



**Some Important Uses of Pyrethroids on Crops
in Arizona, New Mexico and Colorado**
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Who We Are

The Arizona Pest Management Center (APMC) is host to the University of Arizona's expert IPM scientists including Ph.D. entomologists, weed scientists and plant pathologists with expertise in the strategic tactical use of pesticides within IPM programs that protect economic, environmental and human health interests of stakeholders and the society at large.

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These comments are the independent assessment of the authors and the Arizona Pest Management Center as part of our role to contribute federal comments on issues of pest management importance and do not imply endorsement by the University of Arizona or USDA of any products, services, or organizations mentioned, shown, or indirectly implied in this document.

Our Data and Expert Information

Through cooperative agreements with Arizona Department of Agriculture, the Arizona Pest Management Center obtains use of, improves upon, and conducts studies with ADA's Form L-1080 data. Growers, pest control advisors and applicators complete and submit these forms to the state when required by statute as a record of pesticide use. These data contain information on 100% of custom-applied (i.e., for hire) pesticides in the state of Arizona. Grower self-applied pesticide applications may be under-represented in these data. In addition, the Arizona Pest Management Center is host to scientists in the discipline of IPM including experts in the usage of these compounds in our agricultural systems. We actively solicit input from stakeholders in Arizona including those in the regulated user community, particularly to better understand use patterns, use benefits, and availability and efficacy of alternatives. The comments within are based on the extensive data contained in the Arizona Pest Management Center Pesticide Use Database, collected summary input from stakeholders and the expertise of APMC member faculty.

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Diversity and Importance of Pyrethroid Use in Arizona Cropping Systems

Pyrethroids are effective broad-spectrum insecticides that pose very low risks to applicators and terrestrial ecosystems. Several pyrethroid active ingredients, contained in a large number of available brand name and generic products generally at low cost relative to newer chemistries, are used across a large number of crops in Arizona and also in structural, urban, and veterinarian pest control. The Arizona Pest Management Center Pesticide Use Database identified over 100 distinct crops in in Arizona with some use of pyrethroids between 2012 and 2016. Crops with an average of 1,000 or more acres treated annually are presented in Table 1. This report focuses on some of the primary agricultural uses of pyrethroid insecticides, benefits, and alternative practices, for a select group of crops in Arizona, New Mexico and Colorado. These comments are not intended to present a comprehensive report of all important uses. With respect to Arizona, for uses in certain crops, we refer the reader the other submitted comments. Dr. John Palumbo, Professor and Extension Entomologist with 27 years of experience in Arizona vegetable and melon production, submitted comments that cover leafy green vegetables, cole crops and melon uses in Arizona. Comments submitted by Arizona Farm Bureau Federation also provide information on leafy vegetables as well as alfalfa. **Our report focuses primarily on**

alfalfa and other important field crops in Arizona, Colorado and New Mexico, as well as Arizona sweet corn and Arizona and New Mexico Chile pepper and pecan production.

Table 1: Arizona Crops, Mean Acres Treated with Pyrethroids Annually, 2012 - 2016. Crops with over 1,000ac treated shown. Source: Arizona Pest Management Center Pesticide Use Database, unpublished data.

CROP NAME	MEAN ACRES TREATED ANNUALLY
ALFALFA	257,942
LETTUCE, HEAD	101,911
LETTUCE, LEAF	68,016
COTTON	44,696
LETTUCE, ROMAINE	23,017
BROCCOLI	18,239
CORN, UNSPECIFIED	15,643
SPINACH	15,258
CORN, FIELD	12,180
CAULIFLOWER	10,143
CANTALOUPE	9,692
CABBAGE, UNSPECIFIED	9,654
CELERY	3,010
MELON, UNSPECIFIED	2,894
PECAN	2,476
CORN, GRAIN	2,288
POTATO	2,267
BEAN, DRY	2,054
LETTUCE, UNSPECIFIED	2,004
BEAN, UNSPECIFIED	1,965
BEANS	1,824
MELON, WATERMELON	1,398
SORGHUM, MILO	1,286
BEAN, PINTO	1,236
KALE	1,204
BARLEY	1,184
ONION, DRY	1,180

Pyrethroid use in Alfalfa: Arizona, Southeastern California, New Mexico, Colorado

