ABSTRACT: 432

EFFECTS OF GLYPHOSATE APPLICATION RATES AND FREQUENCY ON SOYBEAN SUDDEN DEATH SYNDROME

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Sudden death syndrome (SDS), caused by *Fusarium virguliforme*, is a major soybean disease in North America. Outbreaks of SDS have been reported by farmers following applications of Roundup weather MAX (potassium salt of glyphosate 48.8%) at rates higher than recommended. The rate of glyphosate applications have been increasing since the introduction of |Roundup Ready (RR) soybeans in 1996. The United States Department of Agriculture (USDA) data shows that the commercial application rate of Roundup was 9.12 fl oz (0.57 lb active ingredient) per acre in 1996 and in 2006 this was increased to 19.68 fl oz (1.23 lb a.i) per acre. One of the reasons for higher application rates and increased glyphosate application frequency by the growers was to manage glyphosate resistant weeds and the availability of cheaper generic glyphosates. Trials were carried out under greenhouse conditions to understand (a) the effect of glyphosate spray frequency and the varietal reaction to glyphosate sprays at 22 fl oz per acre, and (b) the effect of application rates at 16, 22 and 33 fl oz per acre on SDS incidence and severity. In all trials, soybean seeds were planted in a potting mixture to which 1% *F. virguliforme* inoculum grown on steam sterilized white Milo was added. Appropriate unsprayed and un-inoculated controls were maintained in all trials. Soybean plants were evaluated for stand count, SDS expression and SDS severity 4 weeks after the application of Roundup. Results of our studies showed that incidence and severity of SDS increased when soybean plants received higher rates and more than one spray at the recommended rate of glyphosate. This suggests that over the years, glyphosate effects on the occurrence of SDS in RR soybeans remain unchanged.

Effects of glyphosate application rates and frequency on soybean sudden death syndrome

S.S. Navi[1], L. Jing[2] and X.B. Yang[1]

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[2]Inner Mongolia Agricultural University, P. R. China

Disclaimer

Products tested in our studies do not imply endorsement of one company over another, nor did discrimination intended against any similar products.

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[1]Iowa State University, U.S.A.
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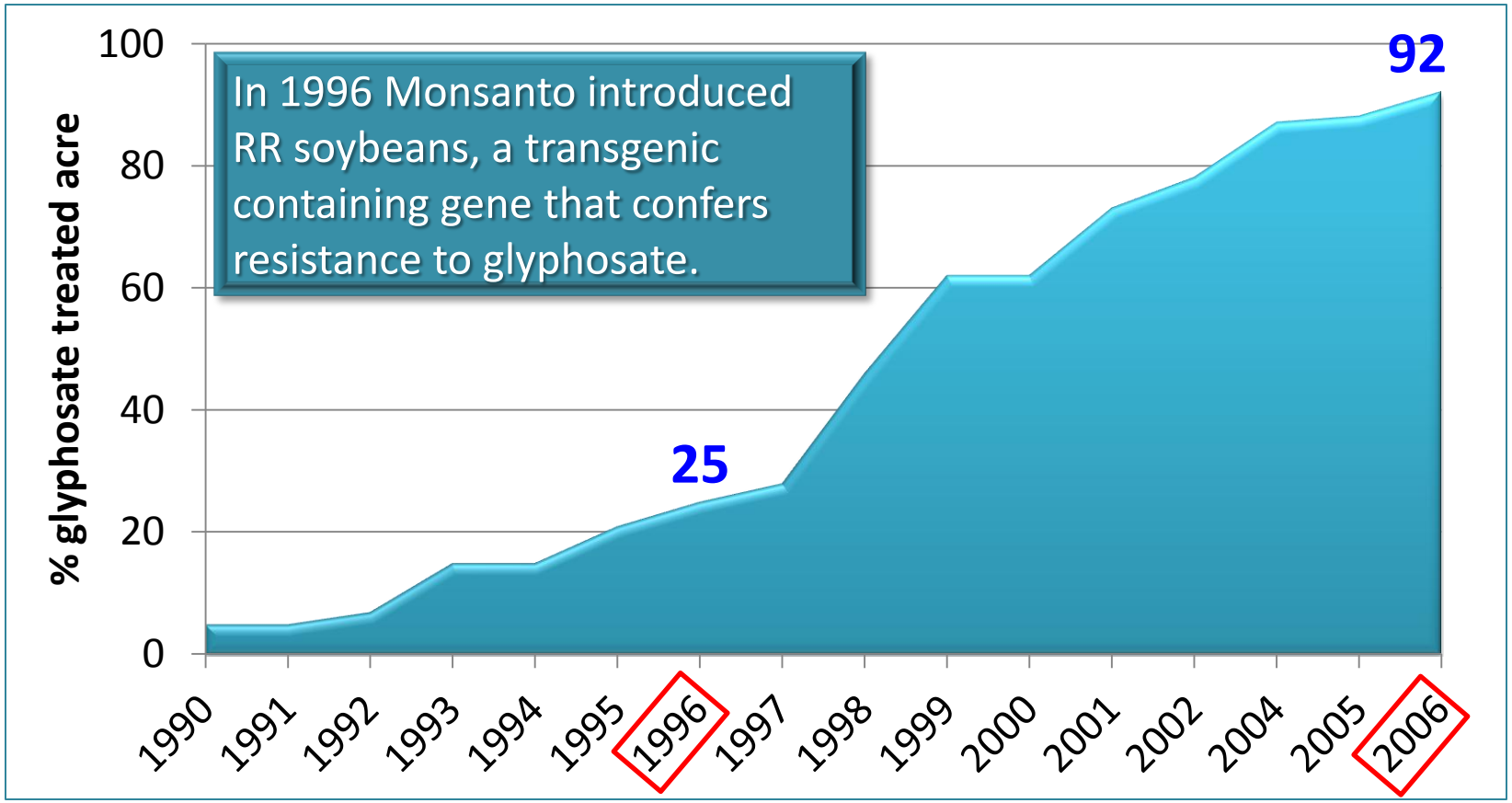
What is Roundup (Glyphosate)?

- Roundup is a broad-spectrum, non-selective, post emergence systemic herbicide.
- A.I.: Glyphosate, N-(phosphonomethyl) glycine, in the form of its potassium salt 48.8% (= 660 g/L or 5.5 lb/gal) and other ingredients 51.2%.
- Glyphosate inhibits EPSPS (5-enolpyruvyl shikimate-3-phosphate synthase) in plants & bacteria.

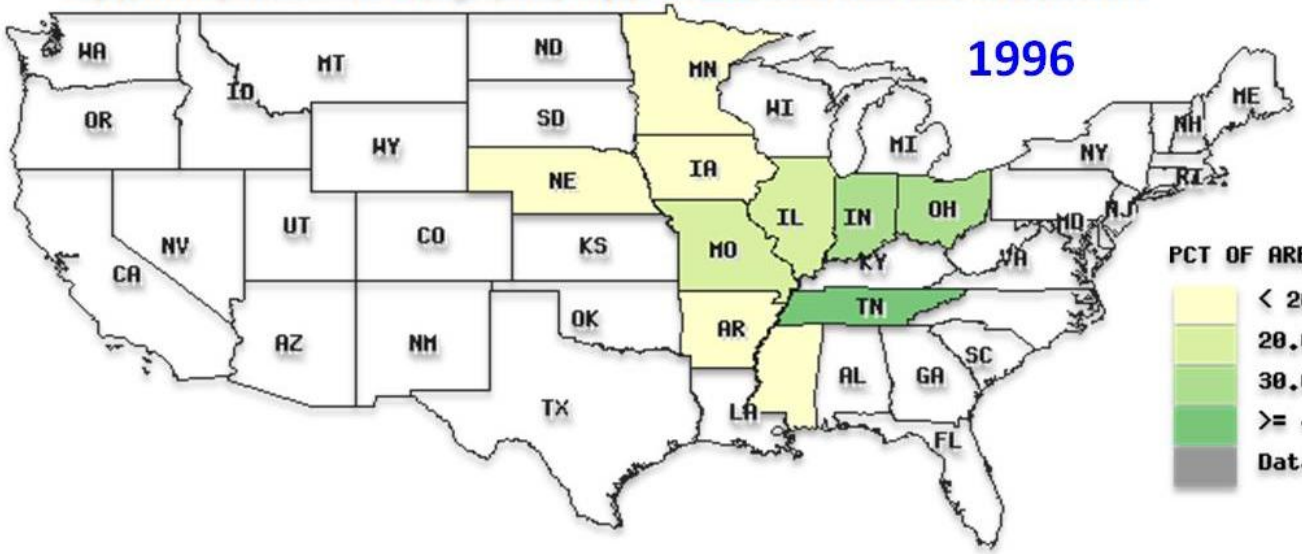
% Average glyphosate sprayed soybean planted in the United States



Data source: http://www.pestmanagement.info/nass/act_dsp_usage_excel.cfm

% Avg Glyphosate sprayed soybean planted in the U.S.

http://www.quickstats.nass.usda.gov/data/maps/94772DEB-D395-3162-B36C-4DE588904379



