



cenusa bioenergy

## **Sustainable Production and Distribution of Bioenergy for the Central USA**

Agro-ecosystem Approach to Sustainable Biofuels Production via the Pyrolysis-Biochar Platform (USDA-NIFA AFRI CAP) • Grant no. 2011-68005-30411

# Switchgrass Establishment, Weed Control, and Seed Quality

Rob Mitchell

USDA-ARS

Grain, Forage, and Bioenergy Research Unit  
Lincoln, Nebraska



# Reports and Extension Publications

Biofuels and Sustainability Reports

March 2010



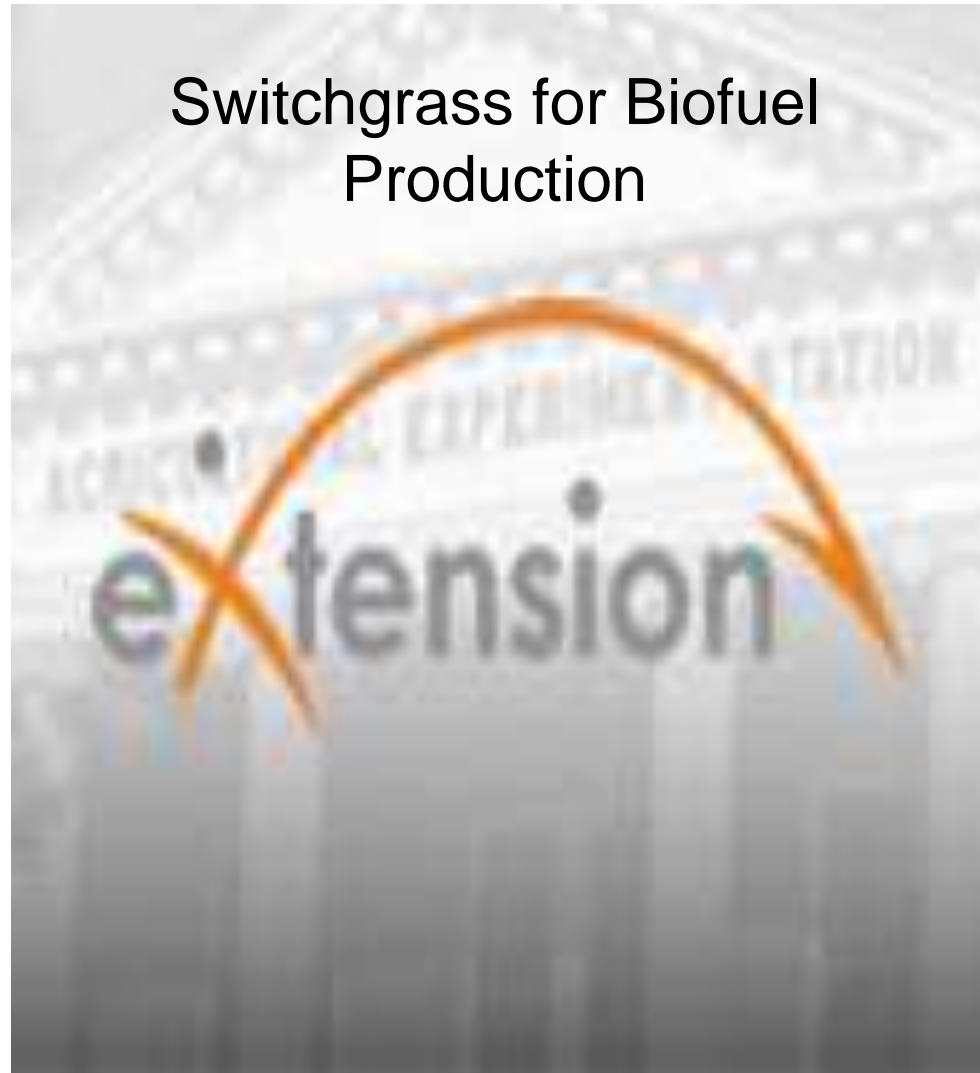
## Grasslands, Rangelands, and Agricultural Systems

Rob Mitchell, Linda Wallace, Wallace Wilhelm, Gary Varvel,  
and Brian Wienhold



[www.esa.org/biofuelsreports](http://www.esa.org/biofuelsreports)

## Switchgrass for Biofuel Production



[www.extension.org/pages/26635/switchgrass-for-biofuel-production](http://www.extension.org/pages/26635/switchgrass-for-biofuel-production)

# Establishing Switchgrass

How do you get from this...