Arizona and Riverside County, California

In 2016, Arizona growers produced 280,000 acres of alfalfa, over 2.4 million tons, valued at over \$361 million (USDA-NASS 2017a). Several pyrethroid active ingredients are among the most commonly used insecticides in alfalfa. In a December 2016 insecticide use survey of Arizona pest control advisors (PCAs, n=18), six pyrethroid AIs were identified as having been used in 2016 for insect control, with four being used on an average of 10 to 50% of acres. In order of average percent acres treated in 2016, these were beta-cyfluthrin (50.3%), zeta-cypermethrin

(26.9%), lambda-cyhalothrin (24.2%), cyfluthrin (13.6%), cyfluthrin gamma (in a pre-mix with chlorpyrifos, 1.4%) and permethrin (1.1%). In viewing these numbers, it is important to note that aphid pressure in 2016 was much lower than is typical, due to a naturally occurring infection of an entomopathogenic fungus and higher than average parasitism among aphid populations. In years with higher aphid populations, PCAs rely heavily on these pyrethroids to control aphids. These numbers also reflect a year when PCAs had access to an important selective chemistry for lepidopteran control, flubendiamide (Belt), which was labeled for use against several alfalfa pests, including alfalfa caterpillar and several armyworm and cutworm species. Currently, EPA has placed a hold on manufacture of Belt for use in alfalfa, corn and some other crops, so it will not be available once the current retail supply is exhausted. One PCA we spoke with indicated that, without flubendiamide (Belt), he would need to use zeta-cypermethrin (Mustang) to control alfalfa caterpillar in the summer. When asked about historical use of pyrethroids in the survey, 44% and 33% of PCA respondents indicated they used beta-cyfluthrin and lambda-cyhalothrin every year, respectively. 16.7% indicated use of zeta-cypermethrin and cyfluthrin every year.

Primary target insect pests in Arizona alfalfa include several aphids (pea aphid, blue alfalfa aphid, cowpea aphid, spotted alfalfa aphid), Egyptian alfalfa weevil, lepidopteran pests, and leafhoppers. Based on interviews with Arizona PCAs, pyrethroids are often mixed with other insecticides targeting weevils in the spring to enhance control of aphids, which are active at the same time. They are used against alfalfa caterpillar in the summer (particularly when flubendiamide is not available). Because of their broad-spectrum activity, pyrethroids are used by PCAs against each of these economically important pest groups. In some cases, these pyrethroids offer an alternative to other, more environmentally toxic and enduring insecticides, including organophosphates and carbamates. A PCA who manages alfalfa in La Paz County in western Arizona and the adjacent region in Riverside County, California, outlined the seasonal use patterns for pyrethroids in his region. In this system, pyrethroids are used two different times of the year, in fall and spring. They mainly use beta-cyfluthrin and lambda-cyhalothrin. In the fall, a single application of Baythroid (beta-cyfluthrin) is used for management of the hopper complex (3 cornered alfalfa hopper and Mexican leafhopper) as well as cutworm (if present). In the spring, a combination of a pyrethroid and an OP (malathion) is used to control aphid species and Egyptian alfalfa weevil. This is an economical and effective approach for them. “We try to narrow it down to just those two periods of use for pyrethroids, to maintain a large span of the year when populations are not exposed to these AIs for resistance management. With Sivanto (flupyradifurone) now available in alfalfa, we get good control of leafhopper, so we don’t need to use pyrethroids all year long. Steward (indoxacarb) is another product used against Egyptian alfalfa weevil that helps us eliminate some pyrethroid uses, although it is more expensive. We have not seen much loss of efficacy of pyrethroids against Egyptian alfalfa weevil, like they are reporting up in the San Joaquin Valley.” In this part of Arizona and California, pyrethroids are not often used for lepidopteran control in alfalfa. They mainly use Bt, which is economical and is quite effective, and also helps to preserve the natural enemy complex. Indoxacarb (Steward) or chlorantraniliprole (Coragen) are also used for lepidopteran control in alfalfa. However, in 2016, there was a cutworm outbreak in several alfalfa production areas in Arizona and California. Pyrethroids provided effective and economic remedies for this problem at time of lower hay prices.

