

Evaluating Group 15 Herbicide Efficacy on Pigweed Species in Sunflower (22-W01)

**Quincy Law*, Kirk Howatt,
Joseph Ikley, and Keith Biggers**

* quincy.law@ndsu.edu

NDSU

PLANT SCIENCES



Outline

- Introduction
- Research objectives
- Methodology
- Results
- Discussion



Pigweeds (*Amaranthus* spp.)

- Monoecious pigweeds
 - Redroot pigweed, Powell amaranth, others
- Dioecious pigweeds
 - Waterhemp, Palmer amaranth



Pigweed Control in Sunflower

- No effective foliar herbicides for ALS-resistant pigweed control in sunflower
 - Reliance on soil residual herbicides and crop competition



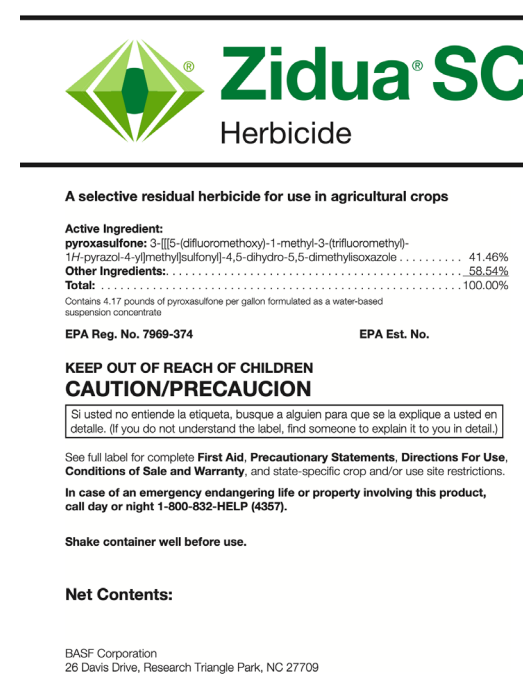
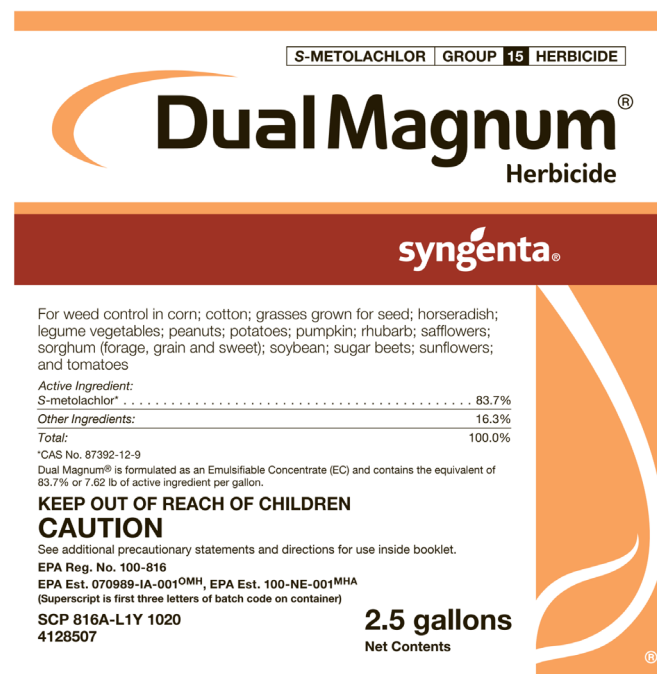
Pigweed Control in Sunflower

- No effective foliar herbicides for ALS-resistant pigweed control in sunflower
 - Reliance on soil residual herbicides and crop competition
- Soil residual options limited to Groups 3, 14, and 15
 - Pigweed species are resistant to all three SOAs



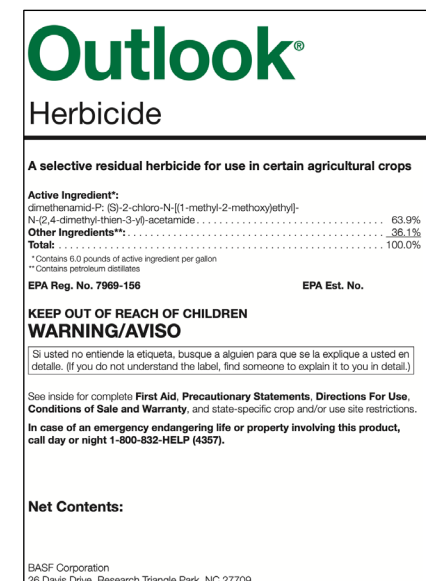
Group 15 Herbicides in Sunflower

- Group 15 herbicides inhibit very long-chain fatty acid synthesis
 - S-metolachlor and pyroxasulfone are labeled in sunflower



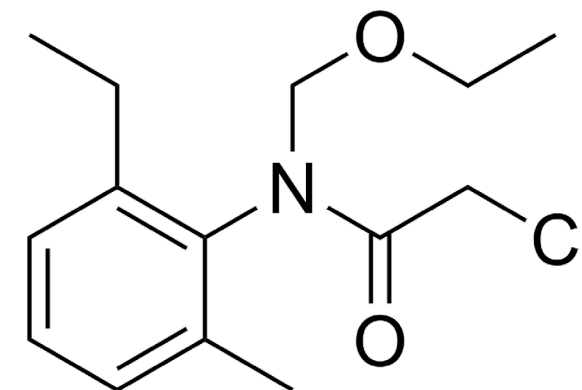
Background

- Group 15 herbicides inhibit very long-chain fatty acid synthesis
 - S-metolachlor and pyroxasulfone are labeled in sunflower
- Acetochlor, dimethenamid-P, and flufenacet are three other Group 15 herbicides that may be:
 - Safe on sunflower
 - Efficacious on pigweeds



Acetochlor on Sunflower

- **Acetochlor** at 1.78 lb a.i. A⁻¹ (Jursik et al., 2016)
 - Caused up to 30% sunflower crop injury
 - Reduced growth
 - Shortened internodes
 - Did not reduce yield
- **Acetochlor** at ≥2.06 lb a.i. A⁻¹ (Brighenti et al., 1998)
 - Reduced oil seed content and yield of 'M-742'



Other Group 15 Herbicides on Sunflower

- **Dimethenamid-P** at 0.89 lb a.i. A⁻¹
 - Good tolerance ($\leq 12\%$) (Jursik et al., 2016)
- **S-metolachlor** at 1.03 lb a.i. A⁻¹
 - Very good tolerance ($\leq 6\%$) (Jursik et al., 2016)
- **Flufenacet** at 0.32 lb a.i. A⁻¹ + linuron or aclonifen
 - Relatively safe (Pannacci et al., 2007)



Objectives

- Determine the efficacy/influence of Group 15 herbicides, with and without sulfentrazone, on:
 - Pigweed control
 - Sunflower injury
 - Sunflower yield
 - Pesticide residue



Methodology

- Field trial, randomized complete block design
 - 4 blocks
 - 8×2 factorial
 - 16 total treatments
 - 8 herbicides
 - 2 sulfentrazone rates
 - 0 oz a.i. A⁻¹
 - 4 oz a.i. A⁻¹
- Non-oilseed hybrid

Herbicide	Trade name	Rate	Product rate
		lb a.i. A ⁻¹	A ⁻¹
Non-treated	n/a	n/a	n/a
Hand-weeded	n/a	n/a	n/a
S-metolachlor	Dual Magnum	1.9	2 pt EC
Pyroxasulfone	Zidua	0.21	6.5 fl oz SC
Acetochlor	Warrant	1.5	2 qt ME
Dimethenamid-P	Outlook	1.5	2 qt EC
Flufenacet	Sunfire, Cadou	0.75	23 fl oz SC
Pendimethalin	Prowl H2O	1.5	3.2 pt ACS



Methodology

- Field trial, randomized complete block design
 - 4 blocks
 - 8×2 factorial
 - 16 total treatments
 - 8 herbicides
 - 2 sulfentrazone rates
 - 0 oz a.i. A⁻¹
 - 4 oz a.i. A⁻¹
- Non-oilseed hybrid

Herbicide	Trade name	Rate	Product rate
		lb a.i. A ⁻¹	A ⁻¹
Non-treated	n/a	n/a	n/a
Hand-weeded	n/a	n/a	n/a
S-metolachlor	Dual Magnum	1.9	2 pt EC
Pyroxasulfone	Zidua	0.21	6.5 fl oz SC
Acetochlor	Warrant	1.5	2 qt ME
Dimethenamid-P	Outlook	1.5	2 qt EC
Flufenacet	Sunfire, Cadou	0.75	23 fl oz SC
Pendimethalin	Prowl H2O	1.5	3.2 pt ACS



Methodology

- Field trial, randomized complete block design
 - 4 blocks
 - 8×2 factorial
 - 16 total treatments
 - 8 herbicides
 - 2 sulfentrazone rates
 - 0 oz a.i. A⁻¹
 - 4 oz a.i. A⁻¹
- Non-oilseed hybrid

Herbicide	Trade name	Rate	Product rate
		lb a.i. A ⁻¹	A ⁻¹
Non-treated	n/a	n/a	n/a
Hand-weeded	n/a	n/a	n/a
S-metolachlor	Dual Magnum	1.9	2 pt EC
Pyroxasulfone	Zidua	0.21	6.5 fl oz SC
Acetochlor	Warrant	1.5	2 qt ME
Dimethenamid-P	Outlook	1.5	2 qt EC
Flufenacet	Sunfire, Cadou	0.75	23 fl oz SC
Pendimethalin	Prowl H2O	1.5	3.2 pt ACS



Methodology

- Field trial, randomized complete block design
 - 4 blocks
 - 8×2 factorial
 - 16 total treatments
 - 8 herbicides
 - 2 sulfentrazone rates
 - 0 oz a.i. A⁻¹
 - 4 oz a.i. A⁻¹
- Non-oilseed hybrid

Herbicide	Trade name	Rate	Product rate
		lb a.i. A ⁻¹	A ⁻¹
Non-treated	n/a	n/a	n/a
Hand-weeded	n/a	n/a	n/a
S-metolachlor	Dual Magnum	1.9	2 pt EC
Pyroxasulfone	Zidua	0.21	6.5 fl oz SC
Acetochlor	Warrant	1.5	2 qt ME
Dimethenamid-P	Outlook	1.5	2 qt EC
Flufenacet	Sunfire, Cadou	0.75	23 fl oz SC
Pendimethalin	Prowl H2O	1.5	3.2 pt ACS



Research Sites

- **Site 1:** Fargo, ND
 - Waterhemp and other monoecious pigweeds
 - Bare ground
- **Site 2:** Valley City, ND
 - Palmer amaranth, waterhemp, and other monoecious pigweeds
- **Site 3:** Fargo, ND
 - Waterhemp and other monoecious pigweeds
 - Yield, residue analysis



Data Collected

- Visual pigweed control (%) and herbicide injury (%) were evaluated every 2 weeks after planting (WAP)
- Pigweed biomass collected from all three sites
- Sunflower biomass collected from Site 2
- Sunflower yield, herbicide residue samples, and pigweed biomass collected from Site 3

