Non-Chemical Weed Control in Rice Systems

December 5, 2019

Whitney Brim-DeForest, PhD

UCCE Rice Advisor

Weeds in California Rice

- Can reduce yields by as much as 50%-100%, if uncontrolled
- Particularly problematic in systems where the same crop is planted in a similar fashion, year after year
  - California rice: flooded, without rotation, for 100 years
- Most weed control:
  - Combination of flooding and herbicides

Grasses

Late watergrass

Early watergrass

Barnyardgrass

Sprangletop

Sedges & broadleafs

Smallflower umbrella sedge

Ricefield bulrush

Redstem

Arrowhead

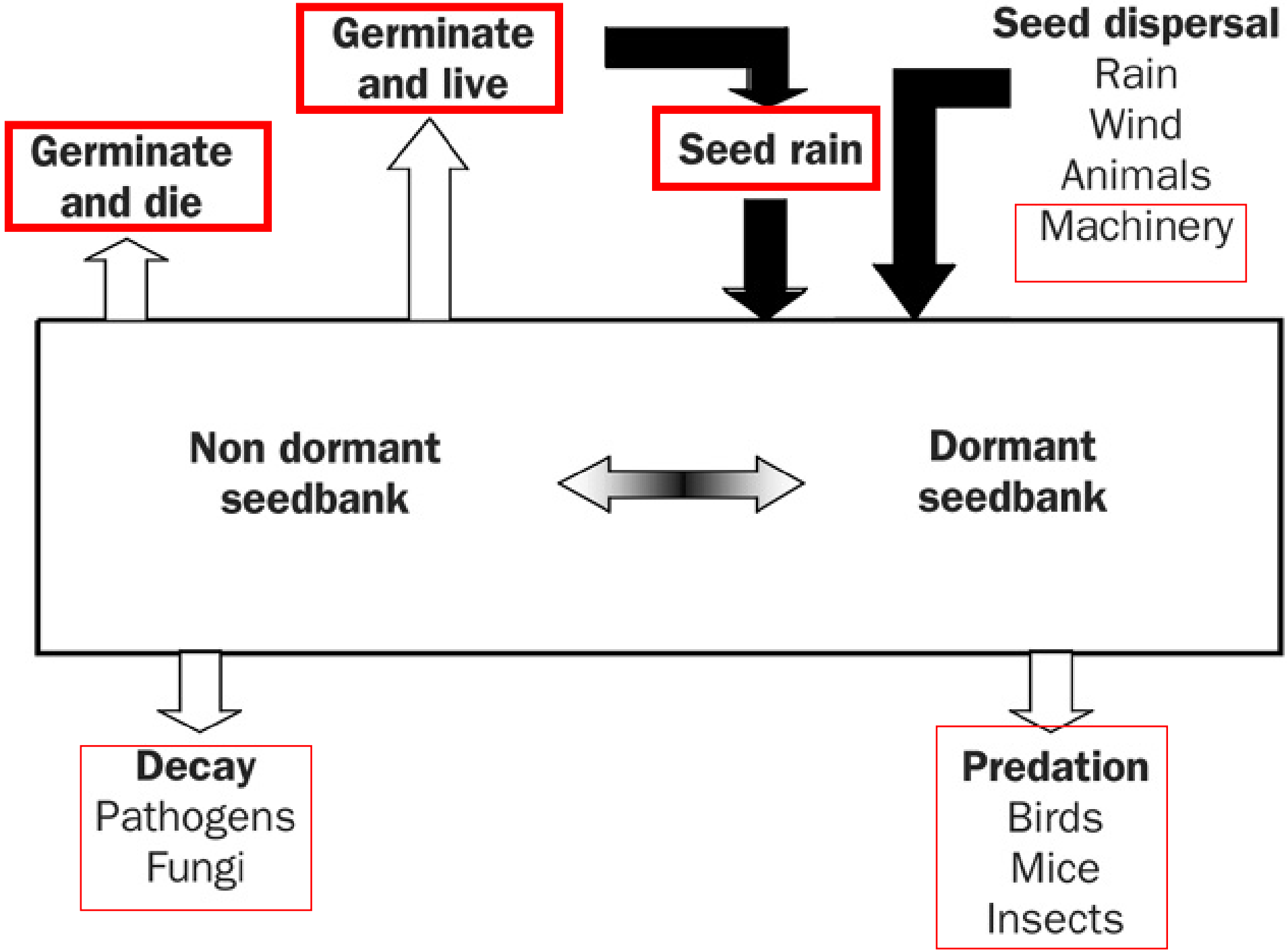
Water plantain

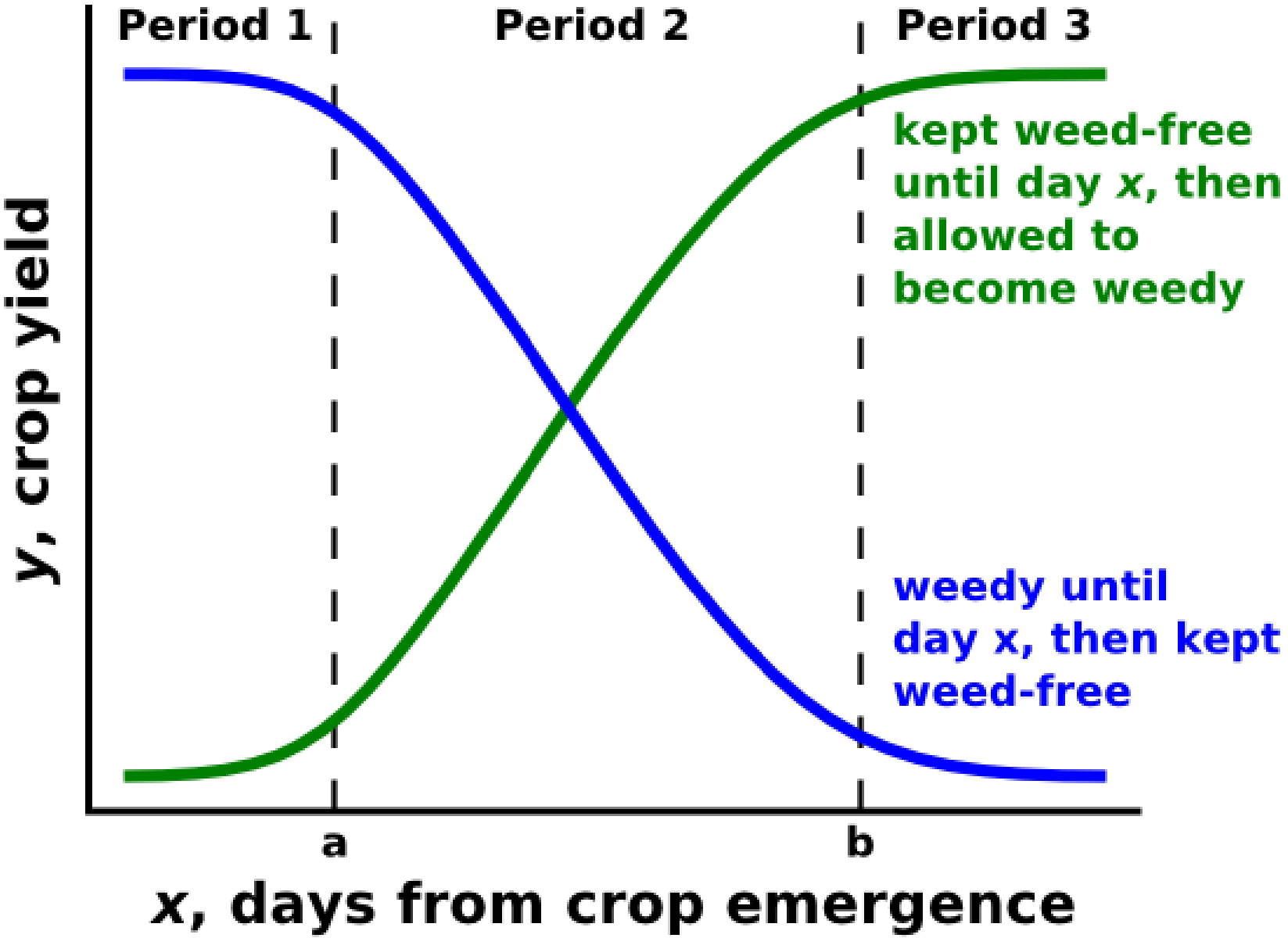
Weedy Rice: 7 biotypes

Photos: Timothy Blank, CCIA

Major Principles of Weed Management:

1) Managing weed seedbank (reducing)
2) Preventing more seeds from being deposited in the seedbank
3) Knowing the "critical period of competition" – for each weed (most yield damage)


Germinate and live
Germinate and die
Seed rain
Seed dispersal
Rain
Wind
Animals
Machinery
Non dormant seedbank
Dormant seedbank
Decay
Pathogens
Fungi
Predation
Birds
Mice
Insects



Ed Zaborski, University of Illinois (adapted from Altieri, 1995).

“Many little hammers……”

Pesticides
Cultural
Mechanical
Sanitary
Biological
Host Plant Resistance

NOTE:
Some practices may fall into several categories

What is “Cultural Control”?

Agronomic practices that:

Optimize growing conditions for the crop

AND/OR

Create unfavorable conditions for the pest

Cultural Control Examples

- **Irrigation:**
  - Example: flooding suppresses some weed species (i.e. rice)
  - Example: drip irrigation waters only area around crop roots

- **Burning residues:**
  - Example: can kill some large weed seeds
  - UNKNOWN how well this works in rice

- **Tillage:**
  - Shallow tillage can disturb shallow-rooted annuals

What is Mechanical Control?

Uses machinery and/or other tools to control pests:

- Tillage
- Physical barriers (black plastic, mulch)

What is Sanitary Control?

Methods to avoid introducing a pest into a field:

- Cleaning field equipment
- Planting certified seed
- Quarantines

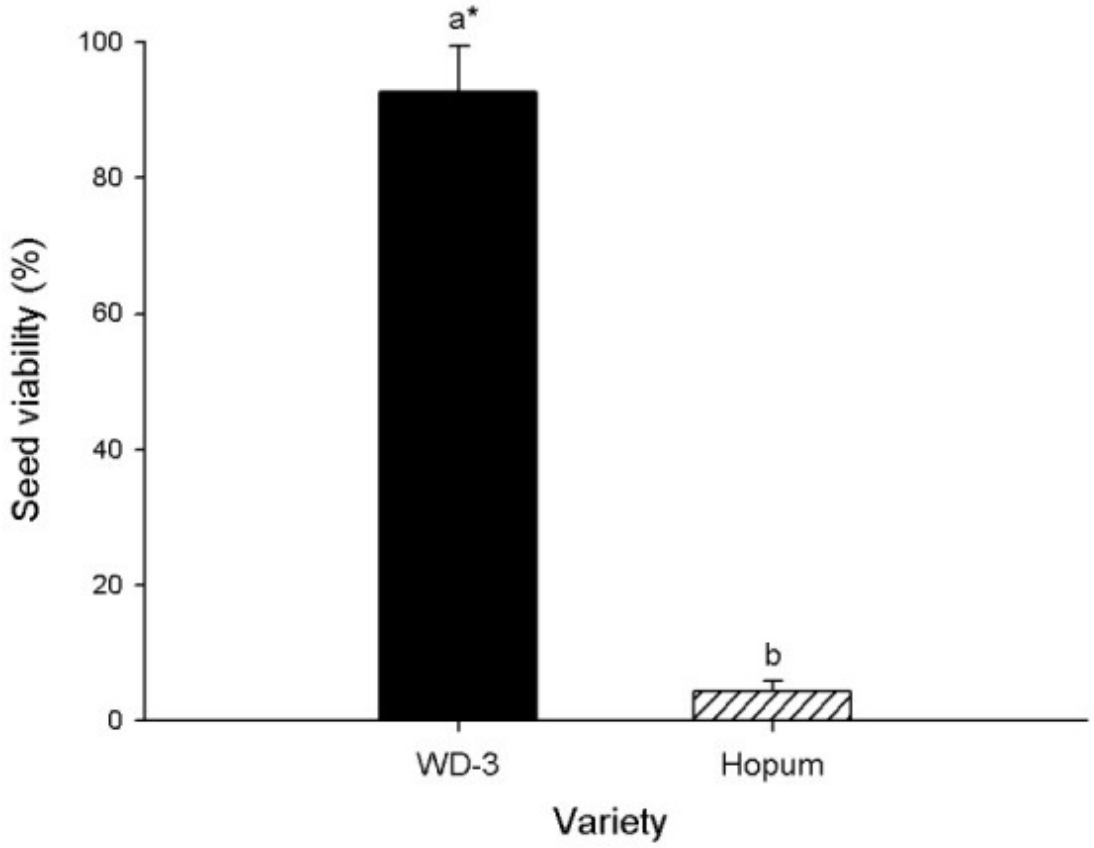
Use of Non-Chemical Controls in Rice

1. Winter Flooding
2. Stale Seedbed
3. Irrigation Management
4. Crop rotation or fallow
5. Sanitation

6. Cover crops?
7. Burning?

Winter flooding

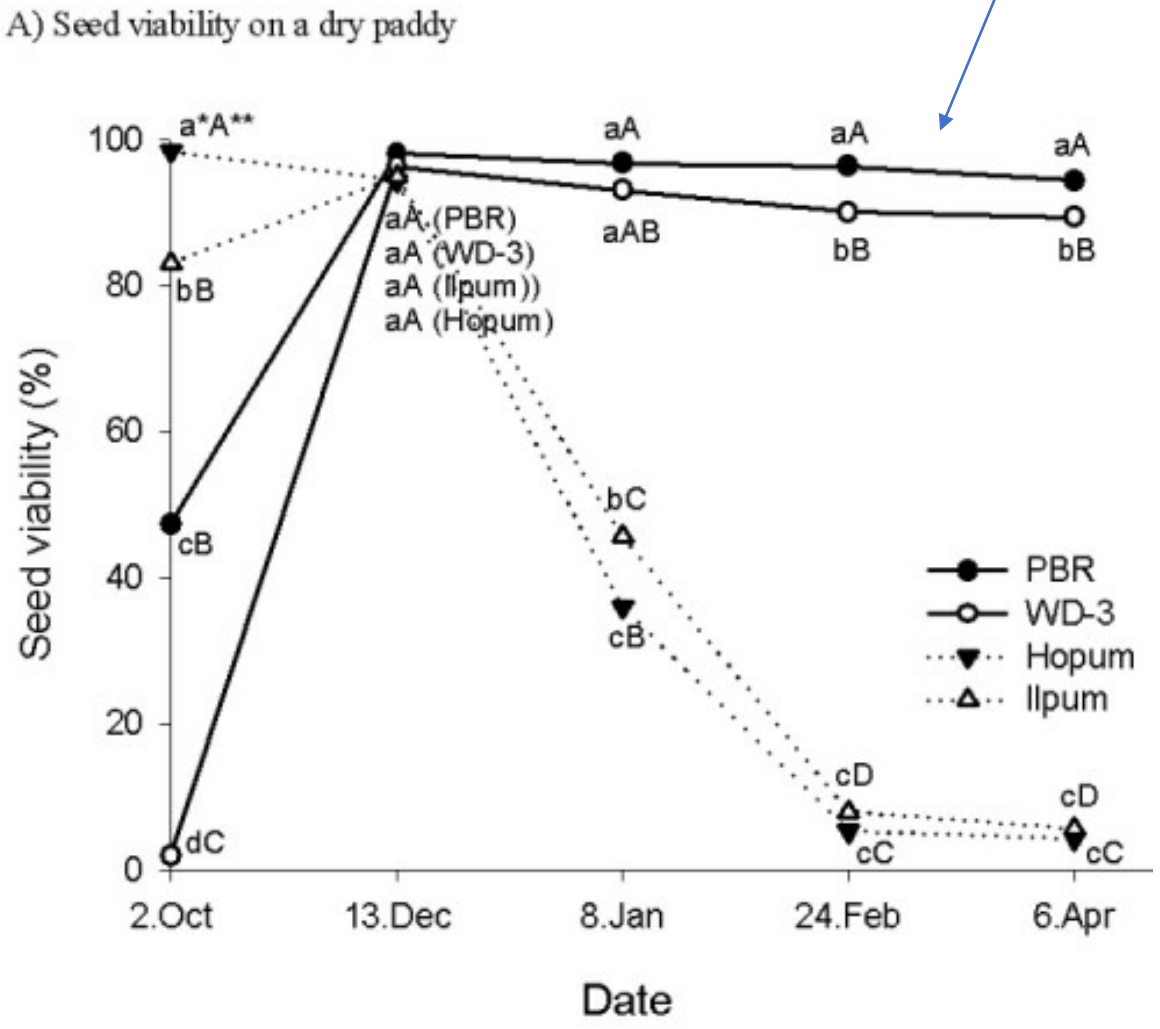
- Seed viability of weedy rice (WD-3) and cultivated rice (Hopum) after wintering on the surface of a paddy field
- November 2008 to April 2009



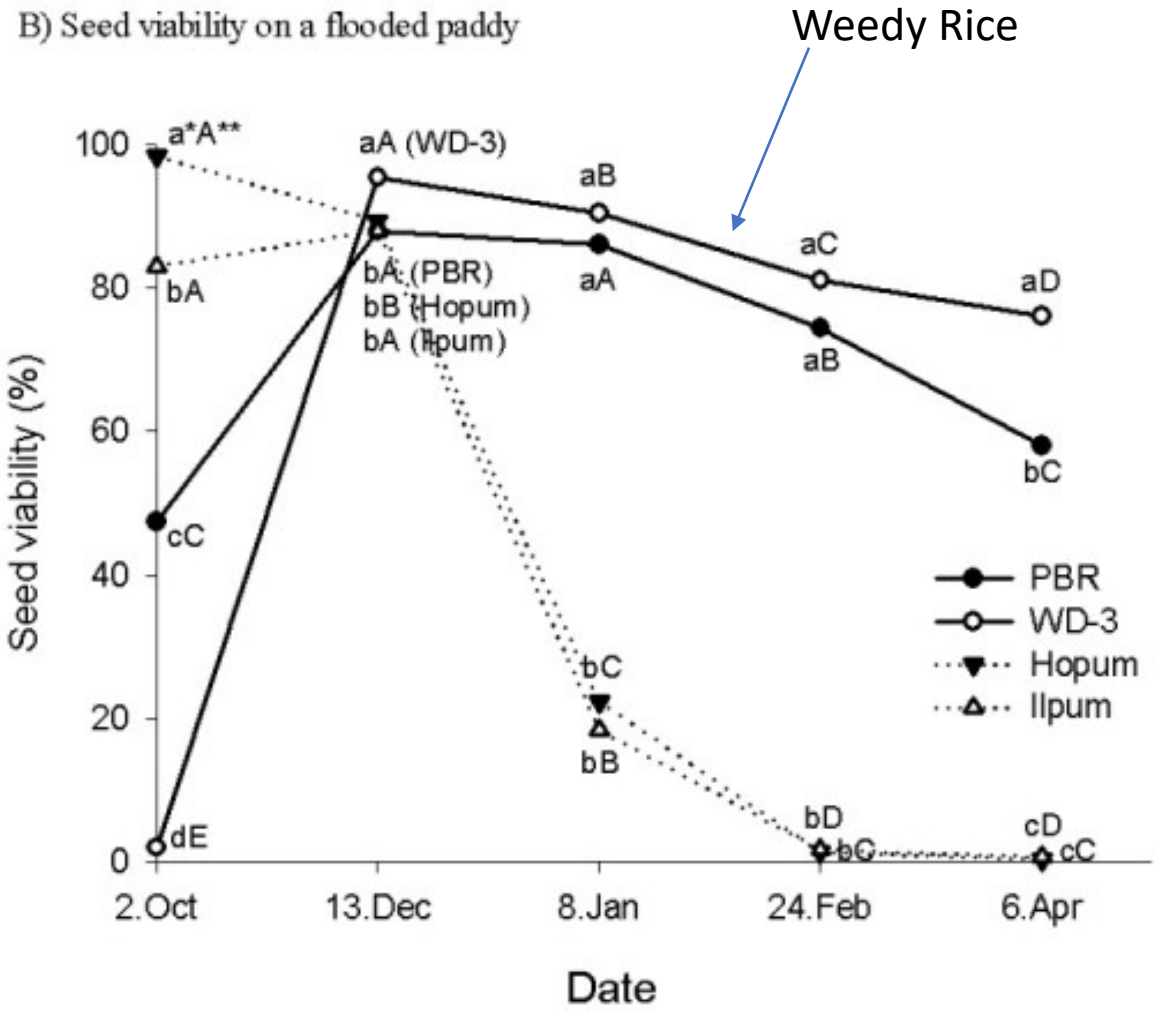
- Does this work for other weed species?
  - Unknown at this time
  - Likely similar pattern for large-seeded weeds (watergrass)

Baek and Chung, 2012

Weedy Rice

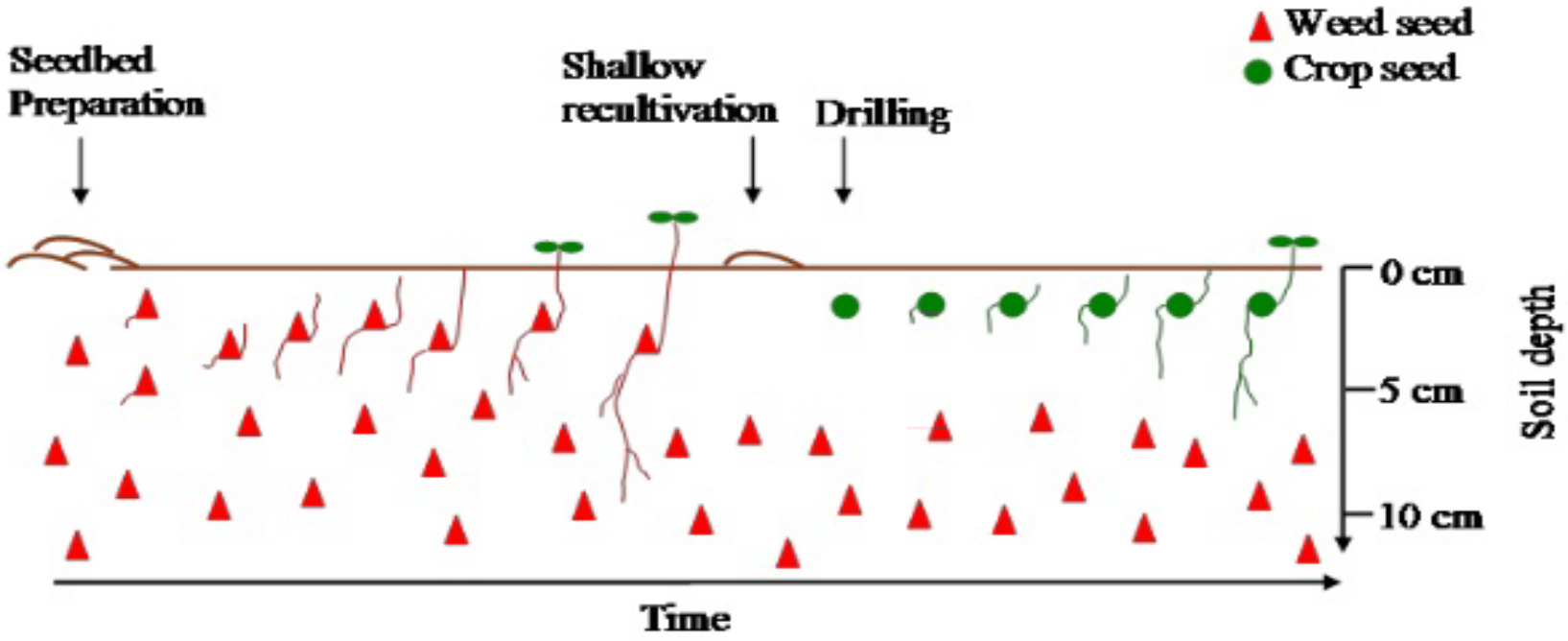


Weedy Rice



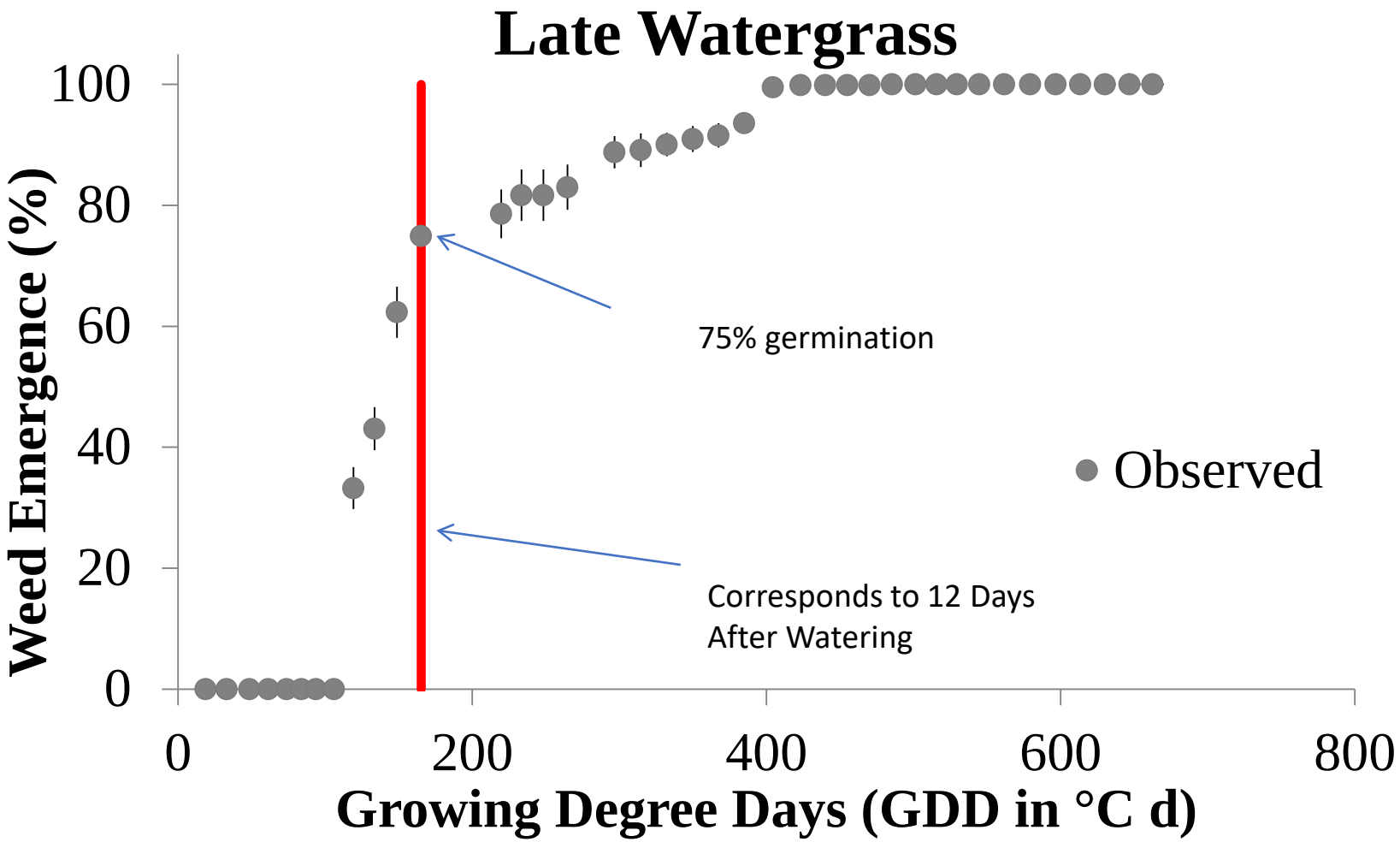
Baek and Chung, 2012

Stale (False) Seedbed



Stale Seedbed: Application in Rice

- Field flooded and then water was allowed to subside
- Timing of application based on GDD predictions for late watergrass
- Sprayed glyphosate 12 Days After beginning of watering based on :
  - Predicted 90% emergence for Flood:
    - 154 GDD