A PCA in central Arizona (Pinal County) confirmed that the same two pyrethroid AIs, beta-cyfluthrin and lambda-cyhalothrin, are the most important for them. Almost 100% of their pyrethroid use is for aphid and Egyptian alfalfa weevil control. Generally, they apply pyrethroids in mixtures with malathion, or sometimes dimethoate, for control of aphids and weevil. Mixing these modes of action improves efficacy and helps to slow development of resistance in insect populations. Similar to the western part of the state, they no longer use pyrethroids for lepidopteran control because there are better options.

Resistance to pyrethroids is a concern, and they are rotated with insecticides that have different modes of action to minimize concerns about resistances. One PCA in Yuma County, Arizona who works in vegetables as well as alfalfa and cotton, indicated his concerns about resistances in the pyrethroids. “We have used so much [pyrethroids] I don’t know if they are doing much good. It was a replacement for OPs and carbamates. We used to spray a lot of alfalfa, but hopefully will spray less now that Sivanto (flupyradifurone) is available.” Sivanto is labeled for control of aphids, some hoppers and whiteflies in alfalfa.

New Mexico

In 2016, New Mexico growers produced over 190,000 acres of alfalfa, yielding 4.6 tons per acre, valued at over \$20 million (USDA-NASS 2017b). According to Dr. Mark Marsalis, Agronomist and Extension Forage Specialist with New Mexico State University, alfalfa is New Mexico’s number one cash crop. Loss of access to pyrethroids for insect management in alfalfa and other forage and grain crops would be extremely detrimental to their growers. Along with chlorpyrifos (Lorsban), several pyrethroid active ingredients form the basis of their effective control programs in these crops, with very few (and often ineffective) other insecticide options available to control insect pests. In alfalfa, growers use cyfluthrin, beta-cyfluthrin, gamma- and lambda-cyhalothrin, cypermethrin and zeta-cypermethrin, as well as permethrin to manage a variety of insect pests. Their primary target pests are alfalfa weevil, various aphids (pea, cowpea, blue), cutworms, and grasshoppers. Besiege (lambda-cyhalothrin + chlorantraniliprole) has been shown to be particularly effective compared to other products for control of grasshoppers.

Colorado

In 2016, Colorado growers harvested 680,000 acres of alfalfa, yielding 3.5 tons per acre, valued at \$357 million (USDA-NASS 2017c). According to Dr. Frank Peairs, Professor of Entomology, Extension Specialist and State IPM Coordinator, all pyrethroid active ingredients that are labeled on alfalfa are used by Colorado growers to some extent, with lambda-cyhalothrin, beta-cyfluthrin, and zeta-cypermethrin being the most commonly used. The main target pest for most applications is alfalfa weevil. A single application at maximum label rates is used when weevils reach economic thresholds. Pyrethroids are economical and generally offer effective control of weevils, although there have been occasional reports from crop consultants of reduced effectiveness. Thus, resistance is a potential concern. Alternative insecticides for weevil control include chlorpyrifos and indoxacarb. Both of these alternatives pose problems: chlorpyrifos (an organophosphate) because of its higher risk profile, and indoxacarb, because it is much more expensive than pyrethroids, would have significant negative environmental and economic consequences for growers. Non-chemical management strategies for alfalfa weevil include early

harvesting of alfalfa in some areas. Growers also use pyrethroids to control army cutworm when needed in alfalfa, although this is not a common situation.