...to this?

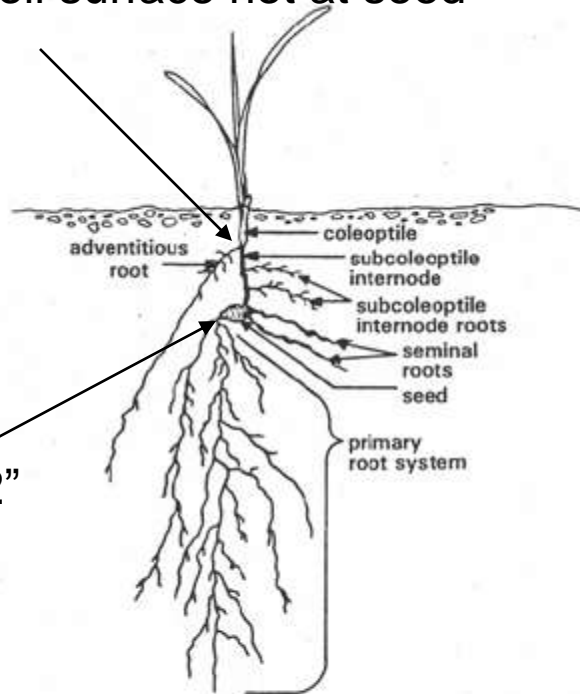


# Switchgrass Establishment Recipe

- Is switchgrass feasible for the area?
  - Suitable for dryland corn = suitable for switchgrass
  - Plant 2 to 3 weeks either side of optimum corn planting date
- Develop a good seedbed
  - No-till seed into soybean stubble
  - Clean till and pack to leave a faint footprint
- Use high quality certified seed of adapted material
- Plant at least 30 PLS per ft<sup>2</sup> 1/4" to 1/2" deep
- Manage weeds ASAP!
  - Pre-emergent application of 1 qt. of atrazine plus 8 oz of quinclorac/acre
  - Mow or spray broadleaves with 1-2 qt./a of 2,4-D in summer
- Spend money on quality seed & weed control

# Switchgrass seedling morphology, seedbed firmness, and planting depth

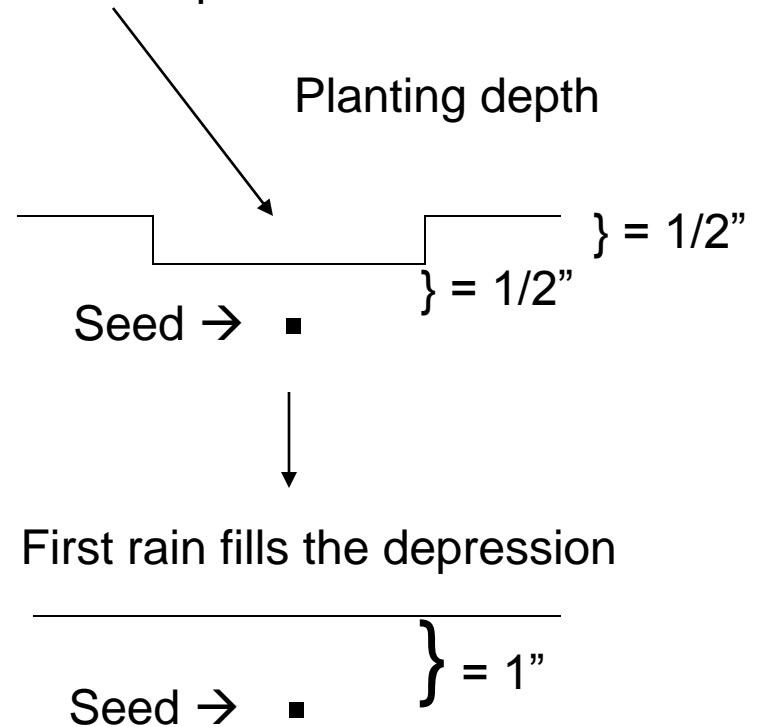
Seedlings develop adventitious roots at soil surface not at seed



Seed < 1/2" deep

Fig. 3-4. The generalized grass seedling (Newman & Moser, 1988a).