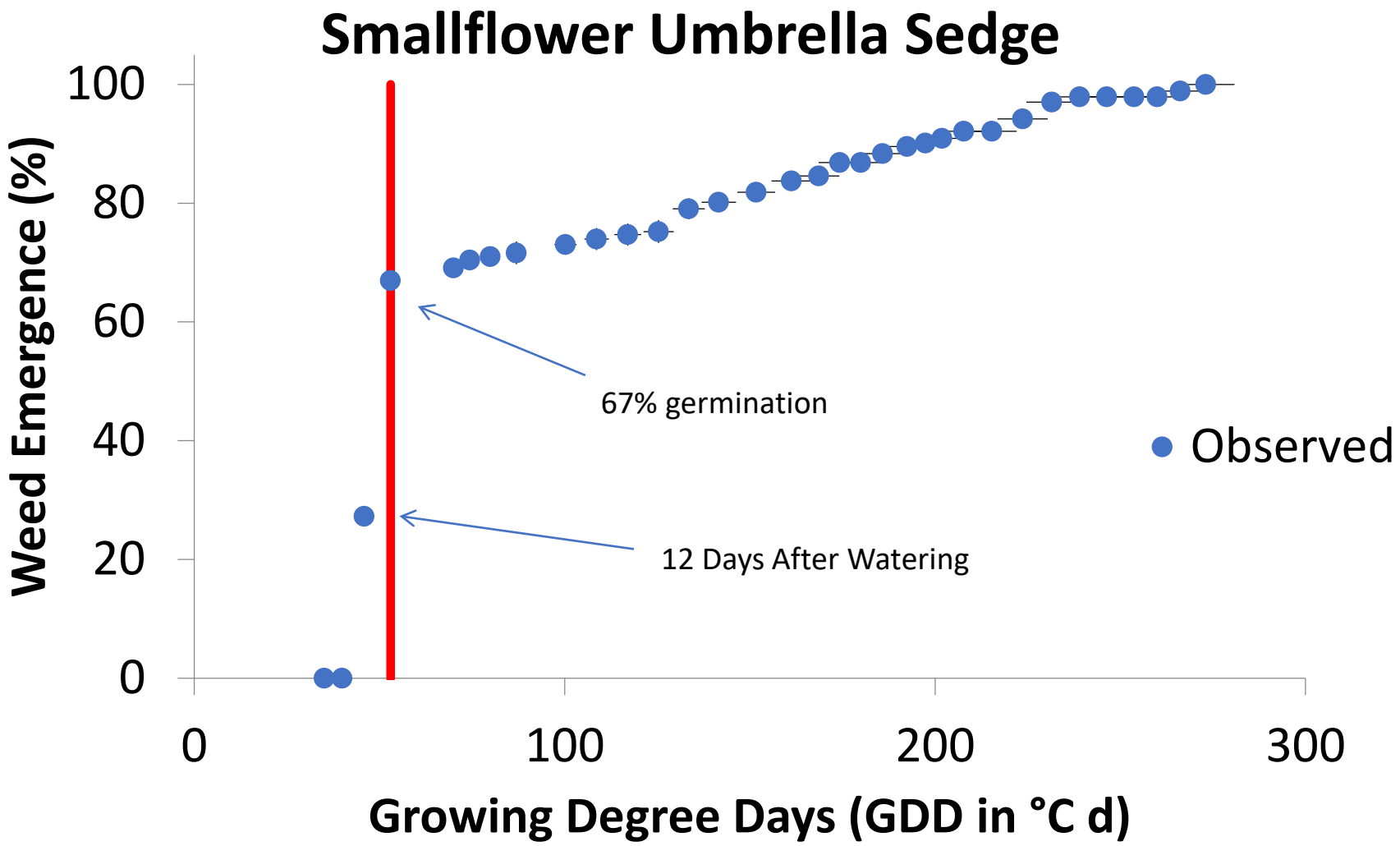

Late Watergrass
Weed Emergence (%)
100
80
60
40
20
0
0
200
400
600
800
Growing Degree Days (GDD in °C d)
75% germination
Corresponds to 12 Days
After Watering
Observed

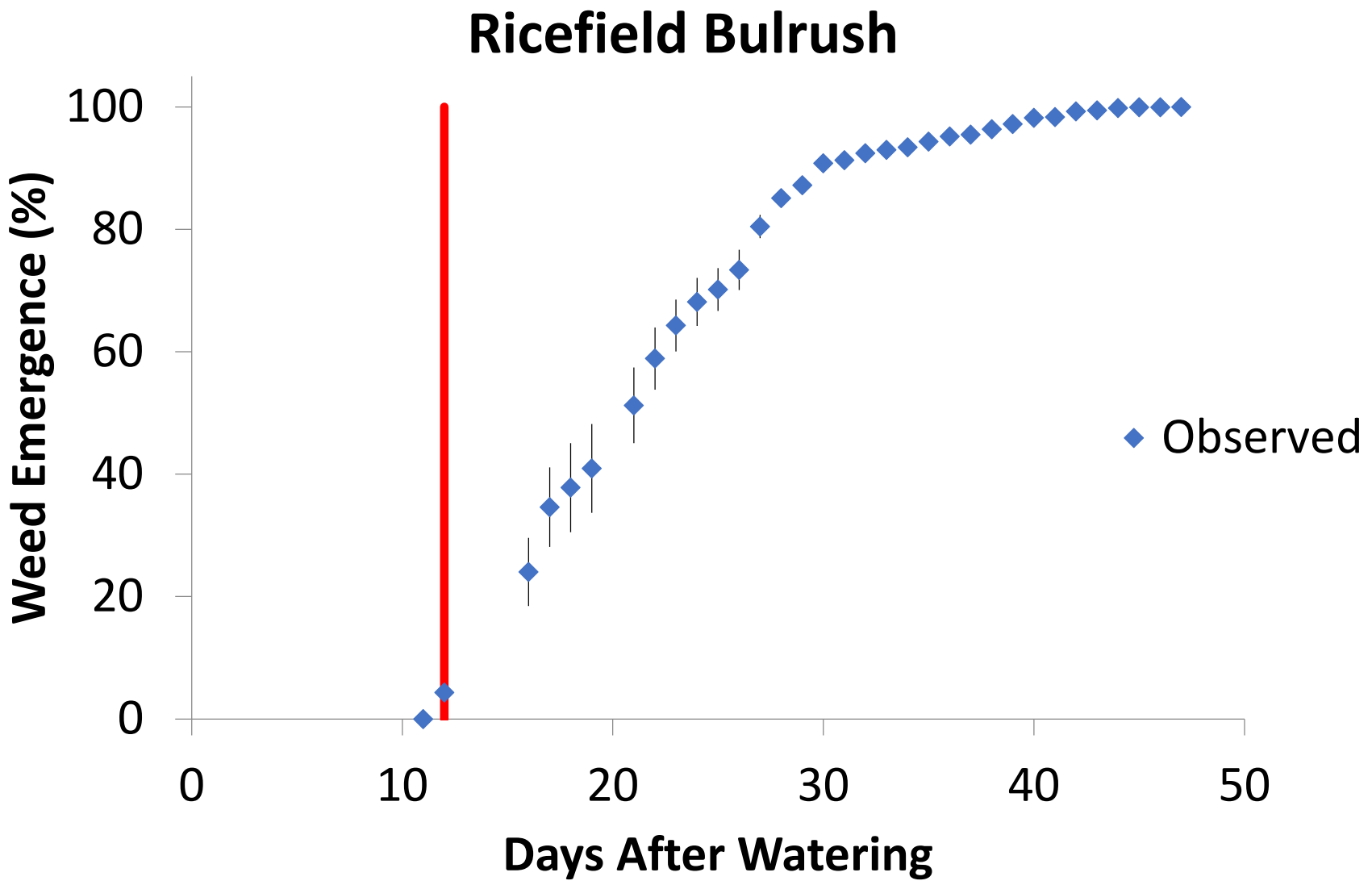
Stale Seedbed

Conventional Flood

Stale Seedbed

Conventional Flood


Smallflower Umbrella Sedge
Weed Emergence (%)
100
80
60
40
20
0
0
100
200
300
Growing Degree Days (GDD in °C d)
67% germination
12 Days After Watering
Observed


Ricefield Bulrush
Weed Emergence (%)
100
80
60
40
20
0
0
10
20
30
40
50
Days After Watering
Observed

Stale Seedbed

- Instead of using a chemical method (glyphosate), tillage could also be used
  - Must be shallow tillage, to ensure that more weed seeds are not brought to the surface
- Alternatively, could be used during a fallow season:
  - Repeated flushing and tilling
- Most effective for watergrass/barnyardgrass species

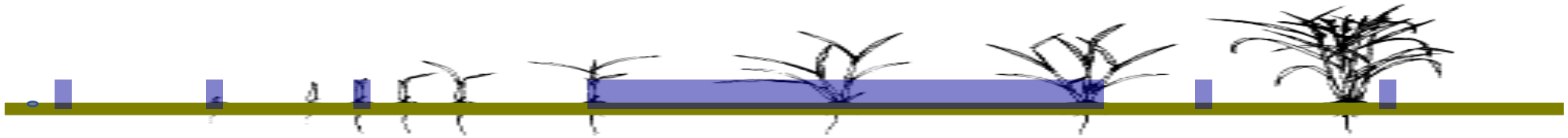
Irrigation Management

- Alternative irrigation methods:
  - Dry-seeding (using a drill) vs. wet-seeding
  - No permanent flood (flush irrigation)
  - Systems from other parts of the world:
    - **Alternate Wetting and Drying (AWD)**

- **Why? Different weeds germinate under different irrigation systems**

A

DRILL-SEEDED ALTERNATE WET DRY



Drill-Seed, Flush
Flowering

Tiller initiation

Tillering

Panicle initiation

B

WATER-SEEDED ALTERNATE WET DRY

Flood, Seed
Flowering

Tiller initiation

Tillering

Panicle initiation

C

WATER-SEEDED CONTROL

Flood, Seed
Flowering

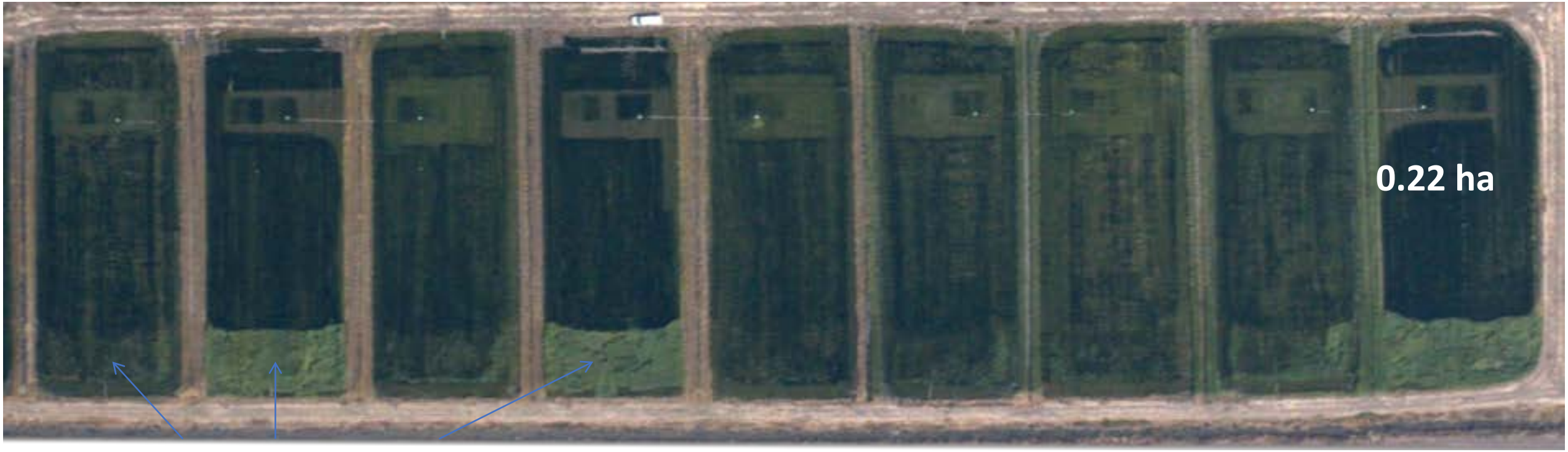
Tiller initiation

Tillering

Panicle initiation

Experimental Setup

WS-Control DS-AWD WS-AWD DS-AWD WS-AWD WS-Control WS-AWD WS-Control DS-AWD

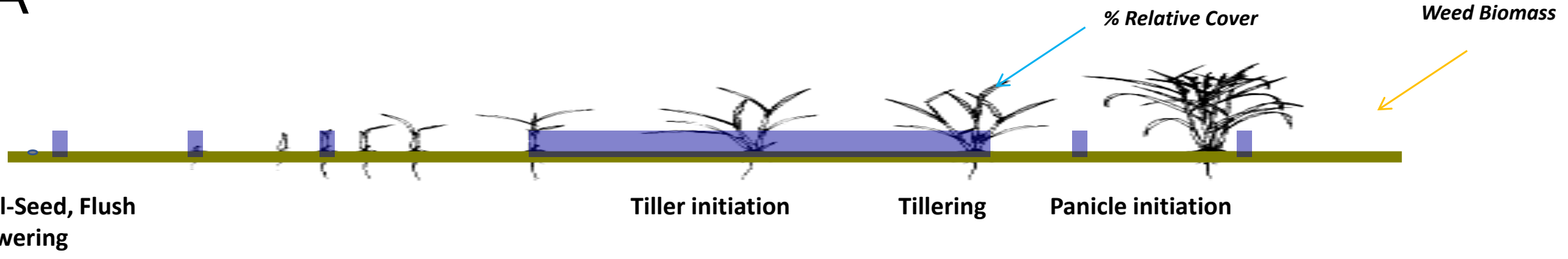


Weedy Sections

DS-AWD = Drill-Seeded Alternate Wet Dry
WS-AWD = Water-Seeded Alternate Wet Dry
WS-Control = Water-Seeded Control