<20 to >49%

Avg 25%

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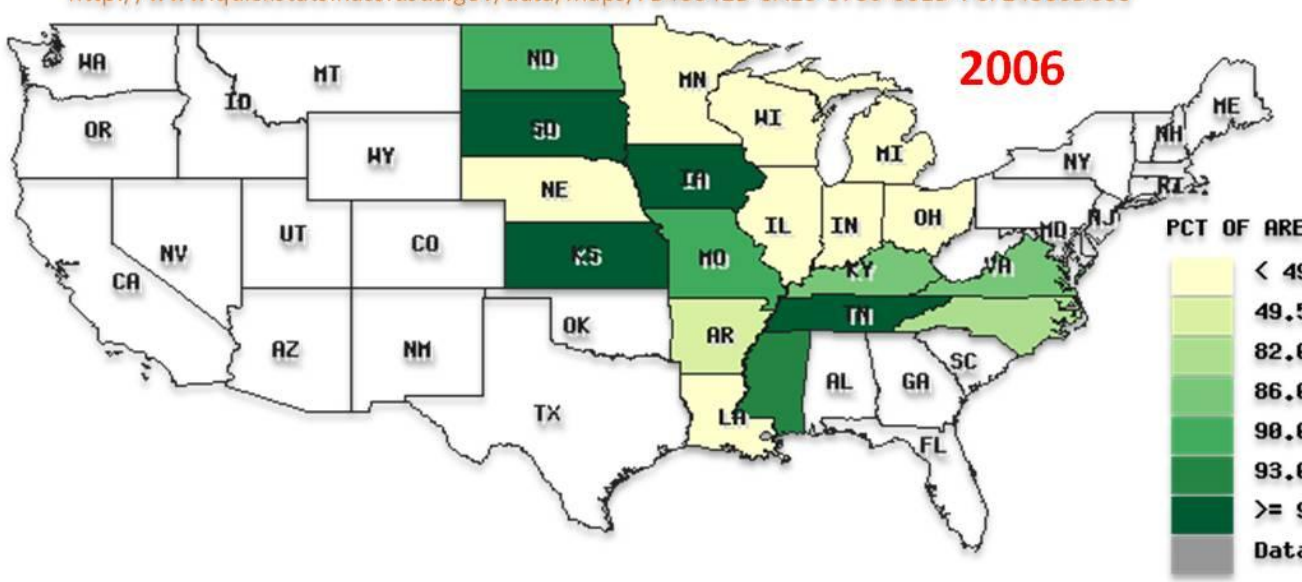

<49 to >95%

Avg 92%

Avg number of Glyphosate applications

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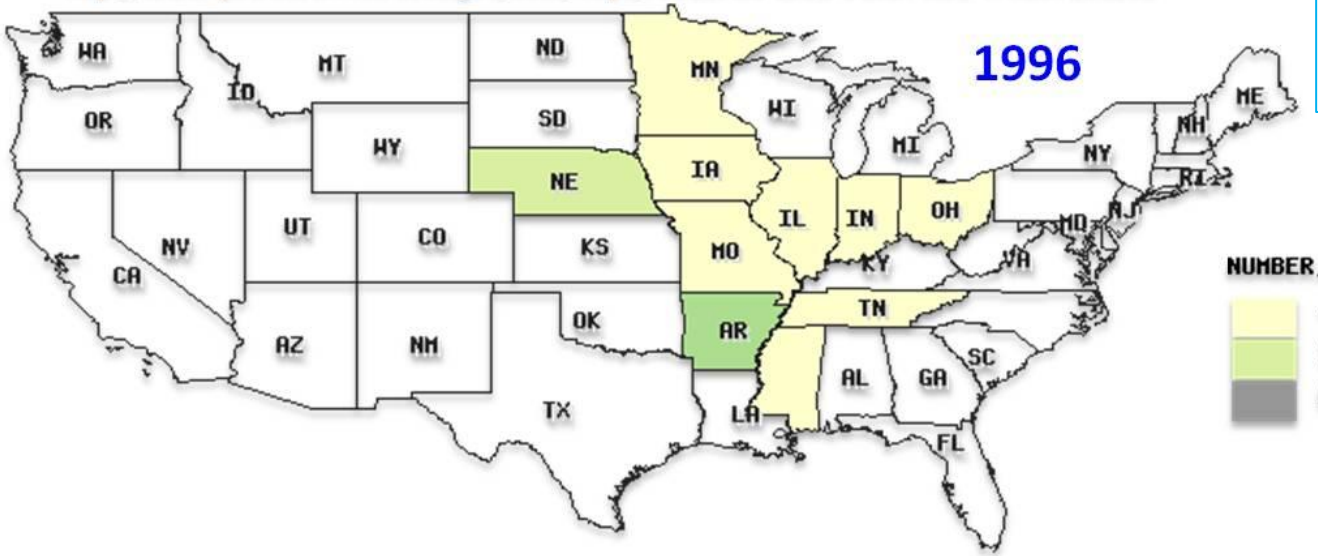
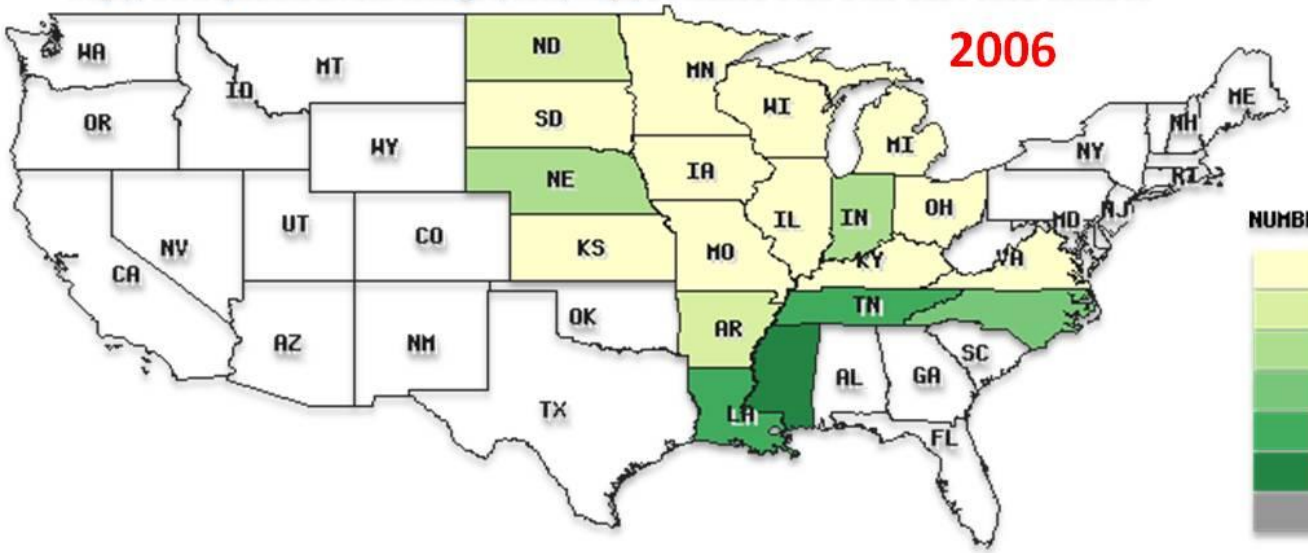


<1.2 to >1.3

Avg 1.1

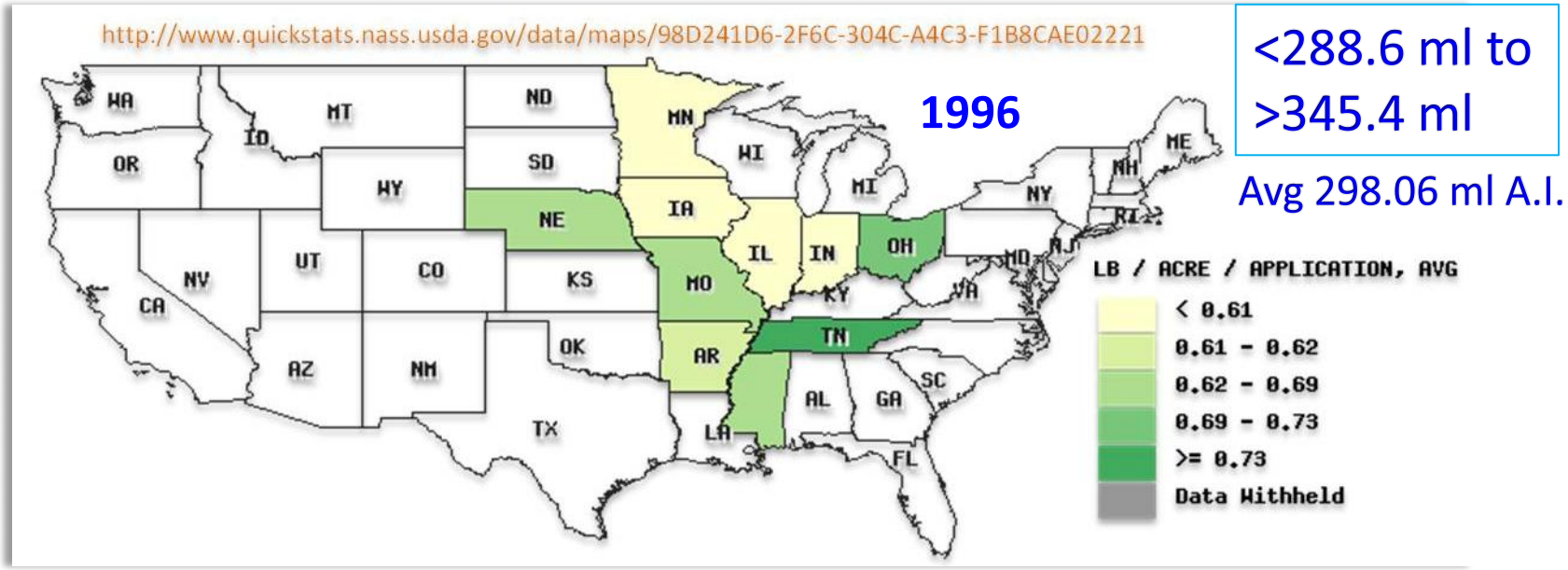
http://www.quickstats.nass.usda.gov/data/maps/D648E0DE-6465-340E-BCE4-5B63F5B30D05



