Estrategias de manejo integrado para *Amaranthus palmeri*

El antes, el durante y el después de la llegada del problema

UF IFAS UNIVERSITY of FLORIDA

Ramon Leon, Ph.D.

Temas

1. ¿Qué es *Amaranthus palmeri*?
2. Prevención
3. Estrategias integradas para su manejo en etapas iniciales del problema
4. Acciones agresivas cuando el problema está establecido

Amaranthus palmeri

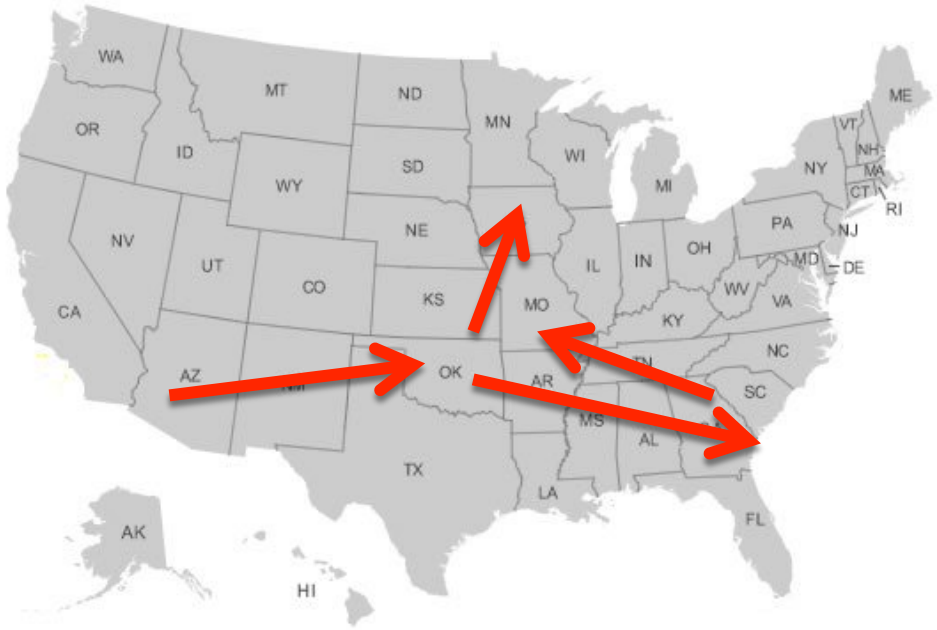
- Nativa del suroeste de Norte America en el desierto de Sonora
- Condiciones nativas:
  - Sequía
  - Poca disponibilidad de nutrientes
  - Poca perturbación agrícola

Amaranthus palmeri

- Alta capacidad de crecimiento en campos agrícolas

- Humedad del suelo vía riego o lluvias y fertilización incrementan su potencial de crecimiento y reproducción

Amaranthus palmeri

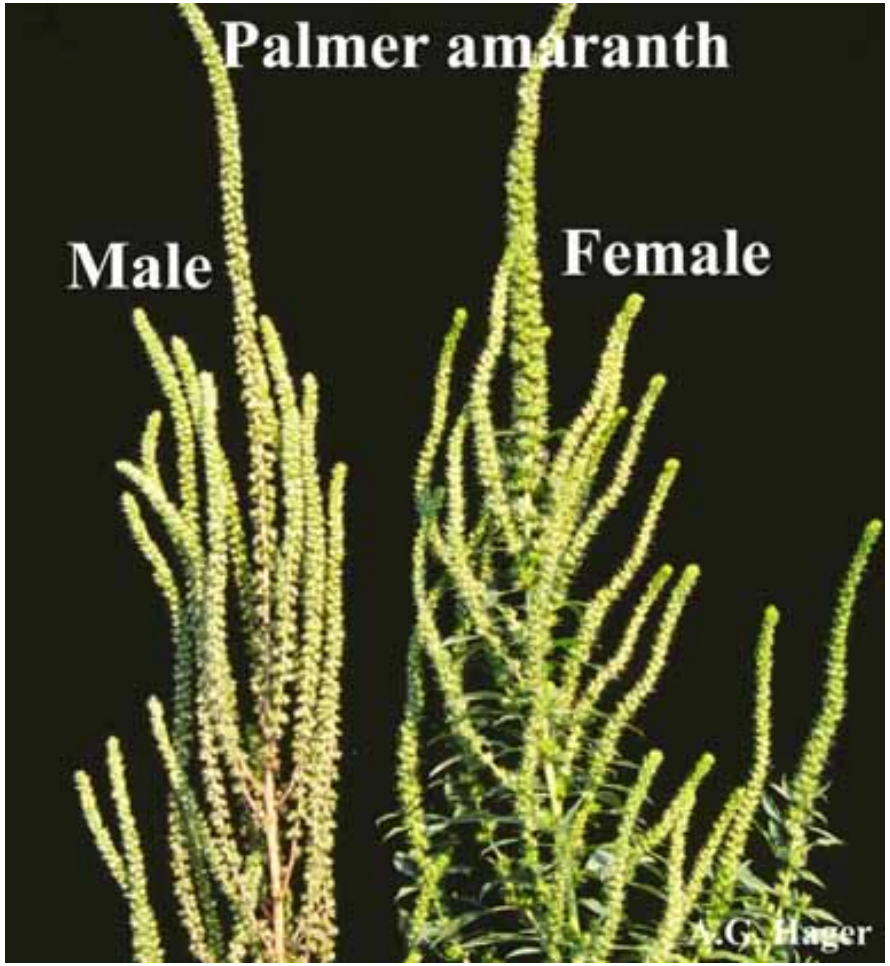


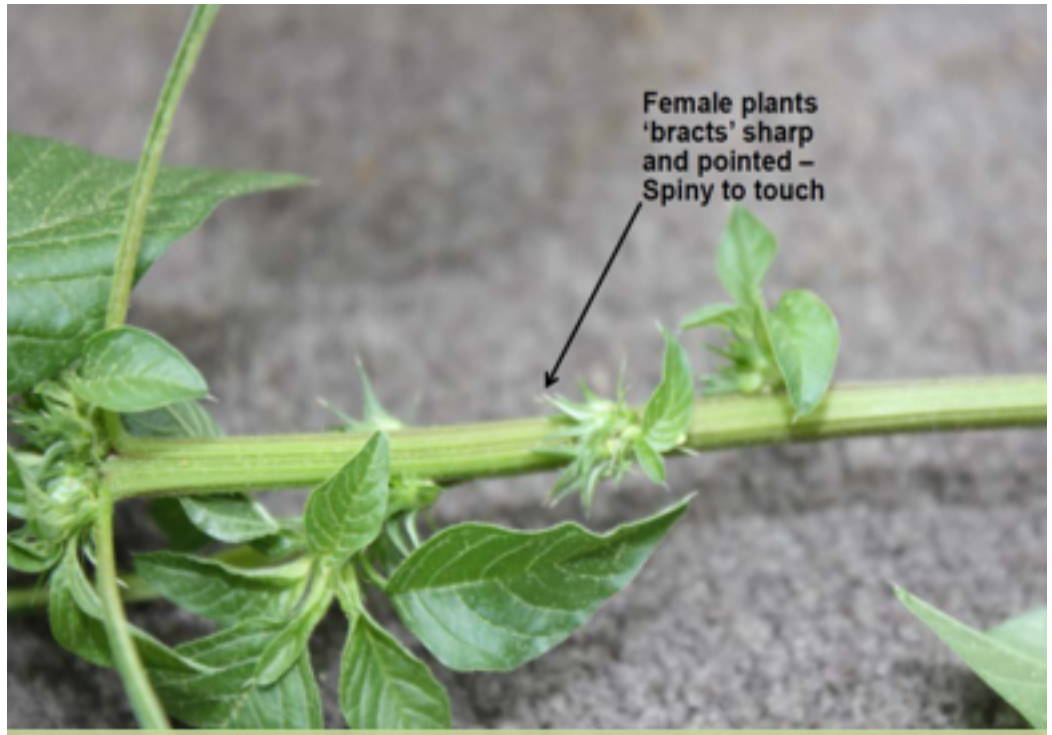
- *Amaranthus palmeri* es una mala hierba que se ha convertido en un problema muy serio en el Sur y el Medio Oeste de Estados Unidos en menos de 25 años