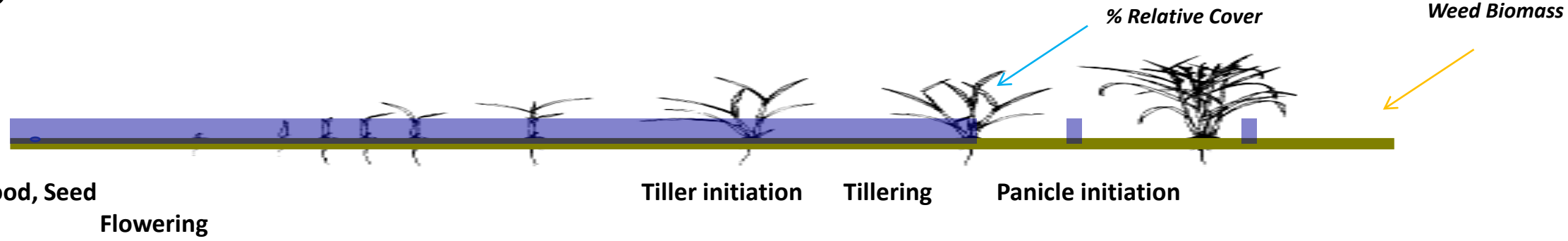
A

DRILL-SEEDED ALTERNATE WET DRY



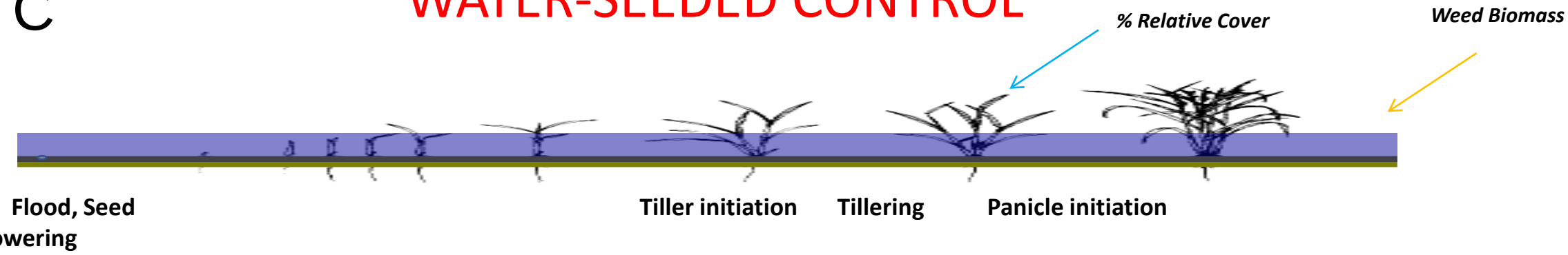
B

WATER-SEEDED ALTERNATE WET DRY



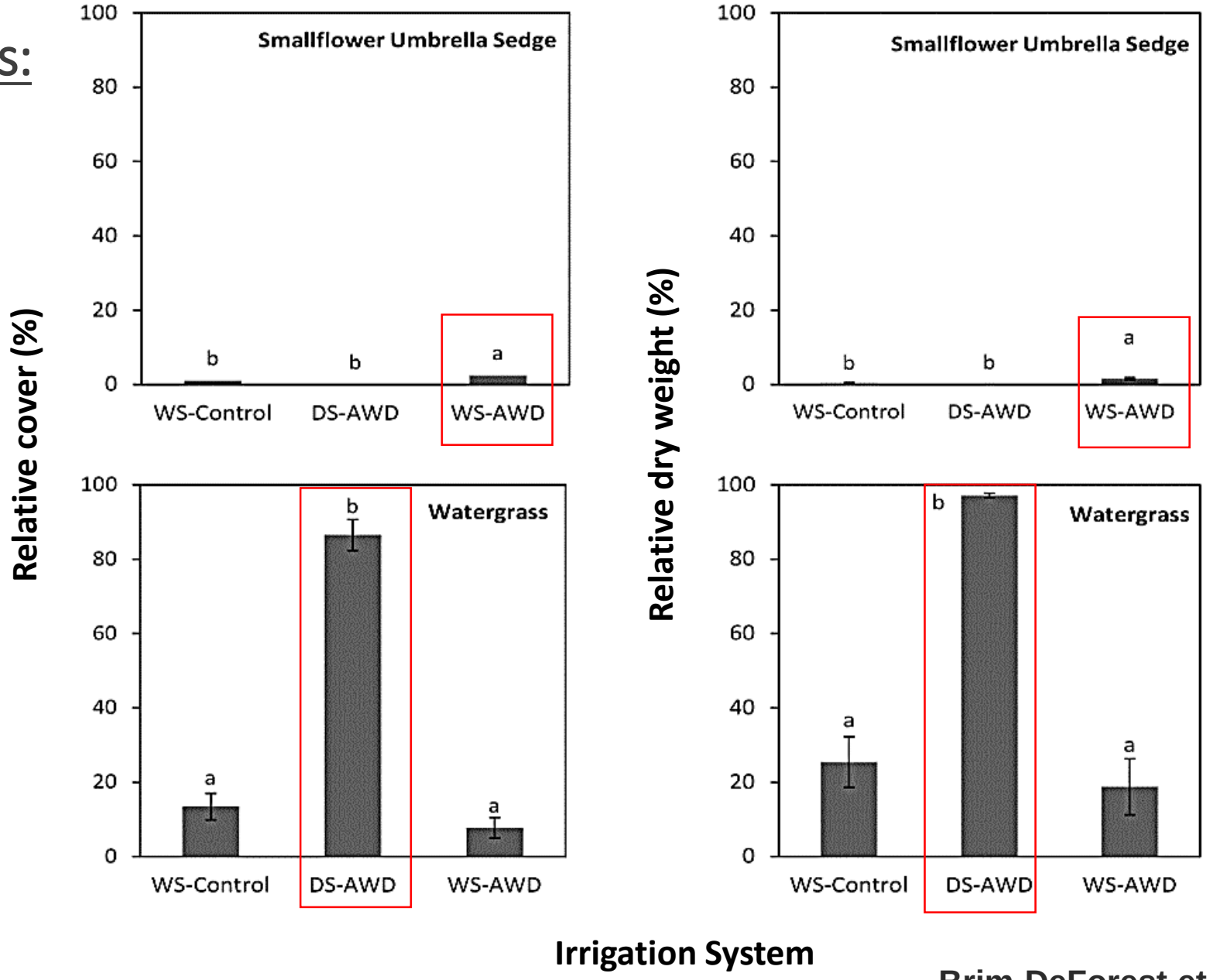
C

WATER-SEEDED CONTROL



Within-Season Differences: Smallflower and Watergrass

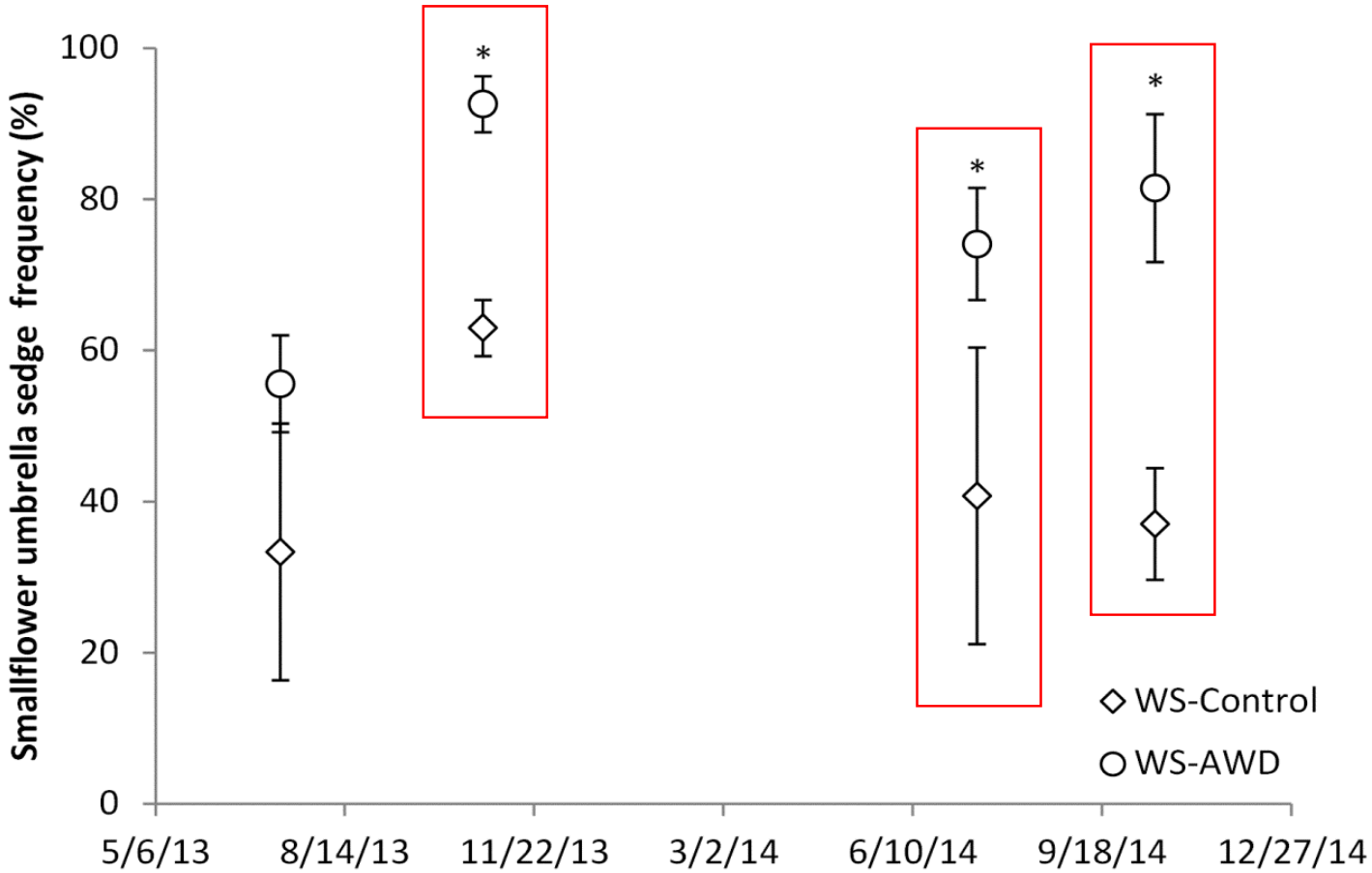
% Cover at Tillering



Note: Different letters indicate significant differences at $P < 0.05$

Brim-DeForest et al. 2017

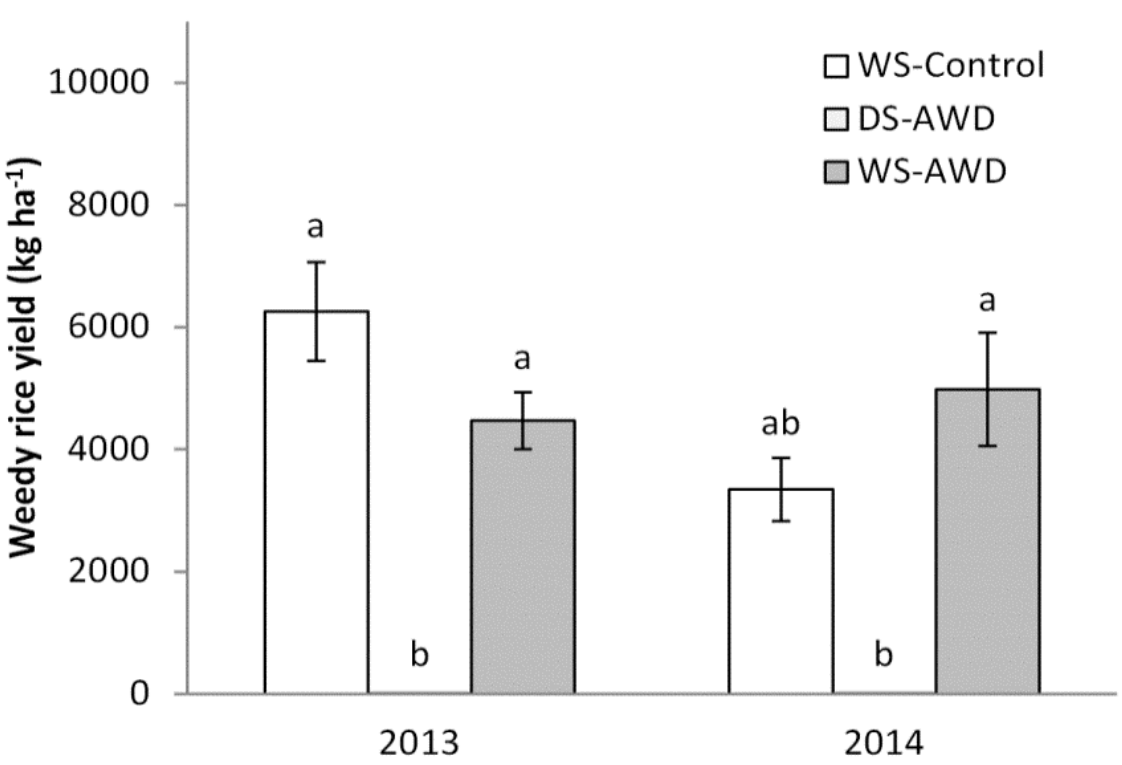
Frequency: Smallflower Umbrella Sedge

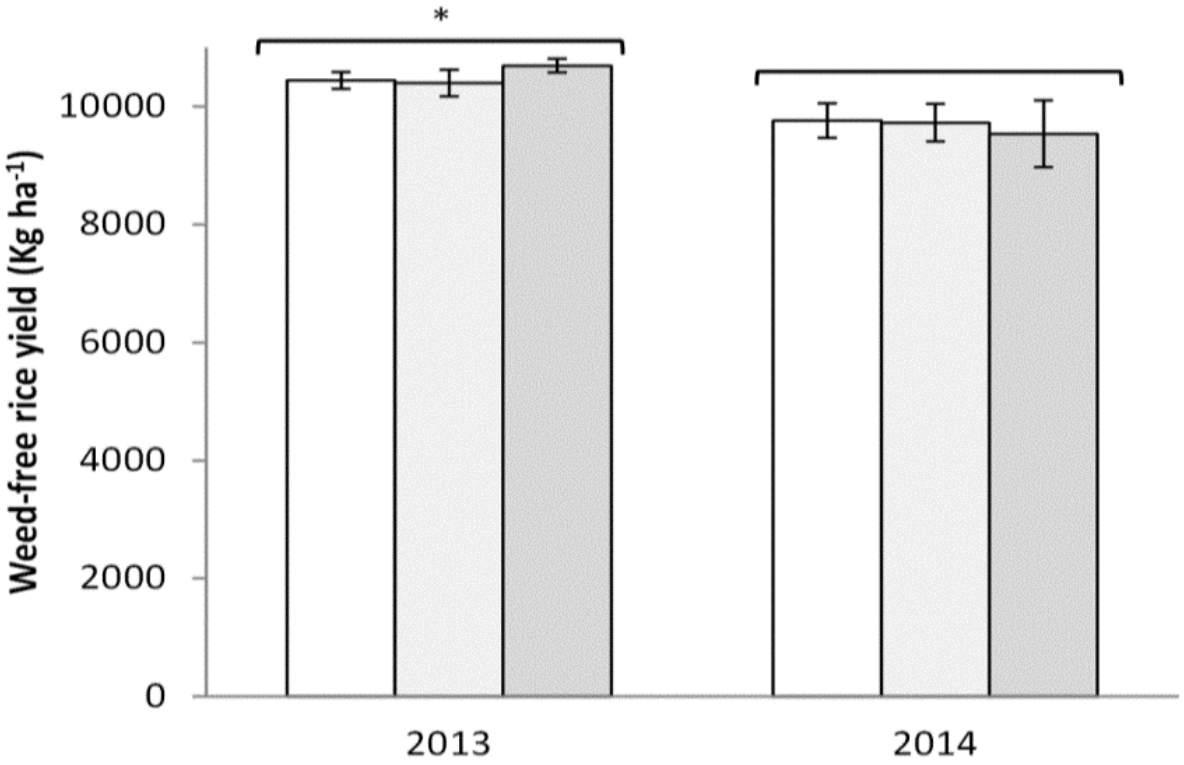


* P < 0.05

Brim-DeForest et al. 2017

Yields – Weedy vs Weed-Free





Note: Different letters indicate significant differences at $P < 0.05$

Brim-DeForest et al. 2017

Conclusions

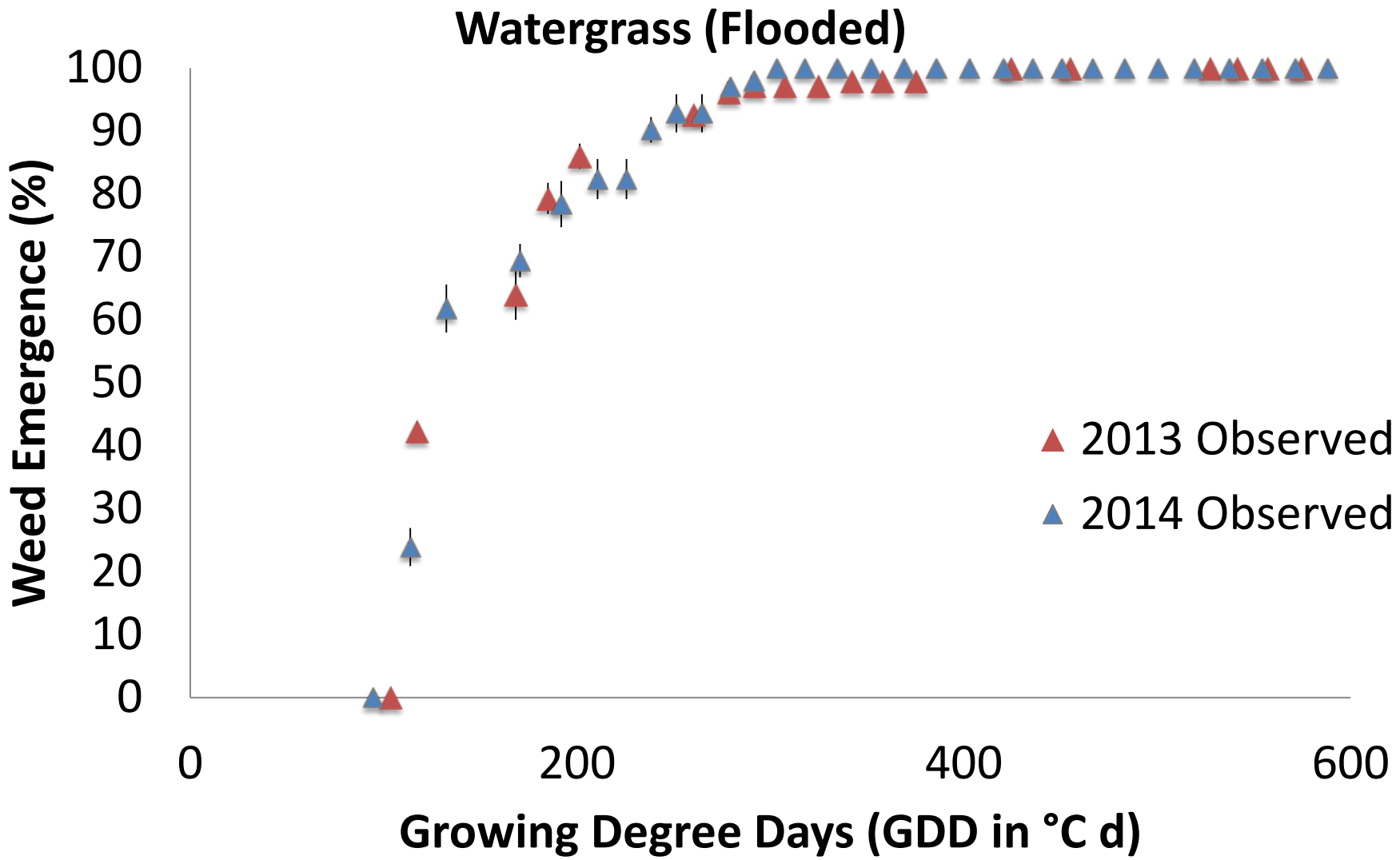
- Water-seeded systems dominated by grasses, sedges and broadleaves
- Dry-seeded system dominated by grasses