<1.7 to >2.3

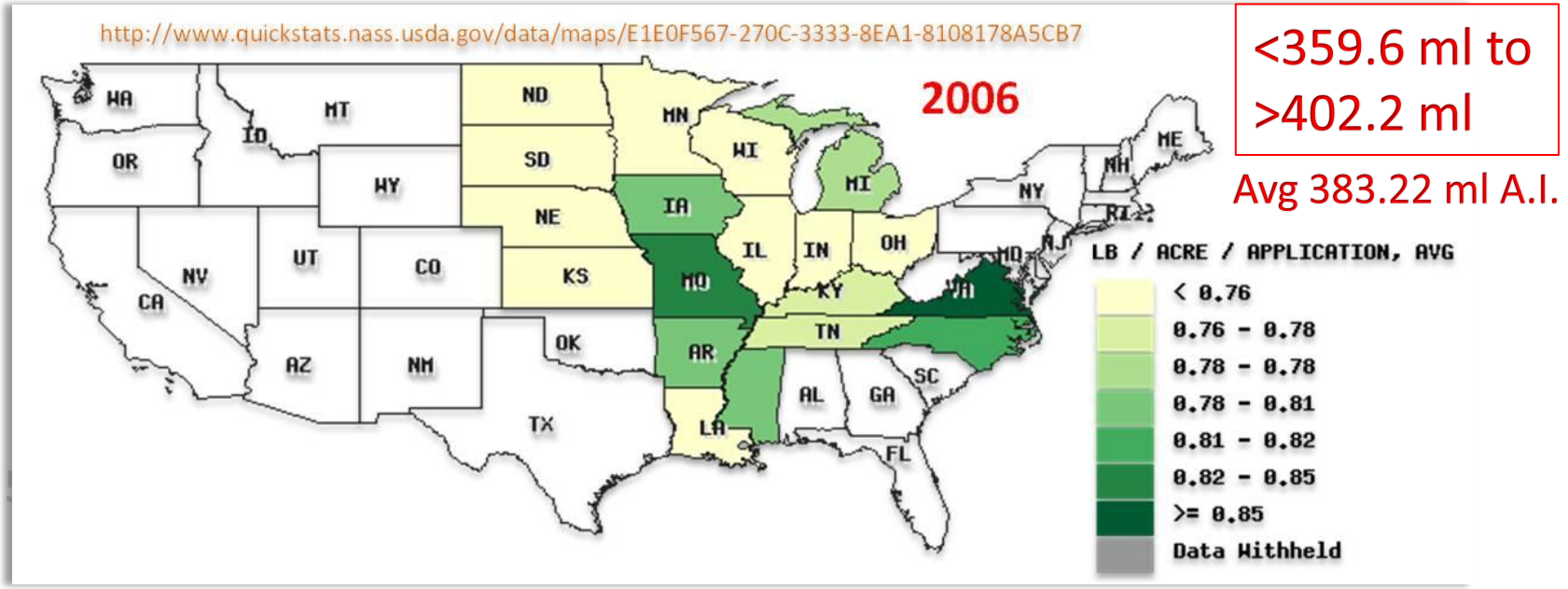
Avg 1.7

Avg Glyphosate use /acre/application



<288.6 ml to >345.4 ml

Avg 298.06 ml A.I.



<359.6 ml to >402.2 ml

Avg 383.22 ml A.I.

Avg Glyphosate use /acre/year

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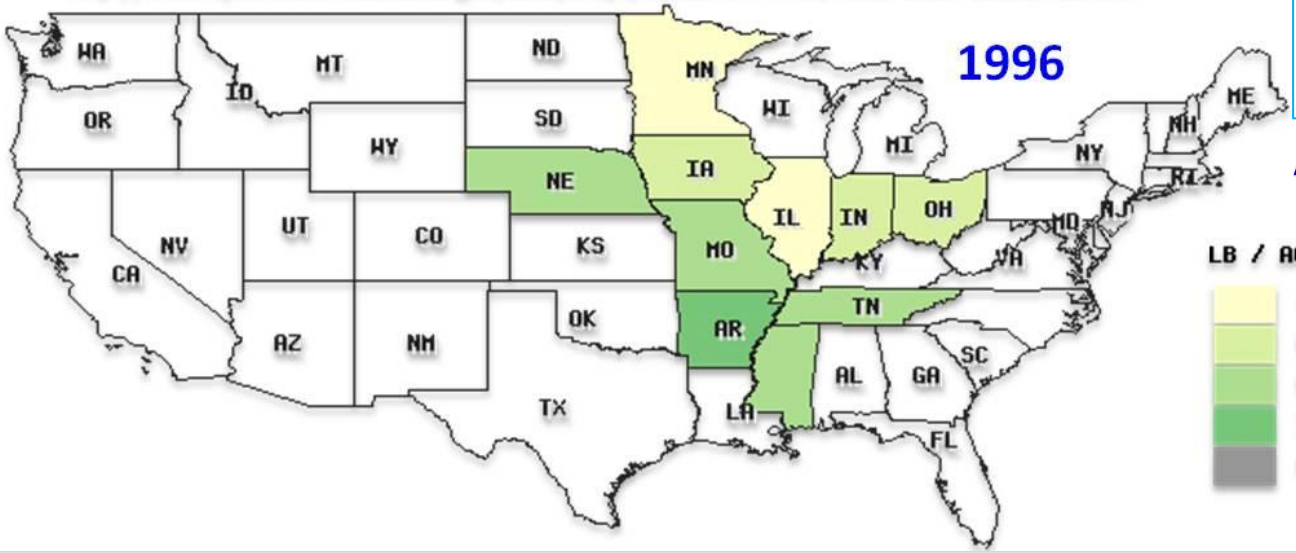

<269.7 ml to >411.6 ml

Avg 326.45 ml A.I.

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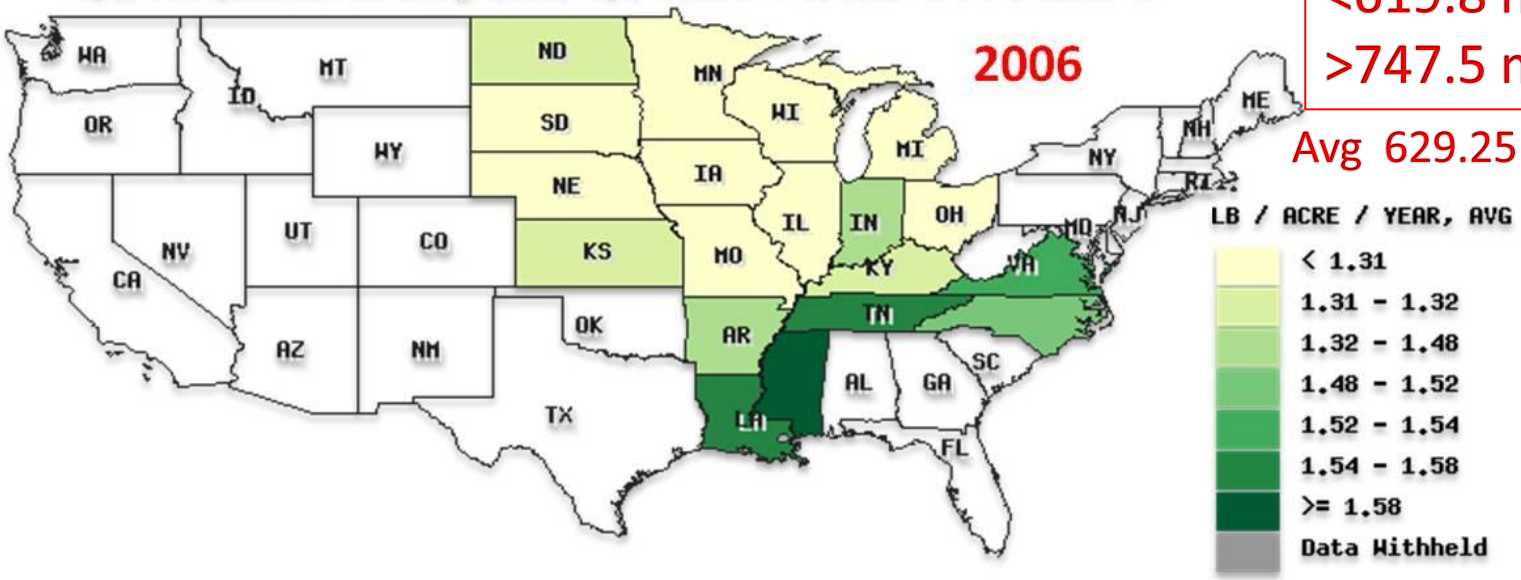
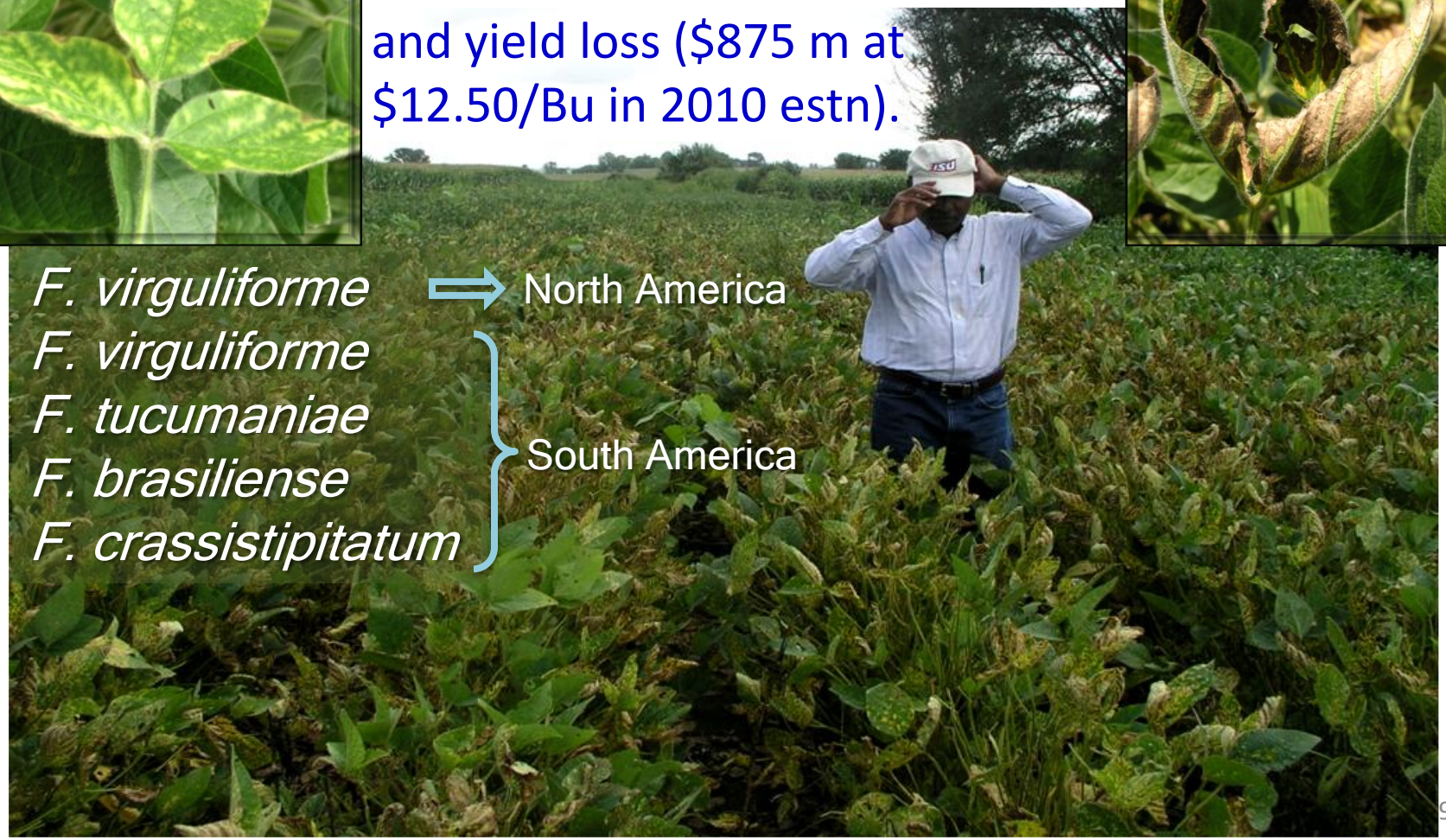