- Ha evolucionado resistencia a diferentes mecanismos de acción de herbicidas

- Especie dioica = alta variabilidad genética

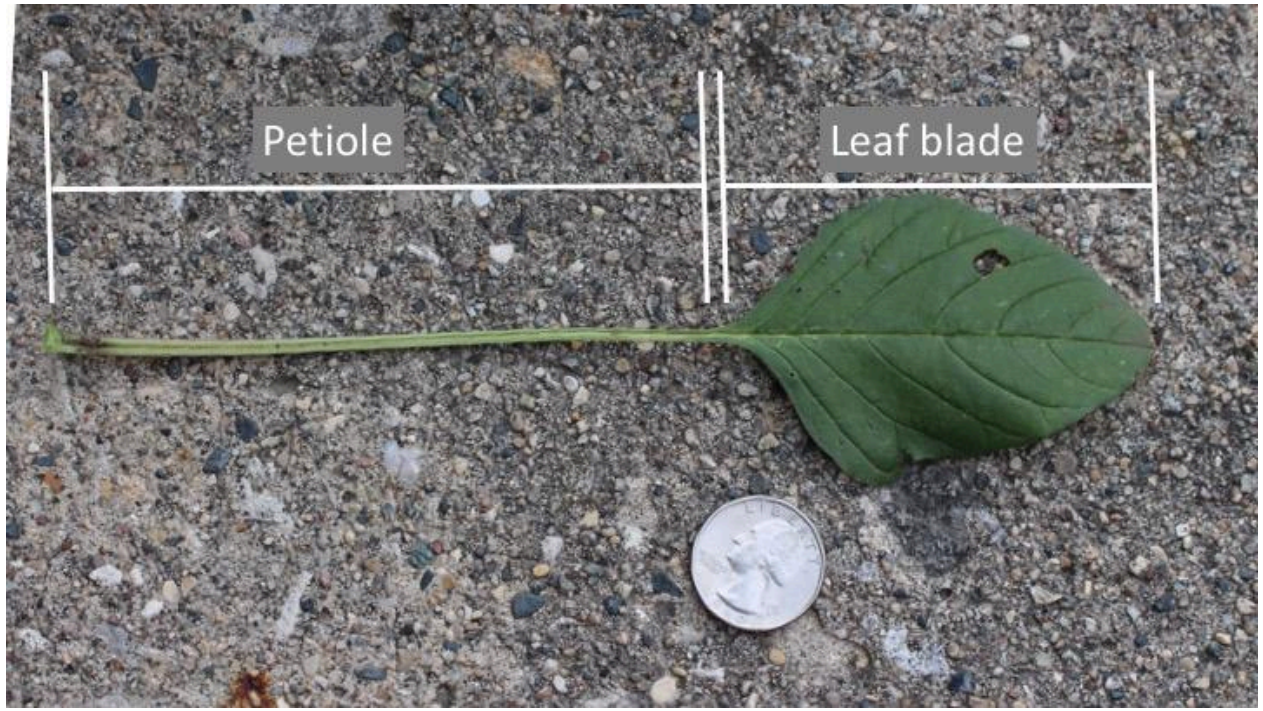
Amaranthus palmeri





Palmer amaranth stem

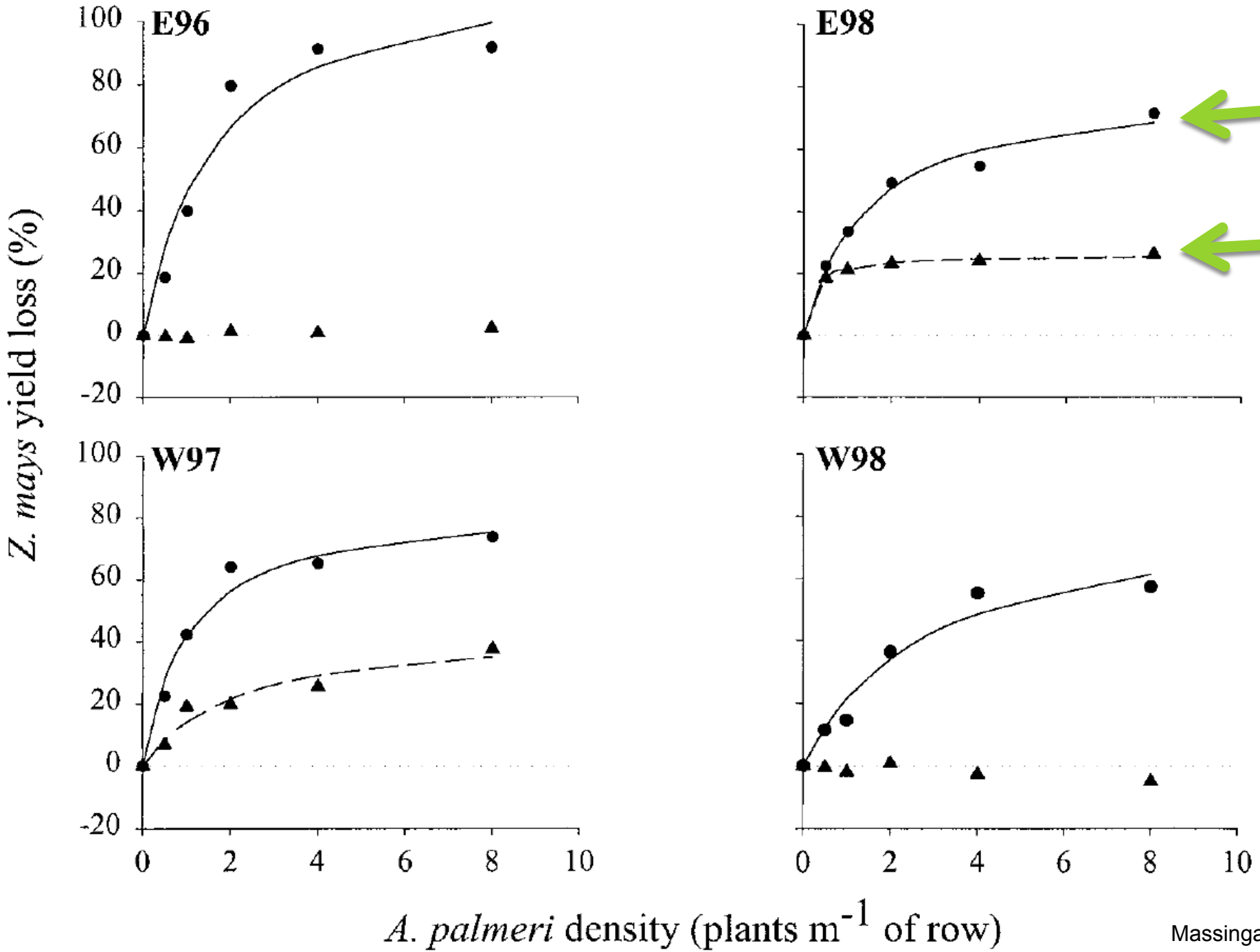
Amaranthus palmeri



Alto potencial de interferencia con el maíz

Alto potencial de interferencia con el maíz

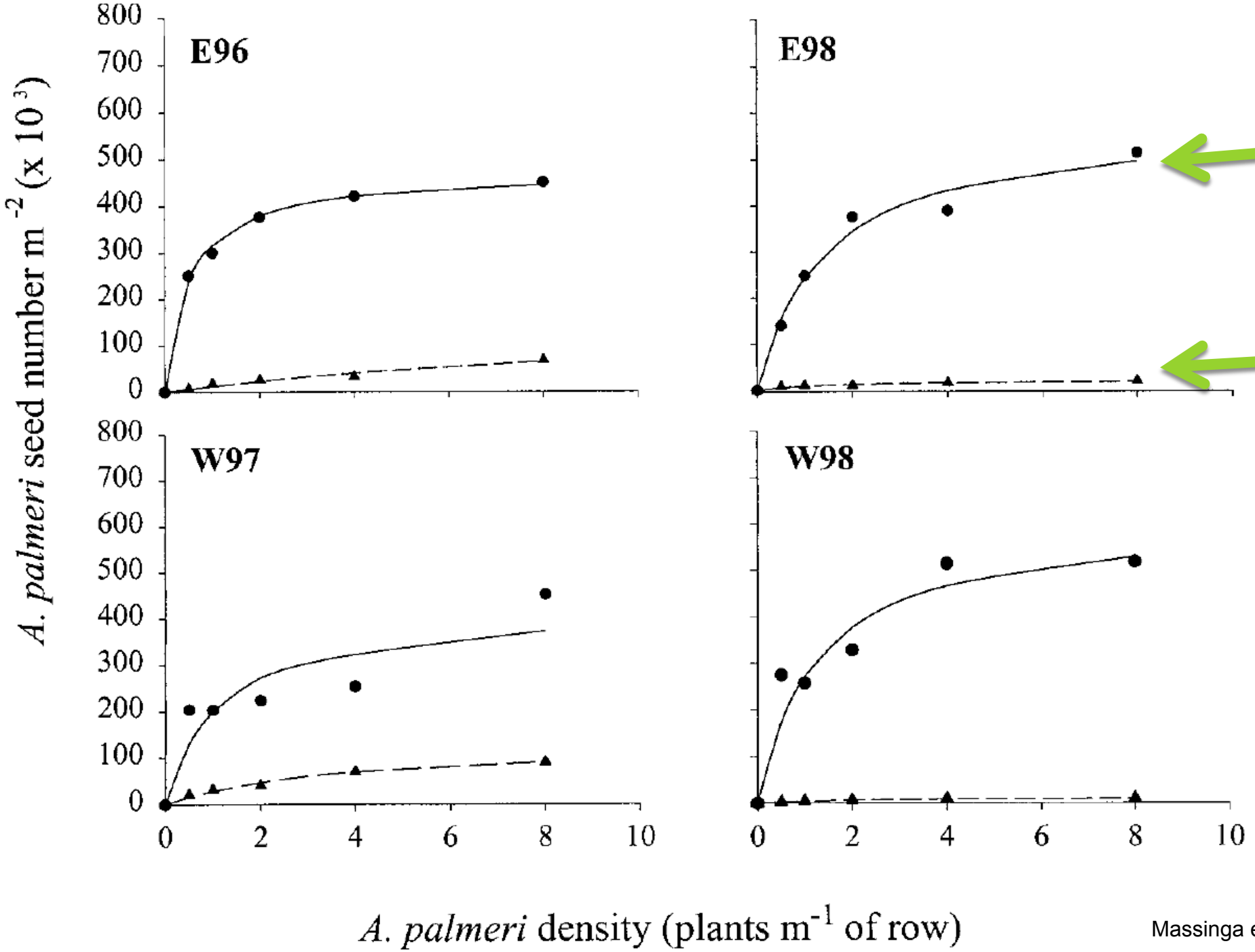
- Rápido crecimiento poblacional
- Plantas puede alcanzar más de dos metro y producir gran área foliar