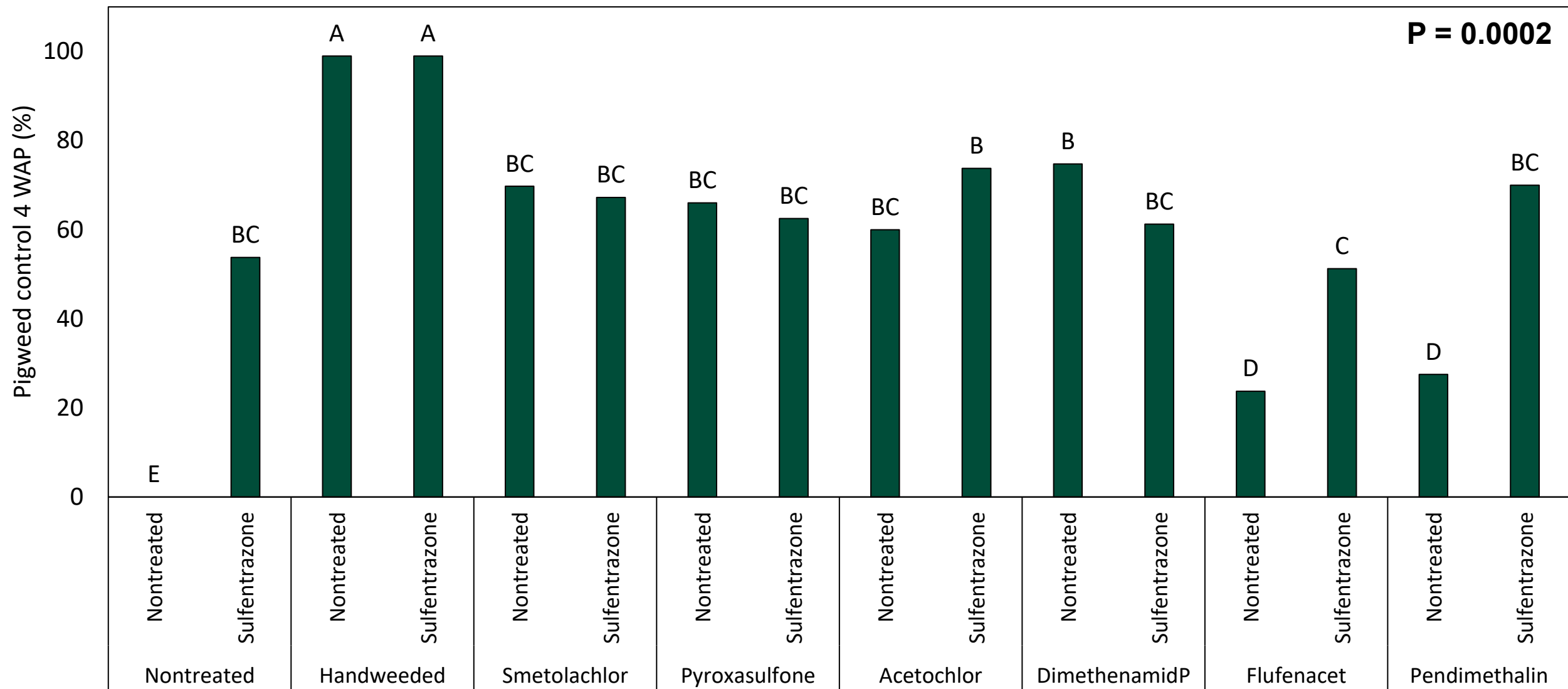


Results – Sunflower Injury

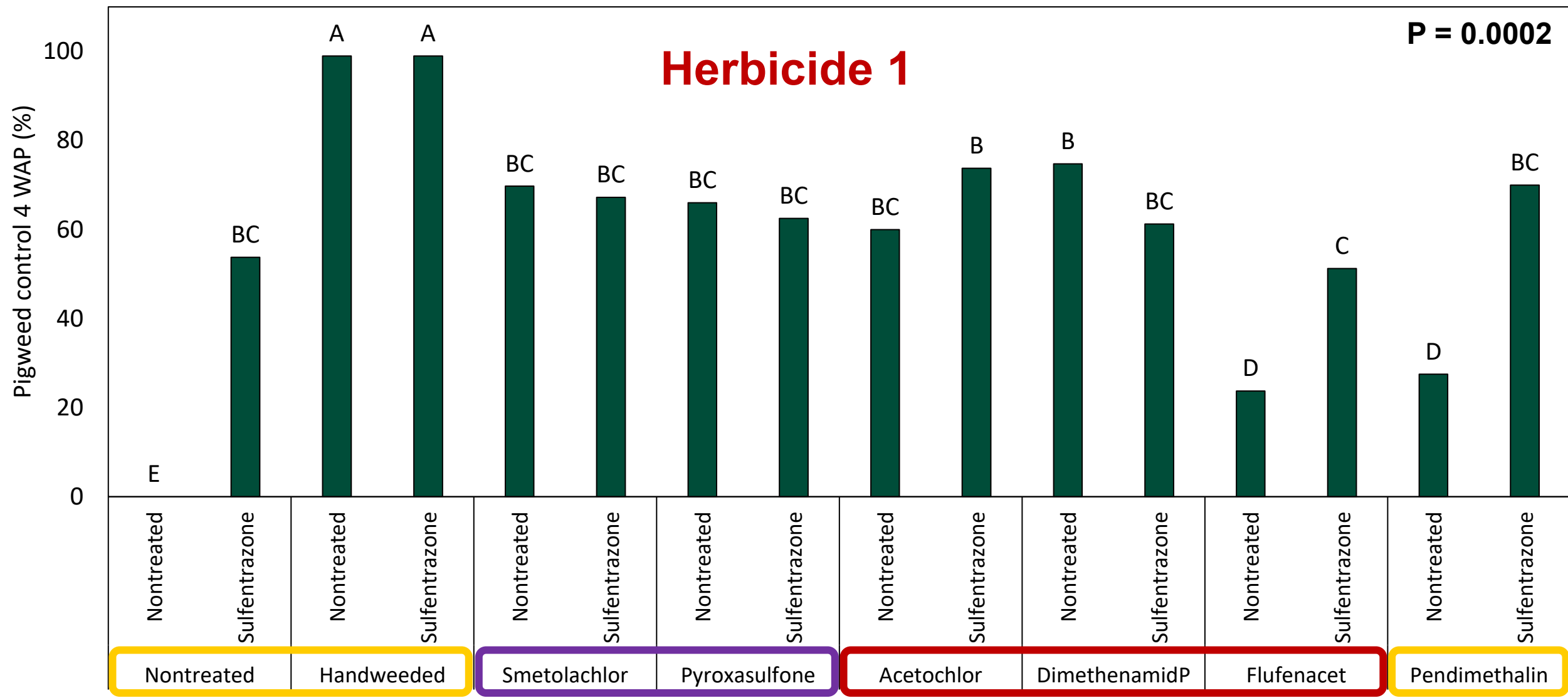
- Apparent injury observed on young, individual plants
 - Plot-level injury $\leq 10\%$
 - Not statistically significant



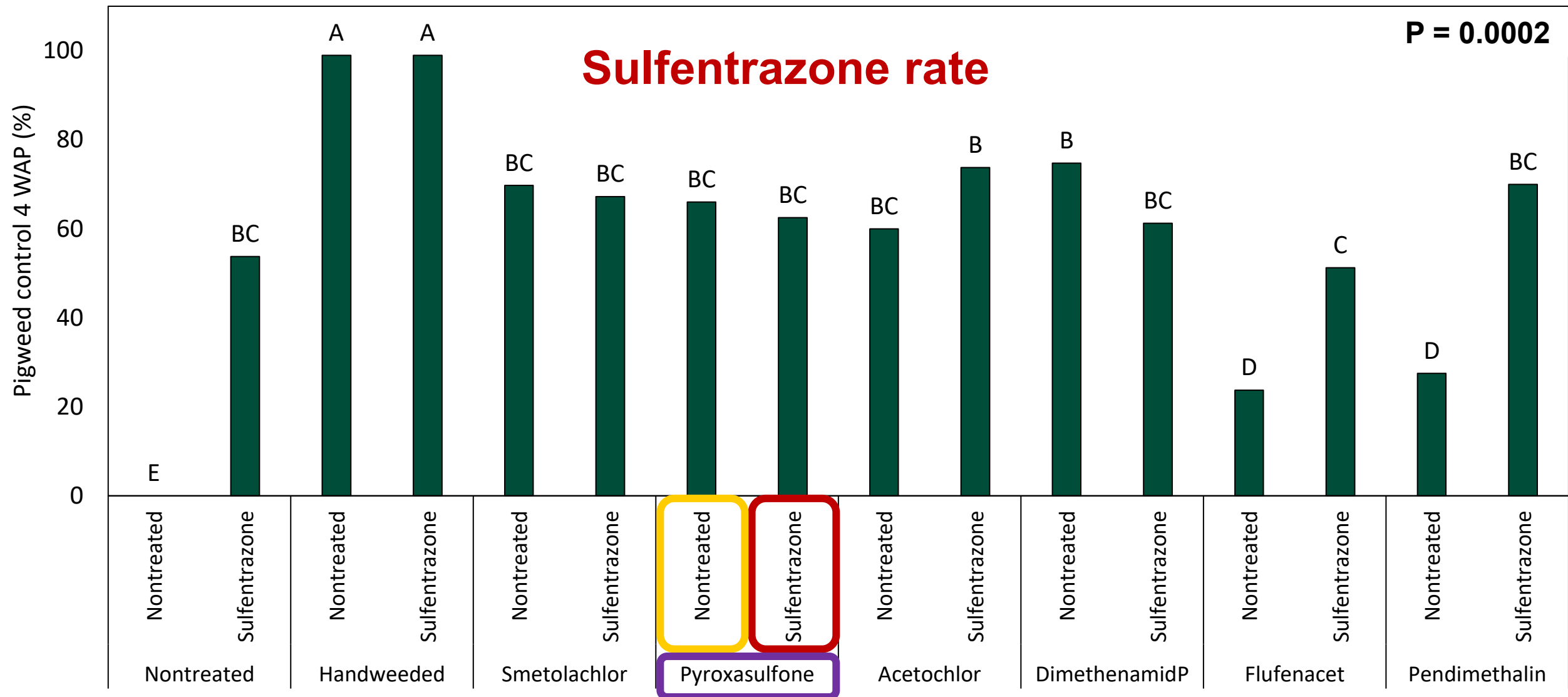
Results – Pigweed Control 4 WAP (Site 1)



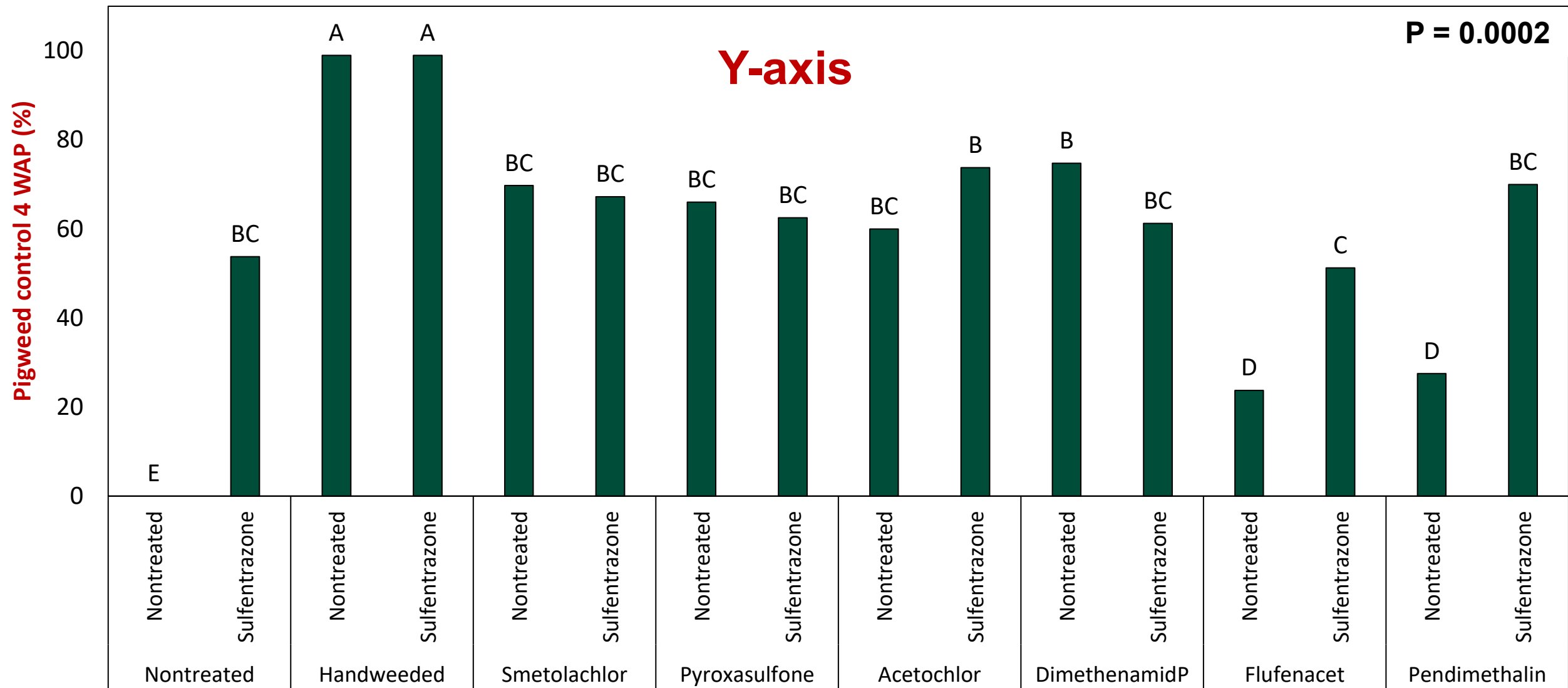
Results – Pigweed Control 4 WAP (Site 1)