Soft seedbed with packer wheel depression



First rain fills the depression

The seed is too deep and will struggle to emerge

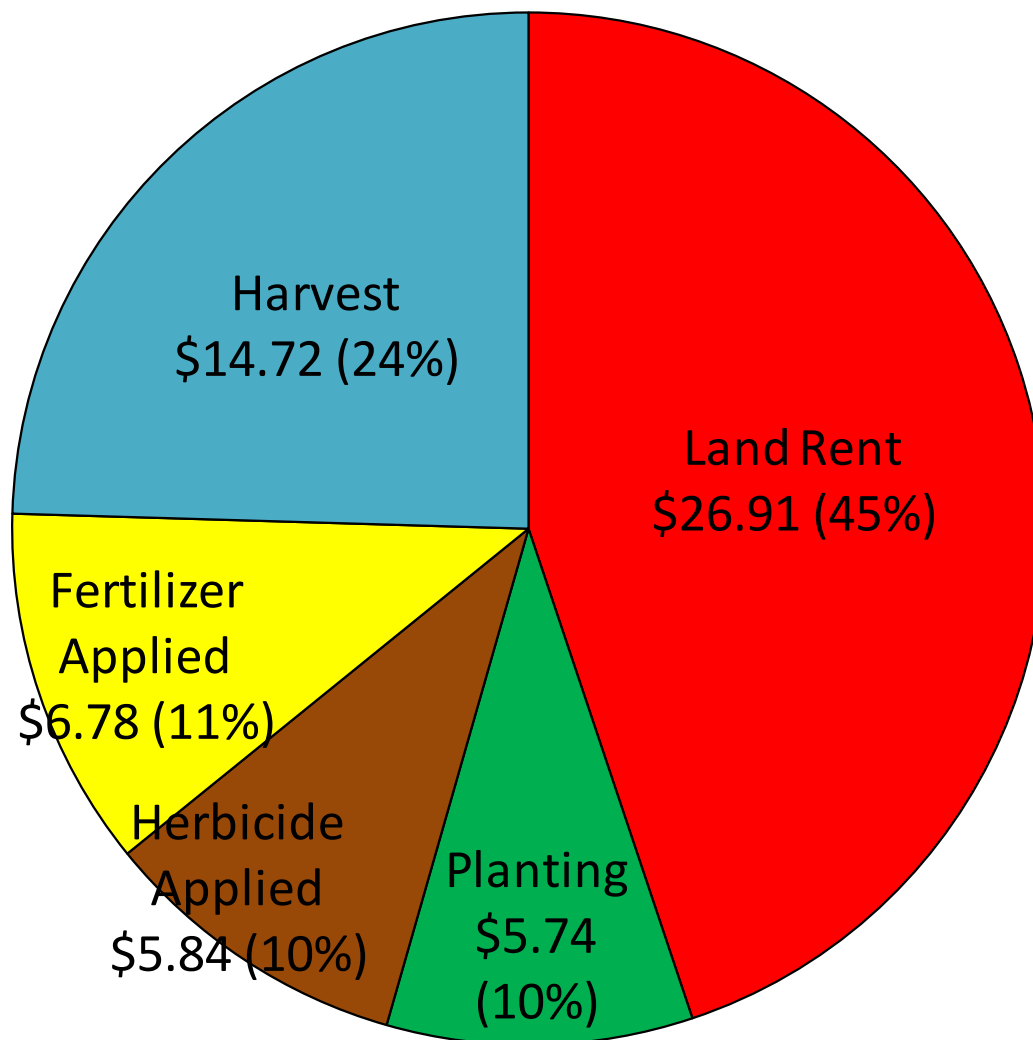
# Is switchgrass difficult to establish?

No. Harvestable yields are typical during the planting year.