Pyrethroid Use in Arizona Cotton

In 2016, Arizona growers harvested 118,000 acres of upland cotton valued at over \$129 million and 11,000 acres of pima cotton (value estimate not provided) (USDA-NASS 2017a). Arizona cotton has benefited from deployment of very selective insect management technologies, including Bt cotton for pink bollworm control and a number of selective insecticides for other key pests, silverleaf whiteflies and Lygus bugs (*Lygus hesperus*). As a result, the importance of pyrethroids and other broad-spectrum insecticides has greatly diminished over the years. However, pyrethroids continue to be important because of the many ways they can contribute to the management of unusual, sporadic, and occasional pest problems for which we do not have selective alternatives. These tend to be for pests that impact stand or plant establishment in cotton, things like darkling beetles and some other beetle species, grasshoppers, crickets, false chinch bugs, and a few other occasional pest problems. Pyrethroids may also play a role in the control of some (non Brown Stink Bug) stink bug species in-season, in those few instances where they occur in damaging numbers. Because of our small agricultural footprint relative to the adjacent or nearby desert lands, some of these pests can be very localized problems that emerge from the desert. And when they do, they can do so in great numbers. Pyrethroids, as mammalian safe options, are preferred for their broad spectrum of activity and safety to handlers, especially in contrast to some potential organophosphate or carbamate alternatives. It should also be noted that while pyrethroids have significant aquatic hazards, we do not practice agriculture in riparian habitats typically in Arizona. Pyrethroids also have a potential fit wherever we have some moth pests attacking non-Bt cotton, including Pima cottons. Overall, pyrethroids hold, very much, a niche status in our system. Most growers would prefer not to use them in our selective system. But, for those times when the occasional or unusual pest emerges, sometimes in great numbers off the desert, pyrethroids remain a critical pest control tool.

According to the Arizona Pest Management Center Pesticide Use Database, the most commonly used pyrethroid active ingredient in cotton by far is bifenthrin, with a much smaller amount of lambda-cyhalothrin and beta-cyfluthrin. But pyrethroid use overall is occurring annually on a small percentage of cotton acres.

Pyrethroid use in Corn: Arizona, New Mexico, Colorado

Arizona

Field Corn. In 2016, Arizona growers harvested 94,000 acres of corn grown for silage (44,000ac) or grain (50,000ac). Grain corn alone was valued at nearly \$50 million (no estimate available for silage corn) (USDA-NASS 2017a). The corn grown for silage and grain in central and southeastern Arizona is primarily Bt corn, and this greatly reduces, but does not always eliminate, the need for insecticides to control worms in corn. Some Bt events have not been fully effective against certain lepidopteran pests, including southwest corn borer and fall armyworm. According to three PCAs who work in central and southeastern AZ, pyrethroids are used much

less than in the past, but they still have some important uses. Bifenthrin is generally the pyrethroid of choice if one is needed in corn, because, compared with other AIs, it is less likely to flare mites. In fact, it is used specifically to control mites. Lambda-cyhalothrin is used to control southwest corn borer if it is a problem. It is highly effective when targeting first-generation southwestern corn borers in the whorl with ground applications. Pyrethroids may also be used for fall armyworm control. Intrepid (methoxyfenozide) works well on fall armyworm, but it is much more expensive.

Sweet Corn. According to a central Arizona pest control advisor (PCA), several pyrethroid AIs are used to manage corn earworm and other lepidopteran pests in sweet corn. A high proportion of sweet corn produced in Arizona currently is for California markets. Quarantine guidelines for export of sweet corn to CA require insecticide treatment every two days to prevent ear infestation by southwestern corn borer or European corn borer. The main pyrethroid AIs used against lepidopteran pests in sweet corn are zeta-cypermethrin (Mustang), esfenvalerate (Asana) and lambda-cyhalothrin (Warrior or generic). They are used in combination with methomyl (Lannate) or alone. The pyrethroids are a critical component of the control program, particularly because of the Belt (flubendiamide) labeling issue (see Alfalfa section).

New Mexico

In 2016, New Mexico growers harvested 116,000 acres of corn grown for silage (75,000ac) or grain (41,000ac). Grain corn alone was valued at over \$23 million (no estimate available for silage corn) (USDA-NASS 2017b). According to Dr. Mark Marsalis, Extension Forage Specialist with New Mexico State University, use of pyrethroids has decreased in corn significantly due to the availability of more selective products such as Intrepid (methoxyfenozide) and Prevathon (chlorantraniliprole). However, growers still use cyfluthrin, beta-cyfluthrin, gamma- and lambda-cyhalothrin, cypermethrin and zeta-cypermethrin, permethrin, and bifenthrin to manage primarily lepidopteran pests. The major pests are fall armyworm, cutworms, corn earworm and corn borers (in non-Bt varieties). Some seed treatments also contain permethrin to help with management of grubs, wireworms, cutworms, seedcorn maggots, and other pests at stand establishment. Several other pyrethroids are used as an in-the-row seed treatment at planting, but to a much lesser degree. Besiege (lambda-cyhalothrin + chlorantraniliprole) has been shown to be particularly effective compared to other products for control of grasshoppers.

