.25, and EL3=25.00 ppm of EL-436, respectively. * = statistically different from check.

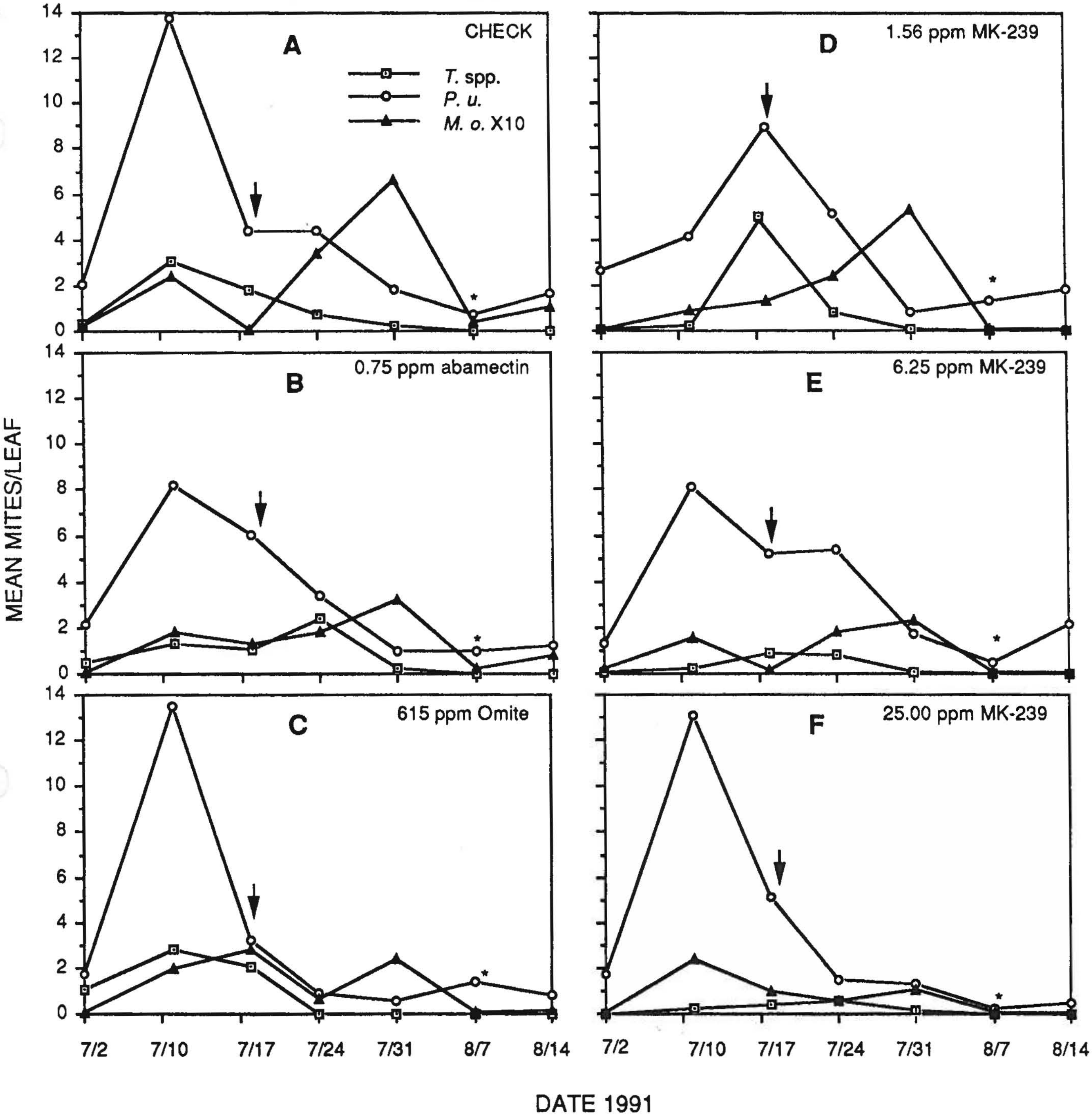


Fig. 3. Kerman orchard. Arrow indicates application of acaricides. *T.* spp.=all stages of *Tetranychus* spp. (predominantly Pacific spider mite), *P. u.*=active stages of European red mite (*Panonychus ulmi*), *M. o.* x10= *Metaseiulus occidentalis* (all instars multiplied by ten). *= generalist predators detected (western flower thrips).