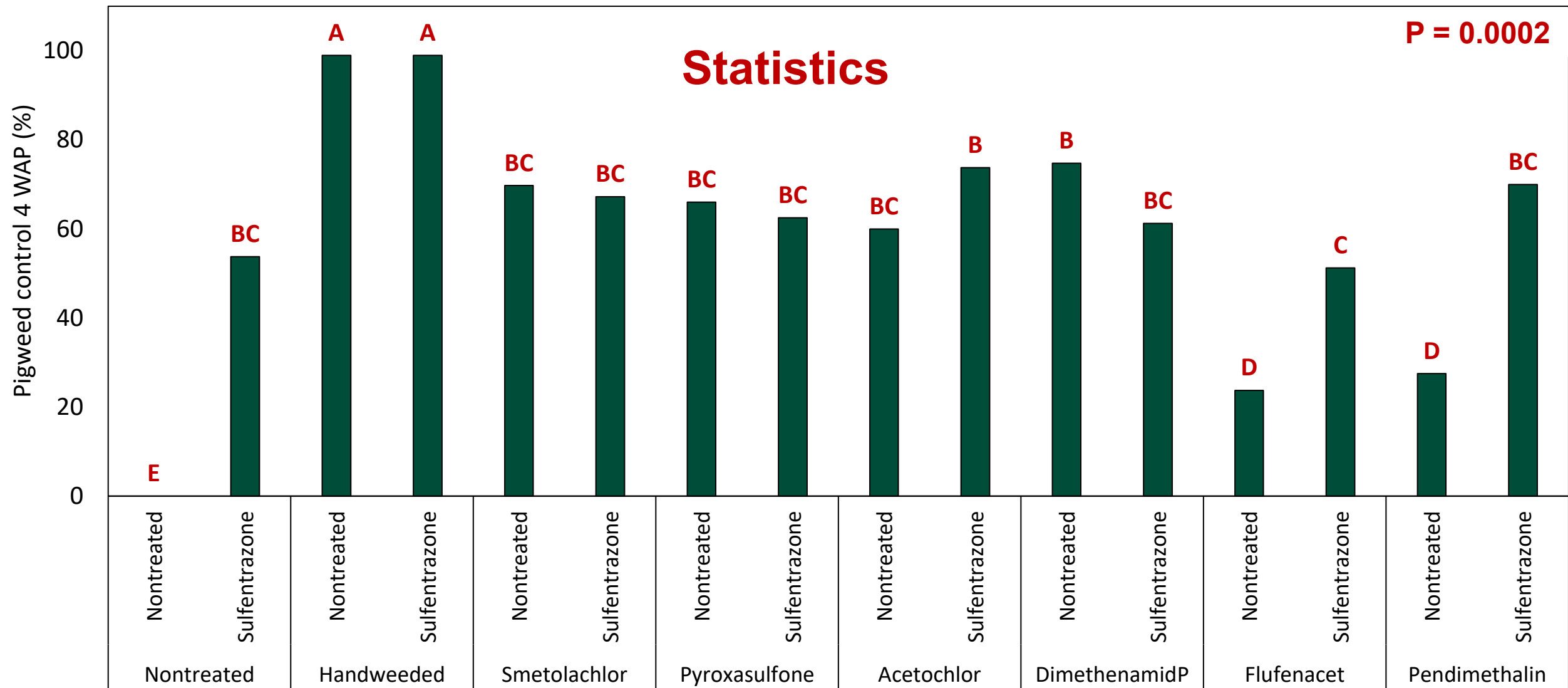
Results – Pigweed Control 4 WAP (Site 1)



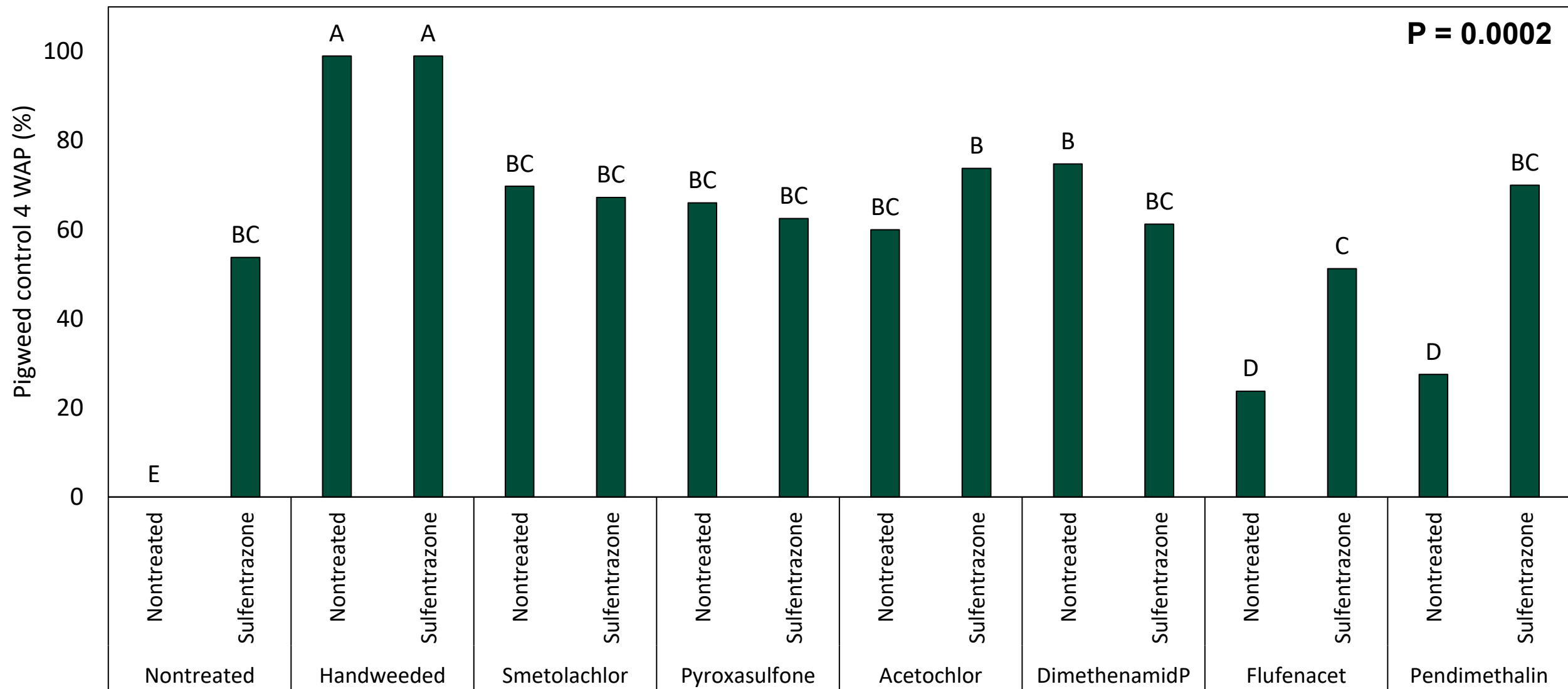
Results – Pigweed Control 4 WAP (Site 1)



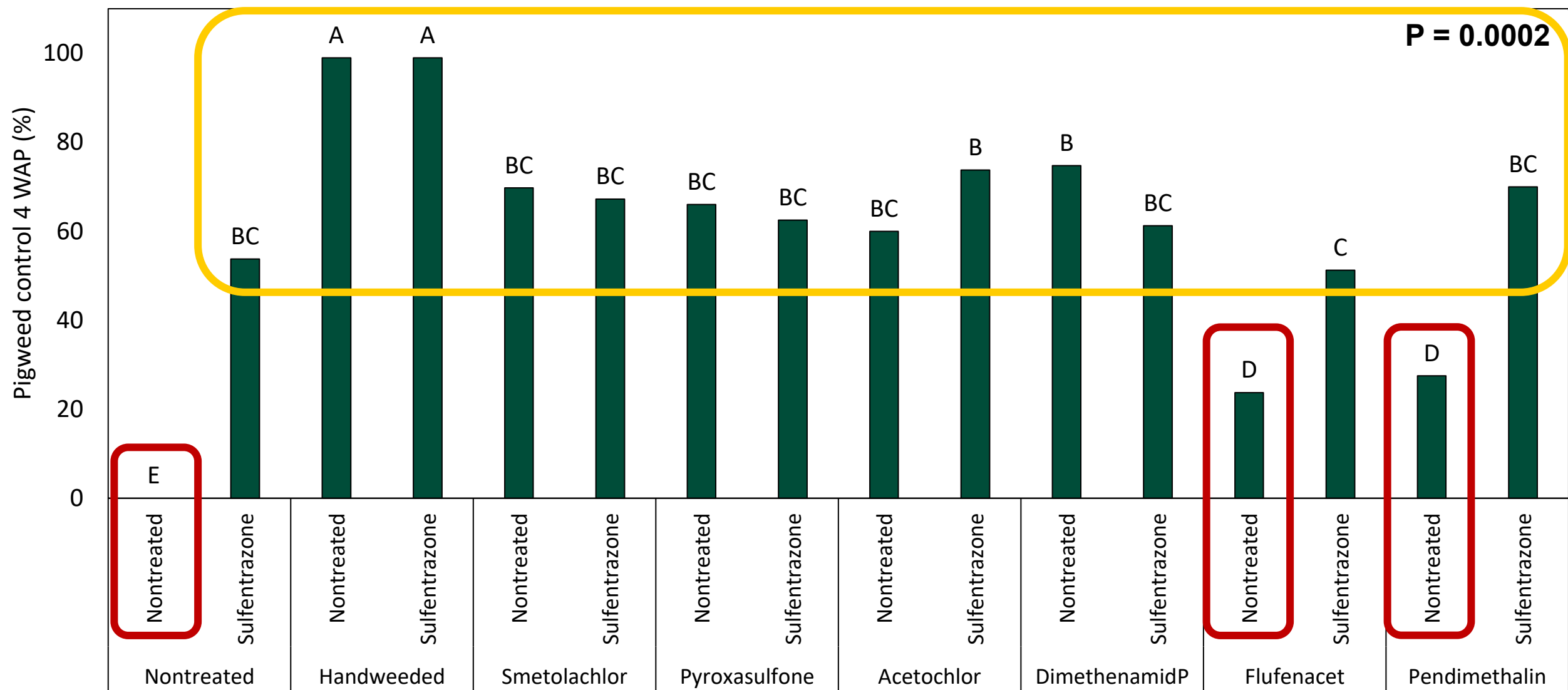
Results – Pigweed Control 4 WAP (Site 1)