Emergencia con el maíz

Emergencia 30 d después del maíz

Massinga et al. (2001) Weed Sci 49:202-208

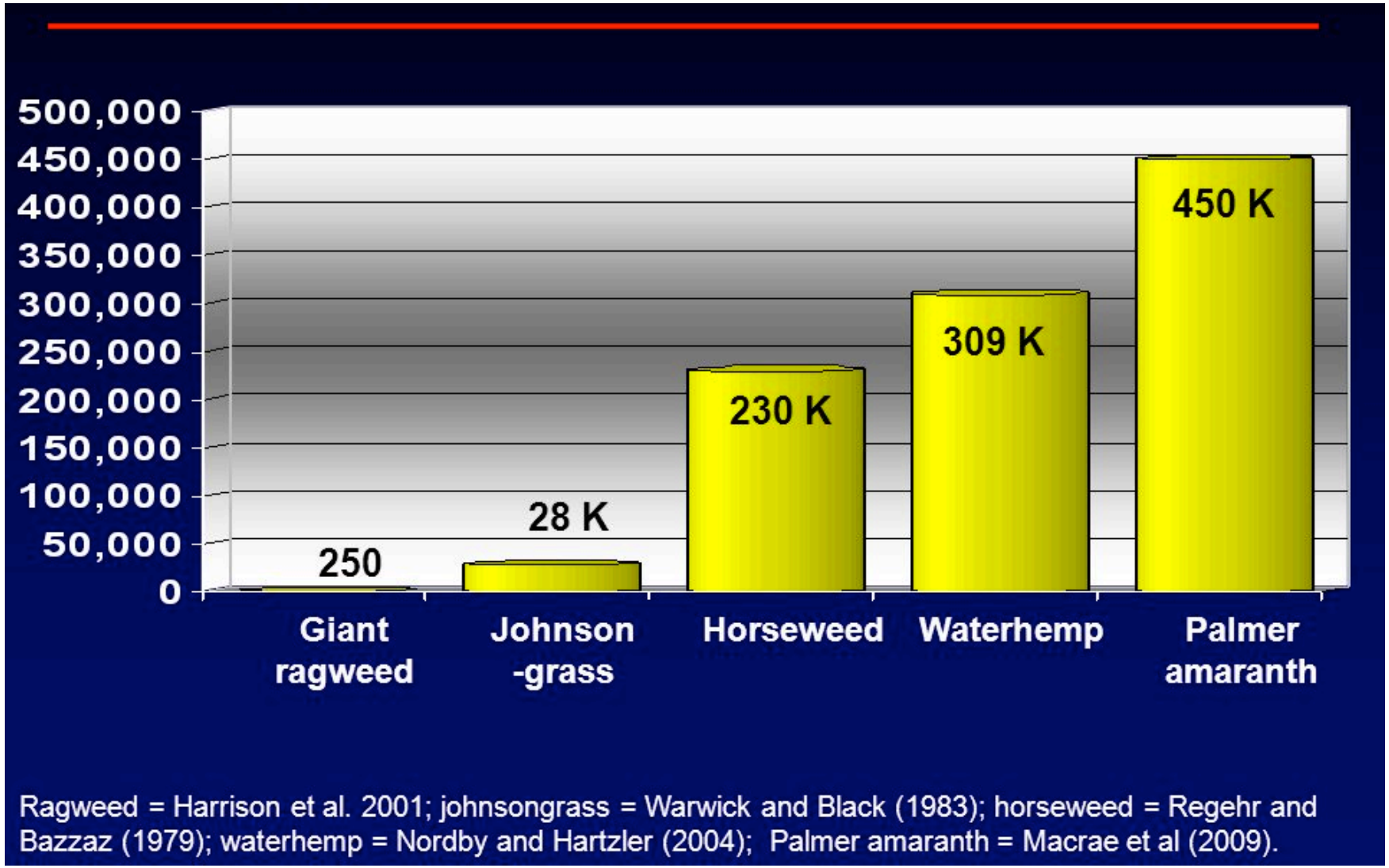


Emergencia con el maíz

Emergencia 30 d después del maíz

Massinga et al. (2001) Weed Sci 49:202-208

Producción de semillas por planta en especies resistente a glifosato



Ragweed = Harrison et al. 2001; johnsongrass = Warwick and Black (1983); horseweed = Regehr and Bazzaz (1979); waterhemp = Nordby and Hartzler (2004); Palmer amaranth = Macrae et al (2009).

Rápido crecimiento

- Acciones de control deben ser planificadas e implementadas más rápidamente que para otras especies de malas hierbas

- Aplicaciones tardías son la principal causa de la rápida evolución de resistencia a herbicidas en esta especie

Herbicide Resistant Palmer Amaranth Globally
(Amaranthus palmeri)

#	Country	FirstYear	Situation	Active Ingredients	Site of Action
1	United States (South Carolina)	1989	Cotton, and Soybean	trifluralin	Microtubule inhibitors (K1/3)
2	United States (Texas)	1993	Corn (maize), and Sorghum	atrazine	Photosystem II inhibitors (C1/5)
3	United States (Kansas)	1993	Alfalfa, Corn (maize), Sorghum, and Soybean	imazethapyr	ALS inhibitors (B/2)
4	United States (Arkansas)	1994	Soybean	chlorimuron-ethyl, diclosulam, imazaquin, imazethapyr, and pyrithiobac-sodium	ALS inhibitors (B/2)
5	United States (Tennessee)	1994	Cotton, and Soybean	imazaquin, and pyrithiobac-sodium	ALS inhibitors (B/2)
6	United States (Kansas)	1995	Corn (maize), and Sorghum	atrazine	Photosystem II inhibitors (C1/5)
7	United States (North Carolina)	1995	Soybean	chlorimuron-ethyl	ALS inhibitors (B/2)
8	United States (South Carolina)	1997	Corn (maize), Cotton, Peanut (groundnut), and Soybean	imazapic, imazaquin, and imazethapyr	ALS inhibitors (B/2)
9	United States (Tennessee)	1998	Cotton, and Soybean	trifluralin	Microtubule inhibitors (K1/3)

Heap (2017) weedscience.org

9	United States (Tennessee)	1998	Cotton, and Soybean	trifluralin	Microtubule inhibitors (K1/3)
10	United States (Georgia)	2000	Peanut (groundnut)	imazapic, and imazethapyr	ALS inhibitors (B/2)
11	United States (Georgia)	2005	Cotton, and Soybean	glyphosate	EPSP synthase inhibitors (G/9)
12	United States (North Carolina)	2005	Corn (maize), Cotton, and Soybean	glyphosate	EPSP synthase inhibitors (G/9)
13	United States (Arkansas)	2006	Cotton, and Soybean	glyphosate	EPSP synthase inhibitors (G/9)
14	United States (Tennessee)	2006	Corn (maize), Cotton, and Soybean	glyphosate	EPSP synthase inhibitors (G/9)
15	United States (South Carolina)	2006	Cotton, and Soybean	glyphosate	EPSP synthase inhibitors (G/9)
16	United States (New Mexico)	2007	Orchards, and Pecan nut	glyphosate	EPSP synthase inhibitors (G/9)

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18	United States (Mississippi)	2008	Cotton	glyphosate, and pyrithiobac-sodium	**Multiple Resistance: 2 Sites of Action** ALS inhibitors (B/2) EPSP synthase inhibitors (G/9)
19	United States (Florida)	2008	Cropland	imazapic, and pyrithiobac-sodium	ALS inhibitors (B/2)
20	United States (Alabama)	2008	Soybean	glyphosate	EPSP synthase inhibitors (G/9)
21	United States (Missouri)	2008	Corn (maize), Cotton, and Soybean	glyphosate	EPSP synthase inhibitors (G/9)
22	United States (Georgia)	2008	Cotton	glyphosate, and pyrithiobac-sodium	**Multiple Resistance: 2 Sites of Action** ALS inhibitors (B/2) EPSP synthase inhibitors (G/9)
23	United States (Georgia)	2008	Corn (maize)	atrazine	Photosystem II inhibitors (C1/5)
24	United States (Tennessee)	2009	Cotton, and Soybean	chlorimuron-ethyl, glyphosate, and pyrithiobac-sodium	**Multiple Resistance: 2 Sites of Action** ALS inhibitors (B/2) EPSP synthase inhibitors (G/9)
25	United States (Kansas)	2009	Corn (maize), and Sorghum	atrazine, mesotrione, pyrasulfotole, tembotrione, thifensulfuron-methyl, and topramezone	**Multiple Resistance: 3 Sites of Action** ALS inhibitors (B/2) Photosystem II inhibitors (C1/5) HPPD inhibitors (F2/27)