<619.8 ml to >747.5 ml

Avg 629.25 ml A.I.

What is Sudden death syndrome (SDS)?

- SDS is a root disease caused by soil borne *Fusarium* spp.
- SDS results in severe defoliation and yield loss ($875 m at $12.50/Bu in 2010 estn).

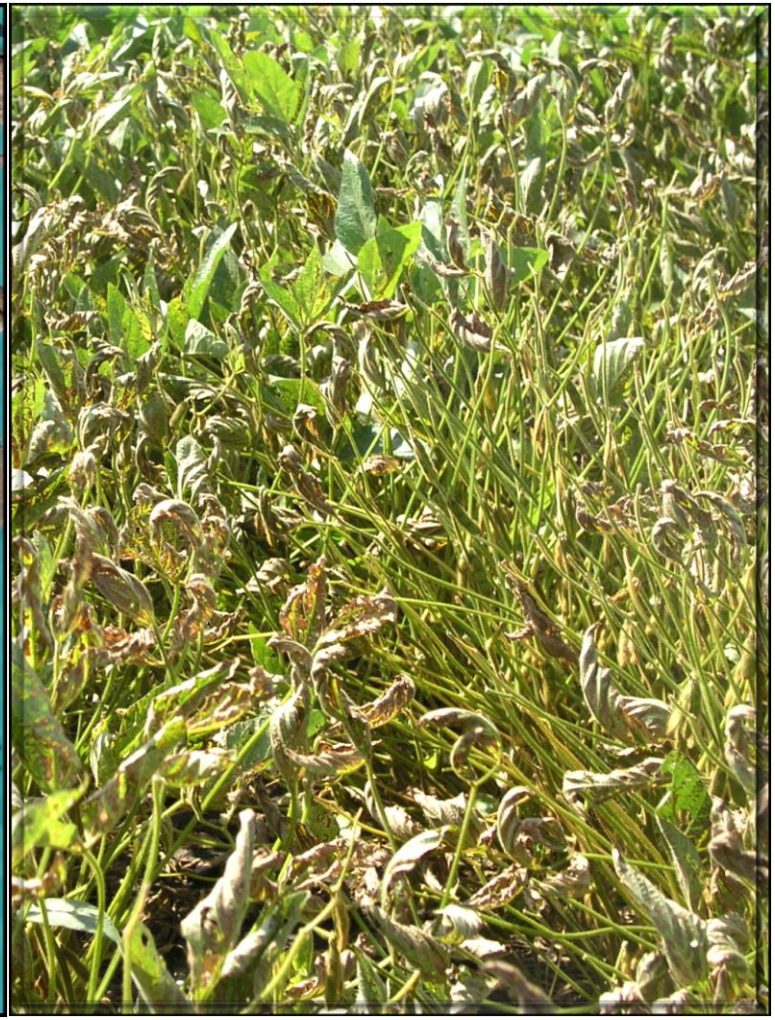


F. virguliforme ⇨ North America

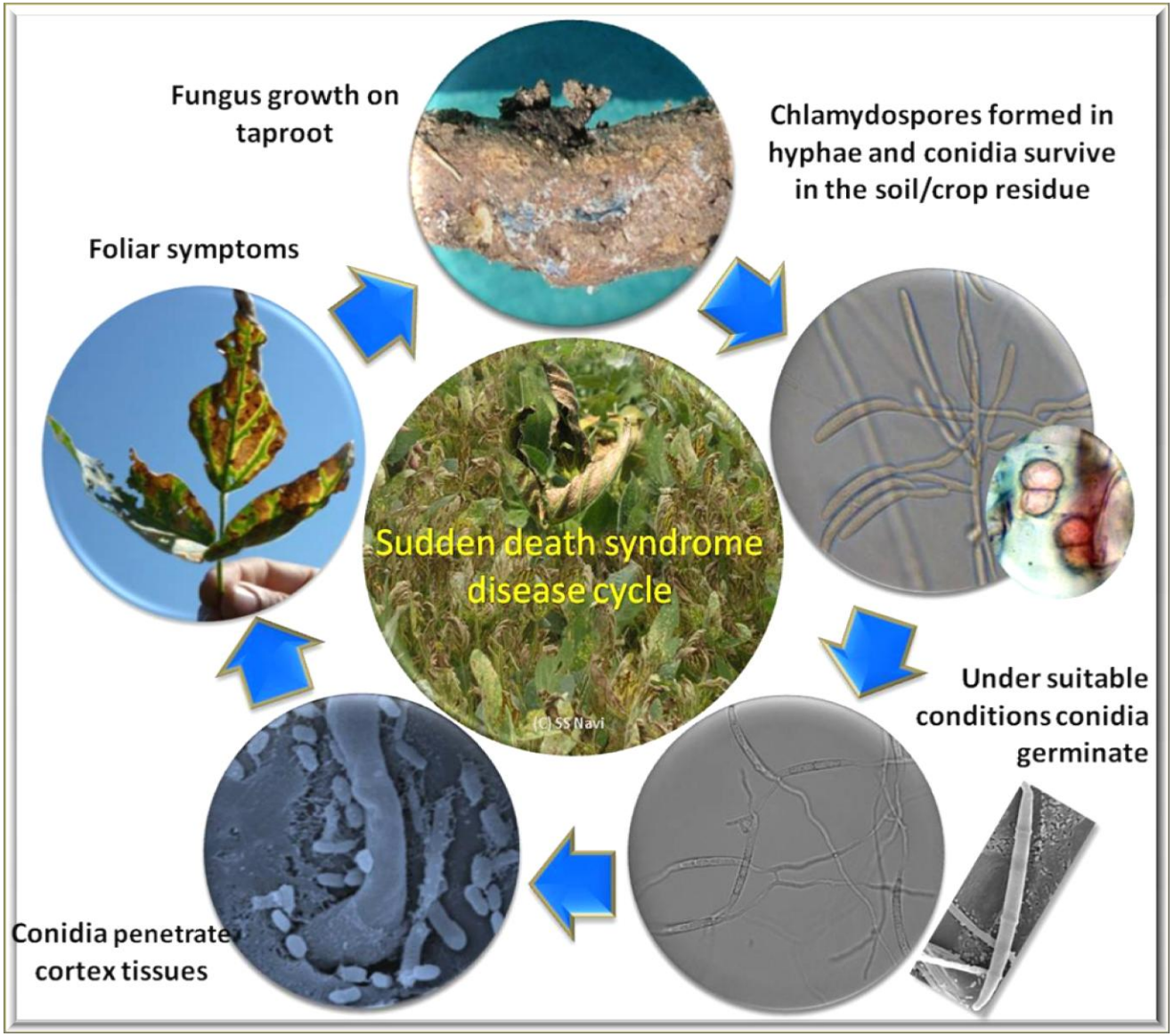
F. virguliforme
F. tucumaniae
F. brasiliense
F. crassistipitatum
} South America

PM 2:53 JUN/ 5/2012

Fungus
on taproot



Disease cycle



SDS first detections

Canada (1998)
(Anderson and Tenuta 1998)

USA (1971)
(Roy et al 1997)

Brazil (1992)
(Nakajima et al. 1993, 1996)

Bolivia (2002)
(Yorinori 2002)

Paraguay (1999)
(Yorinori 1999)

Uruguay (2003)
(Ploper et al. 2003)

Argentina (1991)
(Ploper1993)

F. virguliforme
F. tucumaniae
F. brasiliense
F. crassistipitatum

Disease Control and Pest Management

Effects of Herbicides on *Fusarium solani* f. sp. *glycines* and Development of Sudden Death Syndrome in Glyphosate-Tolerant Soybean

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Department of Plant Pathology, Iowa State University, Ames 50011.
Current address of H. Scherm: Department of Plant Pathology, University of Georgia, Athens 30602.
Accepted for publication 6 October 1999.

