

Weed Management Options in Transplanted Bell Peppers in California

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Weed control in pepper production fields in California can be challenging:

- peppers are slow growing and do not effectively compete with weeds for the first 40-60 days in the crop production cycle;
- peppers have a long growing season (e.g. April-May planting to September-November harvest) that subjects them to infestation with cool as well as warm season weeds;
- weed removal operations must be continued throughout the long growing season to maintain the yield and quality of the crop, so weed control costs can easily be \$500/Acre.

Common weeds in peppers include several species of nightshades and pigweeds, but also lambs-quarters, purslane, sowthistle, and grasses, especially barnyardgrass and junglerice. Depending on the location in the state, specific weeds can make weed control in peppers more difficult. In particular, yellow nutsedge and field bindweed are problematic in nearly all production districts. Puncturevine is troublesome in the Central Valley, and on the Central Coast little mallow (*Malva parviflora*) is difficult to control, particularly late in the growing season. The difficulty of late-season weeds is that growers have already spent a large portion of their weed control budget to control weeds earlier in the season. Additionally growers are reticent to send crews into pepper fields with significant weed pressure late in the season because the crop plant becomes brittle and damages easily. The good news is that there are a number of cultural practices as well as registered herbicides that are now available to help manage weeds profitably. Peppers are produced in two ways: with the use of plastic mulch on the beds and on bare soil (without the use of plastic mulch). Weed control in these two systems varies considerably.

Plastic mulch culture: Opaque plastic mulches are used in pepper production and do not allow light through to the soil that can stimulate weed germination. As a result, the mulch provides a barrier to weed growth over a large portion of the bed. However, weeds can emerge through the planting holes and in the furrows. Preplant fumigants such as metam sodium (Vapam, K-Pam) are commonly used to control both weeds and soilborne pathogens. In addition, oxyfluorfen (Goal Tender) is registered for use under the plastic and provides additional control of weeds such as little mallow, which is not controlled by fumigants. Weeds can be problematic in the furrows if moisture becomes available from late-season rains or irrigation water. Flumioxazin (Chateau) was registered under an indemnified 24c label in 2011 for use as a spray directed to the furrow and can provide control of a wide spectrum of broadleaf weeds. Weed control in plastic culture can be very good, but hand weeding is used to control escaped weeds.

Bare soil culture: Transplanting is the most common method of establishing peppers in bare soil culture on beds. Beds are treated a number of ways prior to transplanting depending on the growers schedule, but significant weed control and reductions in weed control expense can be

achieved with preplant cultural practices such as preirrigation and selection of sites with low populations of problematic weeds such as yellow nutsedge and field bindweed. Preplant fumigation can be carried out with materials such as metam sodium applied through the drip system and can help reduce weed pressure as well as soilborne diseases. The full range of preplant and preemergence materials listed in Table 1 is available for use on transplanted peppers. They can be selected based on the weed spectrum present at the site (Table 2). Early season weeds can generally be successfully controlled with the combination of preplant cultural practices, herbicides and mechanical cultivation; as a result, hand weeding costs can be minimized at this point in the growth cycle. Approximately 30-40 days after transplanting, before the crop canopy begins to close, the layby herbicide treatments are generally made. The available materials provide good control of a wide spectrum of broadleaf and grass weeds.

Table 1. Registered herbicides for use on peppers

Preplant	Preemergence	Layby	Post Emergence
glyphosate	oxyfluorfen ^{1,2}	DCPA	halosulfuron
paraquat	bensulide	pendimethalin	clethodim
oxyfluorfen ^{1,2}	napropamide	s-metolachlor	sethoxydim
carfentrazone	trifluralin		carfentrazone ³
pelargonic acid	s-metolachlor		pelargonic acid ³
metam sodium	pendimethalin		flumioxazin ⁴

1 – applied to beds up to 30 days prior to planting, beds must be thoroughly tilled before planting; 2 – applied to shaped beds under plastic mulch; 3 – applied as hooded application between rows to burn down weeds; 4 – applied to row middles to provide preemergence weed control.