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29	United States (South Carolina)	2010	Corn (maize), Cotton, and Soybean	glyphosate, pyrithiobac-sodium, thifensulfuron-methyl, and trifloxysulfuron-sodium	**Multiple Resistance: 2 Sites of Action** ALS inhibitors (B/2) EPSP synthase inhibitors (G/9)
30	United States (Georgia)	2010	Corn (maize)	atrazine, glyphosate, imazapic, and pyrithiobac-sodium	**Multiple Resistance: 3 Sites of Action** ALS inhibitors (B/2) Photosystem II inhibitors (C1/5) EPSP synthase inhibitors (G/9)
31	United States (Kentucky)	2010	Soybean	glyphosate	EPSP synthase inhibitors (G/9)
32	United States (Michigan)	2011	Soybean	glyphosate	EPSP synthase inhibitors (G/9)
33	United States (Virginia)	2011	Soybean	glyphosate	EPSP synthase inhibitors (G/9)
34	United States (Nebraska)	2011	Corn (maize)	atrazine	Photosystem II inhibitors (C1/5)
35	United States (Nebraska)	2011	Corn (maize)	mesotrione, tembotrione, and topramezone	HPPD inhibitors (F2/27)
36	United States (Kansas)	2011	Cotton, and Soybean	glyphosate	EPSP synthase inhibitors (G/9)
37	United States (Texas)	2011	Cotton	glyphosate	EPSP synthase inhibitors (G/9)
38	United States (Arkansas)	2011	Soybean	fomesafen	PPO inhibitors (E/14)
39	United States (Arizona)	2012	Cotton	glyphosate, and pyrithiobac-sodium	**Multiple Resistance: 2 Sites of Action** ALS inhibitors (B/2) EPSP synthase inhibitors (G/9)

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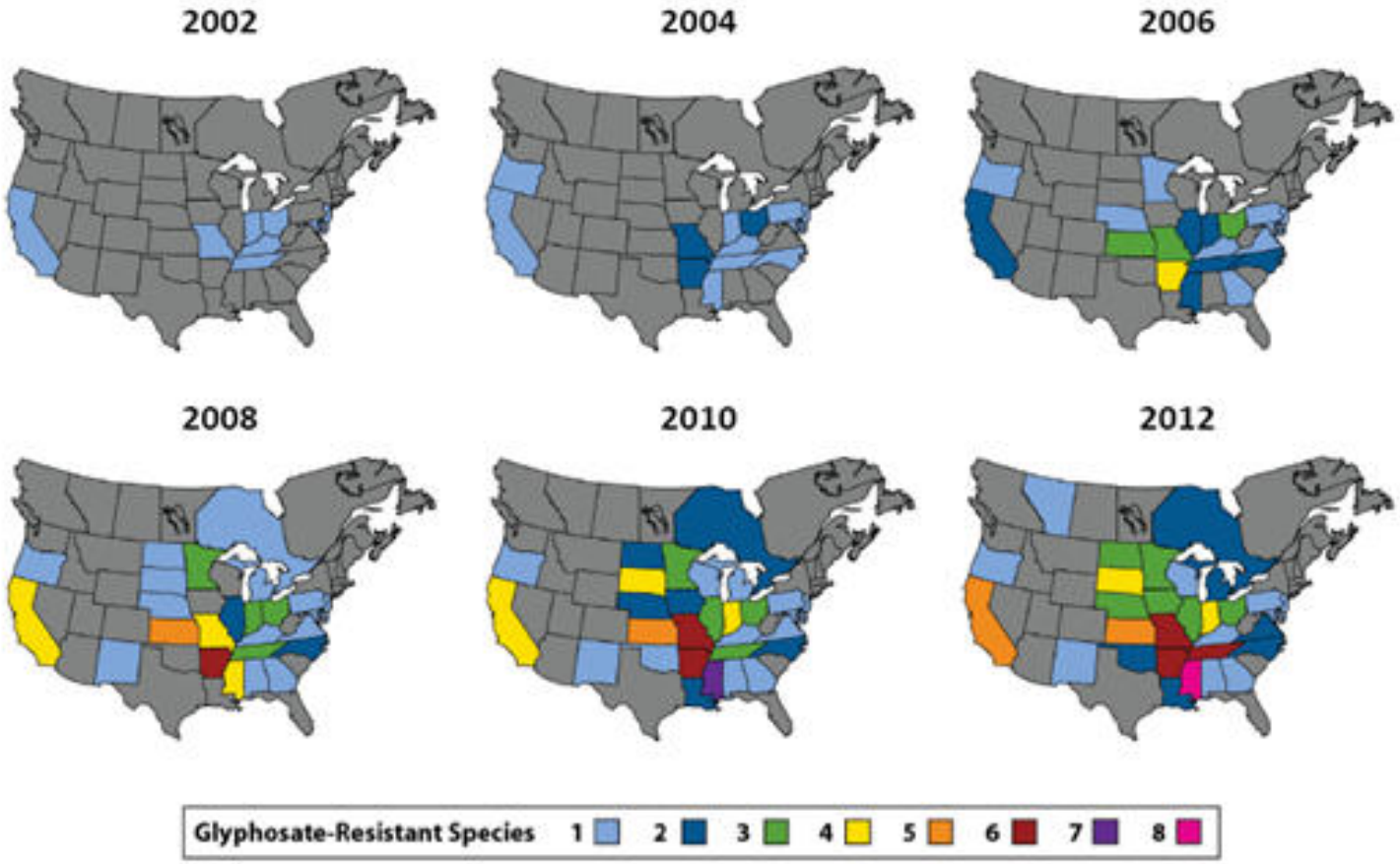
46	United States (Florida)	2013	Soybean	glyphosate, and imazapic	**Multiple Resistance: 2 Sites of Action** ALS inhibitors (B/2) EPSP synthase inhibitors (G/9)
47	United States (Wisconsin)	2013	Corn (maize), and Soybean	glyphosate	EPSP synthase inhibitors (G/9)
48	United States (Delaware)	2014	Soybean	chlorimuron-ethyl, and glyphosate	**Multiple Resistance: 2 Sites of Action** ALS inhibitors (B/2) EPSP synthase inhibitors (G/9)
49	United States (Maryland)	2014	Soybean	chlorimuron-ethyl, and glyphosate	**Multiple Resistance: 2 Sites of Action** ALS inhibitors (B/2) EPSP synthase inhibitors (G/9)
50	United States (New Jersey)	2014	Soybean	glyphosate	EPSP synthase inhibitors (G/9)
51	United States (Nebraska)	2014	Corn (maize)	atrazine, mesotrione, tembotrione, and topramezone	**Multiple Resistance: 2 Sites of Action** Photosystem II inhibitors (C1/5) HPPD inhibitors (F2/27)
52	Argentina	2015	Soybean	glyphosate	EPSP synthase inhibitors (G/9)
53	Brazil	2015	Cotton	glyphosate	EPSP synthase inhibitors (G/9)
54	United States (Tennessee)	2015	Soybean	fomesafen, and glyphosate	**Multiple Resistance: 2 Sites of Action** PPO inhibitors (E/14) EPSP synthase inhibitors (G/9)
55	United States (California)	2015	Corn (maize)	glyphosate	EPSP synthase inhibitors (G/9)
56	Brazil	2016	Corn (maize), Cotton, and Soybean	chlorimuron-ethyl, cloransulam-methyl, glyphosate, and imazethapyr	**Multiple Resistance: 2 Sites of Action** ALS inhibitors (B/2) EPSP synthase inhibitors (G/9)
57	United States (Nebraska)	2016	Soybean	atrazine, and glyphosate	**Multiple Resistance: 2 Sites of Action** Photosystem II inhibitors (C1/5) EPSP synthase inhibitors (G/9)
58	United States (Illinois)	2016	Corn (maize), Horseradish, and Soybean	fomesafen, glyphosate, and lactofen	**Multiple Resistance: 2 Sites of Action** PPO inhibitors (E/14) EPSP synthase inhibitors (G/9)

¿Qué hacer antes del establecimiento del problema?