Phytopath. 2000, 90:57-66

Sanogo, S., Yang, X. B., and Scherm, H. 2000. Effects of h
Fusarium solani f. sp. *glycines* and development of sudde
drome in glyphosate-tolerant soybean. Phytopathology 90:57-

Sudden death syndrome of soybean, caused by *Fusarium solani* f. sp. *glycines*, is a disease of increasing economic importance in the United States. Although the ecology of sudden death syndrome has been extensively studied in relation to crop management practices such as tillage, irrigation, and cultivar selection, there is no information on the effects of herbicides on this disease. Three herbicides (lactofen, glyphosate, and imazethapyr) commonly used in soybean were evaluated for their effects on the phenology of *F. solani* f. sp. *glycines* and the development of sudden death syndrome in four soybean cultivars varying in resistance to the disease and in tolerance to glyphosate. Conidial germination, my
sporulation in vitro were reduced by glyphosate and
lactofen. In growth-chamber and greenhouse experiments, there was a significant increase in disease severity and frequency of isolation of *F. solani* f. sp. *glycines* from roots of all cultivars after application of imazethapyr or glyphosate compared with the control treatment (no herbicide applied). Conversely, disease severity and isolation frequency of *F. solani* f. sp. *glycines* decreased after application of lactofen. Across all herbicide treatments, severity of sudden death syndrome and isolation frequency were lower in disease-resistant than in susceptible cultivars. Results suggest that glyphosate-tolerant and -nontolerant cultivars respond similarly to infection by *F. solani* f. sp. *glycines* after herbicide application.

Additional keywords: *Glycine max*, herbicide stress.

Field Response of Glyphosate-Tolerant Soybean to Herbicides and Sudden Death Syndrome

S. Sanogo, X. B. Yang, and **P. Lundeen,** Department of Plant Pathology, Iowa State University, Ames 50011

Plant Dis. 2001, 85:773-779

ABSTRACT
Sanogo, S., Yang, X. B., and Lundeen, P. 2001. Field response of glyphosate-tolerant soybean to
herbicides and sudden death syndrome. Plant Dis. 85:773-779.

Three-year field experiments were conducted to assess the developmen
drome (caused by *Fusarium solani* f. sp. *glycines*) in three soy
and A3071) and nontolerant (BSR101), to glyphosate foll
cides (acifluorfen, glyphosate, imazethapyr, and l
north-central region of the United States. G
whereas cultivars P9344 and BSR
significant cultivar–herbicid
disease and the frequency of
Across all herbicide treatmen
resistant cultivar than in the su
application of acifluorfen, glyphosate, and imazethapyr compared with nontreated or lactofen-treated plants. The results obtained indicate that the response of glyphosate-tolerant soybeans to sudden death syndrome is not different from the response of conventional soybeans to this disease following application of the selected herbicides, and the resistance of soybean to sudden death syndrome was not changed with application of glyphosate.
beans in the
den death syndrome,
There was no statistically
severity of foliar symptoms of the
sp. *glycines* from roots of soybean plants.
sudden death syndrome was lower in the disease-
ble ones. There was an increase in the disease levels under

(26,38), in
n-glyphosate-tolerant crops
this
as been shown to increase
arious fungal pathogens in
and to suppress plant
nd enhance disease susceptibility
various crops and weeds (5,19,21,22, 24,25,30,40,45).

The goal of this study was to assess the field response of glyphosate-tolerant and conventional soybeans to sudden death syndrome following application of selected herbicides commonly used in soybean in the north-central region of the United States.

MATERIALS AND METHODS

Herbicides and cultivars. Four herbicides were tested in this study: acifluorfen (Blazer), glyphosate (Roundup Ultra), imazethapyr (Pursuit 2AS), and lactofen

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Review

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Glyphosate Effects on Plant Mineral Nutrition, Crop Rhizosphere Microbiota, and Plant Disease in Glyphosate-Resistant Crops

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ited States
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J. Agric. Food Chem. 2012, 60:10375–10397

ABSTRACT: Claims have been made recently that glyphosate-resistant (GR) crops sometimes have mineral deficiencies and increased plant disease. This review evaluates the literature that is germane to these claims. Our conclusions are: (1) although there is conflicting literature on the effects of glyphosate on mineral nutrition on GR crops, most of the literature indicates that mineral nutrition in GR crops is not affected by either the GR trait or by application of glyphosate; (2) most of the available data support the view that neither the GR transgenes nor glyphosate use in GR crops increases crop disease; and (3) yield data on GR crops do not support the hypotheses that there are substantive mineral nutrition or disease problems that are specific to GR crops.

KEYWORDS: *glyphosate, glyphosate-resistant crop, corn, cotton, soybean, maize, plant disease, mineral nutrition*

Objectives

To study the effect of glyphosate

- spray rates @ 16, 22 and 33 fl oz/Ac on sudden death syndrome (16= 230.88 ml, 22= 317.46 ml, and 33= 476.19 ml A.I.)
- spray frequency @ 22 fl oz/Ac for 1×, 2× and 3× on SDS.
- on varietal response to SDS in sprayed @ 22 fl oz/Ac and unsprayed treatments.

Methods – objective 1

The effect of Roundup spray rates @ 16, 22 & 33 fl oz/Ac on SDS (P93Y13RR and P92M76RR)

Treatments: 8

- FV inoculated, roundup sprayed (at 16, 22 and 33 fl oz/Ac) -- 3
- FV inoculated, roundup not sprayed -- 1
- Not inoculated and not sprayed -- 1
- Not inoculated but roundup sprayed (at 16, 22 and 33 fl oz/Ac) -- 3

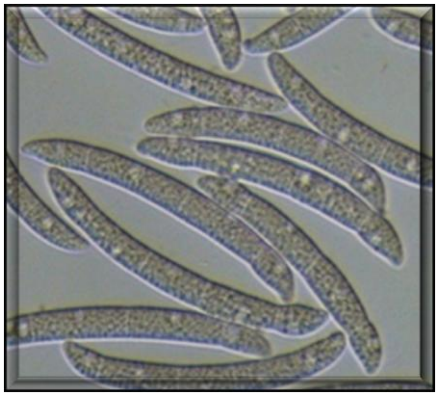
Replications: 4 (5 cups/rep)

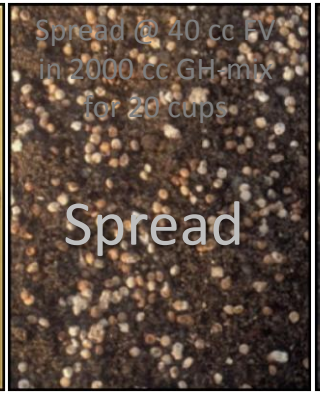
Design: RCBD

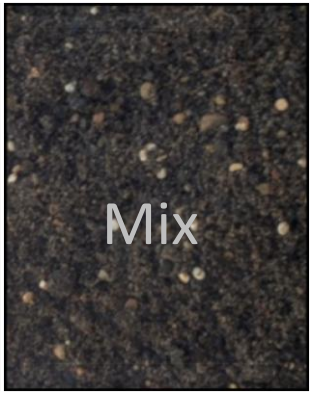
16 fl oz = 473.12 ml = 230.88 ml A.I.; 22 fl oz = 650.54 ml = 317.46 ml A.I.
33 fl oz = 975.81 ml = 476.19 ml A.I.

Inoculation and planting

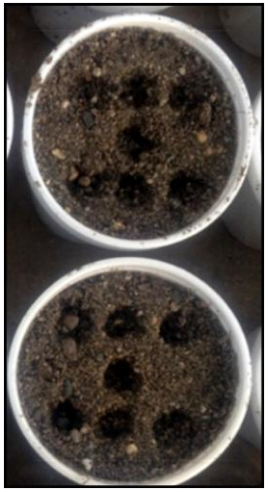
Fungus grown on white Milo was mixed with potting mixture.

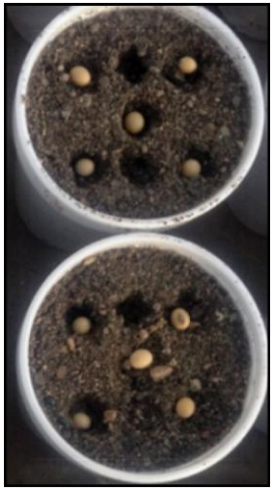


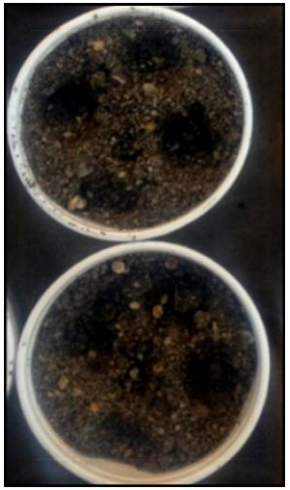




Cups were filled and 5-7 seeds/cup planted.