- Due to 100% yield losses, DS-AWD is only a viable option with excellent weed control
- WS-AWD may be a viable means to reduce water usage while maintaining yields and weed control
  - Increase in smallflower umbrella sedge in WS-AWD system compared to WS-Control

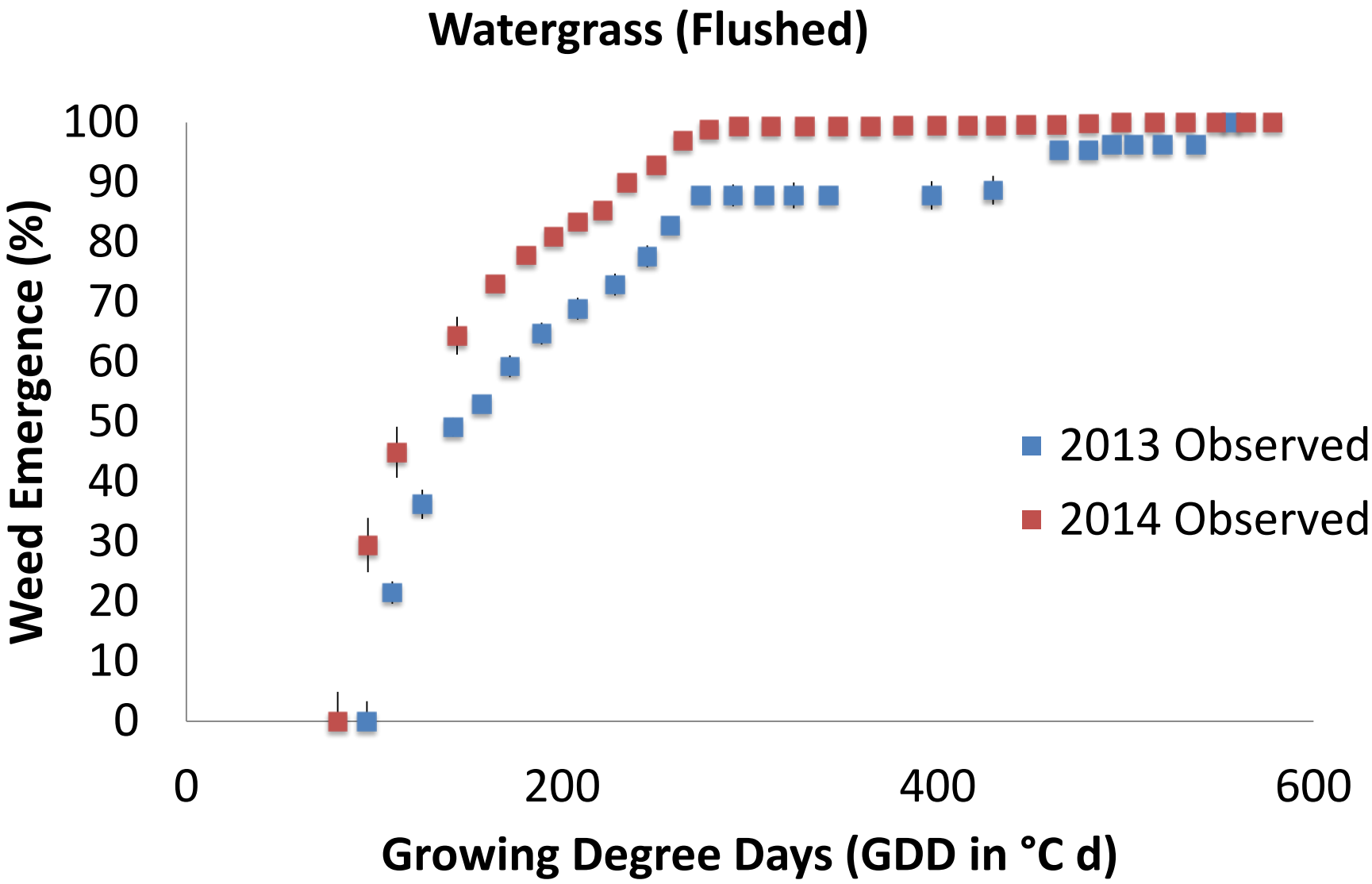
Timing of Emergence

Species-Specific Emergence Data Under Variable Irrigation Systems

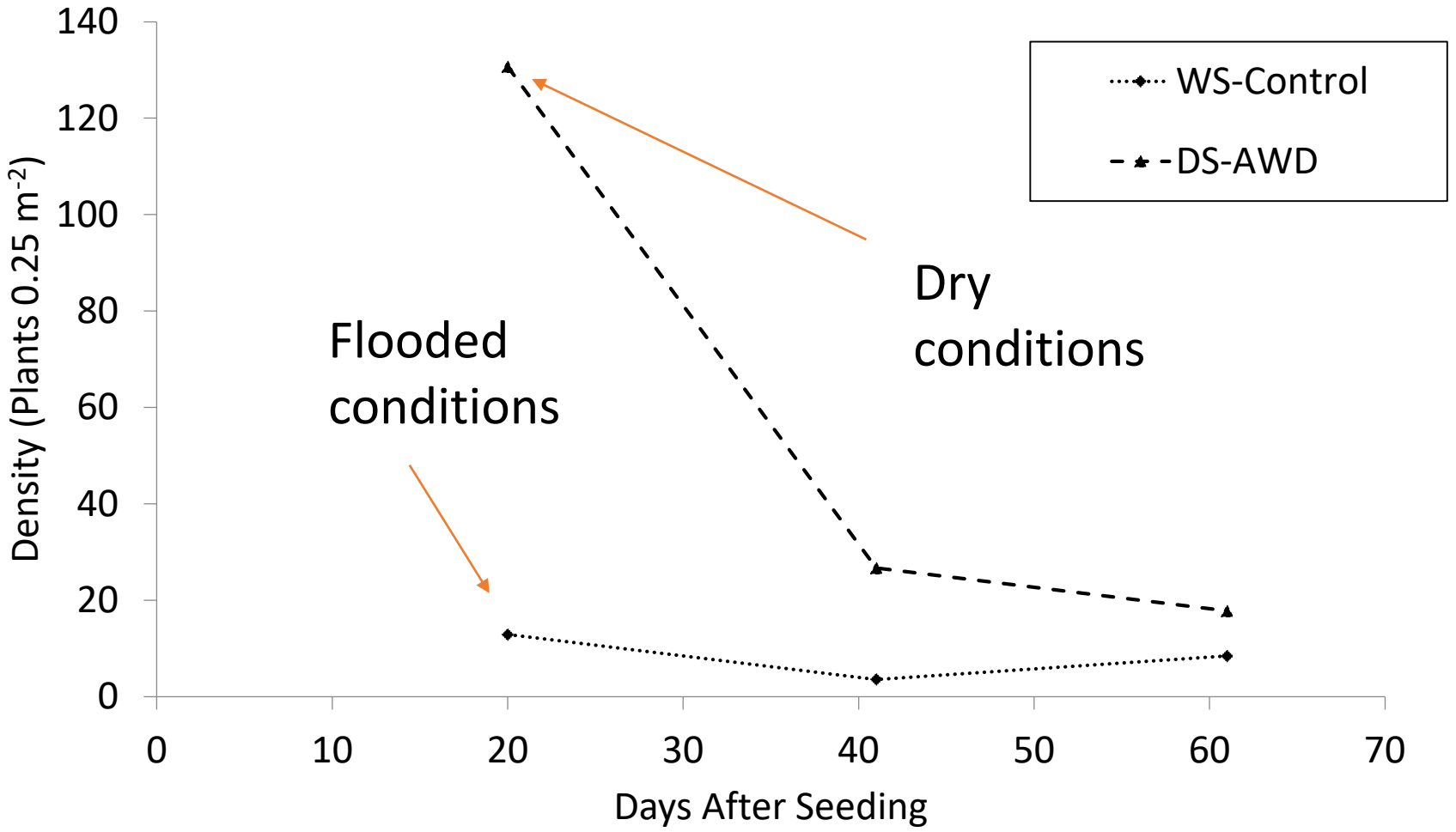
Watergrass Complex (mimic)

- Rapid emergence (most plants emerge around the same time)
- Emerges under all irrigation systems


Watergrass (Flooded)
Weed Emergence (%)
100
90
80
70
60
50
40
30
20
10
0
0
200
400
600
Growing Degree Days (GDD in °C d)
2013 Observed
2014 Observed


Watergrass (Flushed)
Weed Emergence (%)
100
90
80
70
60
50
40
30
20
10
0
0
200
400
600
Growing Degree Days (GDD in °C d)
2013 Observed
2014 Observed