Table 2. Susceptibility of weeds to pepper herbicides

Weed Species	bensulide	DCPA	S-metolachlor	napropamide	pendimethalin	trifluralin
Chickweed	P	C	C	C	C	C
Nettleleaf goosefoot	P	C	P	C	C	C
Groundsel	N	N	N	C	N	N
Henbit	N	P	-	N	C	C
Lambsquarters	C	C	P	C	C	C
Little Mallow	N	P	P	P	P	N
Burning nettle	P	P	C	P	N	N
Black nightshade	N	P	C	N	N	N
Hairy nightshade	N	P	C	N	N	N
Yellow nutsedge	N	N	P	N	N	N
Pigweed	C	C	C	C	C	C
Purslane	C	C	C	C	C	C
Shepherd's purse	N	N	P	P	P	N
Sowthistle	N	P	P	C	N	N

N = no control; P = partial control; C = controlled

There are several postemergent herbicides registered for use on peppers that can control specific weed problems in established peppers: the grass materials, clethodim (Select) and sethoxydim (Poast) as well as the nutsedge and broadleaf material halosulfuron (Sanda).

Since 2004 tandem field studies have been conducted in two of the four major growing regions of California (Central Valley and Central Coast) looking for selective preemergence herbicides suitable for use in transplanted bell pepper production on unmulched beds. Application timings include at planting and at layby. At planting applications have looked at pre-transplant, post-transplant over the top, and post-transplant directed spray for some of the herbicides in order to achieve better crop safety. Crop phytotoxicity and weed control ratings, weed counts and bell pepper yields were collected. Pigweeds (prostrate, tumble and redroot), nightshades (black, hairy, and groundcherry), common lambsquarters, common purslane, common groundsel, puncturevine and junglerice were the main weeds tested. Trial results investigating weed control and crop safety of flumioxazin, oxyfluorfen, s-metolachlor, and pendimethalin compared to DCPA and napropamide have led to changes in label registrations for California.

One weed that escapes control is little mallow. Over the past several years we have experimented with flumioxazin (Chateau) as a layby material for use on the pepper beds to control this weed. It controls mallow better than the currently available materials (Table 3). One of the difficulties has been finding an effective way to get the material to the soil surface without damaging pepper foliage or fruit. We looked at a number of techniques (granular formulation, applying the herbicide to dry fertilizer, through the sprinklers, etc.), but we have not found a way to apply the herbicide without it causing too much damage to the pepper plant. As a result, flumioxazin is only registered for use in peppers in the furrow, but not on the bed.

Table 3. Comparison of layby weed treatments				
Treatment	Application	Material/A	Mallow per 6 ft²	Total weeds per 6 ft²
Untreated	---	---	5.0	39.0
S-metolachlor + pendimethalin	Directed	1.5 pints 2.0 pints	5.3	12.0
flumioxazin ¹	Directed	3.0 oz	1.0	9.0

1 – not registered for this use

San Joaquin Valley Layby Experiments with Preemergence Herbicides: Field trials investigating six preemergence herbicides at 1x and 2x rates were compared to an untreated check and two standard herbicide treatments in transplanted bell peppers in 2011 and 2012. One herbicide (Outlook) was applied at a 4x rate. All applications were made at layby and the crop had no previous (at planting) herbicide applications. The herbicide trials were conducted at the UC West Side Research and Extension Center in Five Points in Fresno County. Soil type is a

Panoche Clay Loam. Bell peppers were transplanted in single rows into 40” beds using a commercial transplanter. Within row spacing was 10” between plants and stand establishment was very good. Weed pressure at planting was significant as there was no preemergence herbicide applied at planting.