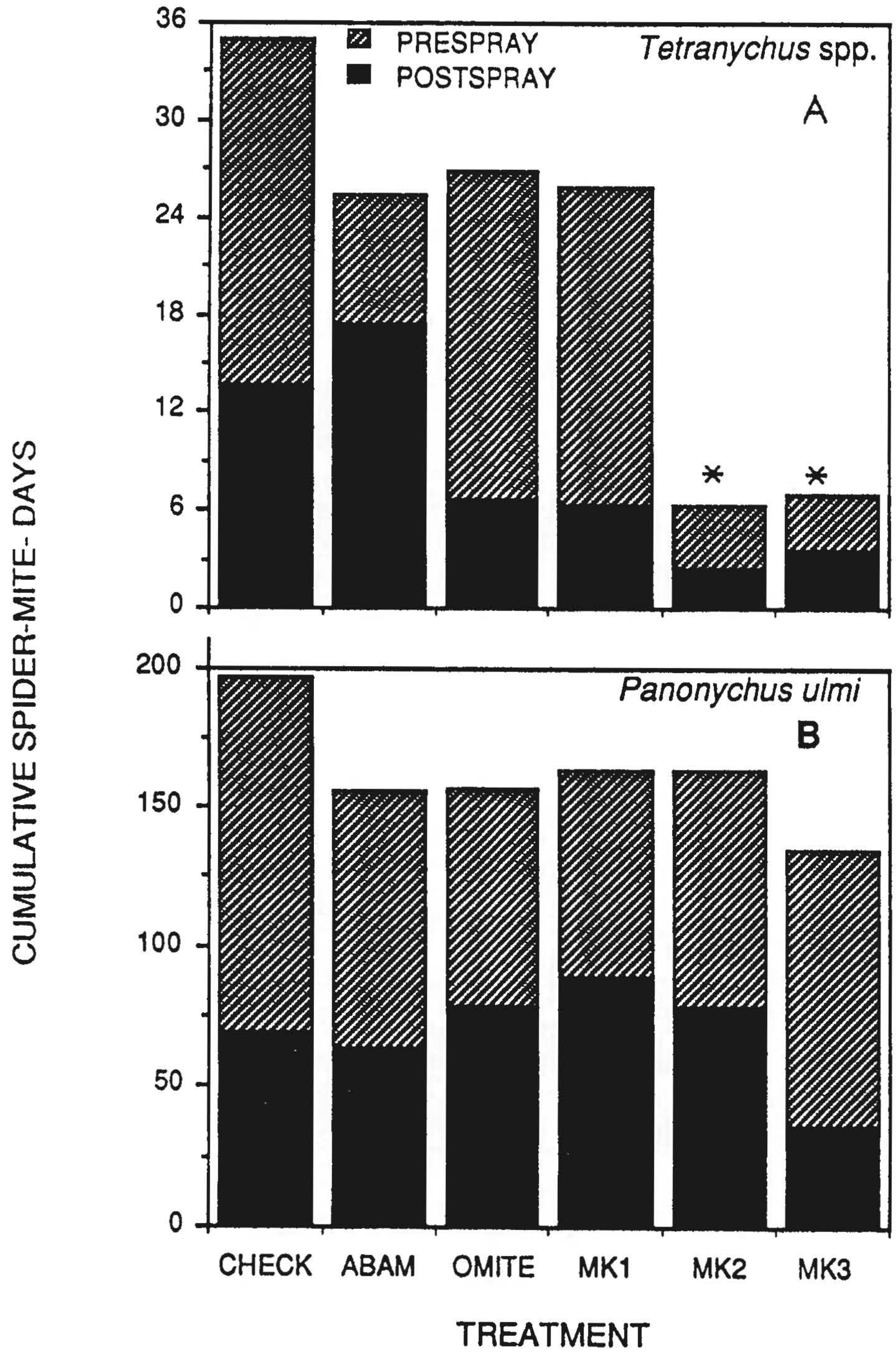