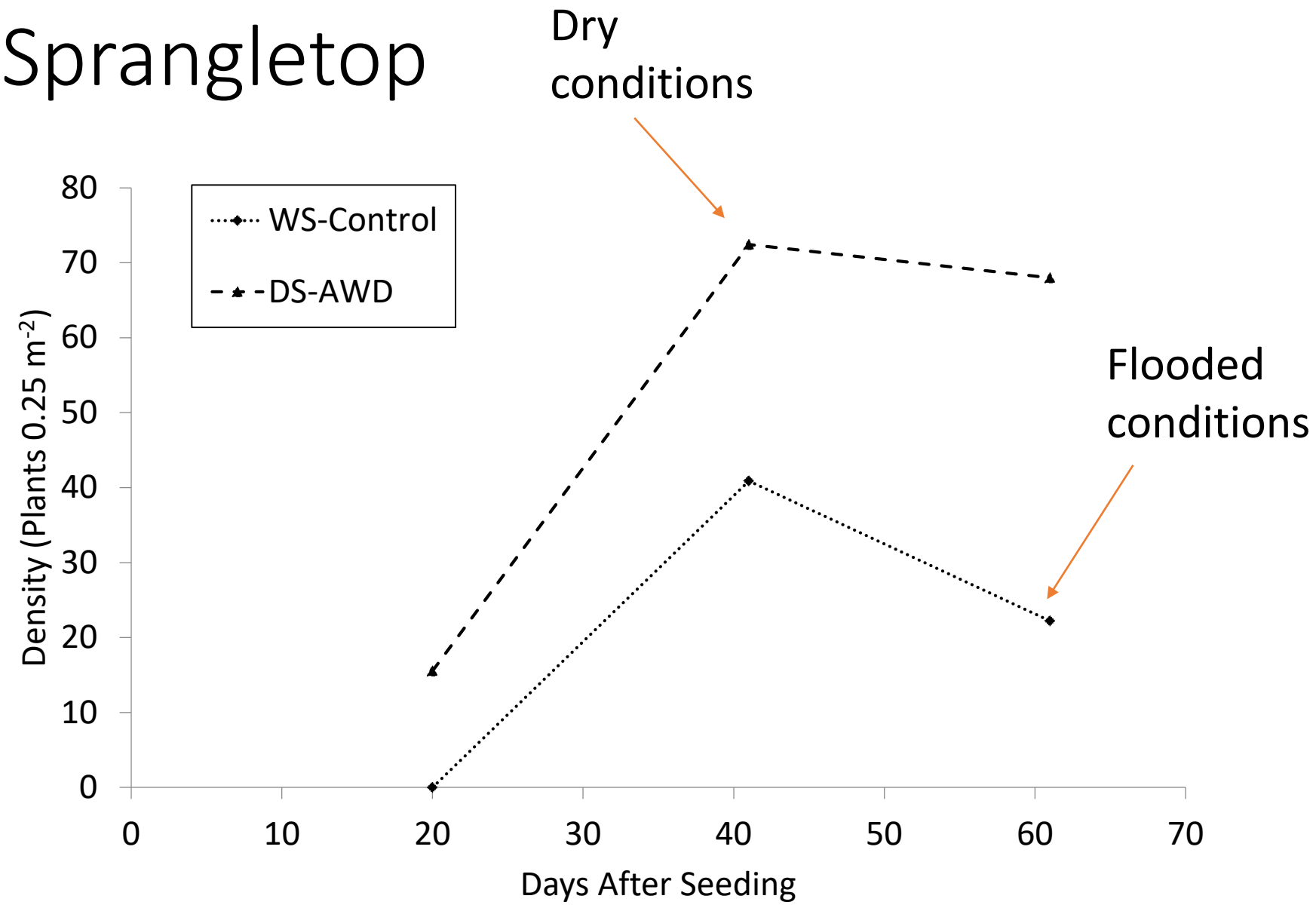
Watergrass Complex (mimic)



Sprangletop

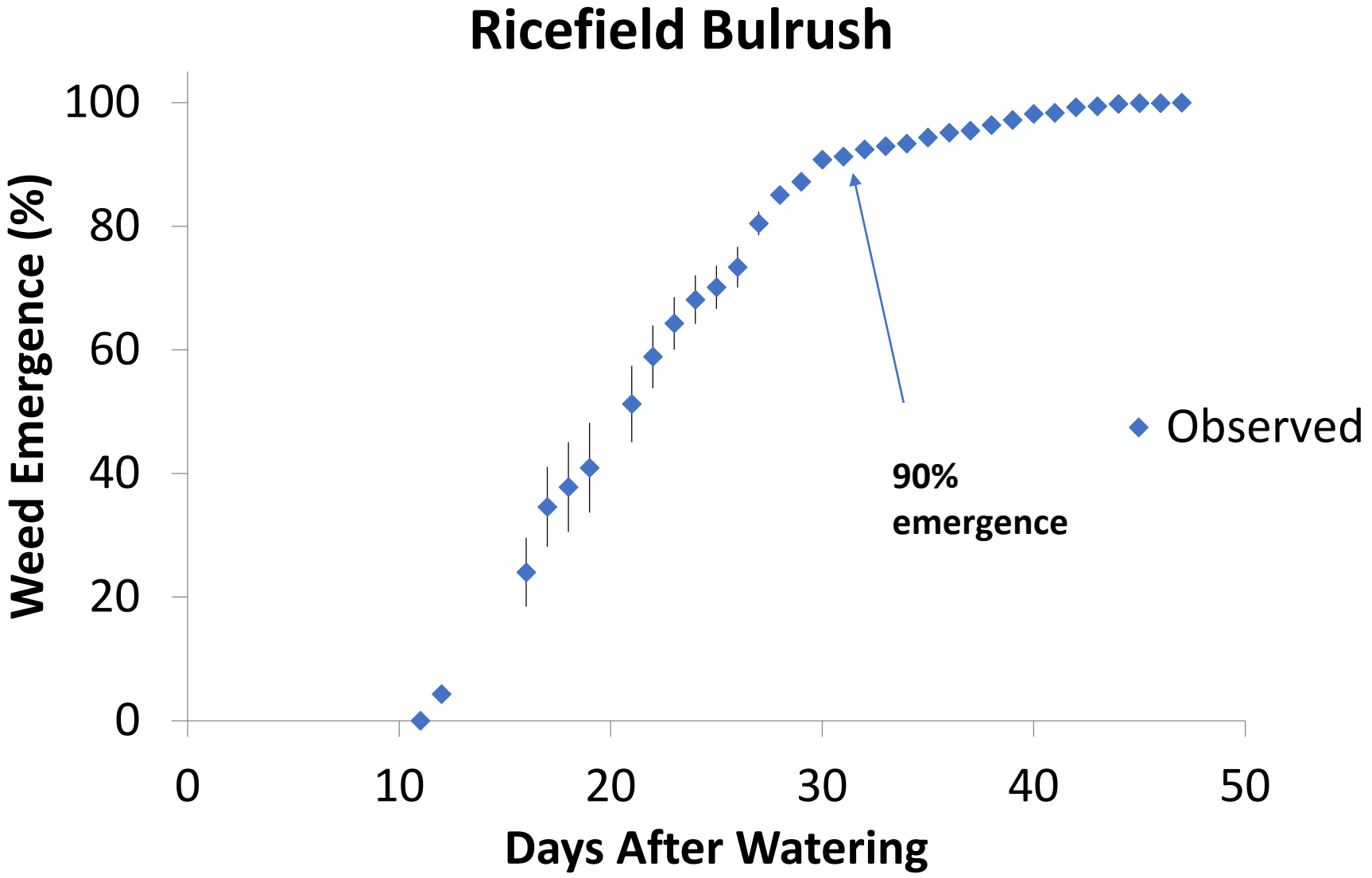
- Emerges under both dry and wet-seeded conditions
- Later emergence initiation in wet-seeded

Sprangletop

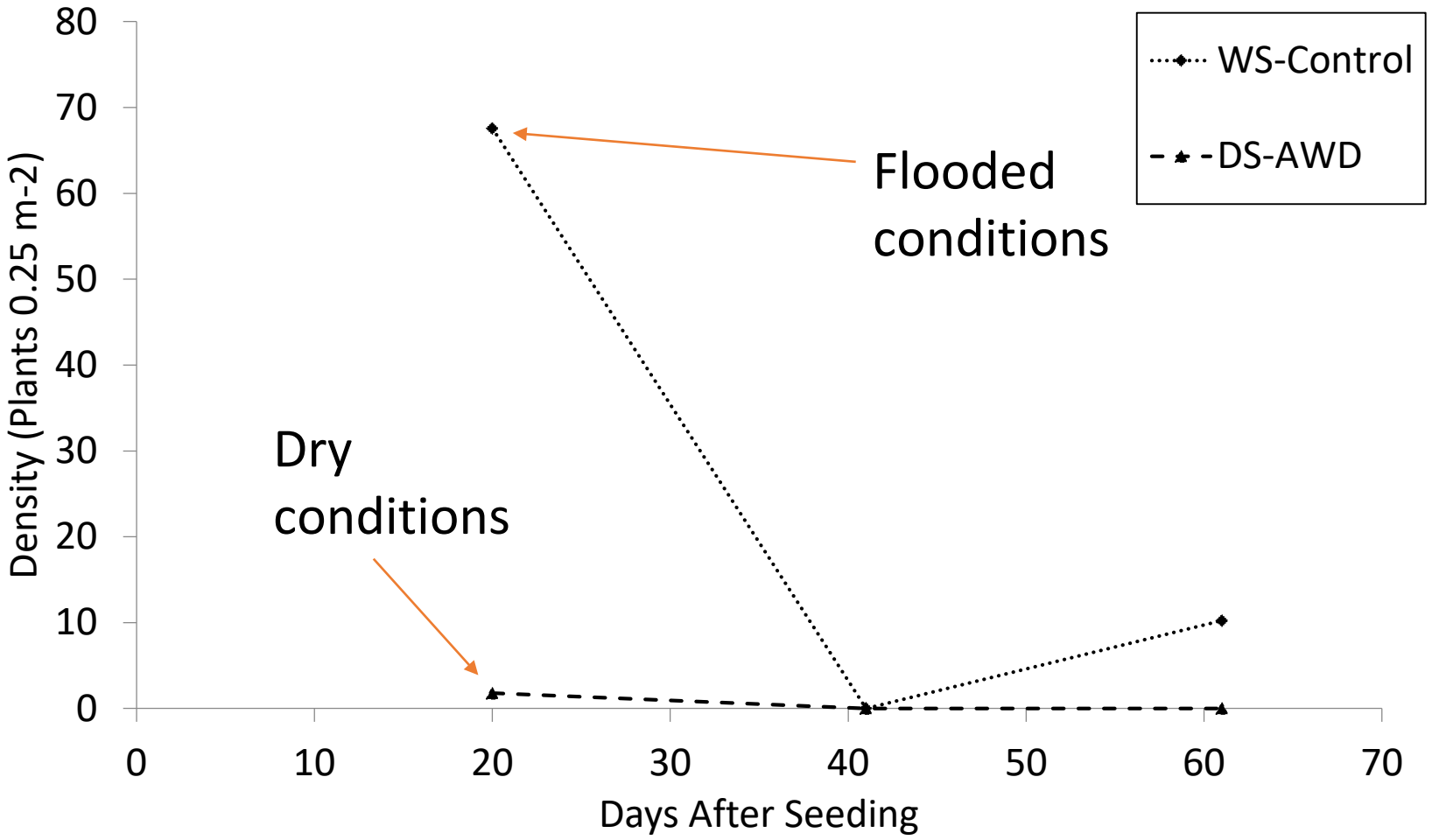


Ricefield Bulrush

- Prolonged emergence period
- Emerges only under flooded conditions

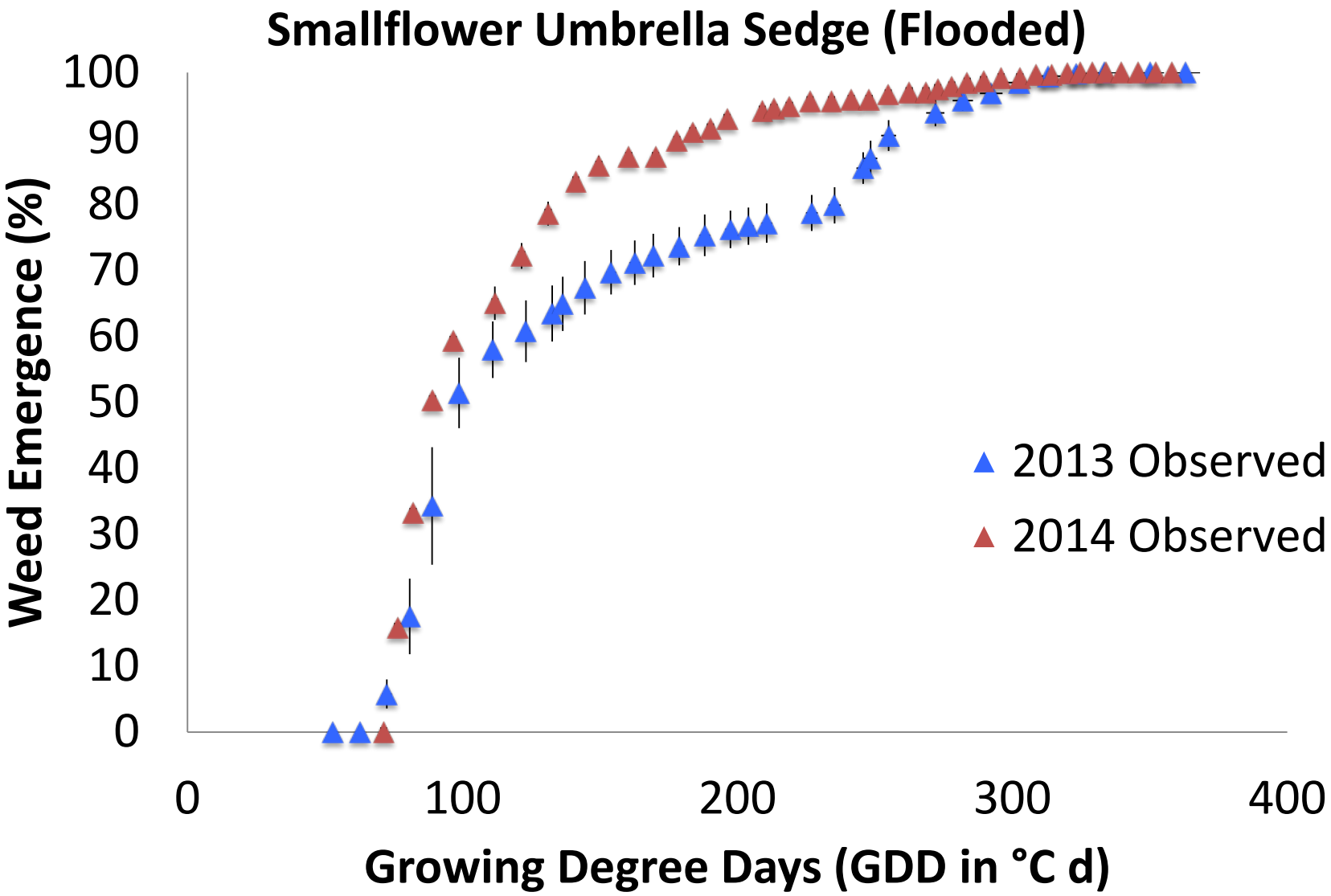

Ricefield Bulrush
Weed Emergence (%)
100
80
60
40
20
0
0
10
20
30
40
50
Days After Watering
90%
emergence
Observed