At layby the entire field was mechanically cultivated and hand weeded so that preemergence herbicides could be applied as layby treatments to weed free plots. The treatments were replicated 4 times in a randomized complete block design in the field. Plot size was either one or two 40-inch bed(s) wide by 70-feet of row length. The sprayer was a CO² backpack sprayer at 30 psi with a two nozzle wand outfitted with 2 XR Teejet nozzles 8003 evs and a water volume of 30 GPA. The herbicide application was aimed at the base of the plants (not over the top), but drop nozzles were not used for a directed spray. The herbicides were set with sprinklers, but the trial was grown under furrow irrigation. The herbicides tested at layby included:

Trade name	Common name
Dual II Magnum	s-metolachlor
Outlook	dimethenamid-p
Prowl H ₂ O	pendimethalin
Sandea	halosulfuron
Sonalan (2011)	ethalfuralin
Nortron (2012)	ethofumesate
Dacthal (2011)	DCPA
Devrinol (2011)	Napropamide

Weed control results are shown in Tables 4 and 5. Nortron, Outlook, Sonalan, and Zeus are not currently registered for use in transplanted bell peppers. These trials show that layby applications of Outlook provide excellent weed control and crop safety. Where Nortron and Zeus contacted the foliage they caused initial phytotoxicity on the leaves, however these symptoms were greatly reduced with time. A 4x application of Outlook resulted in less phytotoxicity to pepper leaves than a 2x rate of Nortron or a 1x rate of Zeus. An application of a 2x rate of Outlook showed the same pepper phytotoxicity as a 1x application of Prowl H₂O, both of which diminished as the peppers grew. In all trials Dual Magnum, Prowl H₂O and Outlook provided excellent results in broadleaf and grass weed control. Sandea is weak on nightshades and Sonalan is a weaker dintroaniline than Prowl and less effective on weeds in general. Zeus was weak on purslane and grasses. Populations of nutsedge and puncturevine were too erratic to include in these results.

Summary: As with all vegetable crops, there are very few new herbicides in development for use on peppers, so research strives to find new uses for older herbicides. In general the array of weed control tools available for use on peppers is varied and effective. A key challenge for the pepper industry moving forward is to keep the current herbicide registrations. Through careful selection and use of these herbicides, hopefully they will be available for use by the pepper industry for many years to come.

Table 4. 2011 Layby Application: Phytotoxicity, Weed Control, and Weed Counts in San Joaquin Valley Trial

Code	Preemergence Herbicide Treatment	Layby	Rate/Acre	June 22	July 8		August 9					Total Brdlvs
				Pepper Stand #	Ratings (1-10)*		----- Weed Counts (~100 ft ²) -----					
					Phyto	Weed	PIGs	Night	Grndcherry	Purslane	Lambs	
1	Untreated	-		67.3	0.1	10	0.3	7.5	7.8 a	5.5 b	0.5	21.5 a
2	Dual Magnum 7.63	1x	1.5 pts	72.3	0.1	10	0.3	6.3	0.0 c	0.8 bc	0.3	7.5 bcd
3	Outlook 6.0	1x	10.7 ozs	68.8	0.1	10	0.3	4.3	0.3 c	1.5 bc	1.0	7.3 bcd
4	Prowl H ₂ O 3.8EC	1x	3 pts	68.5	0.9	10	0.0	4.5	0.0 c	1.0 bc	0.5	6.0 cd
5	Sandea 75%	1x	1.0 oz	73.8	0.8	10	0.0	12.5	0.3 c	3.0 bc	0.0	15.8 abc
6	Sonalan HFX	1x	3.7 pts	65.5	0.5	10	0.0	10.0	3.5 b	2.5 bc	0.3	16.3 ab
7	Zeus 4F	1x	3.2 ozs	68.5	2.0	10	0.0	7.8	3.0 bc	11.5 a	0.8	23.0 a
8	Dual Magnum 7.63	2x	3.0 pts	75.0	0.2	10	0.0	5.8	0.0 c	0.5 bc	0.5	6.8 bcd
9	Outlook 6.0	2x	21.4 ozs	71.3	0.1	10	0.3	4.8	0.3 c	1.8 bc	0.5	7.5 bcd
10	Prowl H ₂ O 3.8EC	2x	6 pts	70.5	1.6	10	0.3	0.5	0.0 c	0.0 c	0.3	1.0 d
11	Sandea 75%	2x	2 ozs	71.8	0.7	10	0.3	6.8	0.5 bc	1.3 bc	1.3	10.0 bcd
12	Sonalan HFX	2x	7.4 pts	72.8	2.0	10	0.5	4.8	0.8 bc	1.3 bc	0.8	8.0 bcd
13	Zeus 4F	2x	6.4 ozs	73.5	2.0	10	0.0	4.3	3.0 bc	5.0 bc	0.8	13.0 abc
14	Dacthal 75WP	1x	9.3 lbs	67.3	0.5	10	0.8	5.3	1.5 bc	1.0 bc	0.3	8.8 bcd
15	Devrinol 50DF	1x	4 lb	73.8	0.1	10	0.0	4.3	2.5 bc	3.0 bc	0.3	10.0 bcd
16	Outlook 6.0	4x	42.8 ozs	63.3	0.5	10	0.0	6.3	0.3 c	0.5 bc	0.5	7.5 bcd
Average				70.2	0.7	10.0	0.2	6.0	1.5	2.5	0.5	10.6
LSD (.05)				NS	0.4	NS	NS	NS	3.1	5.3	NS	10.1
CV%				11.6	37.6		230.8	98.8	146.3	150.1	178.1	67.1