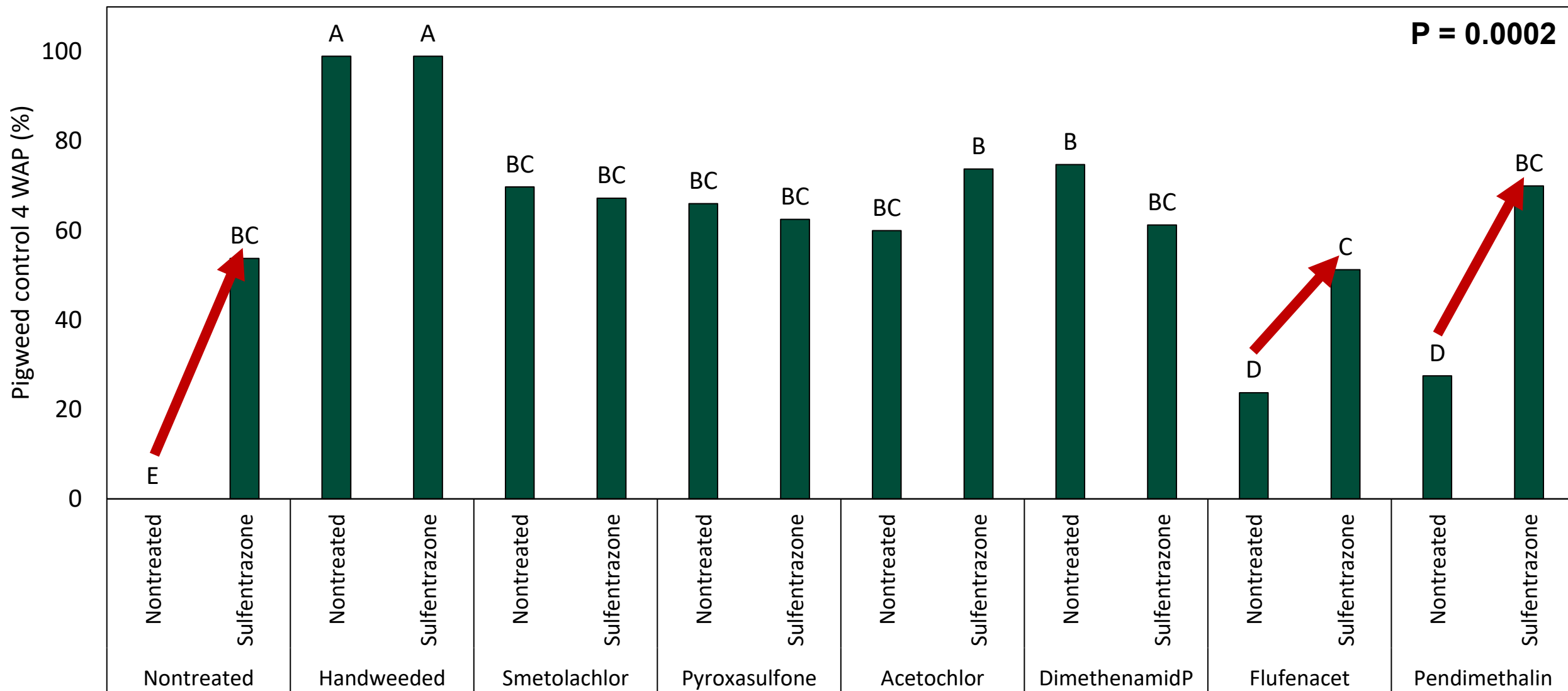
Results – Pigweed Control 4 WAP (Site 1)



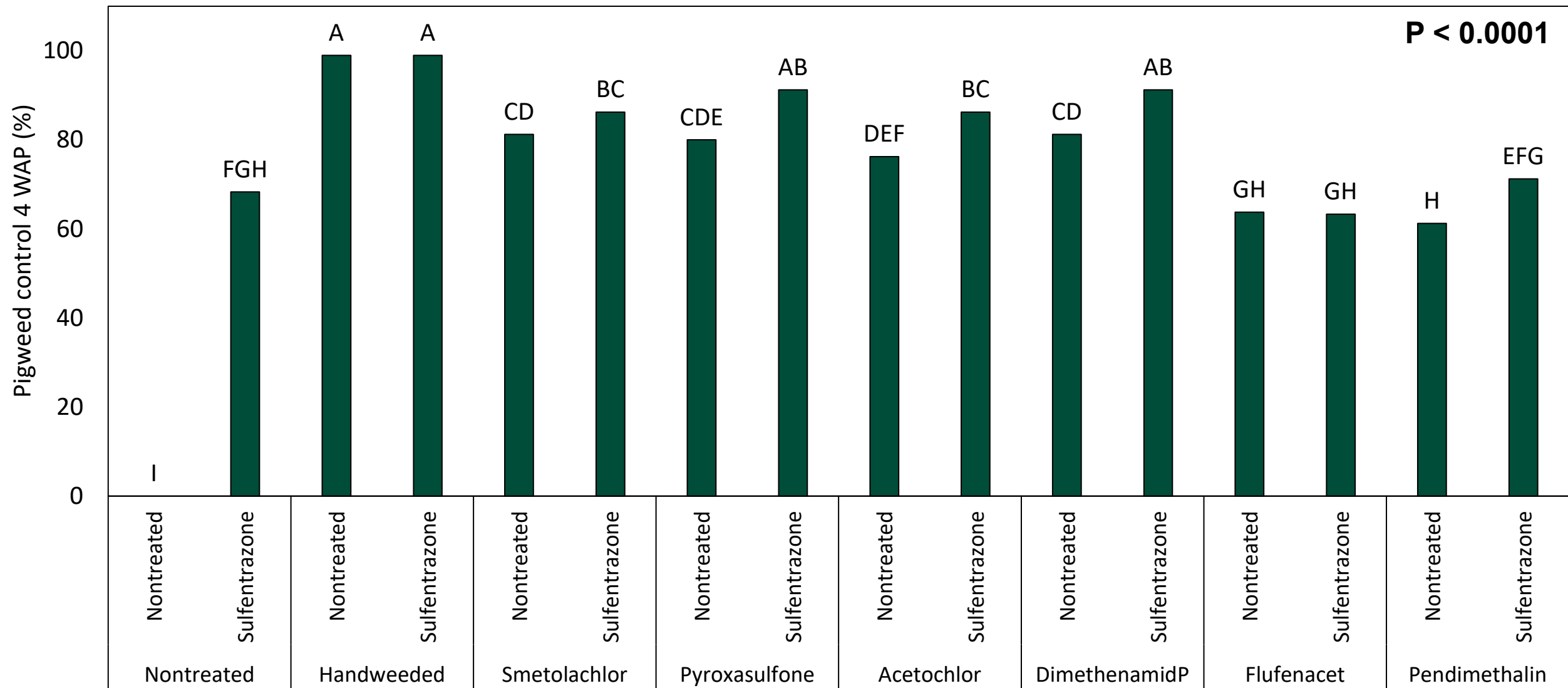
Results – Pigweed Control 4 WAP (Site 1)



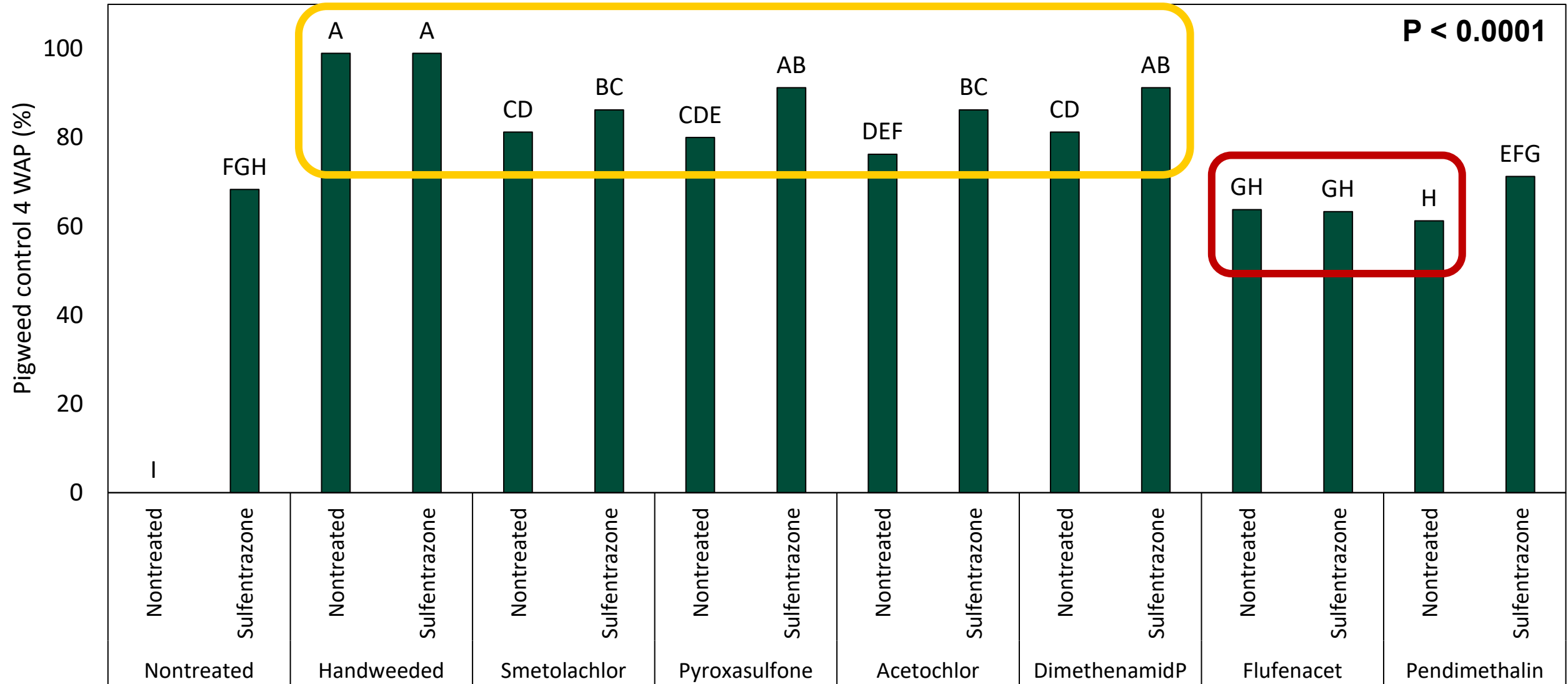
Results – Pigweed Control 4 WAP (Site 1)



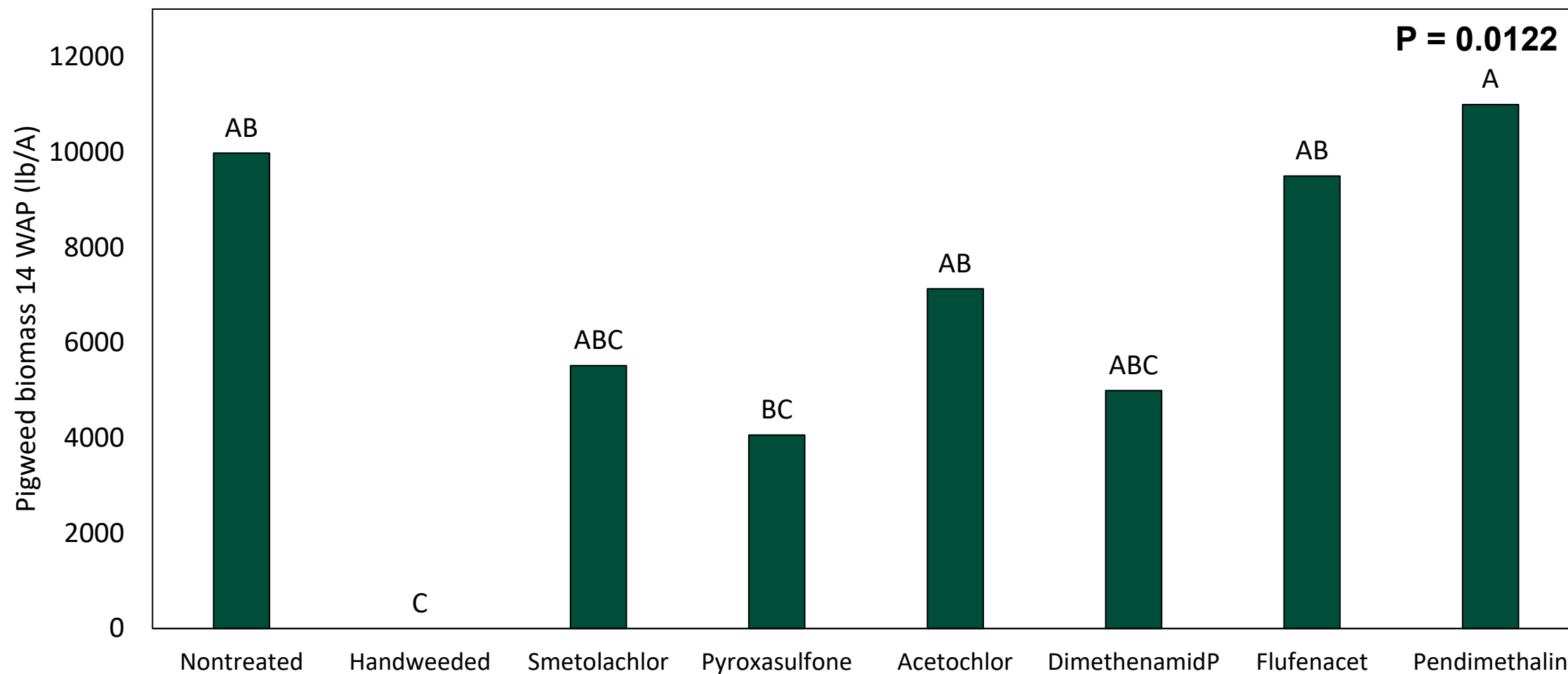
Results – Pigweed Control 4 WAP (Site 2)