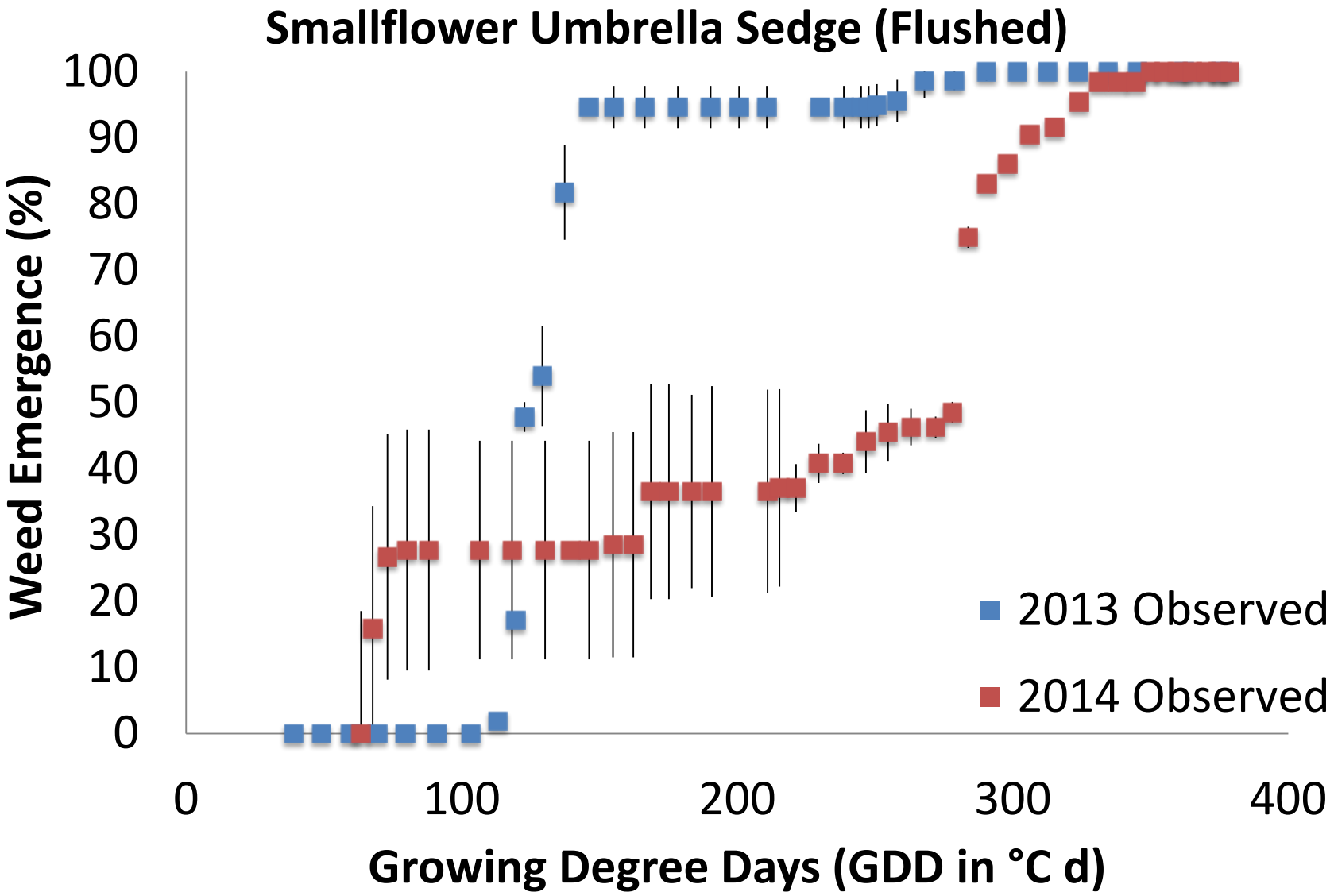
Ricefield Bulrush



Smallflower Umbrella Sedge

- Evidence of biphasic emergence
  - “Second flush”
- Greater numbers of plants emerge under flooded conditions than dry-seeded

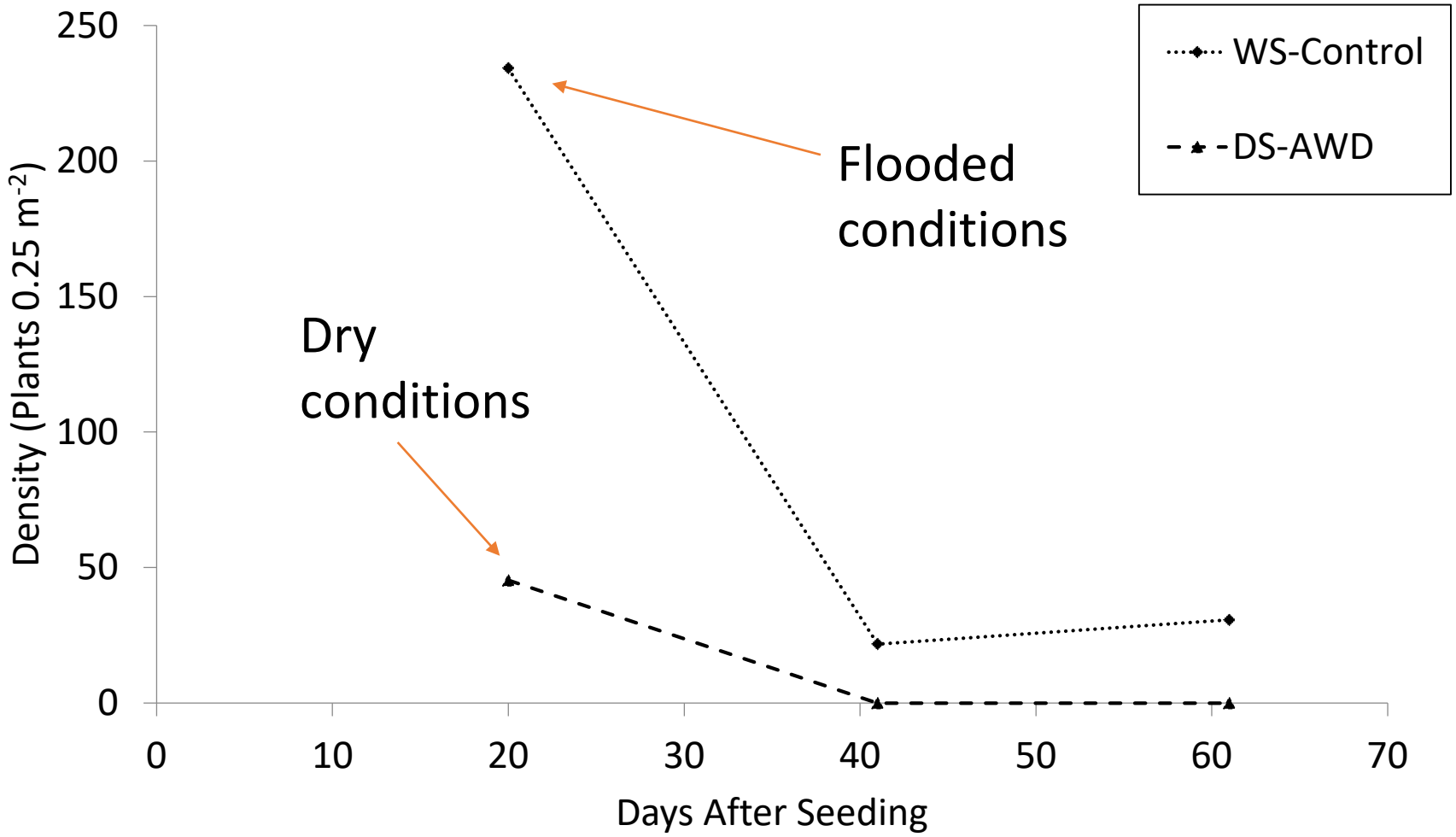

Smallflower Umbrella Sedge (Flooded)
Weed Emergence (%)
100
90
80
70
60
50
40
30
20
10
0
0
100
200
300
400
Growing Degree Days (GDD in °C d)
2013 Observed
2014 Observed


Smallflower Umbrella Sedge (Flushed)
Weed Emergence (%)
100
90
80
70
60
50
40
30
20
10
0
0
100
200
300
400
Growing Degree Days (GDD in °C d)
2013 Observed
2014 Observed

Biphasic Emergence

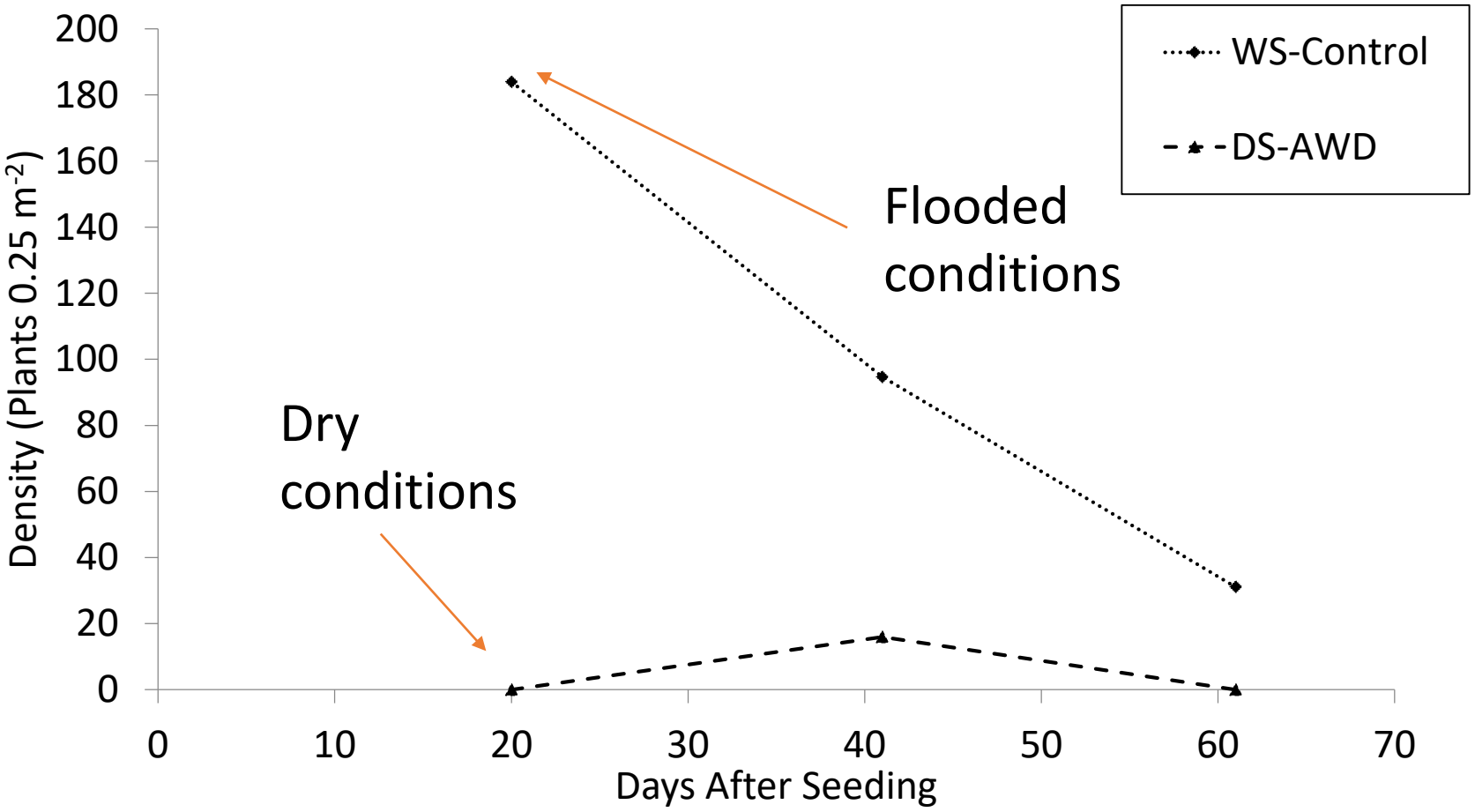
- Indicative of two biotypes in the field:
  - One germinates quickly
    - Low dormancy
  - One germinates more slowly