* One mechanical cultivation & hand in-row weeding on June 15-16, 2011.
Phytotoxicity (1-10): 0=No crop damage; 10=dead.
Not registered for use in peppers: Outlook, Sonalan, Zeus

No herbicides applied until layby on June 17, 2011. Counts=70' row x 18" wide
Weed ratings (1-10): 1=No weed control; 10=100% weed control.
Always follow the label.

Table 5. 2012 Layby Application: Pepper Stand, Crop Phytotoxicity, Weed Control Ratings in San Joaquin Valley Trial

Code	Preemergence Herbicide Layby Treatments		Lbs a.i./A	Material/A	June 7, 2012		June 29	August 16, 2012		
					Pepper Stand		Phyto Rating	Phyto Rating	Broadleaf Control	Grass Control
					W bed	E bed				
1	Dual Magnum 7.63	1x	1.43	1.5 pts	36.0	33.5	0.50	0	8.8	8.8
2	Dual Magnum 7.63	2x	2.86	3 pts	37.3	35.3	0.25	0.25	9.1	9.1
3	Nortron 4SC	1x	1.75	3.5 pts	35.0	33.0	2.00	0	7.0	7.0
4	Nortron 4SC	2x	3.50	7.0 pts	37.3	35.3	4.75	0	7.0	7.0
5	Outlook 6.0	1x	0.05	10.7 ozs	33.0	35.0	0.50	0.25	7.3	7.3
6	Outlook 6.0	2x	1.0	21.4 ozs	38.5	34.0	1.25	0.50	8.3	8.3
7	Prowl H ₂ O 3.8EC	1x	1.5	3 pts	31.8	32.8	1.25	0	9.0	9.0
8	Prowl H ₂ O 3.8EC	2x	3.0	6 pts	36.8	34.3	1.75	0	9.6	9.6
9	Zeus 4F	1x	0.094	3 ozs	36.0	31.8	3.50	0.50	4.3	4.3
10	Zeus 4F	2x	0.188	6 ozs	37.3	32.3	8.25	3.25	4.3	4.3
11	Outlook	4x	2.0	42.8 ozs	35.3	31.3	3.00	2.25	8.1	8.1
12	Untreated	-			34.5	34.8	0.75	0.0	3.5	3.5
Average					35.7	33.6	2.3	0.7	8.7	7.2
LSD (0.05)					8.1	7.2	1.2	1.3	0.7	1.5
CV%					15.75	15.02	36.89	154.6	5.7	14.2
NS					NS	NS	**	**	**	**

* Weed Control Rating: 10 = perfect weed control; 1= no weed control
 Phytotoxicity Rating: 10 = crop totally dead; 0 = no crop injury