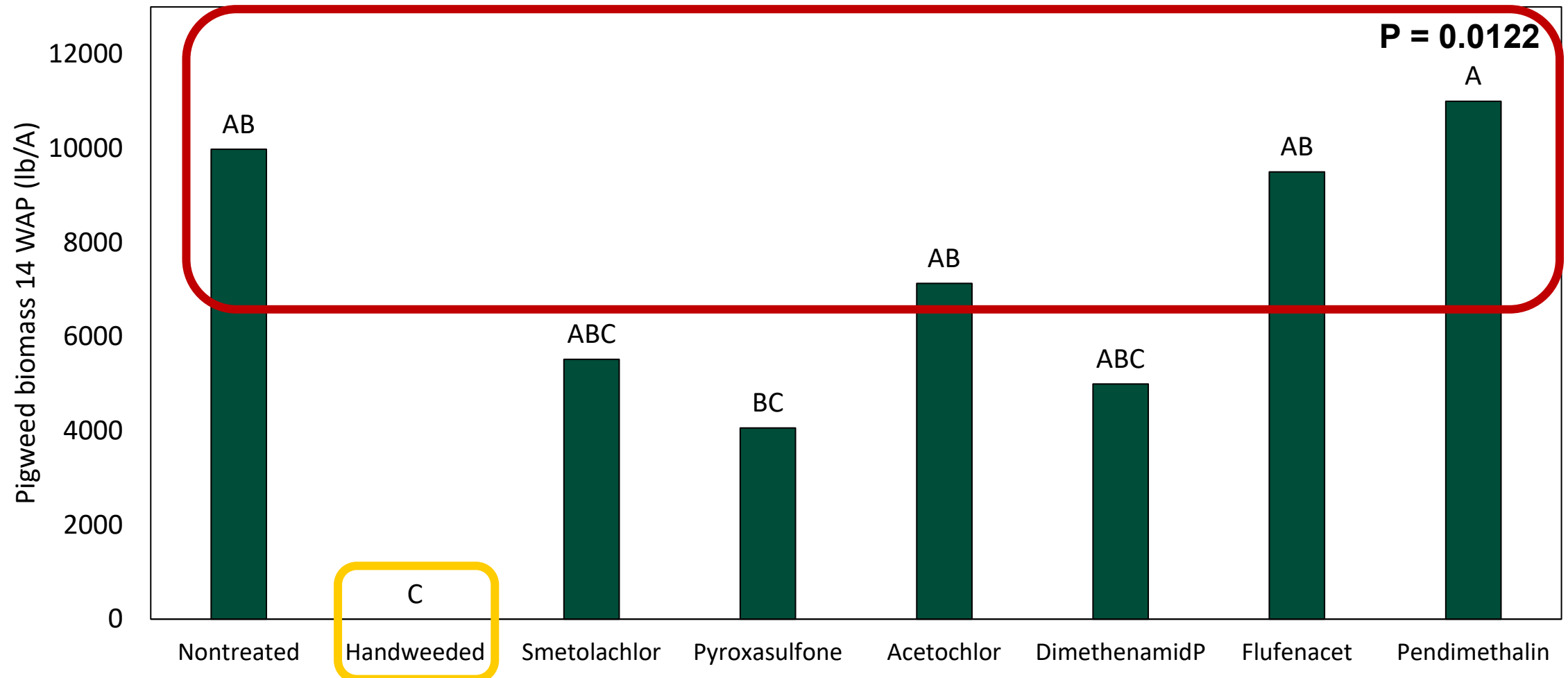
Results – Pigweed Control 4 WAP (Site 2)



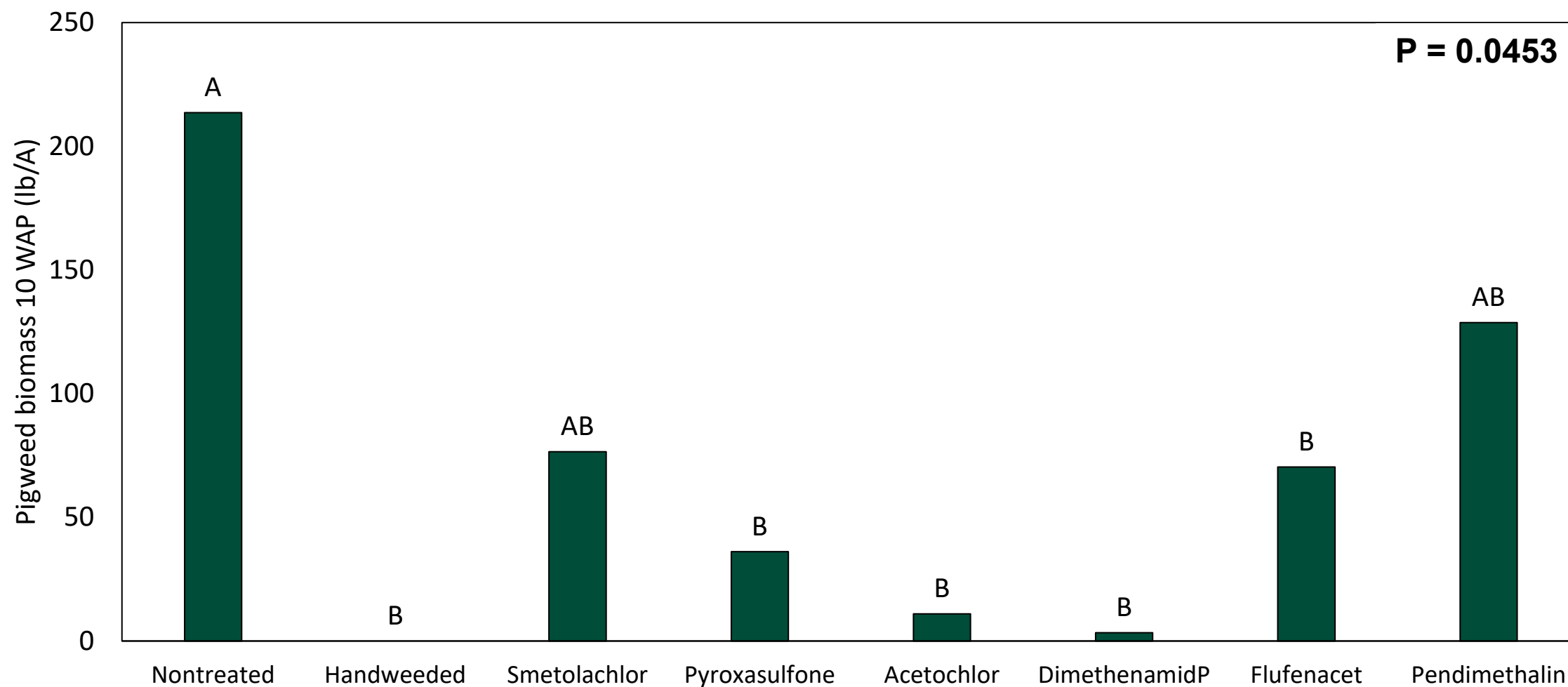
Results – Pigweed Biomass 14 WAP (Site 1)



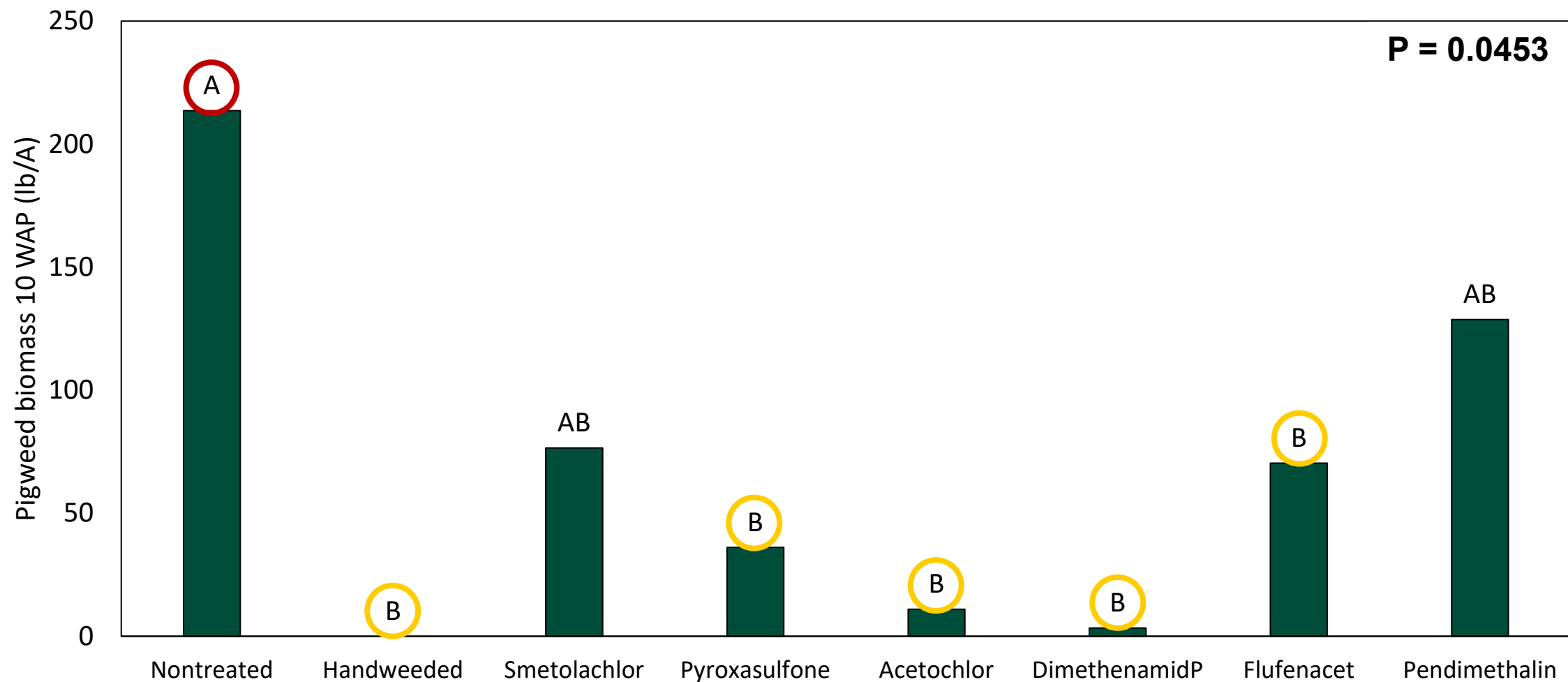
Results – Pigweed Biomass 14 WAP (Site 1)



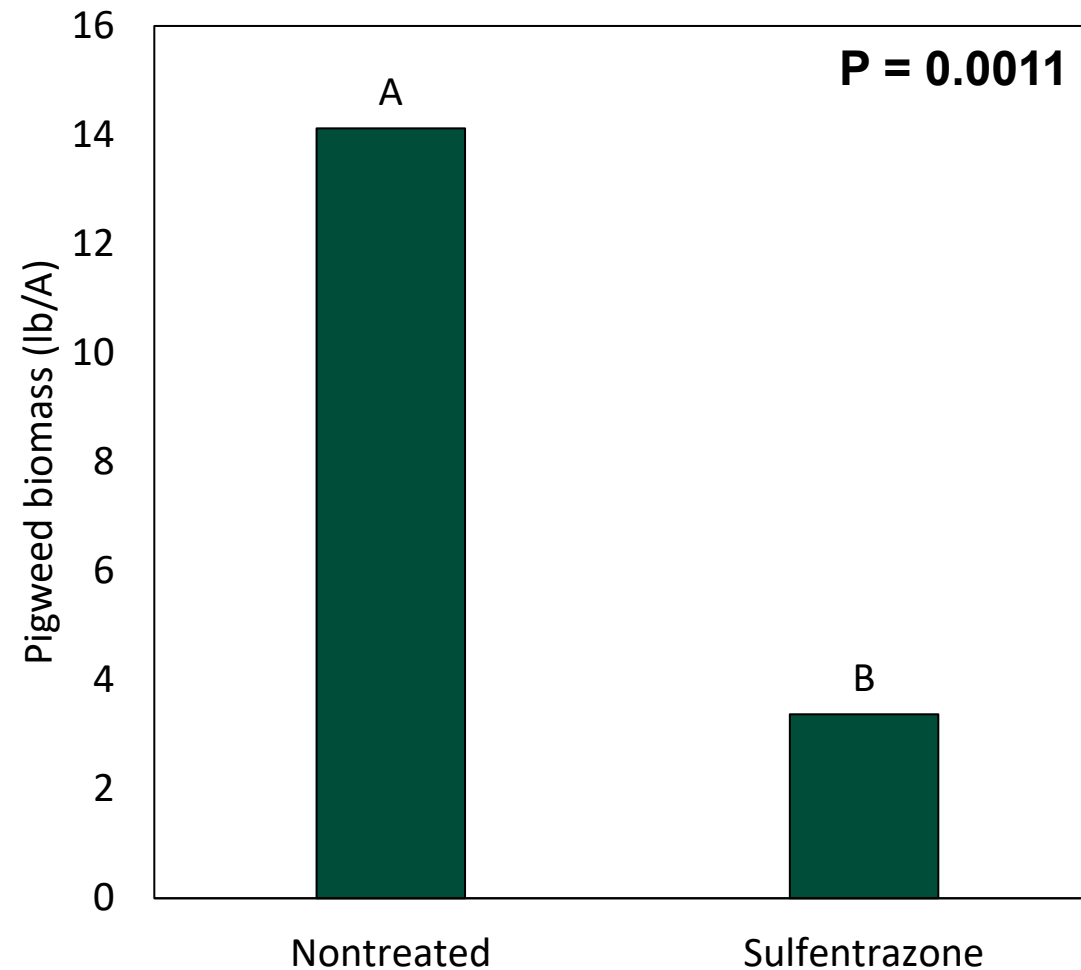
Results – Pigweed Biomass 10 WAP (Site 2)