Colorado

Corn is the number one crop in Colorado, based on value of sales. In 2016, Colorado growers harvested 1,310,000 acres of corn grown for silage (140,000ac) or grain (1,170,000ac). Grain corn alone was valued at over \$569 million (no estimate available for silage corn) (USDA-NASS 2017c). According to Dr. Frank Peairs, Extension Specialist with Colorado State University, several different pyrethroid AIs are used to economically manage key pests in corn, including Banks grass mite (bifenthrin), European corn borer, western bean cutworm and western corn cutworm. Bifenthrin is used at maximum label rates to manage Banks grass mite, with a single application. Bifenthrin is one of only two labeled non-preventative miticides in corn in Colorado. Loss of bifenthrin would be problematic, leaving only one available AI in this situation.

Resistance to pyrethroids has been confirmed for Banks grass mite and also for western corn rootworm. Also, some growers have had concerns about efficacy of some pyrethroids against western bean cutworm. Non-chemical control methods include the use of transgenic hybrids, effective for many pests, but not for Banks grass mite; and crop rotation, which is an important practice for western corn rootworm control. Where transgenic traits have failed, pyrethroids are the most common replacement control strategy.

Pyrethroid use in Wheat: Colorado, New Mexico, Arizona

Wheat is an important crop in Colorado (2.2mil ac.), New Mexico (400,000ac) and Arizona (103,000ac.), with a combined economic value for the three states exceeding \$400 million (USDA-NASS 2017a, b, c, M. Marsalis, pers. comm. 2017). Pyrethroids are used to manage a number of pests in wheat. In Colorado, the primary target pests are aphids, especially Russian wheat aphid, army cutworm and pale western cutworm, according to Dr. Frank Peairs with Colorado State University. Aphids are the most important pest, with cutworm problems becoming less common in recent years. A single application at high label rates is used to control aphids and cutworms. For cutworms, pyrethroids offer the only effective means of control. If pyrethroids were not available to growers it could have devastating economic consequences in outbreak years. According to Dr. Mark Marsalis, New Mexico State University Extension Forage Specialist, primarily chlorpyrifos is used to control aphids (Russian Wheat Aphid / Greenbug) in the spring, and pyrethroids are used to a much lesser degree. But pyrethroids are used for control of cutworms, armyworms, and grasshoppers. Chlorpyrifos has been under EPA review for some time. If New Mexico wheat growers were to lose access to chlorpyrifos, growers' primary alternative for aphid control would be pyrethroids.

Pyrethroid use in Sorghum: New Mexico

In 2016, New Mexico growers harvested 85,000 acres of grain sorghum valued at over \$11 million and 18,000 acres grown for silage (no value estimate available for silage sorghum) (USDA-NASS 2017b). According to Dr. Mark Marsalis, Extension Forage Specialist with New Mexico State University, pyrethroids are important for control of fall armyworm and other whorl-infesting lepidopteran pests, cutworms, corn earworm/fall armyworm (headworm complex), and true bugs that feed on sorghum heads. A variety of pyrethroids are used.

Pyrethroid use in Chile Peppers and Jalapeno: New Mexico, Arizona

New Mexico

Chile peppers are the third most valuable crop in New Mexico, following pecans and alfalfa. An estimated 8,700ac of Chile peppers were harvested in 2016, valued at over \$50 million (USDA-NASS 2017b). A pest management consultant we spoke with provided a good understanding of the role of pyrethroids in Chile pepper management, and he indicated that the same pest issues and management strategies outlined here also apply to jalapeno production in NM (estimated at