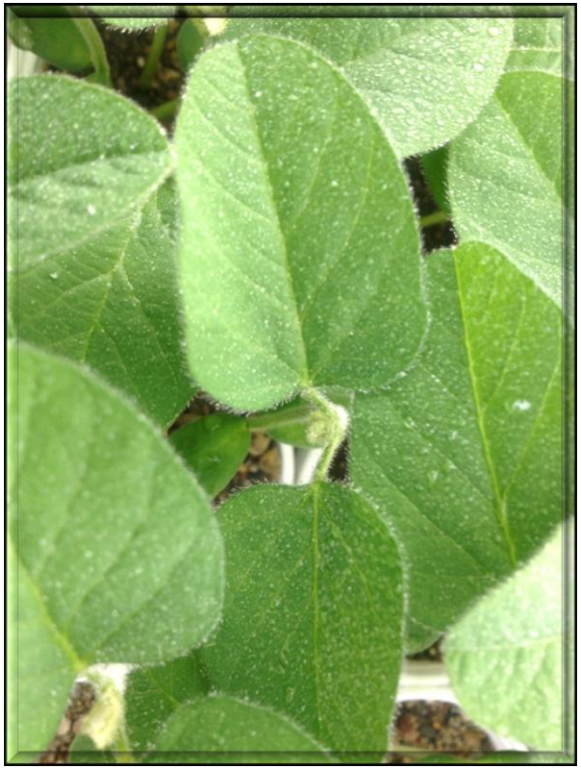






Roundup WeatherMax® spray

Glyphosate was sprayed as per the treatment details indicated in objectives (a week after emergence). Plants were incubated at 24°C with 16 h light.

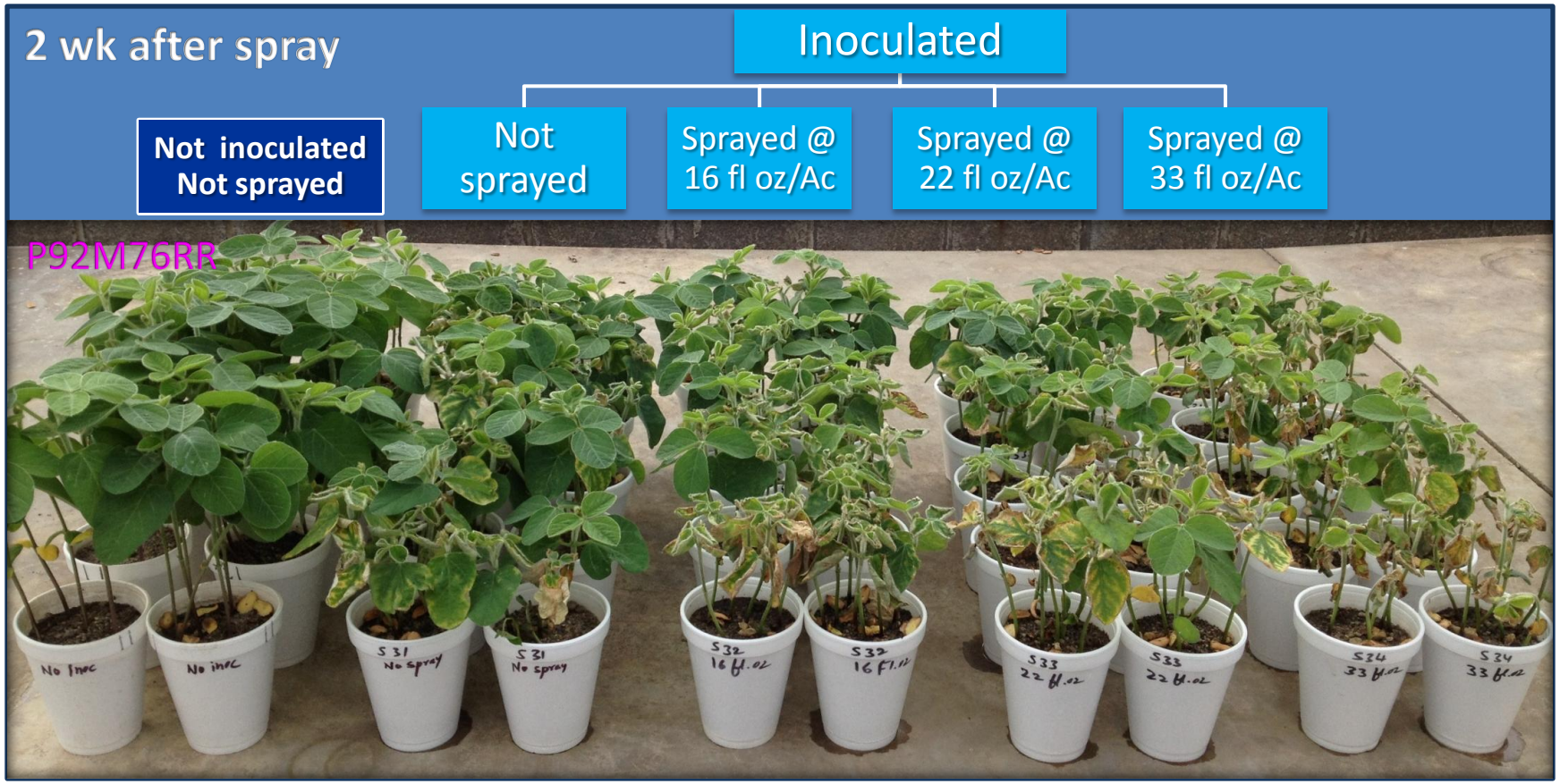


Evaluation

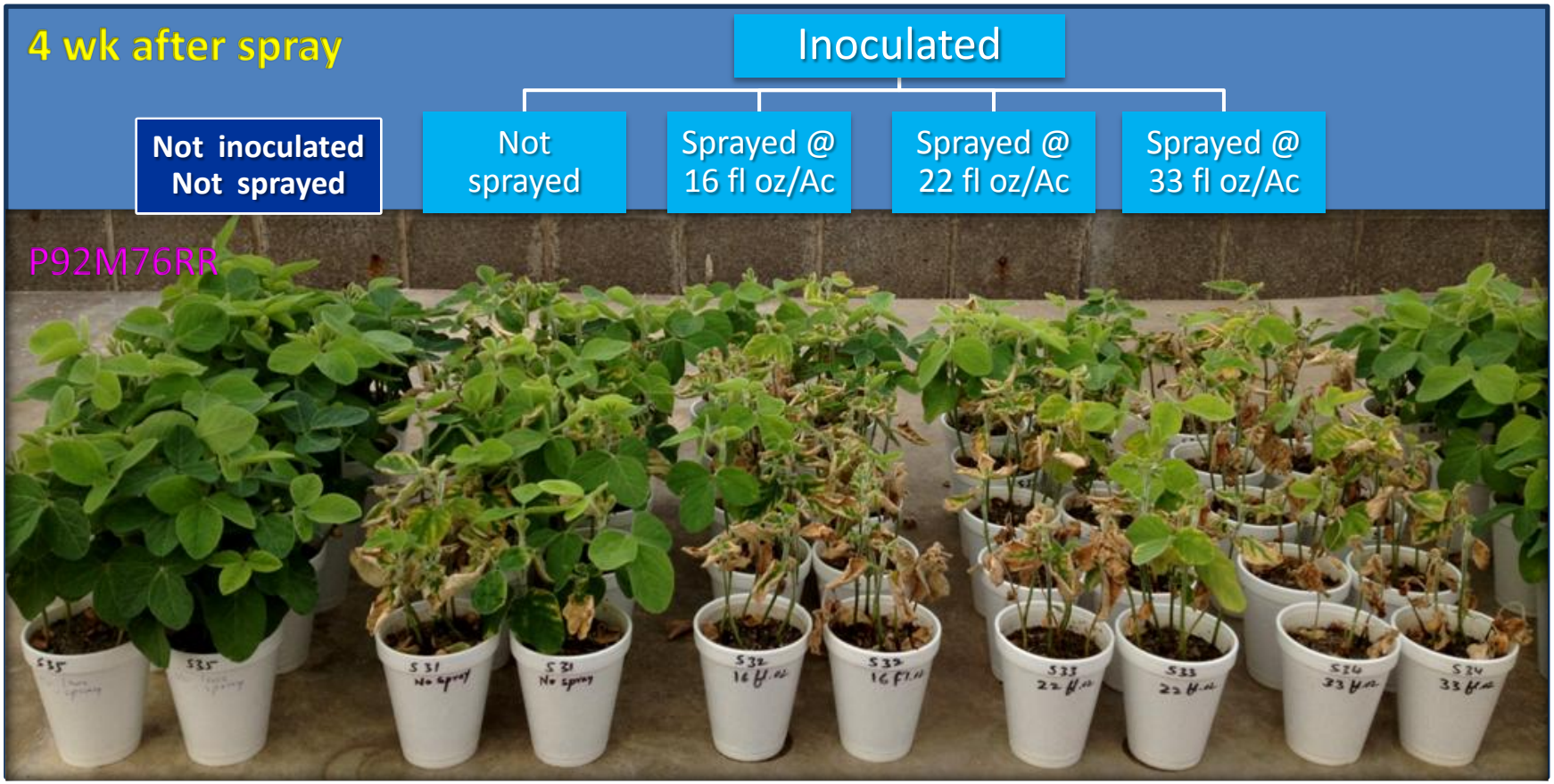
Stand count, SDS count and SDS severity before and after sprays. Also, plant height, % defoliation, top and root biomass (final SDS readings were taken 4 weeks after and the biomass 5 wk after Roundup spray).