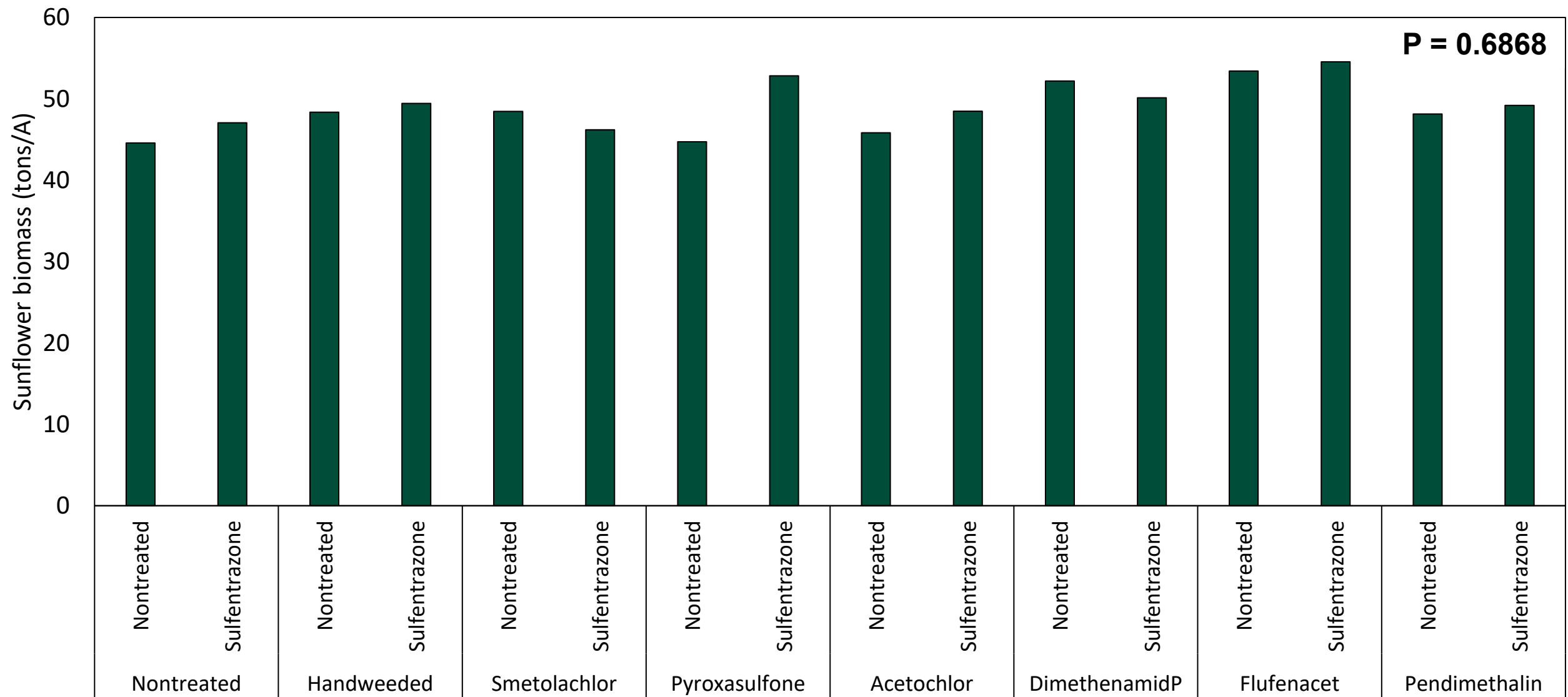
Results – Pigweed Biomass 10 WAP (Site 2)



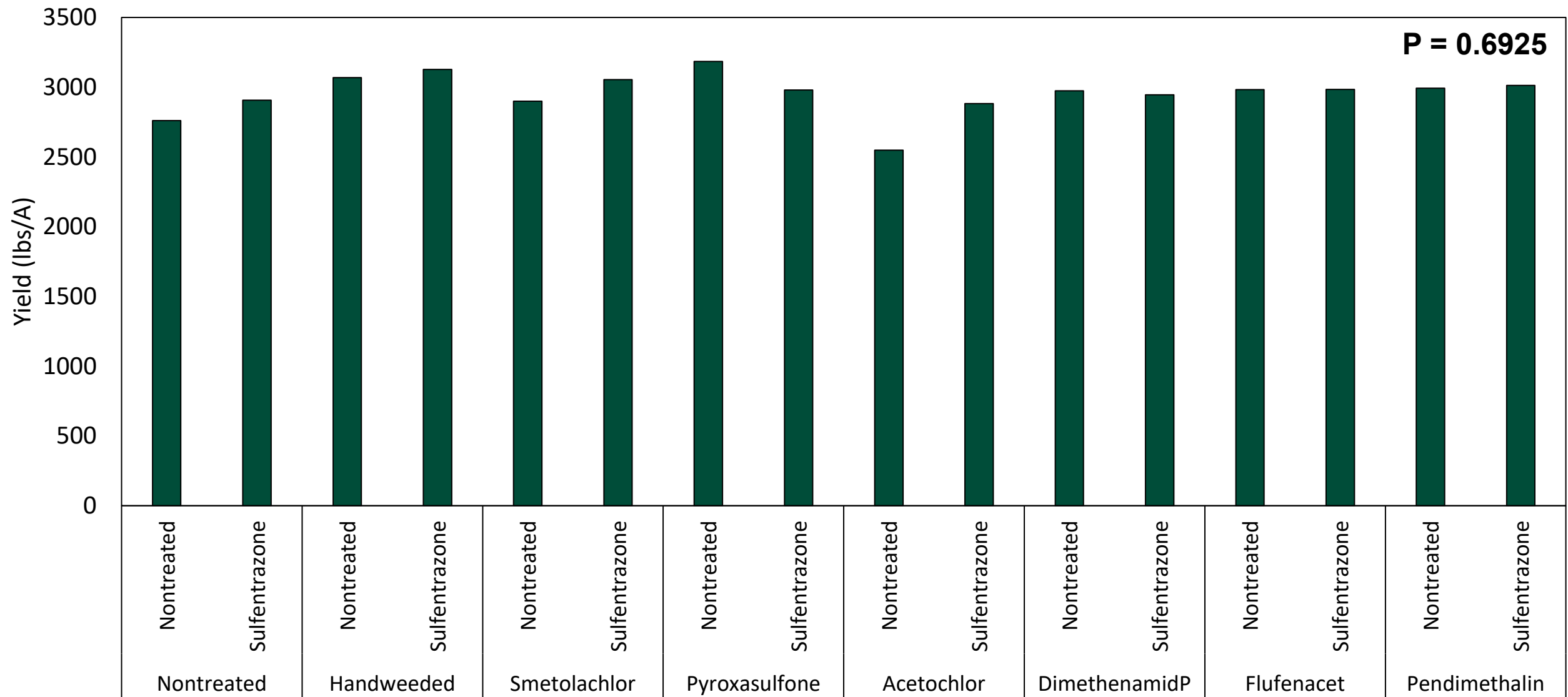
Results – Pigweed Biomass (Site 3)



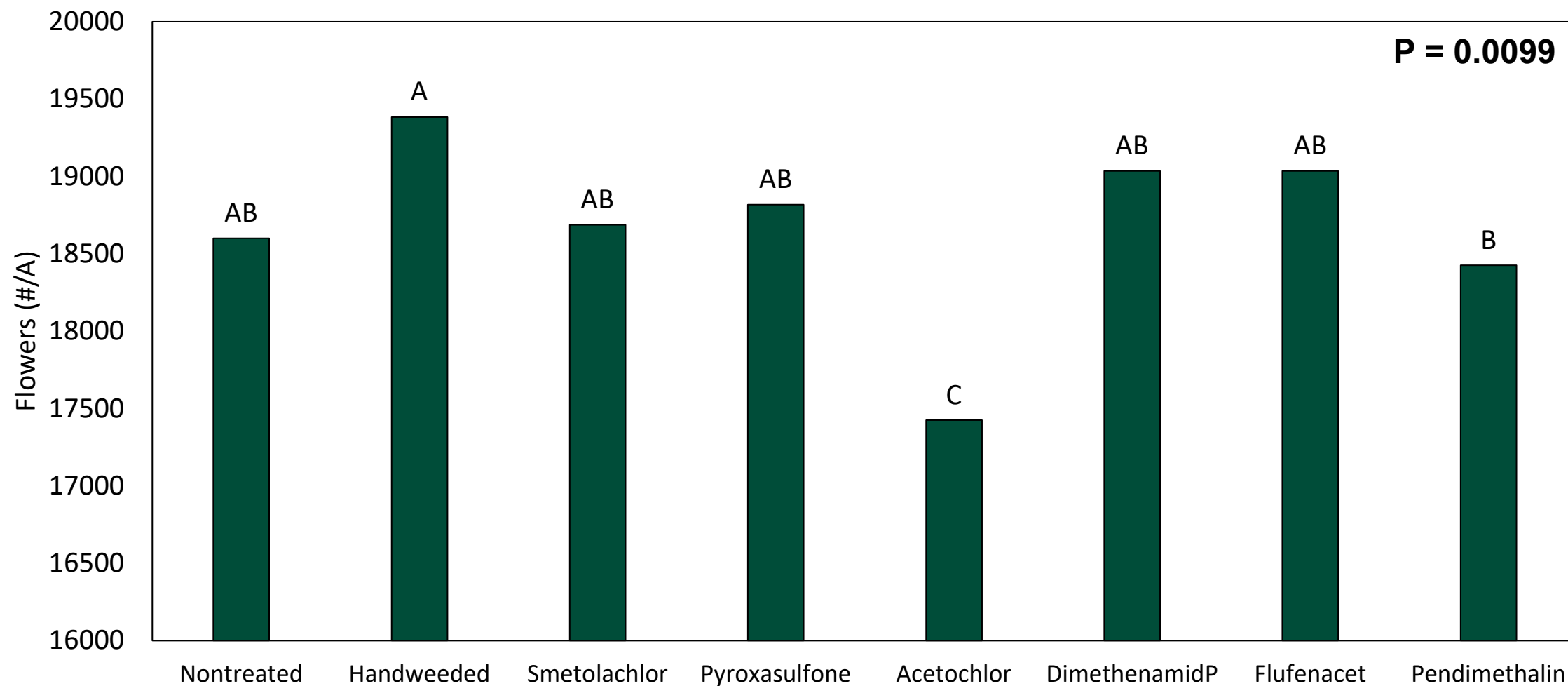
Results – Sunflower Biomass 10 WAP (Site 2)