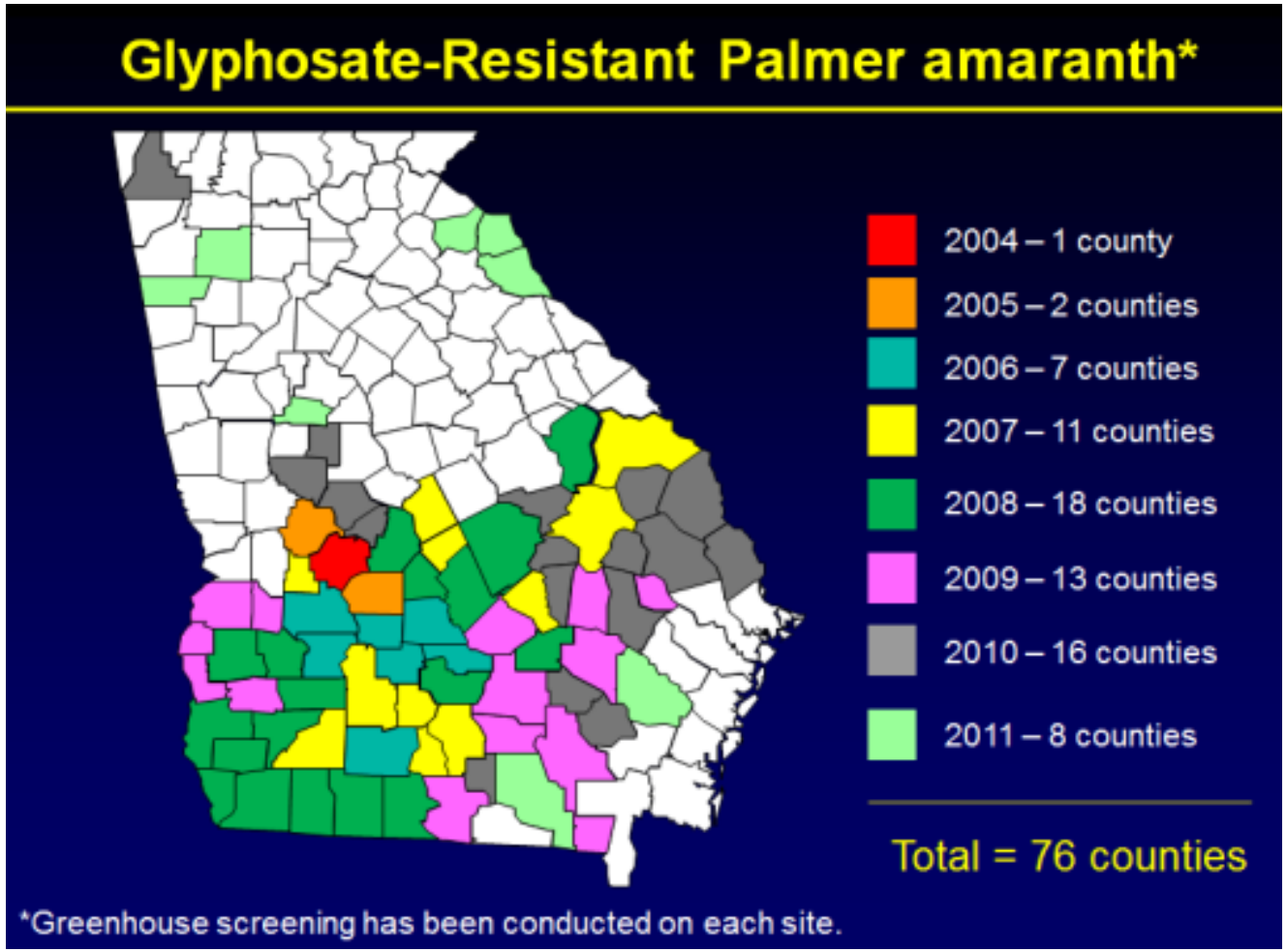
1. Monitoreo intensivo
    1. En finca
    2. Localidad
    3. Región
2. Uso de estrategias integradas
    1. Limpieza de equipo (principal fuente de dispersión de semilla)
    2. Uso de un programa preemergente sólido
    3. Aplicaciones postemergentes a tiempo
    4. Rotación de cultivos con un seguimiento en temporadas de barbecho

Evolución de resistencia a herbicidas



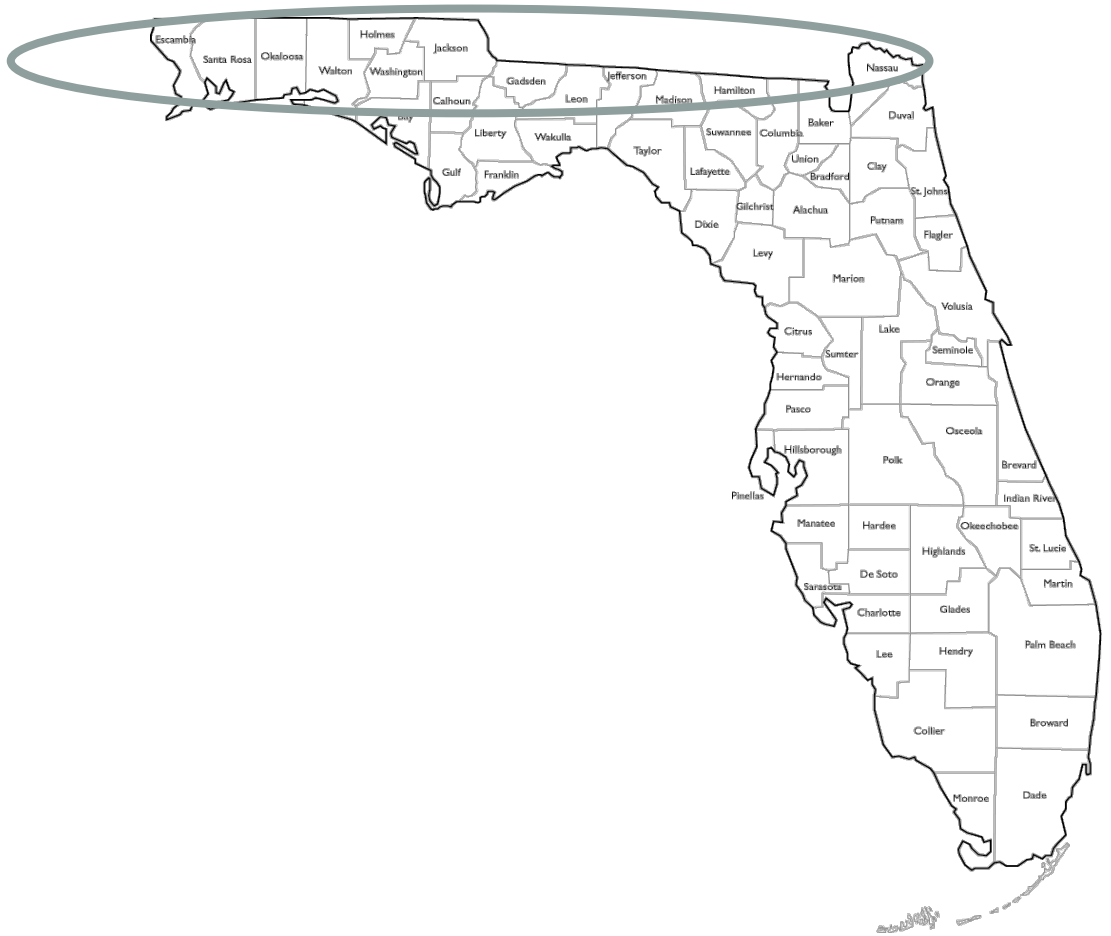
Source: Pioneer.com

Evolución de resistencia a herbicidas



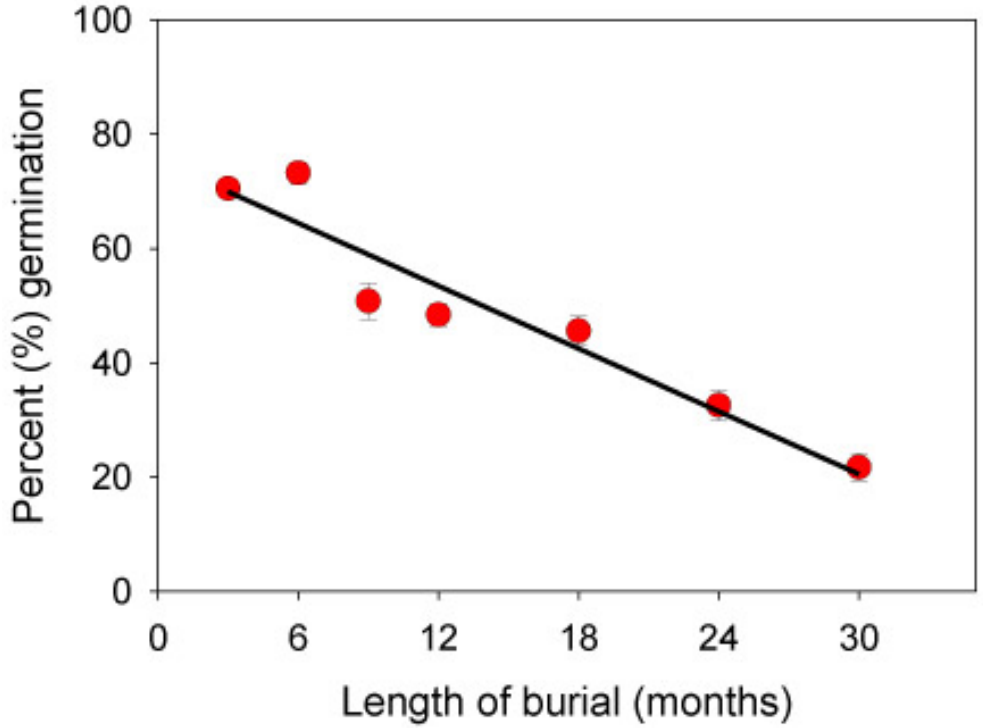
Source: University of Georgia

Evolución de resistencia a herbicidas



¿Qué hacer cuando el problema recién inicia?