100 ac total). Pyrethroids are used early in the season against darkling beetles and sugar beet leafhoppers. Darkling beetles attack seedling peppers from the cotyledon stage to about the 6-leaf stage. Bifenthrin (Capture) is the go-to insecticide for darkling beetles, although beta-cyfluthrin is sometimes used. A single application is used at full label rate when threshold levels are reached. About the time the plants crown, outgrowing susceptibility to darkling beetles, sugar beet leafhoppers become a major concern. They overwinter on a variety of weedy vegetation and are highly mobile. As the desert vegetation begins to dry out, they move into the pepper fields, sometimes in high numbers. Although hopper feeding is not in itself that damaging, they are very effective vectors of curlytop virus, which stunts the plants, causes chlorosis, and results in malformed fruits that cannot be marketed. One of the cultural practices of growers is to thin their fields late, to remove any plants that show signs of infection from the virus. Symptoms are noticeable within one week of virus transmission. They have tried using weeds surrounding pepper fields as a trap crop to kill the leafhoppers, but it was found to be ineffective because hoppers can migrate from long distances. Growers maintain stringent weed management programs around the fields, but the hoppers are too mobile. The virus can be very damaging, with up to 20% losses in some cases. Fields are scouted to ensure timely treatment of leafhoppers to help limit virus infection levels. Full-rate applications of pyrethroids are used when sugar beet leafhoppers exceed threshold. Usually between 2 to 5 sprays are needed, based on scouting, but in extreme cases, it can go as high as 10 sprays at the full label rate. They rotate pyrethroids with other modes of action, but all chemistries used are broad-spectrum, as there are no selective options. Lambda-cyhalothrin is the most efficacious option, but other pyrethroids are also used against the leafhoppers.

Arizona

In 2016, Arizona growers harvested 1,600 acres of Chile peppers valued at over \$4.4 million (USDA-NASS 2017a). Peppers are grown primarily in the southeastern part of the state. A PCA from that region said that, as a general rule, they try to use pyrethroids only later in the season, to help maintain populations of natural enemies in the field. An exception to this is when they have infestations of flea beetles at stand establishment. In this situation, they use a bifenthrin product because it offers the longest residual control among the pyrethroids. Curlytop virus can be an issue in Arizona, but it is more weather-dependent than in New Mexico. Following wetter winters, when there is more weed vegetation than usual, the leafhopper vectors can become a problem in some fields. In this case, beta-cyfluthrin is used. Later in the season, pyrethroid use is more common. The target pest is often armyworm. Growers use methoxyfenozide earlier in the season for armyworm, but will return late with a pyrethroid if needed. Pyrethroids at this later stage may also target leaf miners, stinkbug, Lygus, or lepidopteran larvae. Another Arizona PCA familiar with Chile peppers mentioned that pyrethroids are used for thrips control as well as plant bugs and leaf hoppers. They are used in rotation to help minimize resistance concerns.

Pyrethroid use in Pecans & Pistachios: Arizona

Arizona

Pecans. In 2016, Arizona growers harvested 14,300 acres of pecans valued at over \$67 million (USDA-NASS 2017a). According to Joshua Sherman, University of Arizona Cooperative Extension Commercial Horticulture Agent who works with the pecan industry in southeast Arizona, bifenthrin is the primary pyrethroid insecticide used by pest managers in pecans. It is effective and a low-cost broad-spectrum option. It is primarily used late in the season to control webworms and leafhoppers. They avoid use earlier to maintain predators in the system. It is an important chemistry in the toolbox and is always used in rotation with other modes of action to help reduce development of resistances. Aphid management is also important. Two PCAs we spoke with used bifenthrin for aphid control in pecans, sometimes as a tank-mixture with chlorpyrifos. One PCA indicated that bifenthrin is “heavily used” for aphid control. It is inexpensive and effective, and offers quick knock-down. He said it is also used for management of webworm and walnut caterpillar, defoliating lepidopteran pests, late season. Intrepid is the primary lepidopteran control and is very effective, but they rotate to pyrethroids for resistance management.

Pistachios. In Arizona pistachios, growers are using lambda- cyhalothrin and bifenthrin, mainly for stink bug control. They come out of the desert in large migrational groups, along with leaf footed plant bug and other mirid pests. They cause lesions and stains on the shell, which reduces market value (stained nuts are sold to shelled nut market at a discount). Naval orangeworm is another important pistachio pest. Growers mainly use Intrepid (methoxyfenozide), but pyrethroids are also used and are effective.

Pyrethroid use in Pinto Beans: Arizona

An Arizona pest control advisor from the southeastern part of the state commented on the importance of bifenthrin and lambda-cyhalothrin for pinto bean production. These active ingredients are used against a variety of pests, including loopers, beet armyworm, corn earworm and stink bug. Because pinto beans are a minor crop, very few effective chemistries are available to them for insect pest management. Loss of pyrethroids in pinto beans would cause great economic harm to Arizona growers.

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