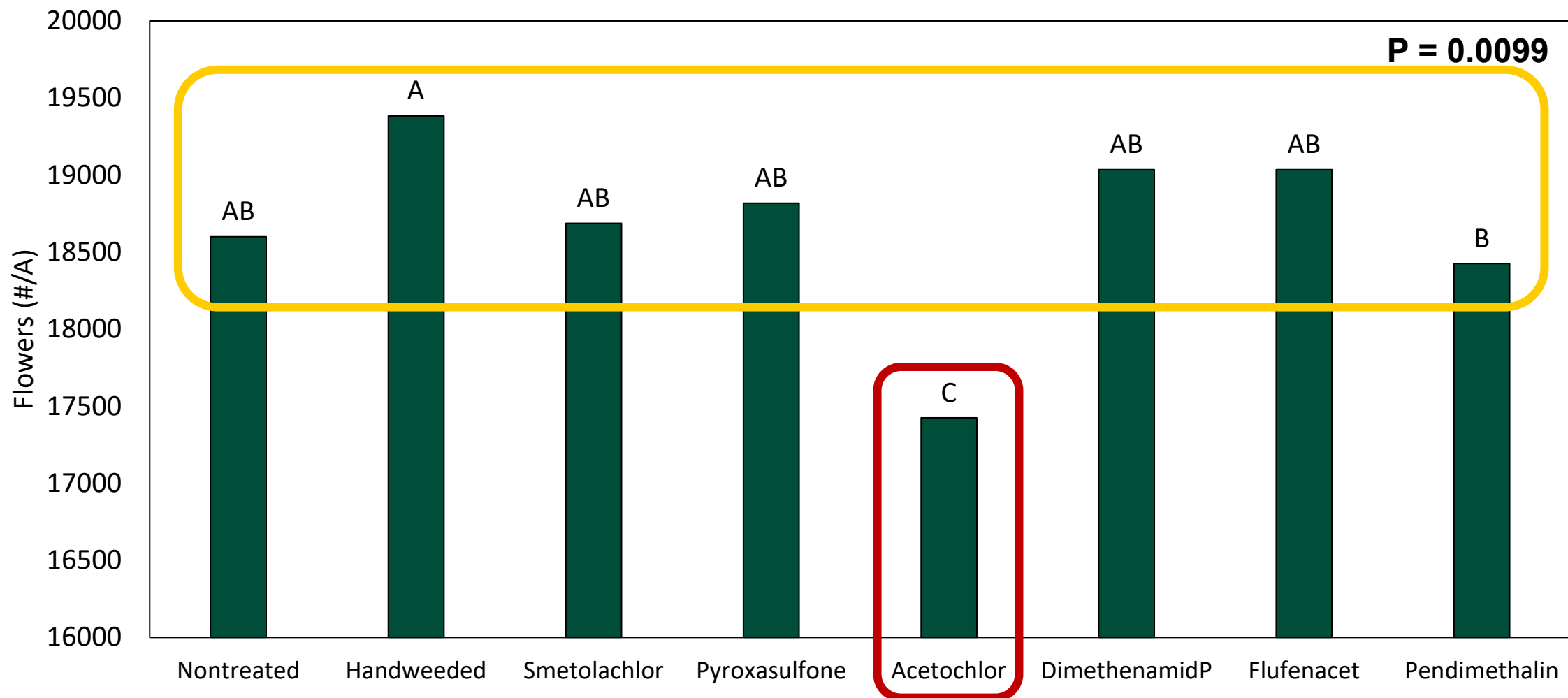
Results – Sunflower Yield (Site 3)



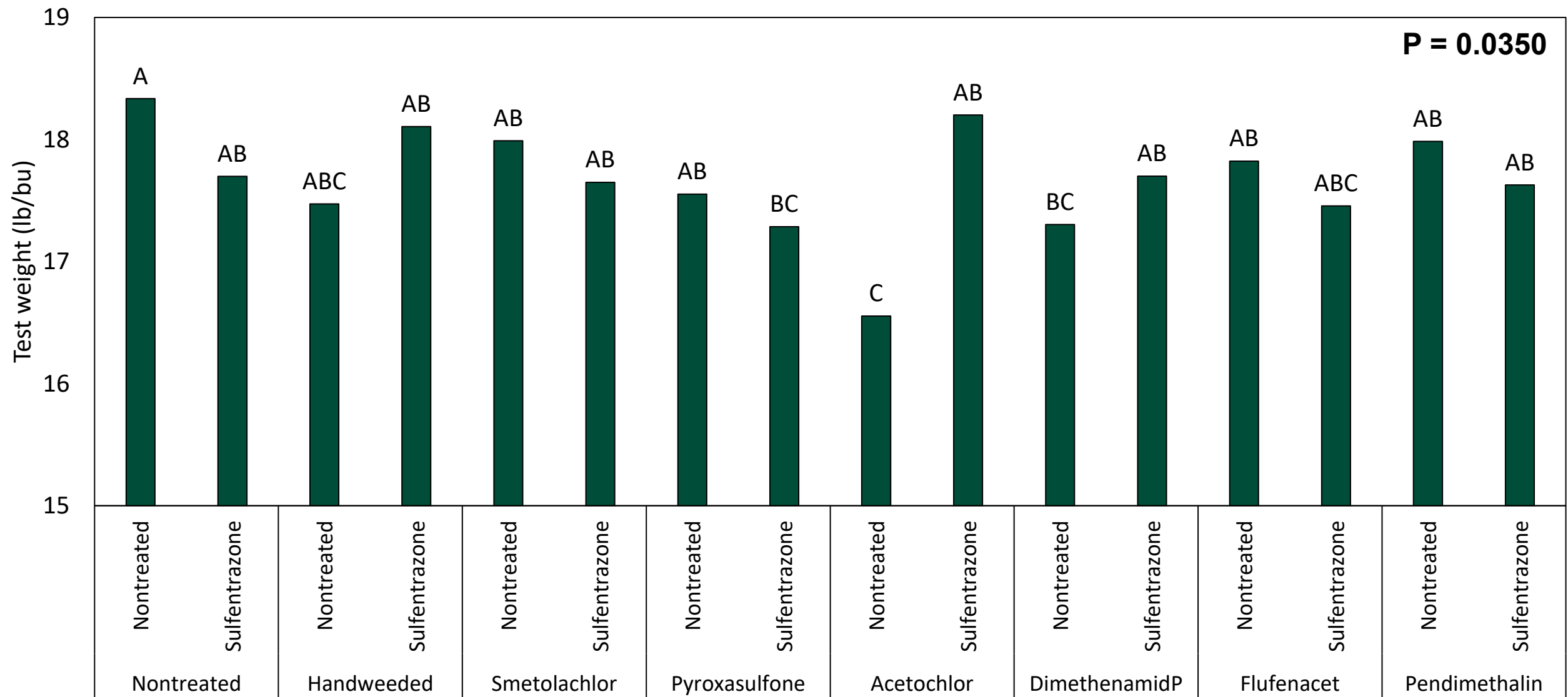
Results – Harvestable Flowers (Site 3)



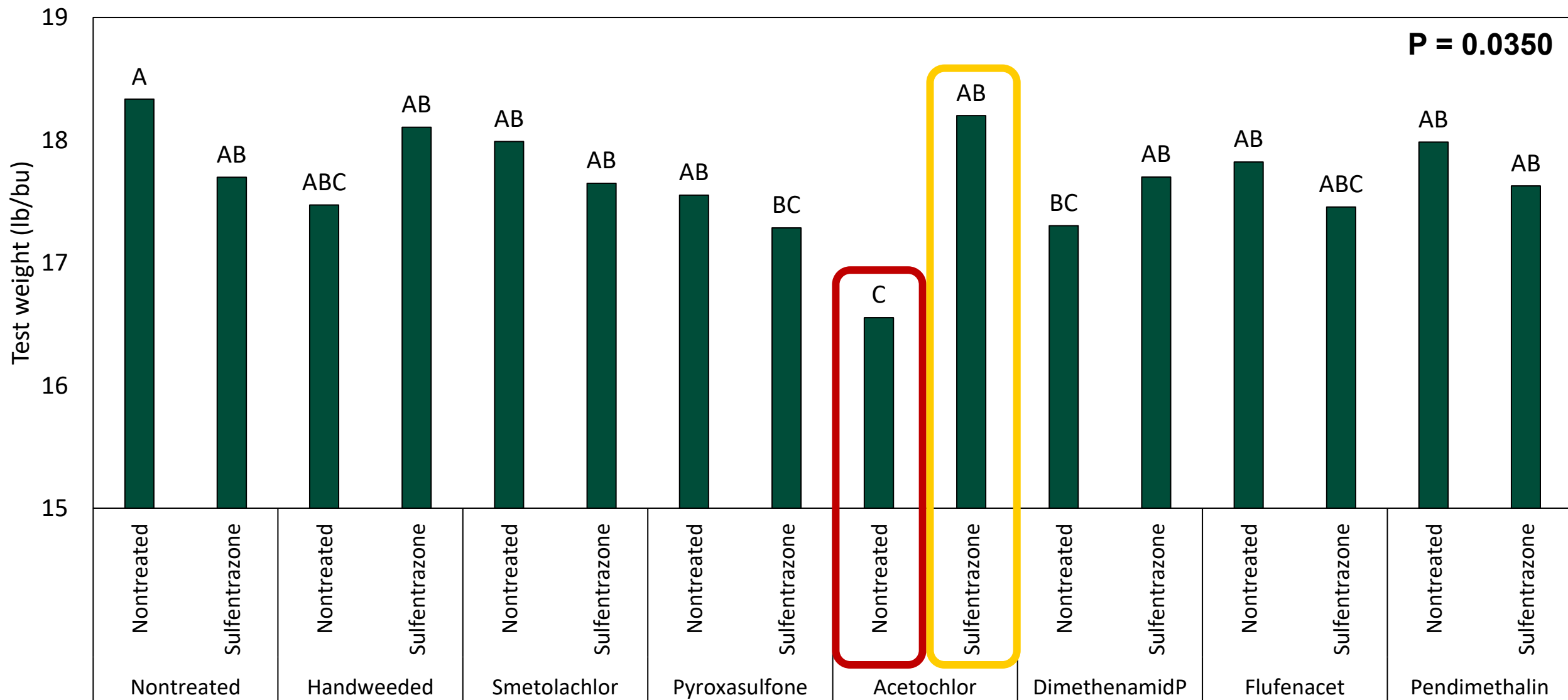
Results – Harvestable Flowers (Site 3)



Results – Test Weight (Site 3)



Results – Test Weight (Site 3)



Results – Herbicide Residue (Site 3)



The Leader in Pesticide Residue Analysis...

ANALYTICAL REPORT



IEH
Laboratories &
Consulting Group

CLIENT: Quincy Law
NDSU, Plant Sciences, Dept 7670
PO Box 6050
Fargo ND 58108

November 16, 2022

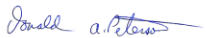
Phone: (701) 318-0242
Fax: (701) 231-8474

quincy.law@ndsu.edu

P. O. No: Law.22.Sun

Project: NSA/SBARE 22-W01

Client Sample	EMA Sample No	Sample	Date Analyzed	Method	Chemical	Amount	RL	Units
Law.22.Sun.103 10/27/22	22110321-01	Sunflower Seeds	11/15/22	LC/MS/MS Extended Screen	Acetochlor	ND	0.01	ppm
			11/15/22	LC/MS/MS Extended Screen	Dimethenamid-P	ND	0.01	ppm
			11/15/22	LC/MS/MS Extended Screen	Flufenacet	ND	0.01	ppm
Law.22.Sun.208 10/27/22	22110321-02	Sunflower Seeds	11/15/22	LC/MS/MS Extended Screen	Acetochlor	ND	0.01	ppm
			11/15/22	LC/MS/MS Extended Screen	Dimethenamid-P	ND	0.01	ppm
			11/15/22	LC/MS/MS Extended Screen	Flufenacet	ND	0.01	ppm
Law.22.Sun.303 10/27/22	22110321-03	Sunflower Seeds	11/15/22	LC/MS/MS Extended Screen	Acetochlor	ND	0.01	ppm
			11/15/22	LC/MS/MS Extended Screen	Dimethenamid-P	ND	0.01	ppm
			11/15/22	LC/MS/MS Extended Screen	Flufenacet	ND	0.01	ppm
Law.22.Sun.408 10/27/22	22110321-04	Sunflower Seeds	11/15/22	LC/MS/MS Extended Screen	Acetochlor	ND	0.01	ppm
			11/15/22	LC/MS/MS Extended Screen	Dimethenamid-P	ND	0.01	ppm
			11/15/22	LC/MS/MS Extended Screen	Flufenacet	ND	0.01	ppm
Law.22.Sun.109 10/27/22	22110321-05	Sunflower Seeds	11/15/22	LC/MS/MS Extended Screen	Acetochlor	ND	0.01	ppm
			11/15/22	LC/MS/MS Extended Screen	Dimethenamid-P	ND	0.01	ppm
			11/15/22	LC/MS/MS Extended Screen	Flufenacet	ND	0.01	ppm
Law.22.Sun.214 10/27/22	22110321-06	Sunflower Seeds	11/15/22	LC/MS/MS Extended Screen	Acetochlor	ND	0.01	ppm
			11/15/22	LC/MS/MS Extended Screen	Dimethenamid-P	ND	0.01	ppm
			11/15/22	LC/MS/MS Extended Screen	Flufenacet	ND	0.01	ppm

Date: 11/16/22 Reviewed by:  Don Peterson, Laboratory Director

Page: 1 of 2

460 N. East Street, Woodland, CA 95776 (530) 666-6890 emalab@emalab.com www.emalab.com



The Leader in Pesticide Residue Analysis...