- Develop a good seedbed (No-till seed into soybean stubble or clean till and pack to leave a faint footprint)
- Plant 2 to 3 weeks either side of optimum corn planting date
- Use high quality certified seed of adapted material
- Plant at least 30 PLS/ft<sup>2</sup> ¼" to 1/2" deep
- Manage weeds (Pre-emergent application of 1 qt. of atrazine plus 8 oz of quinclorac/acre then mow or spray broadleaf weeds with 1 qt./a of 2,4-D in summer)



# Switchgrass Average Annual Production Cost was \$60/US Ton



Costs annualized at 10%

Perrin et al. 2008



# Are special herbicides necessary for switchgrass establishment?


Five Year Average Cumulative Costs	
	Total costs \$/ton
Paramount used (4)	\$44.06
No Paramount (6)	\$77.22

Yes. Applying Paramount in the establishment year reduced production costs (minus land costs) compared with other herbicides and returned \$124/a on a \$20/a investment.

# Harvestable yield in seeding year is critical to economics

Five Year Average Cumulative Costs	
	Total costs \$/ton
Year 1 Harvest (3)	\$44.22
No Year 1 Harvest (7)	\$72.41

# Rapid Establishment at ARDC



5 May 2006



6 October 2006  
2.5 tons/acre

No-till seeded into soybean stubble on 5 May 2006

Pre-emergent application of 1 qt. of atrazine plus 8 oz of quinclorac/acre

Received 5 in of rain for the first 90-days after planting (40% of LTA)

Mowed & sprayed with 1 qt./acre of 2,4-D to control broadleaf weeds in July

Produced 2.5 tons/acre near Mead, NE in the establishment year (50% of our yield goal)

Seed quality & weed control are critical to economical switchgrass production

Switchgrass biomass yield (Mg ha<sup>-1</sup>), switchgrass frequency (%), and weed contribution to biomass (%) in the year after seeding following post-plant preemergence herbicides and combinations at planting at three locations in the Central and Northern Great Plains.

Treatment†	Biomass Yield			Switchgrass Frequency			Weed Contribution to Biomass		
	(Mg ha <sup>-1</sup> )			(%)			(%)		
	NE	SD	ND	NE	SD	ND	NE	SD	ND
A1	4.2	3.7	5.5	81	9	67	25	60	0
A1Q1	6.4	6.2	6.2	81	20	66	7	10	1
A1Q2	7.4	5.9	5.6	77	19	66	9	4	1
A2	5.6	4.5	5.3	80	16	55	7	34	4
Q1	6.7	5.2	6.7	77	11	74	12	5	1
Q2	7.3	4.9	6.2	66	15	49	17	5	3
I1	6.1	5.0	3.7	70	19	8	2	13	28
I1Q1	7.0	5.6	5.1	60	19	20	4	12	5
I1Q2	6.4	--	--	54	--	--	4	--	--
Non-treated	3.9	4.2	5.1	72	8	73	26	46	3
LSD 0.05	0.7	NS	NS	9	NS	5	4	6	7

# Evaluate Stand Frequency to Determine Success

- Frequency is easy to measure since only presence or absence (yes or no) is needed
- Frequency > 40% in the seeding year is a successful stand
- Frequency x 0.4 provides a conservative estimate of plants/m<sup>2</sup>

XX X	XX		X X
X		X X	XXXXXXXX
	X X X	X X	
XX	XX	X X	XX
XXXX	X		X X

# Seed Quality Goal

Develop seed lot based test procedures that increase the probability of successful stand establishment for a given seed lot

# The Seed lot Establishment Test

The Seed lot Establishment Test (SET) is the number of germinable or emerging seeds per gram of a given seed lot

Think of SETS as PLS for a seed lot based on the number of seeds per gram for that specific seed lot

# Trailblazer Seed Weight Variation

Seed lot	Seeds/g	Seeds/pound
1327	597	270,795
1854	708	321,143
G91149	706	320,236
G9743	482	218,632
M94	631	286,217
M97	580	263,084