Results – objective 1

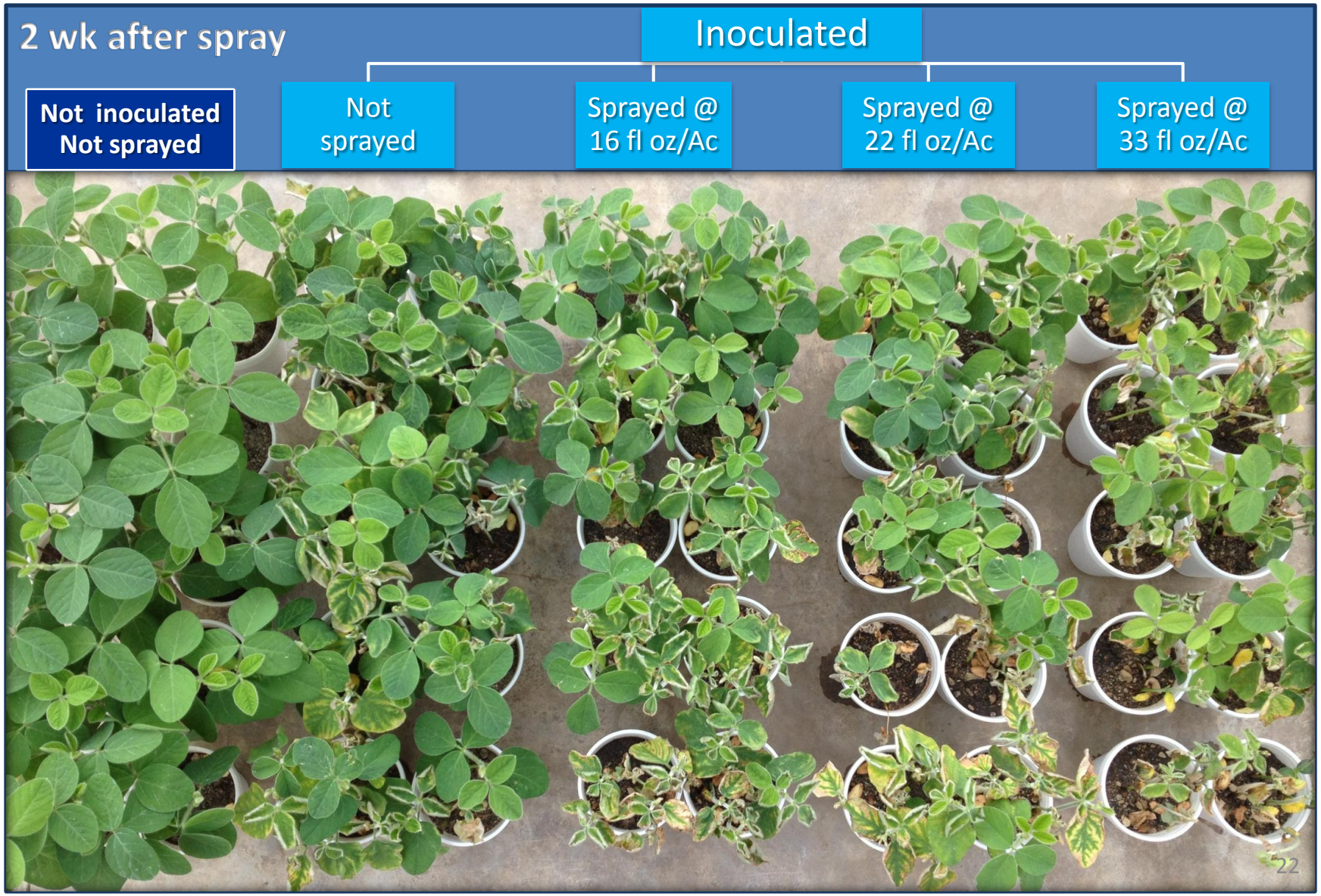
Spray rates of Roundup WeatherMax® on SDS



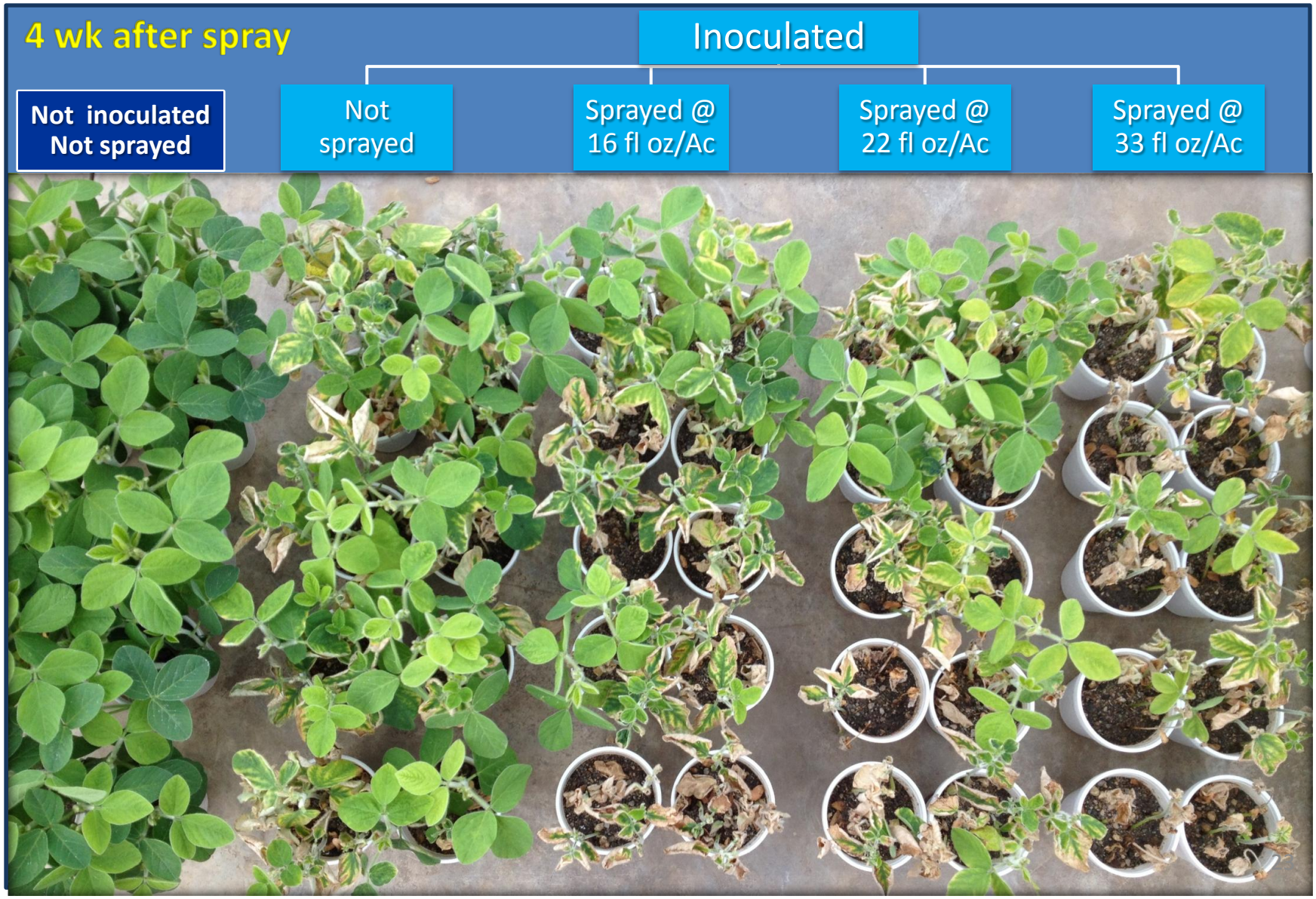
Spray rates of Roundup WeatherMax® on SDS



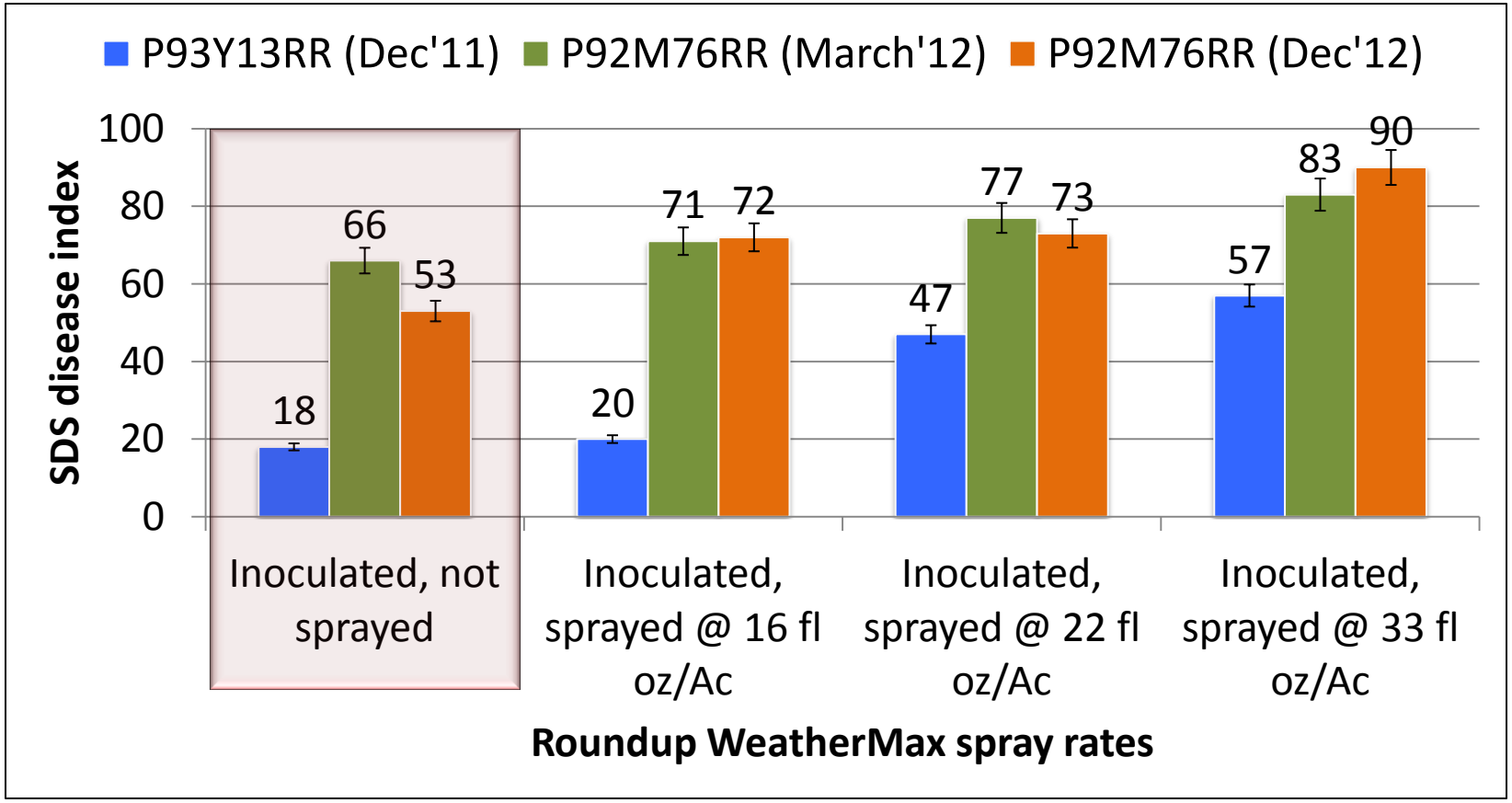
Spray rates of Roundup WeatherMax® on SDS