Smallflower Umbrella Sedge



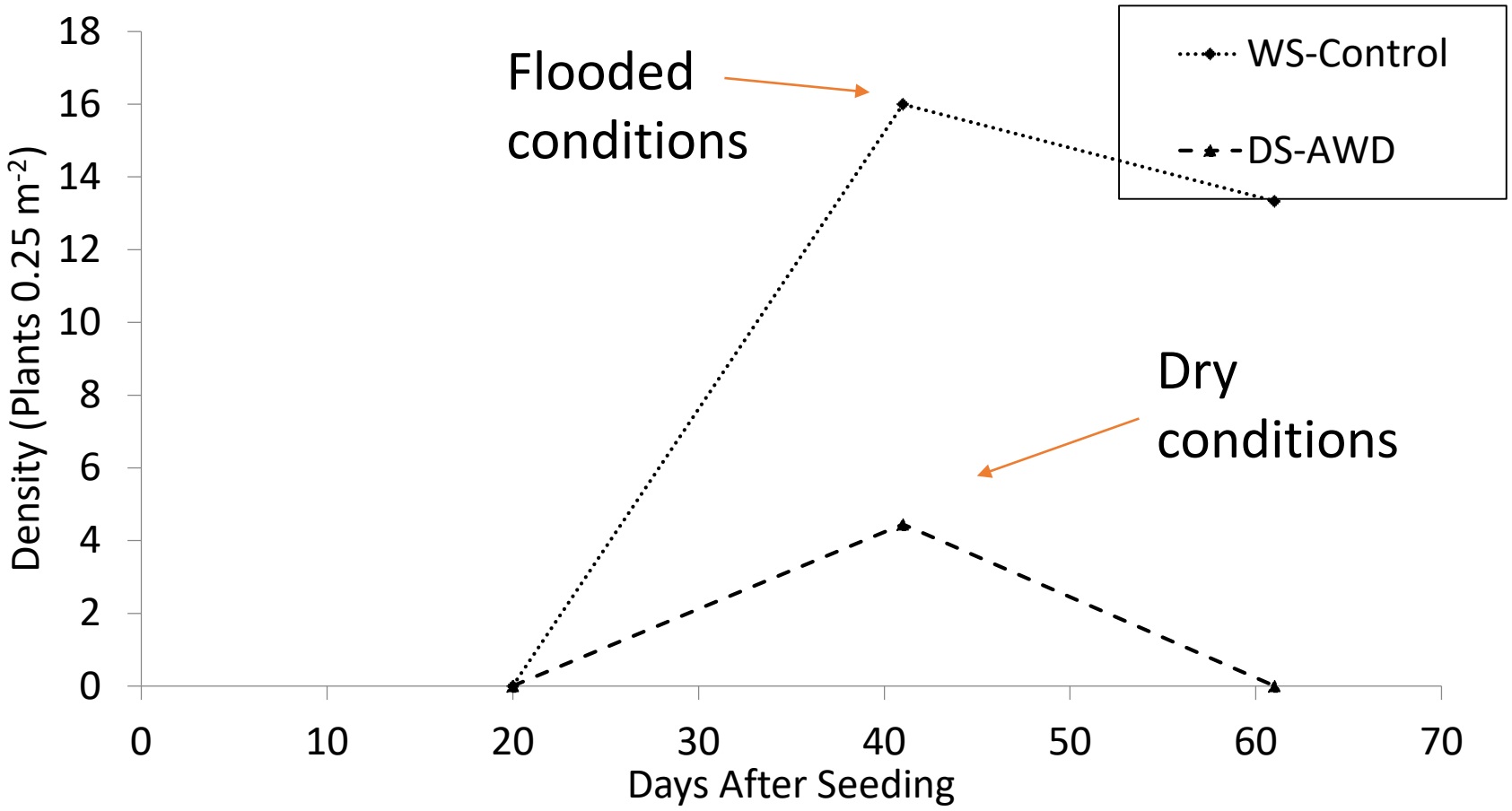
Ducksalad

- No plants by end of season (lifecycle ends)



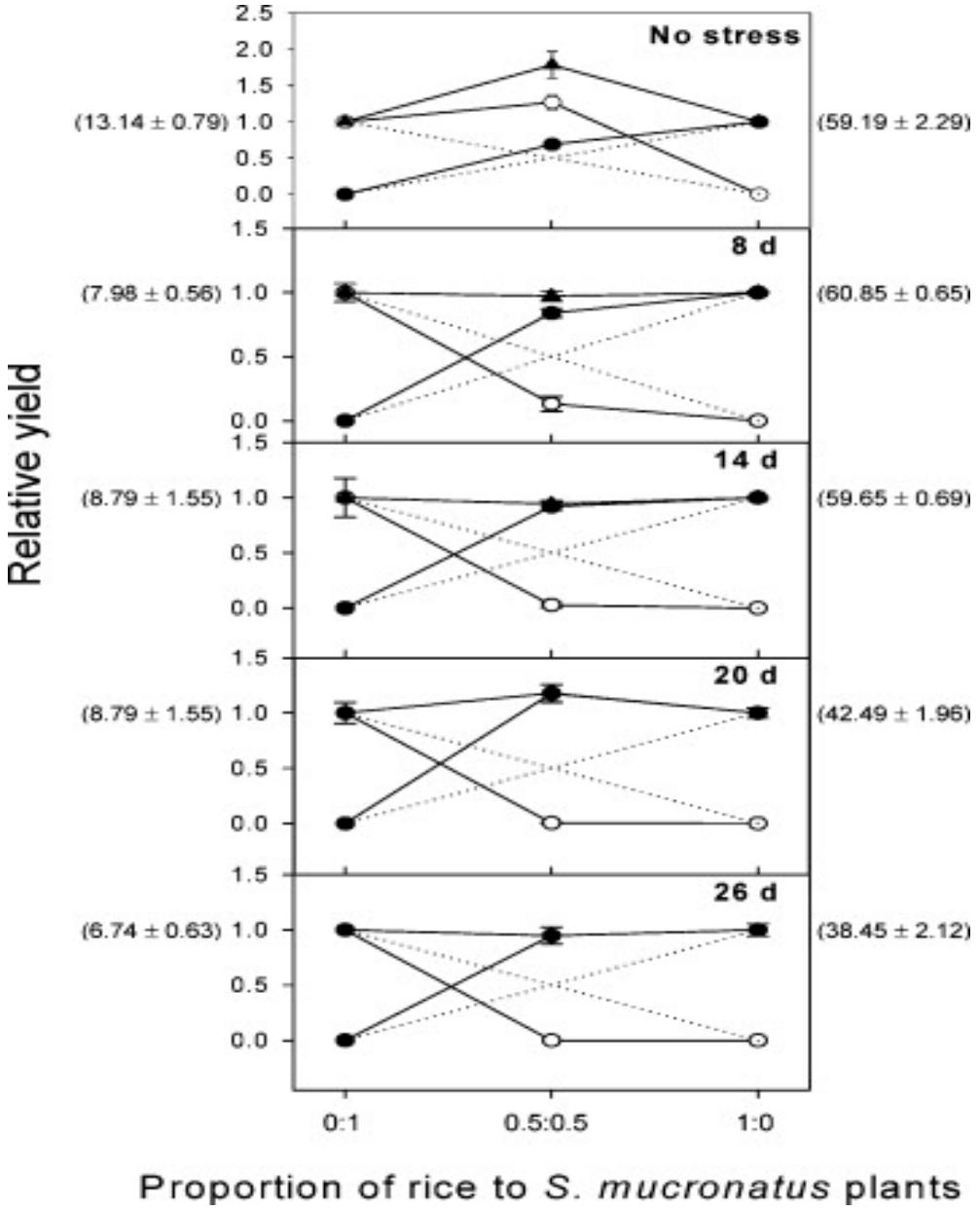
Redstem

- Emergence begins around canopy closure



Irrigation: Dry-Down

- For ricefield bulrush control
- Starts with deep flooding (up to 10 inches approx.)
  - Should reduce grass emergence
- Followed by drain
  - Recommendation from Fischer et al. 2010:
  - 34 DAS
- Unsure of average flood duration under field conditions (grower practices)
- Drain period



rice (●) bulrush (○)

Fischer et al. 2010

Crop Rotation?

- Not a lot of data on this in California rice
- Mostly anecdotal
- Growers are practicing crop rotation, but how much is unknown
- Effects on weeds, diseases, etc. not quantified

- Initial data collection (small survey) this year (2019)

Methods

- Survey mailed to about 1200 people
  - Used Agricultural Commissioner's lists
- Emailed to about 800
  - California Rice Commission email lists

- Response rate
  - Roughly 8%

- Trying to obtain information related to management practices and

Survey Respondents

County	Number of farms managed	Average acreage managed	Std Deviation	Min	Max
Butte	39	754	828	5	300
Sutter	38	1087	1527	28	8500
Yuba	21	597	422	10	1500
Glenn	47	600	1043	24	7000
Colusa	30	991	1923	65	10000
Placer	10	415	224	95	900
Sacramento	9	295	253	40	925
Yolo	16	1837	2530	10	10000
San Joaquin	2	1100	0	1100	1100

Survey Respondents

Grower Demographic	
Rice Grower	145
Pest Control Advisor (PCA)	2
Both Rice grower and PCA	6
Other	3
Average Age	58
Std deviation	13
Min	25
Max	92

	n	%	Acreage
Grew organic rice	11	7.6%	2514
Do not grow organic rice	134	92.4%	1050

Crop Rotation

	Crop rotation
# of responses	139
% did in 2018	12.2%
Average acreage	965
Std deviation	989

Most common crops rotated:

- Sunflowers (10)
- Tomatoes (8)
- Wheat (5)
- Safflower (4)
- Vetch
- Corn
- Bell beans
- Forage hay
- Oatseed
- Pea seed
- Vineseed
- Melons
- Grain
- Dry beans
- Barley
- Wild rice
- Fallow

Crop Rotation

Participants who did not rotate crops (87.8%):

- Soil type (79)
- Field layout (48)
- Marketability of rotation crops (46)
- Lack of equipment/resources (32)
- Landlord/lease agreements
- Small acreage
- Water shortages or flooding
- Alternative winter land use (e.g. duck hunting)

Why Crop Rotation in rice?

- Allows for dry conditions
  - Different weed species emerge
- Can utilize tillage in some crops (not possible during the season in rice)
- Should reduce weed seed bank over time
- Unknown number of years or crops that will maximize weed seed reduction

CROP ROTATION

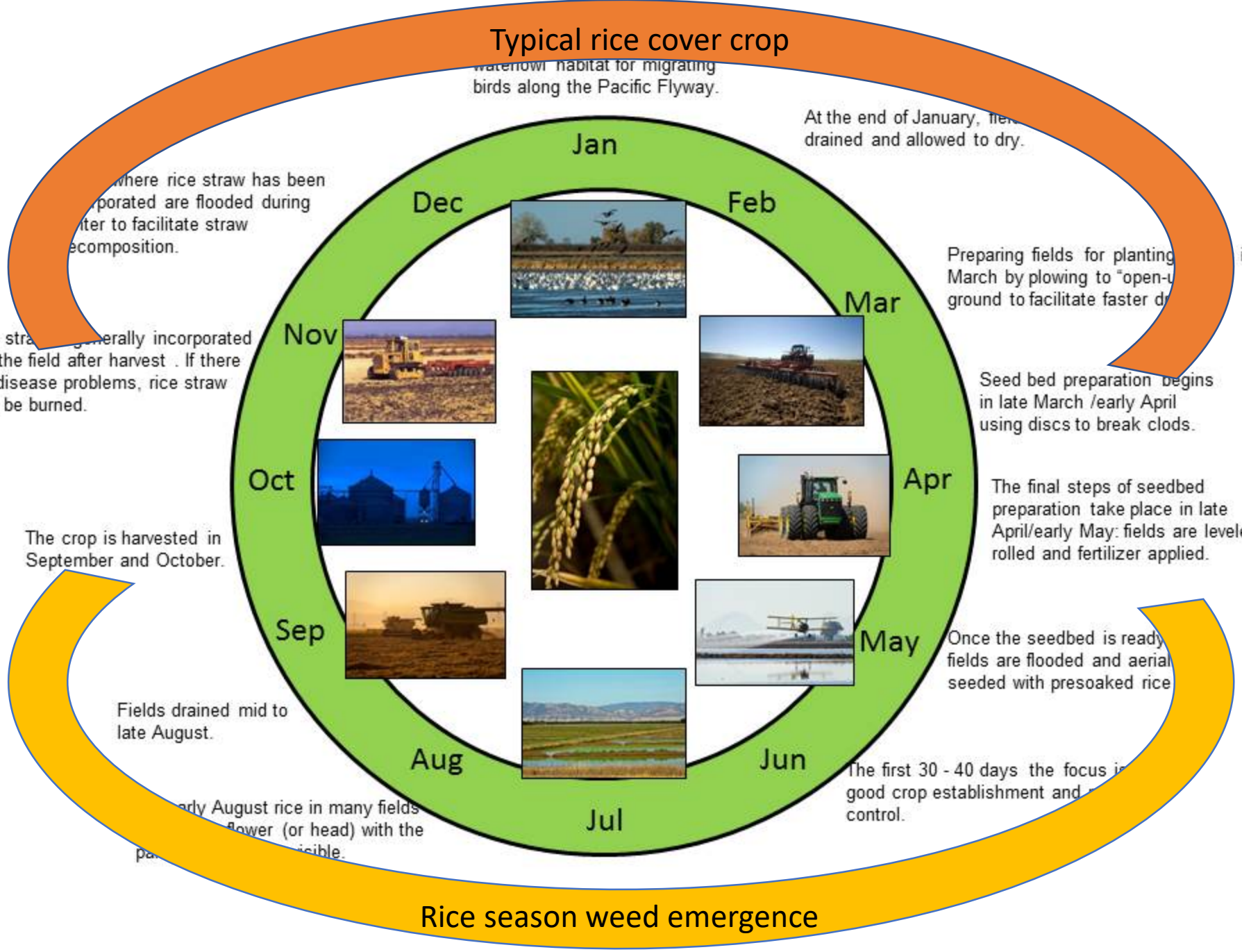
WEED OUTCOME	YEAR 1	YEAR 2	YEAR 3	YEAR 4
Poor				
Fair				
Better						
Best				

Cover Cropping

- Currently used in rice for adding nitrogen (and biomass/carbon) to the soil
- Planted in the fall, tilled under in the spring

- Can it be used for weed control?

Typical rice cover crop



Rice season weed emergence

Photos courtesy of California Rice Commission

When to use

- Cover crop season before not overwinter
- Can use cover crop for weed suppression if planted April-May
- Similar effects to crop rotation

Current use of non-chemical methods in rice

- Not a lot is known….
- Some preliminary data from our survey
- DID NOT include cover cropping
- Unfortunately, hard to correlate the data with county, since many growers farmed over multiple counties
- Respondents = approximately 6% of rice growers
- Planning to redo this survey every 5 to 10 years, should give a better picture of farming practices

Growers: Practice

		Drill /dry seeding	Winter flooding	Burning	Stale seedbed	Crop rotation
	# of responses	152	151	150	143	139
	% did in 2018	9.2%	82.8%	25.3%	7.0%	12.2%
	Average acreage	756	835	108	272	965
	Std deviation	750	1108	115	321	989
Duration:	(122 responses)					
	<1 Month		3.3%			
	1 Month		2.5%			
	2 Months		13.1%			
	3 Months		56.6%			
	4 Months or more		24.6%			

Questions?