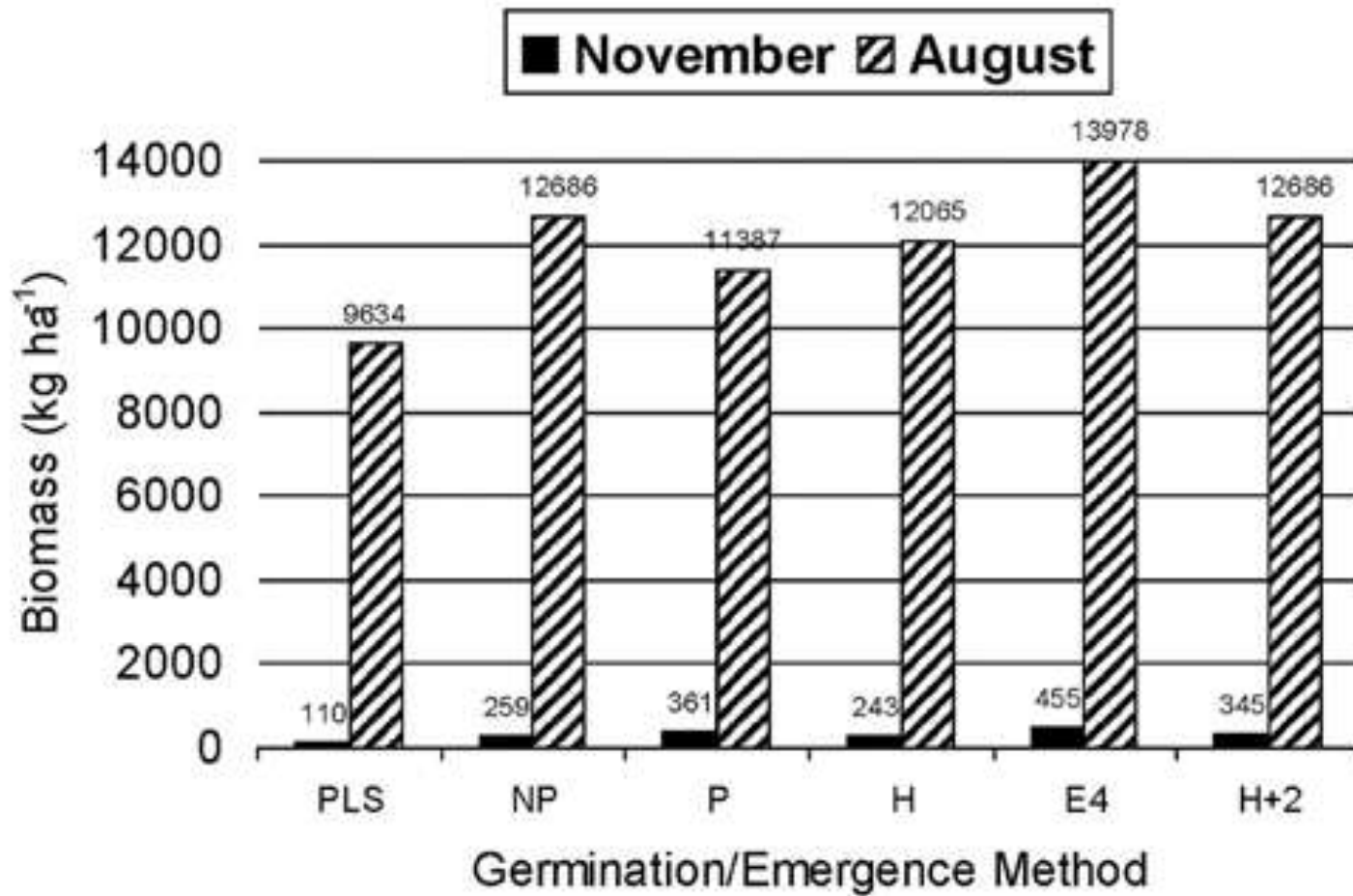
# Materials and Methods

SET	Abbrev.	Protocol
Pure Live Seed	PLS	Standard PLS test (germination x purity) following AOSA Rules for Testing Seeds with pre-chill using published number of 858 seeds g <sup>-1</sup> .
No Pre-chill	NP	SET germinated seeds g <sup>-1</sup> for each seed lot using AOSA Rules for Testing Seeds with no pre-chill.
Pre-chill	P	SET germinated seeds g <sup>-1</sup> for each seed lot using AOSA Rules for Testing Seeds with pre-chill.
Heat Stress	H	SET germinated seeds g <sup>-1</sup> for each seed lot using AOSA Rules for Testing Seeds with no pre-chill following a heat stress treatment (0.25 g of seed placed on top of 2 layers of dry blotter paper in open germination boxes and keep in a dark germination cabinet (95% RH, 50° C) for 12 h).
Emergence Through 4-cm of Sand	E4	SET emerged seedlings 21-d after planting 0.25 g of seed 4-cm deep in sand in germination trays, drenched with Captan (1g/l H <sub>2</sub> O) and watered daily. Sand particle size was 10% Coarse (0.5-1.0 mm), 40% Medium (0.25-0.5 mm), 40% Fine (0.10-0.25 mm), and 10% Very Fine (0.05-0.10 mm).
Heat + 2-cm Emergence	H+2	Combination of Heat Stress procedure combined with emergence through 2 cm of sand. Emerged seedlings counted after 21 days to determine emerged seedlings g <sup>-1</sup> .