1. Más monitoreo
2. No permitir producción de semilla
3. Aplicaciones POST tempranas y secuenciales (***no deben haber plantas que sobrevivan***)
4. Deshierba manual



Sonoskie et al. UGA

Deshierba manual

No dejar las plantas en el campo

Programas de herbicidas para *A. palmeri*

Tipo de maíz	Preemergencia	Postemergencia Temprana	Postemergencia tardía (si se necesita)
Convencional	Atrazina o Atrazina + Dimethenamid o S-metolachlor	Atrazina + Pendimetalina o Atrazina + Tembotrione, Mesotrione, Carfentrazone, Diflufenzopyr, o 2,4-D	2,4-D o Diamba – dirigidos o Diflufenzopyr
Roundup Ready (resistente a glifosato)	Atrazina o Atrazina + Dimethenamid o S-metolachlor	Glifosato + Atrazina, S-metolachlor, Tembotrione, Mesotrione, Carfentrazone	2,4-D o Diamba – dirigidos o Diflufenzopyr
Liberty Link (resistente a glufosinato)	Atrazina o Atrazina + Dimethenamid o S-metolachlor	Glufosinate + Atrazina	2,4-D o Diamba – dirigidos o Diflufenzopyr

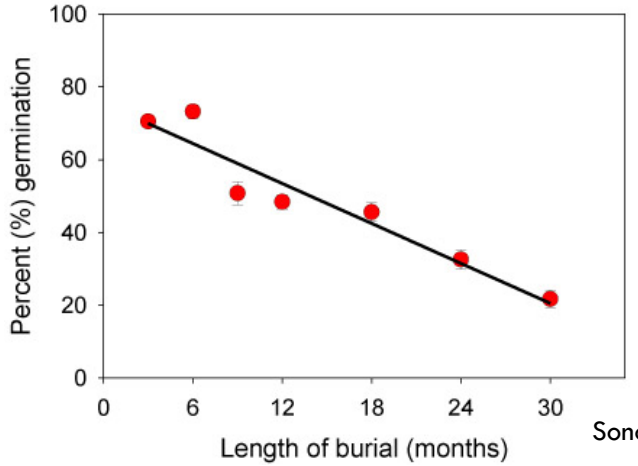
Programas de herbicidas para *A. palmeri*

Tipo de maíz	Preemergencia	Postemergencia Temprana	Postemergencia tardía (si se necesita)
Convencional	FSII o FSII+ VLCFA o VLCFA	FSII+ Mitosis o FSII+ HPPD, HPPD, PPO, auxin, auxin	**Cultivos resistentes a 2,4-D y dicamba = *A. palmeri resistente***
Roundup Ready (resistente a glifosato)	FSII o FSII+ VLCFA o VLCFA	Glicina+ FSII, VLCFA, HPPD, HPPD, PPO	auxina o auxina– dirigidos o auxina
Liberty Link (resistente a glufosinato)	FSII o FSII+ VLCFA o VLCFA	GS + FSII	auxina o auxina– dirigidos o auxina

Resistencia a inhibidores ALS es muy común y evoluciona rápidamente

¿Qué hacer cuando el problema está establecido?

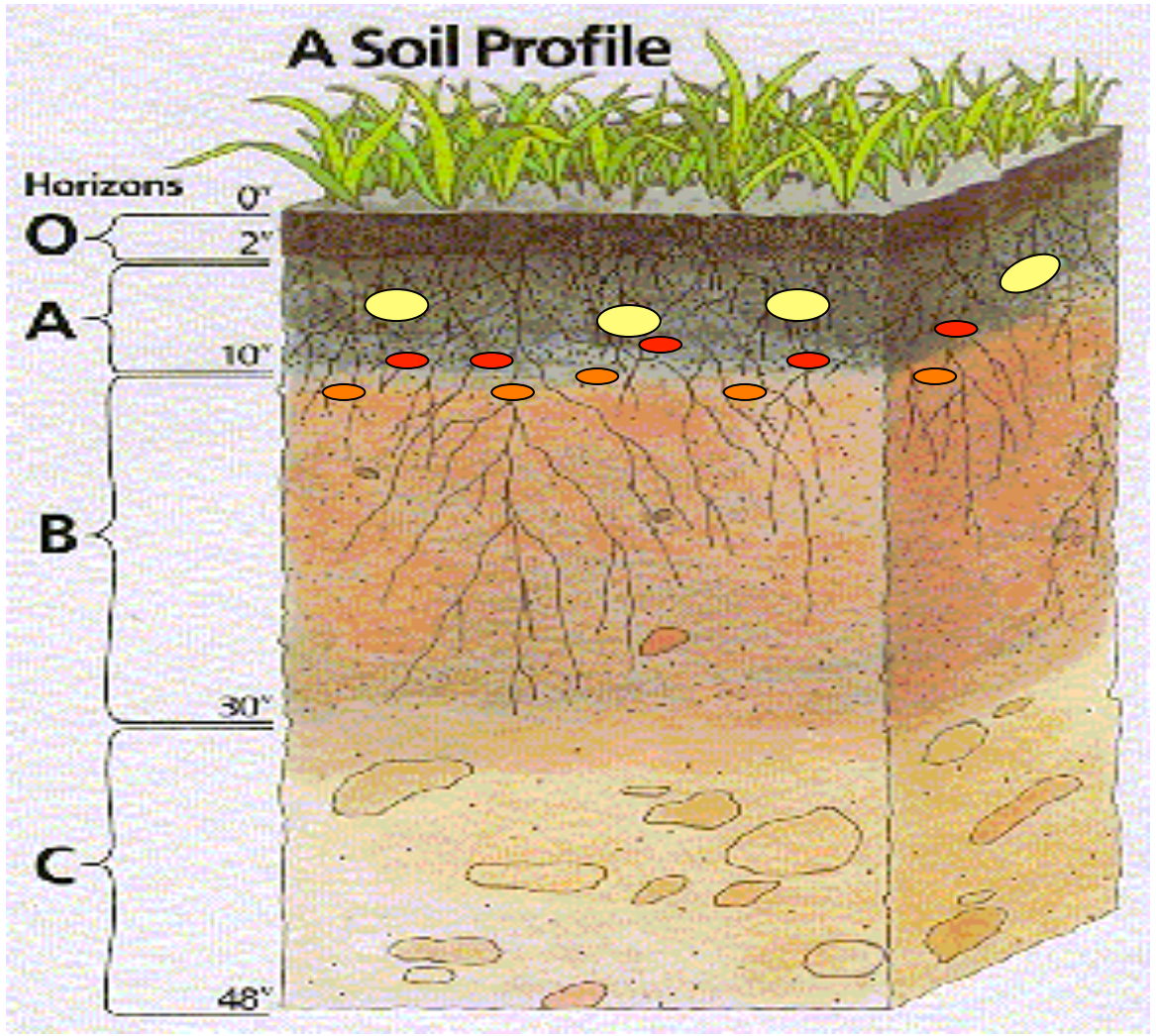
1. Conseguir financiamiento!!!
2. Se deberá invertir en reducir el banco de semillas (al menos 3 años)
3. Se ha propuesto el uso de labranza profunda para enterrar la semilla de *A. palmeri* a profundidades de las que no puede emerger.
4. Coberturas vivas y acolchados para reducir el número de plantas establecidas
5. Combinación con programas de herbicidas