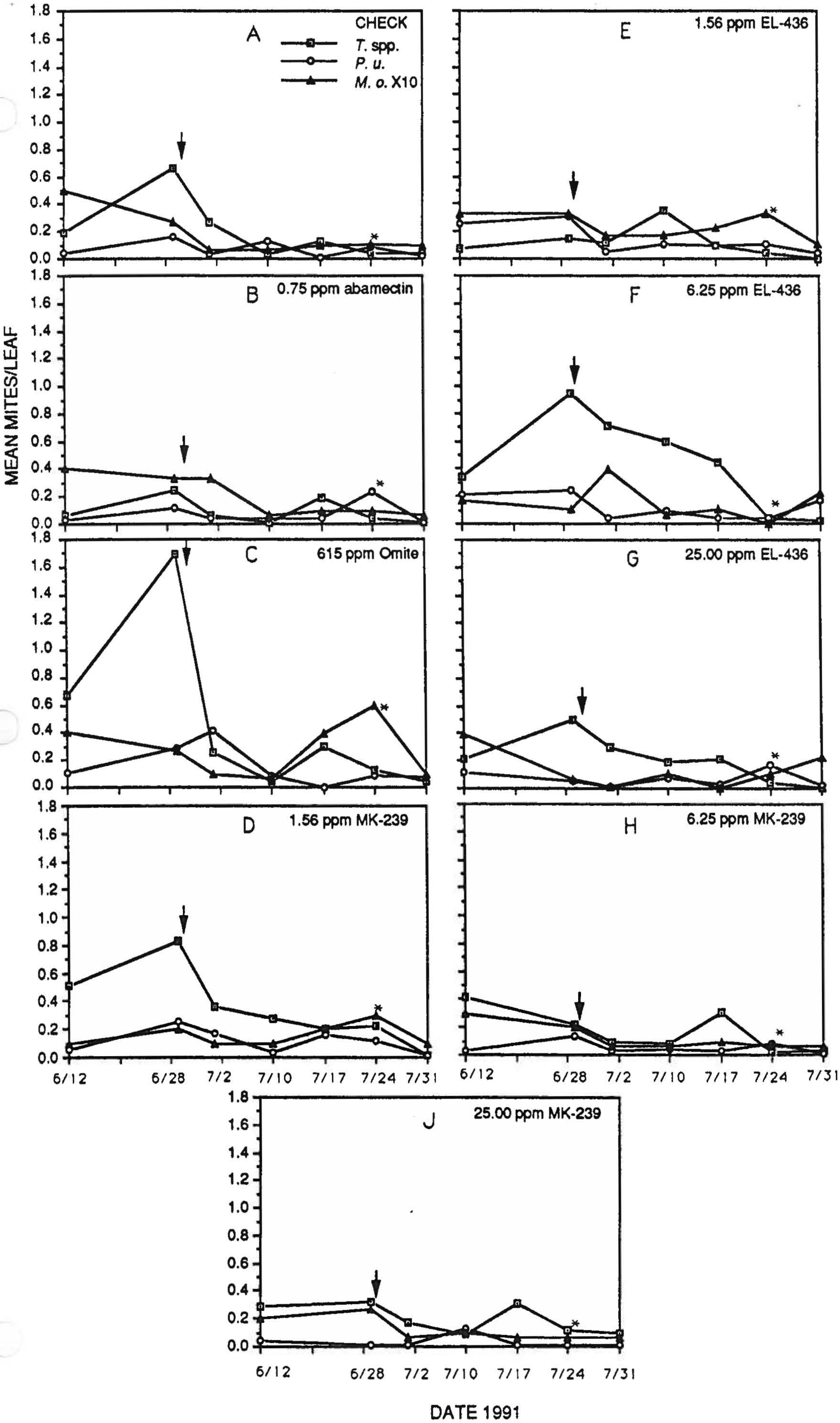