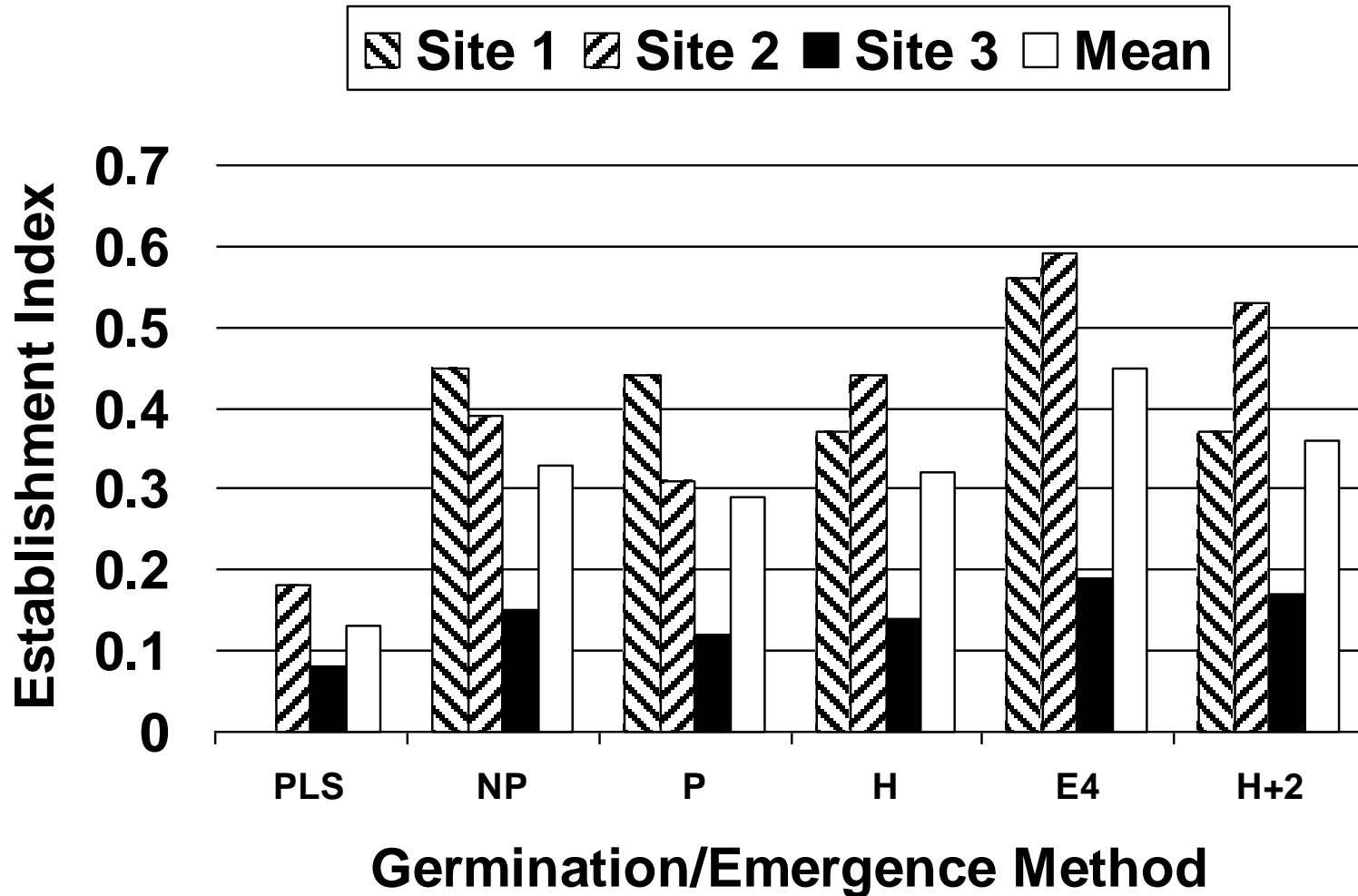
# Plant Frequency 5-mo After Planting

Cultivar	Seed lot	PLS	NP	P	H	E4	H+2
----- Frequency of Occurrence (%) 5 Months Post Planting -----							
---							
Sunburst	2275	37.5	42.5	34.5	42.0	45.0	35.5
Sunburst	2276	15.5	48.5	37.0	38.5	46.5	48.0
CIR	2277	17.5	34.0	28.5	53.5	48.0	44.0
Trailblazer	2278	22.5	42.0	38.5	30.0	38.3	50.5
Trailblazer	2279	34.0	34.0	27.0	36.5	49.5	34.0
Trailblazer	2280	26.5	47.0	40.5	39.5	55.0	42.0
Trailblazer	2289	12.5	35.0	33.0	53.5	56.5	41.5
Shawnee	2290	16.0	40.5	18.5	25.0	58.5	40.0
Shawnee	2291	29.5	36.0	43.0	30.0	35.5	31.5
CIR	12169	16.0	19.5	22.0	47.5	30.0	54.0
Mean		22.8	37.9	32.3	39.6	46.3	42.1
LSD(0.05)		----- 12.6 -----					

# SET Improved Yield



# Establishment Index



# Seed Quality Conclusions

- Seed lots were different
- Germination/Emergence tests resulted in significant differences in establishment success
  - Standard PLS method was a poor predictor of establishment
  - 4 cm emergence from sand was best predictor of establishment
- SETs with vigor tests resulted in stands with greater switchgrass density and biomass

# How Do You Do the 4-cm Emergence from Sand Test?

Place blotter paper and 3 cm of washed sand in germination tray

Weigh 0.25 grams of seed lot and place 4 rows evenly-spaced on sand in germination tray