Sonoskie et al. UGA

Labranza profunda

- Distribución de semillas en el perfil del suelo



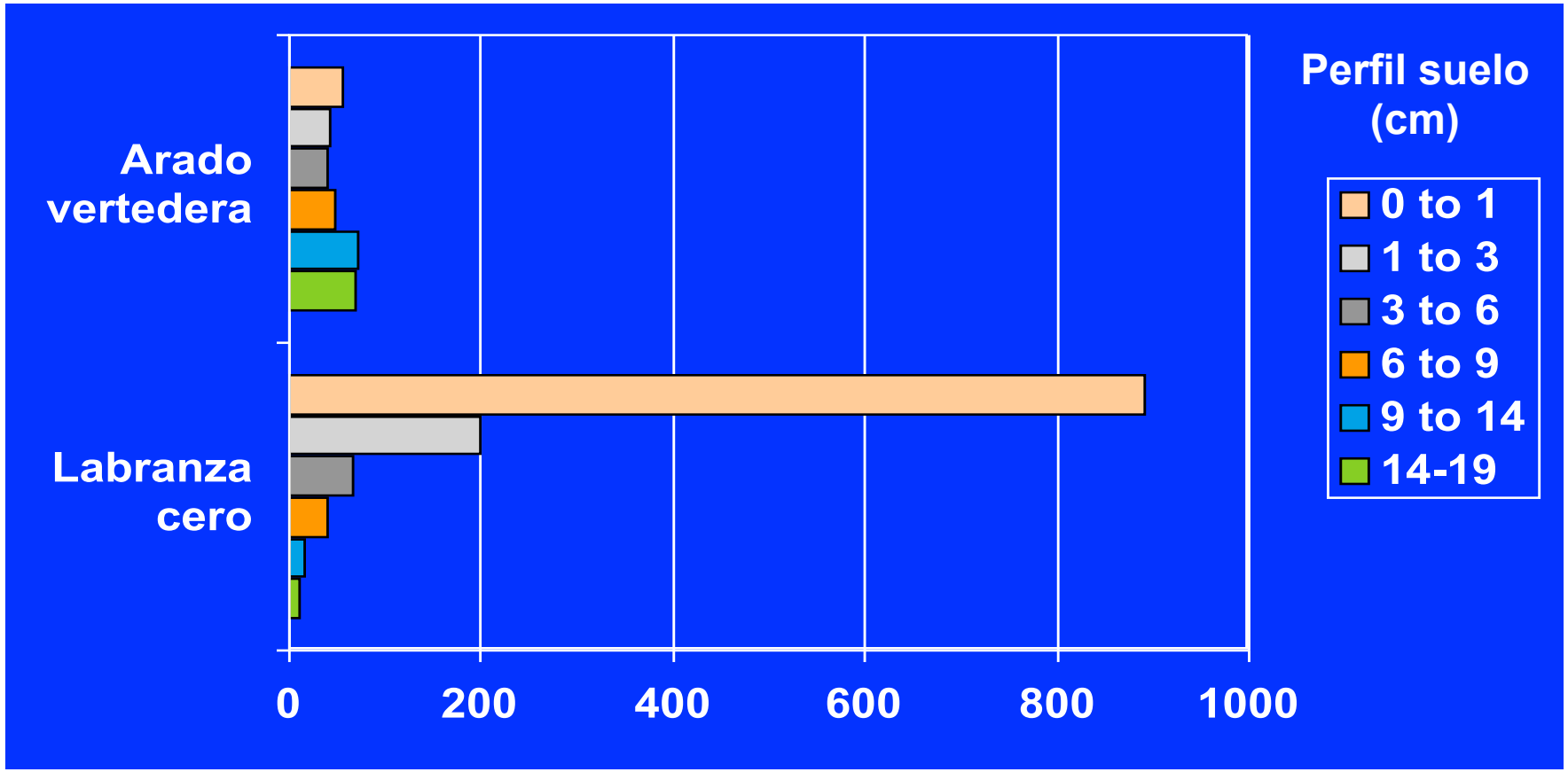
Number of Palmer Amaranth Plants During Early Season. Macon Co., Georgia 2008.*

No Deep Tillage

Deep Turn

No Herbicide Treatment

¡La labranza profunda sólo funciona una vez!



semillas / m ^{3}

Yenish et al. (1992) Weed Sci 40:429-433

Palmer amaranth response to cover crops. Macon County, GA. 2009.

No deep tillage

No cover crop

No deep tillage

Rye cover crop

Staple + Reflex + Direx PRE

Roundup WMax + Parrlay POST

Direx + MSMA Layby

Palmer amaranth response to deep tillage. Macon County, GA. 2009.

No deep tillage

No cover crop

Deep tillage

No cover crop

Staple + Reflex + Direx PRE

Roundup WMax + Parrlay POST

Direx + MSMA Layby

Palmer amaranth response to deep tillage and cover crops. Macon County, GA. 2009.

No deep tillage

No cover crop

Deep tillage

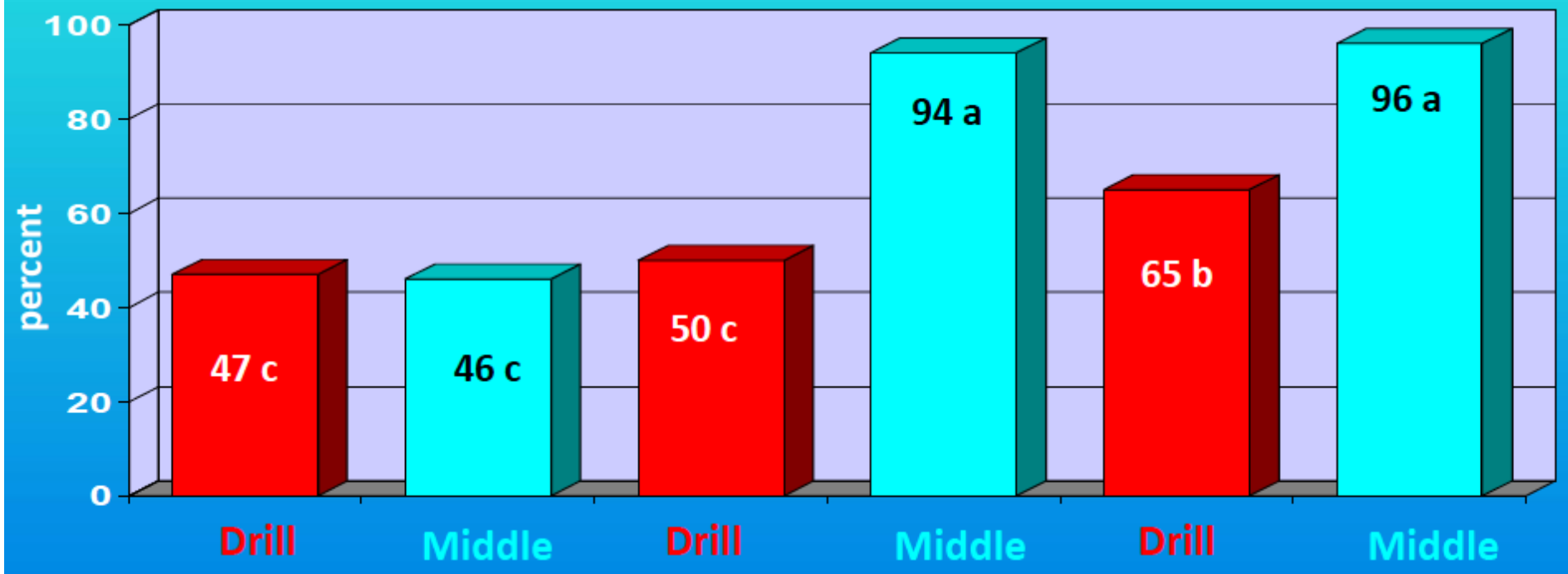
Rye cover crop

Staple + Reflex + Direx PRE

Roundup WMax + Parrlay POST

Direx + MSMA Layby

Reduction in Palmer Amaranth Emergence



Non-treated: 620 plant/m2 in row.