Fig. 4. Cumulative spider- mite-days for A) *Tetranychus* spp. and B) *Panonychus ulmi* in the Kerman orchard during 1991. CHECK= water only, ABAM= 0.75 ppm abamectin, OMITE=615 ppm Omite, MK1=1.56 , MK2=6.25, and MK3=25.00 ppm of MK-239, respectively. * = statistically different from check.

Fig. 5. West Side Field Station. Arrow indicates application of acaricides. *T.* spp.=all stages of *Tetranychus* spp. (predominantly Pacific spider mite), *P. u.*=active stages of European red mite (*Panonychus ulmi*), *M. o.* x10= *Metaseiulus occidentalis* (all instars multiplied by ten). *= generalist predators detected (western flower thrips).



MEAN MITES/LEAF
A
CHECK
T. spp.
P. u.
M. o. X10
B
0.75 ppm abamectin
C
615 ppm Omite
D
1.56 ppm MK-239
E
1.56 ppm EL-436
F
6.25 ppm EL-436
G
25.00 ppm EL-436
H
6.25 ppm MK-239
J
25.00 ppm MK-239
6/12
6/28
7/2
7/10
7/17
7/24
7/31
DATE 1991

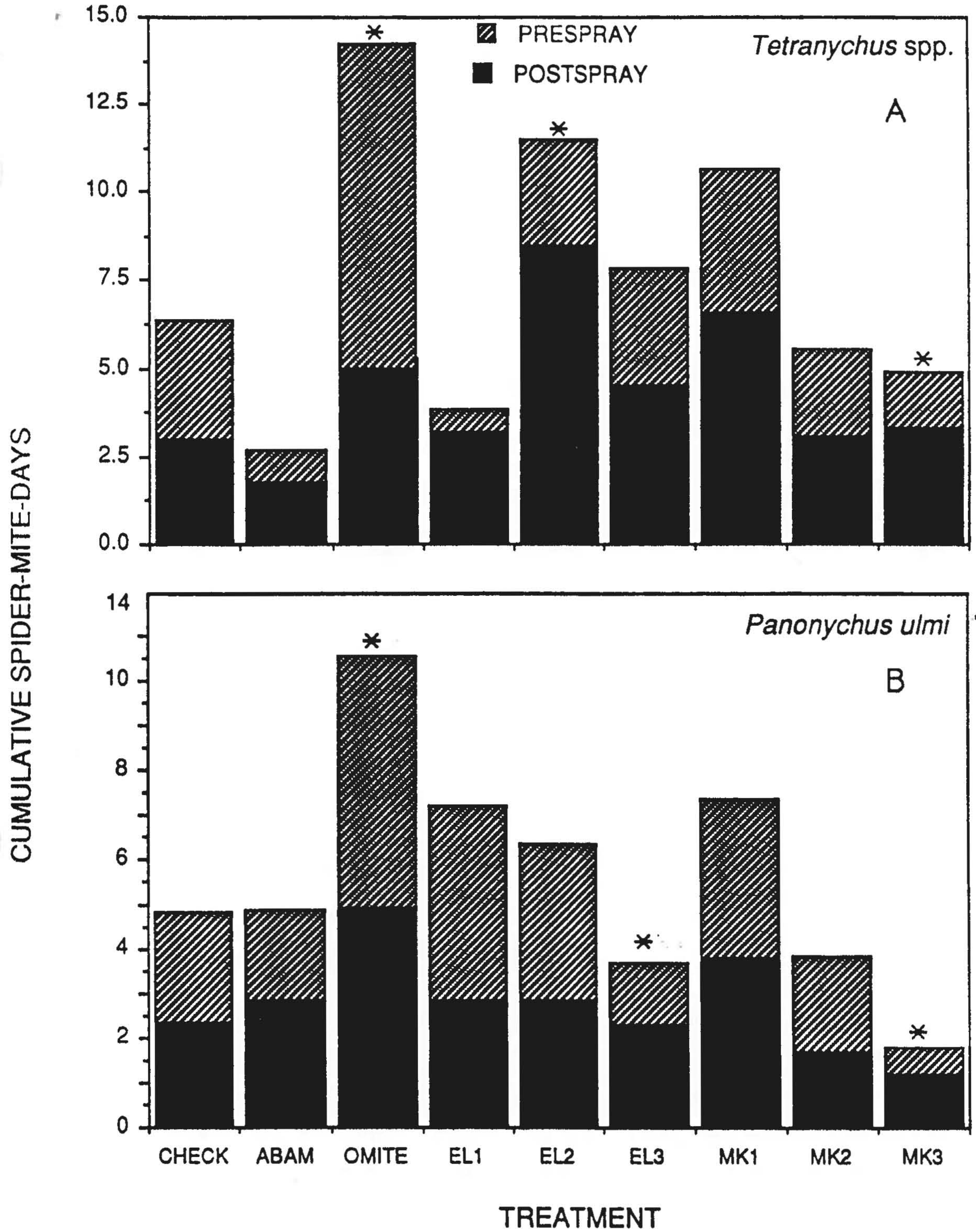


Fig. 6. Cumulative spider-mite-days for A) *Tetranychus* spp. and B) *Panonychus ulmi* in the West Side Field Station orchard during 1991. CHECK= water only, ABAM= 0.75 ppm abamectin, OMITE 15 ppm Omite, MK1=1.56, MK2=6.25, and MK3=25.00 ppm of MK-239, respectively, EL1=1.56, EL2=6.25, and EL3=25.00 ppm of EL-436, respectively. * = statistically different from check.