Cover seed lot with 4 cm of washed sand, apply 1 g/l Captan, and keep moist

Germinate at 15-30° C (16h/8h)

Count the number of seedlings that emerge from each row after 21 days

Multiply x 4 to determine SET/gram of seed lot

SET is then used to determine seeding rate

# Conclusion

Don't cut corners on seeding method,  
weed control, or quality seed

# Truax Flex II 88 Drill Calibration

Goal: Deliver the correct amount of seed at the correct depth into a properly-prepared seed bed

No-Till Drill Details:

- Drive wheel diameter = 7.5' per revolution
- 13 revolutions of the drive wheel = 98.6'
- Drill width = 6' (8 openers on 8" + 4" per side)
- Area planted with 13 revolutions = 98.6' x 6' = 592 ft<sup>2</sup> or 0.0136 acres





# Truax Flex II 88 Drill Calibration

- Target Seeding Rate: 30 PLS/ft<sup>2</sup> (17,760 seeds/13 revolutions)
- Seed lot: seeds/g x (% PLS as decimal) = 722 seeds/g x 0.64 PLS = 462 PLS/g
- 17,760 seeds/13 revolutions ÷ 462 PLS/g = 38.44 g/13 revolutions
- 38.44 g/13 revolutions ÷ 6.35 = 6.05 PLS #/acre



# Truax Flex II 88 Drill Calibration

## Process:

- Collect seed from at least 2 tubes with 13 revolutions of the drive wheel & record weight
- Determine the average seed weight in grams (g)
- Average seed weight/tube x 8 = g of seed delivered
- Adjust sprocket & seed box to deliver desired weight