ANALYTICAL REPORT



IEH
Laboratories &
Consulting Group

CLIENT: Quincy Law
NDSU, Plant Sciences, Dept 7670
PO Box 6050
Fargo ND 58108

November 16, 2022

Phone: (701) 318-0242
Fax: (701) 231-8474

quincy.law@ndsu.edu

P. O. No: Law.22.Sun

Project: NSA/SBARE 22-W01

Client Sample	EMA Sample No	Sample	Date Analyzed	Method	Chemical	Amount	RL	Units
Law.22.Sun.308 10/27/22	22110321-07	Sunflower Seeds	11/15/22	LC/MS/MS Extended Screen	Acetochlor	ND	0.01	ppm
			11/15/22	LC/MS/MS Extended Screen	Dimethenamid-P	ND	0.01	ppm
			11/15/22	LC/MS/MS Extended Screen	Flufenacet	ND	0.01	ppm
Law.22.Sun.409 10/27/22	22110321-08	Sunflower Seeds	11/15/22	LC/MS/MS Extended Screen	Acetochlor	ND	0.01	ppm
			11/15/22	LC/MS/MS Extended Screen	Dimethenamid-P	ND	0.01	ppm
			11/15/22	LC/MS/MS Extended Screen	Flufenacet	ND	0.01	ppm

ND = None Detected at the Reporting Limit (RL)

RL = Reporting Limit

Excess sample and extracts are stored for a minimum 30 of days from the date of analytical report. Special storage arrangements possible.

Results relate only to items tested.

Samples are analyzed as received.

Reports should not be reproduced, except in full, without written consent by Environmental Micro Analysis.

To see the scope of our ISO 17025 accreditation go to <http://emalab.com/ISO17025.pdf>

Date: 11/16/22 Reviewed by:  Don Peterson, Laboratory Director

Page: 2 of 2

460 N. East Street, Woodland, CA 95776 (530) 666-6890 emalab@emalab.com www.emalab.com



Results – Herbicide Residue (Site 3)



The Leader in Pesticide Residue Analysis...

ANALYTICAL REPORT



IEH
Laboratories &
Consulting Group

CLIENT: Quincy Law
NDSU, Plant Sciences, Dept 7670
PO Box 6050
Fargo ND 58108

November 16, 2022

Phone: (701) 318-0242
Fax: (701) 231-8474

quincy.law@ndsu.edu

P. O. No: Law.22.Sun

Project: NSA/SBARE 22-W01

Client Sample	EMA Sample No	Sample	Date Analyzed	Method	Chemical	Amount	RL	Units
Law.22.Sun.103 10/27/22	22110321-01	Sunflower Seeds	11/15/22	LC/MS/MS Extended Screen	Acetochlor	ND	0.01	ppm
			11/15/22	LC/MS/MS Extended Screen	Dimethenamid-P	ND	0.01	ppm
			11/15/22	LC/MS/MS Extended Screen	Flufenacet	ND	0.01	ppm
Law.22.Sun.208 10/27/22	22110321-02	Sunflower Seeds	11/15/22	LC/MS/MS Extended Screen	Acetochlor	ND	0.01	ppm
			11/15/22	LC/MS/MS Extended Screen	Dimethenamid-P	ND	0.01	ppm
			11/15/22	LC/MS/MS Extended Screen	Flufenacet	ND	0.01	ppm
Law.22.Sun.303 10/27/22	22110321-03	Sunflower Seeds	11/15/22	LC/MS/MS Extended Screen	Acetochlor	ND	0.01	ppm
			11/15/22	LC/MS/MS Extended Screen	Dimethenamid-P	ND	0.01	ppm
			11/15/22	LC/MS/MS Extended Screen	Flufenacet	ND	0.01	ppm
Law.22.Sun.408 10/27/22	22110321-04	Sunflower Seeds	11/15/22	LC/MS/MS Extended Screen	Acetochlor	ND	0.01	ppm
			11/15/22	LC/MS/MS Extended Screen	Dimethenamid-P	ND	0.01	ppm
			11/15/22	LC/MS/MS Extended Screen	Flufenacet	ND	0.01	ppm
Law.22.Sun.109 10/27/22	22110321-05	Sunflower Seeds	11/15/22	LC/MS/MS Extended Screen	Acetochlor	ND	0.01	ppm
			11/15/22	LC/MS/MS Extended Screen	Dimethenamid-P	ND	0.01	ppm
			11/15/22	LC/MS/MS Extended Screen	Flufenacet	ND	0.01	ppm
Law.22.Sun.214 10/27/22	22110321-06	Sunflower Seeds	11/15/22	LC/MS/MS Extended Screen	Acetochlor	ND	0.01	ppm
			11/15/22	LC/MS/MS Extended Screen	Dimethenamid-P	ND	0.01	ppm
			11/15/22	LC/MS/MS Extended Screen	Flufenacet	ND	0.01	ppm

Date: 11/16/22 Reviewed by: Donald A. Peterson Don Peterson, Laboratory Director

Page: 1 of 2

460 N. East Street, Woodland, CA 95776 (530) 666-6890 email@emalab.com www.emalab.com



The Leader in Pesticide Residue Analysis...

ANALYTICAL REPORT



IEH
Laboratories &
Consulting Group

CLIENT: Quincy Law
NDSU, Plant Sciences, Dept 7670
PO Box 6050
Fargo ND 58108

November 16, 2022

Phone: (701) 318-0242
Fax: (701) 231-8474

quincy.law@ndsu.edu

P. O. No: Law.22.Sun

Project: NSA/SBARE 22-W01

Client Sample	EMA Sample No	Sample	Date Analyzed	Method	Chemical	Amount	RL	Units
Law.22.Sun.308 10/27/22	22110321-07	Sunflower Seeds	11/15/22	LC/MS/MS Extended Screen	Acetochlor	ND	0.01	ppm
			11/15/22	LC/MS/MS Extended Screen	Dimethenamid-P	ND	0.01	ppm
			11/15/22	LC/MS/MS Extended Screen	Flufenacet	ND	0.01	ppm
Law.22.Sun.409 10/27/22	22110321-08	Sunflower Seeds	11/15/22	LC/MS/MS Extended Screen	Acetochlor	ND	0.01	ppm
			11/15/22	LC/MS/MS Extended Screen	Dimethenamid-P	ND	0.01	ppm
			11/15/22	LC/MS/MS Extended Screen	Flufenacet	ND	0.01	ppm

**No acetochlor, dimethenamid-P,
or flufenacet residue detected
in any sunflower seed sample**

Date: 11/16/22 Reviewed by: Donald A. Peterson Don Peterson, Laboratory Director

Page: 2 of 2

460 N. East Street, Woodland, CA 95776 (530) 666-6890 email@emalab.com www.emalab.com



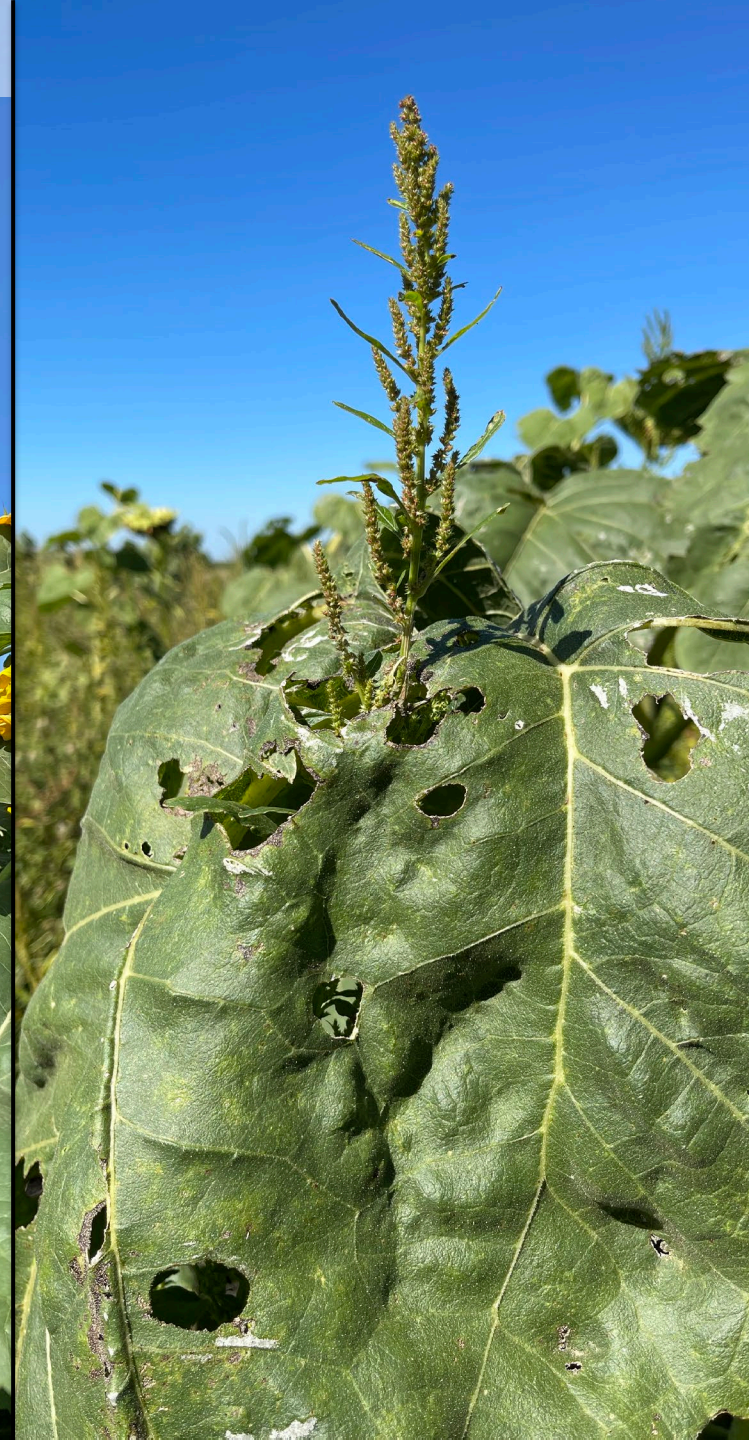
Discussion

- No injury or yield loss observed
- No residues detected in/on seed
- **Acetochlor**
 - Fewer flowers
- **Dimethenamid-P**
 - Good to excellent control
- **Flufenacet**
 - Inconsistent control

Dimethenamid-P + sulfentrazone



8'7" Palmer amaranth 10 WAP



Acknowledgments

- National Sunflower Association
- North Dakota SBARE
- Hatch Project #ND01532
- Law, Howatt, and Ikley Labs



References Cited

- Brighenti, A.M., M.F. Oliveira, and D.L.P. Gazziero. 1998. Sunflower tolerance to pre-emergence broadleaf weed herbicides. Embrapa National Soybean Research Center.
- Jursik, M., J. Soukup, J. Holec, J. Andr, and K. Hamouzova. 2016. Efficacy and selectivity of pre-emergent sunflower herbicides under different soil moisture conditions. Plant Protection Science 51(4):214-222.
- Pannacci, E., F. Graziani, and G. Covarelli. 2007. Use of herbicide mixtures for pre and post-emergence weed control in sunflower (*Helianthus annuus*). Crop Protection 26(8):1150-1157.



Questions?

quincy.law@ndsu.edu