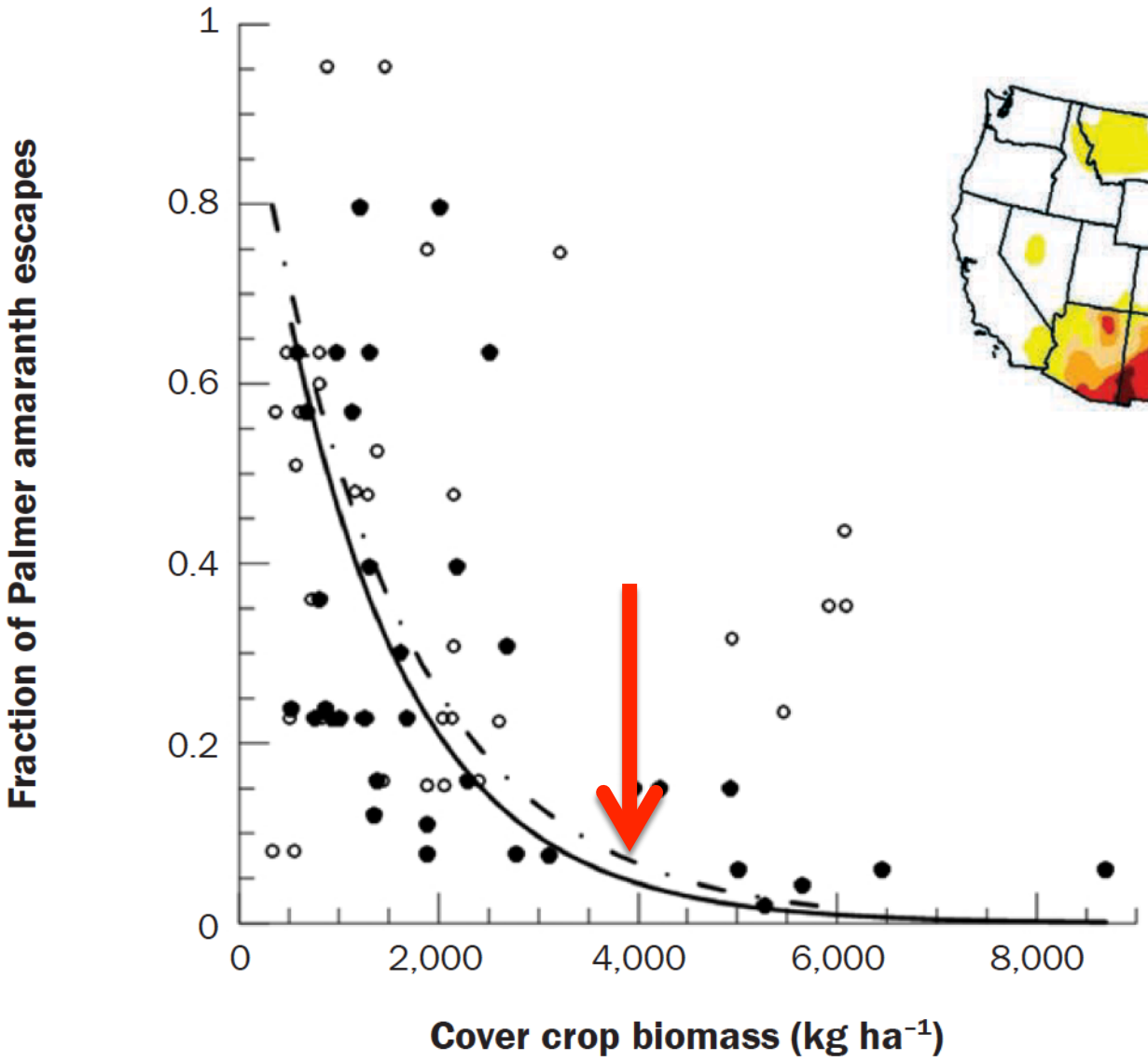
No herbicides applied.

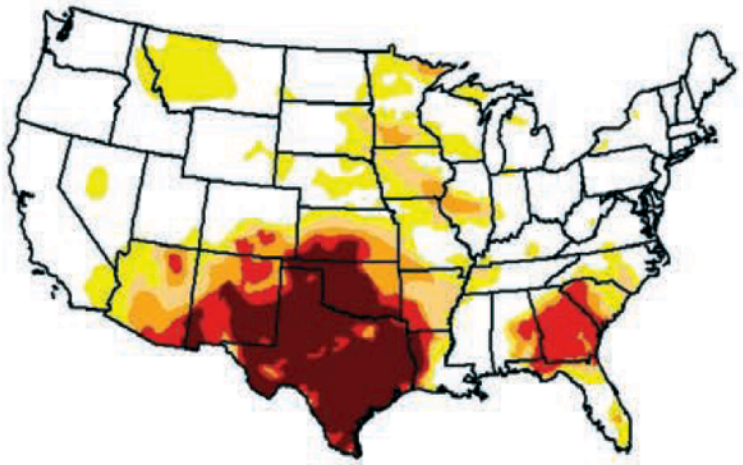
Dr. Bob Nichols et al. 2010

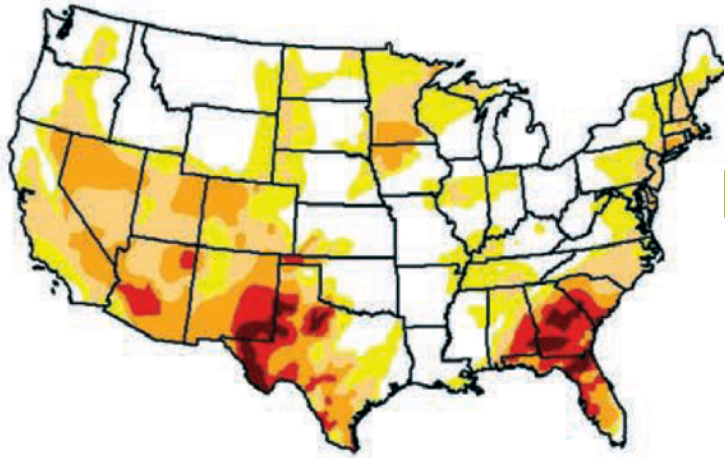
Effect of cover crop (CC) and tillage (Till) on cover crop biomass, Palmer amaranth escapes, and cotton yield by year and location.*

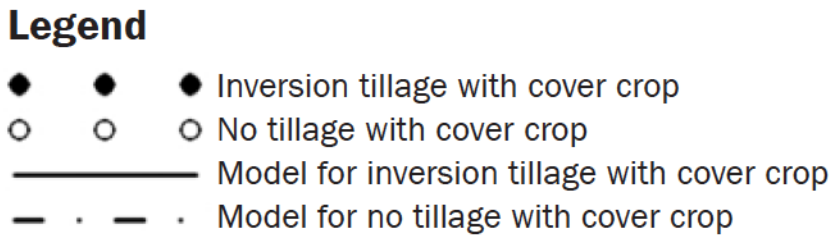
Location County, State	Year	CC Precip‡ (cm)	GDD (units)	Biomass (kg ha^{-1})		Pigweed escapes (plants ha^{-1})			Cotton yield (kg ha^{-1})		
				CC	Till and CC	None	CC	Till and CC	None	CC	Till and CC
Barbour, Alabama	2011	54.5	2,790	3,100b	6,070a	3,850a	1,130ab	230b	1,280	1,170	1,280
	2012	37.4	2,498	570b	1,890a	1,140a	500ab	90b	1,550b	1,710ab	1,960a
Macon, Georgia†	2010	66.7	1,615	4,950	5,650	38,350	12,120	1,610	550	760	1,150
Seminole, Georgia	2011	52.6	3,828	2,600	—	0	0	0	—	—	—
Screven, Georgia	2011	30.3	2,176	3,210b	5,270a	1,020a	760a	20b	—	—	—
Worth, Georgia	2011	46	2,236	5,400	6,790	0b	130b	0b	—	—	—
Calhoun, South	2010	28.5	1,210	2,030	2,450	130,000	26,670	20,000	1,220	1,240	1,350
Carolina†	2011	39.9	1,773	1,960b	4,360a	133,330a	66,670b	20,000b	1,220b	1,240ab	1,350a
Lee, South Carolina	2010	36.7	1,472	900	1,250	176,000a	80,000b	43,330c	1,220	1,110	1,250
	2011	33	1,553	5,820	6,720	170,000a	53,330b	10,000c	700	510	640
Tipton, Tennessee	2010	42.5	2,087	850	990	107,000a	45,000b	44,000b	1,120	1,400	1,340
	2011	63.3	2,108	1,410	1,640	42,800a	18,000b	17,600b	950	1,280	1,060

Price et al. (2016) J Soil Water Conserv 71:1-11









Price et al. (2016) J Soil Water Conserv 71:1-11

Cotton net returns (US$ ha^{-1}) and differences from winter fallow, conservation tillage.

Location and treatment	Net returns (US$ ha^{-1})*		Difference from winter fallow, conservation tillage	
	Year 1†	Year 2	Year 1	Year 2
Lee County, South Carolina				
Winter fallow, conservation tillage	4,388	1,529a		
High-residue, inversion (rye)	4,321	1,217b	−67	−312
High-residue, conservation tillage (rye)	3,824	954c	−564	−575
LSD	NS	147		
Barbour County, Alabama				
Winter fallow, conservation tillage	2,518	2,663b		
High-residue, inversion (rye)	2,362	3,206a	−156	543
High-residue, conservation tillage (rye)	2,160	4,276ab	−358	129
LSD	NS	471		
Tipton County, Tennessee				
Winter fallow, conservation tillage	3,604b	1,883b		
High-residue, inversion (wheat)	4,141ab	1,914b	537	31
High-residue, conservation tillage (wheat)	4,354a	2,371a	750	488
LSD	705	364		
Calhoun County, South Carolina‡				
Winter fallow, conservation tillage	2,998	2,694		
High-residue, inversion (rye)	3,381	2,808	383	114
High-residue, conservation tillage (rye)	3,643	2,568	645	−126
LSD	—	NS		
Macon County, Georgia‡				
Winter fallow, conservation tillage	1,754	—		
High-residue, inversion (rye)	3,534	—	932	—
High-residue, conservation tillage (rye)	2,289	—	211	—

Price et al. (2016) J Soil Water Conserv 71:1-11

Reduciendo las poblaciones de *A. palmeri*

- Alto costo
- El análsis beneficio/costo no se puede hacer pensando en un sólo ciclo de cultivo
- El riesgo económico de **no** manejar las poblaciones es sumamente alto
- Fincas que han podido recuperar su productividad han tenido que invertir en algunos casos hasta más de €250 ha^{-1} por 5 años con el objetivo específico de reducir el banco de semillas de *A. palmeri*
- Prevención y estrategias de erradicación tempranas son las formas más efectivas y económicas de manejar esta mala hierba.