Spray rates of Roundup WeatherMax® on SDS

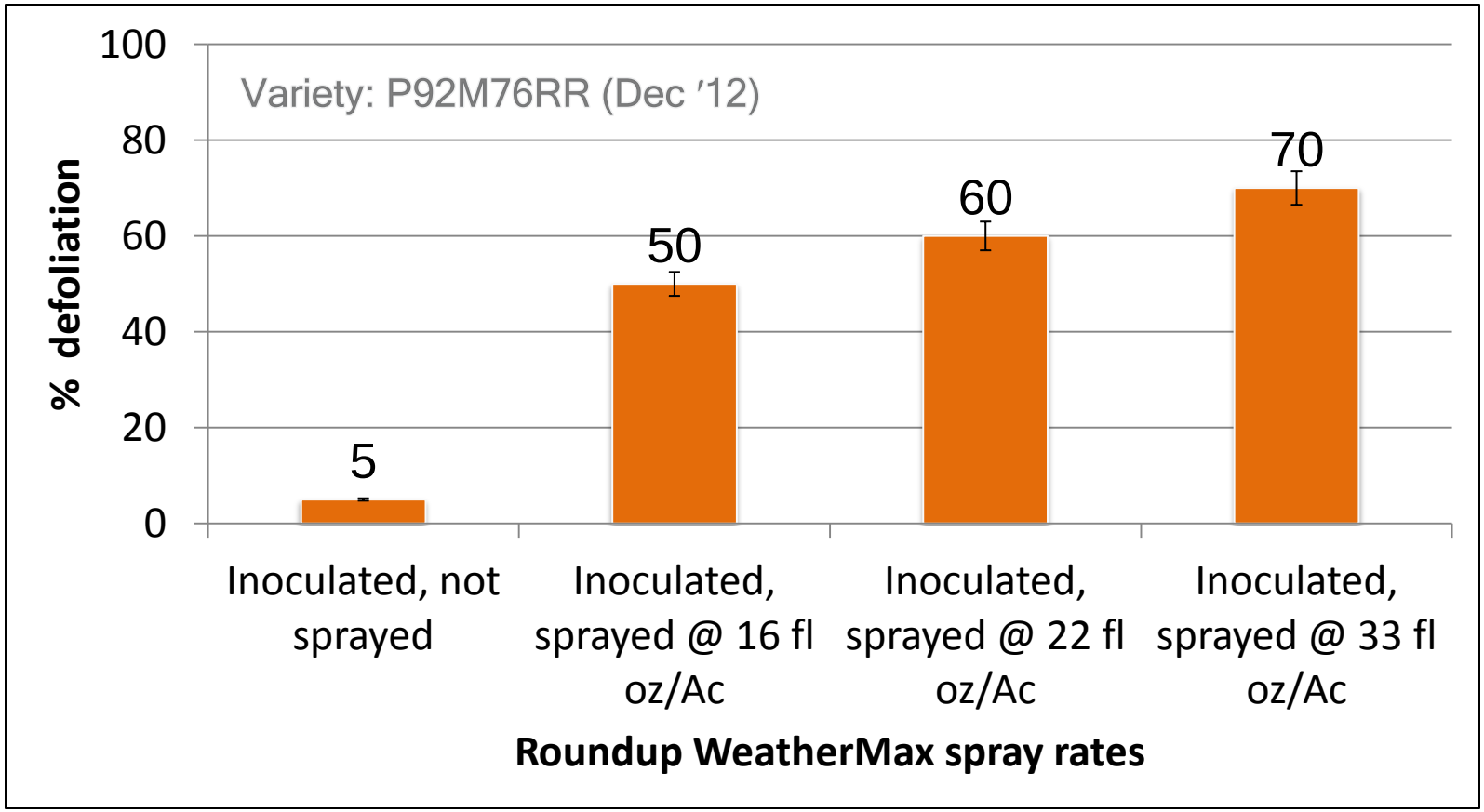


Spray rates of Roundup WeatherMax® on SDS*



*Disease index based on final reading of 4 week after 1st spray. Company rating of P93Y13RR is 5 and P92M76RR is 4 on 1-9 scale where, 1= poor and 9= excellent

Spray rates of Roundup WeatherMax® on % defoliation*



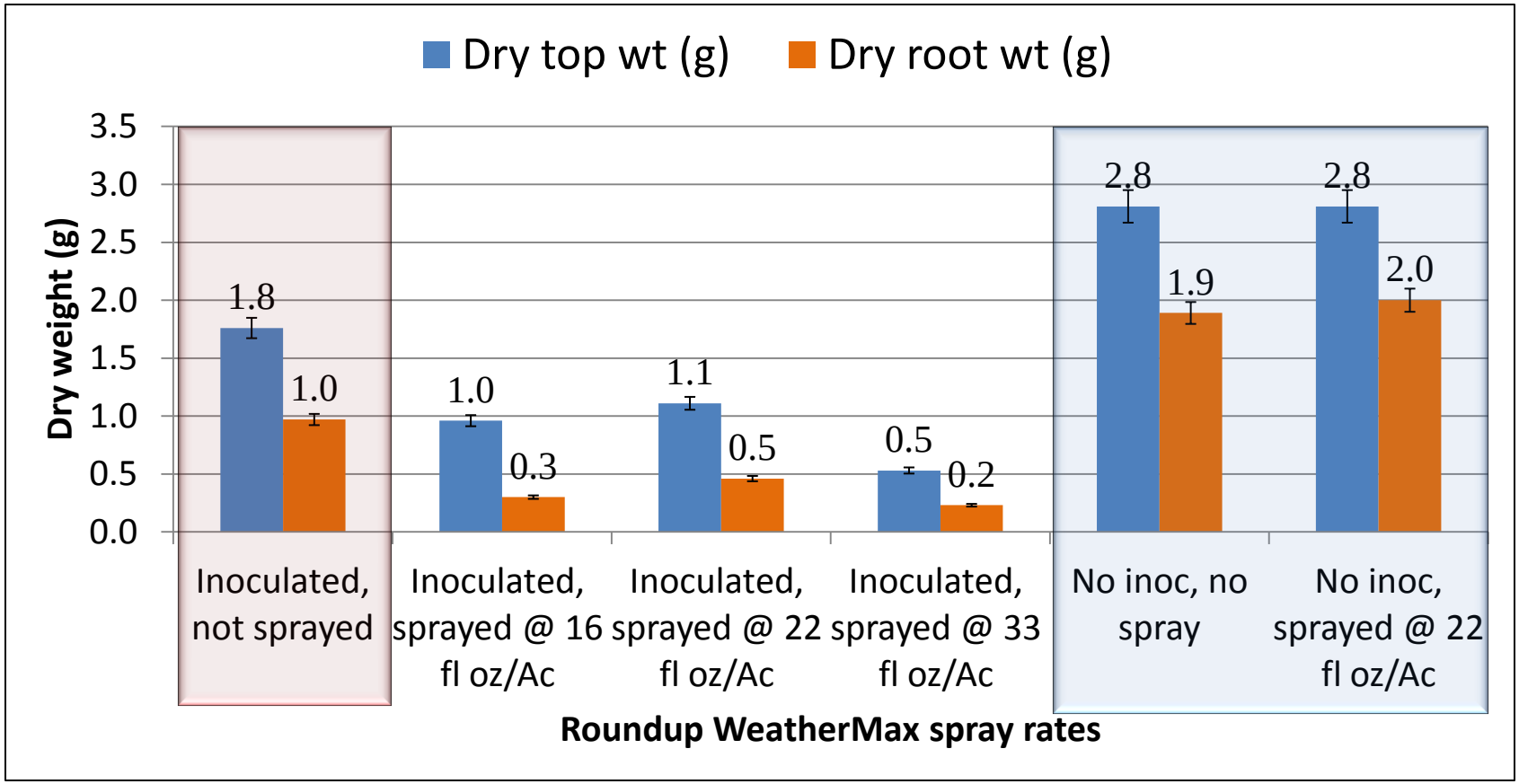
16 fl oz = 230.88 ml A.I.
22 fl oz = 317.46 ml A.I.
33 fl oz = 476.19 ml A.I.

*Based on readings taken 4 week after spray

Spray rates of Roundup WeatherMax® on biomass*

* Readings of 5 weeks after the spray (Variety: P92M76RR)

Spray rates of Roundup WeatherMax® on biomass*



* Average of 50 plants/treatment of variety P92M76RR

Methods – objective 2

The effect of Roundup spray frequency @ 22 fl oz/Ac on SDS (P93Y13RR and P92M76RR)

Treatments: 8

- FV inoculated, roundup sprayed -- 3
  (1×, 2× and 3× @ 22 fl oz/Ac)
- FV inoculated, roundup not sprayed -- 1
- Not inoculated and not sprayed -- 1
- Not inoculated but roundup sprayed -- 3
  (1×, 2× and 3× @ 22 fl oz/Ac)

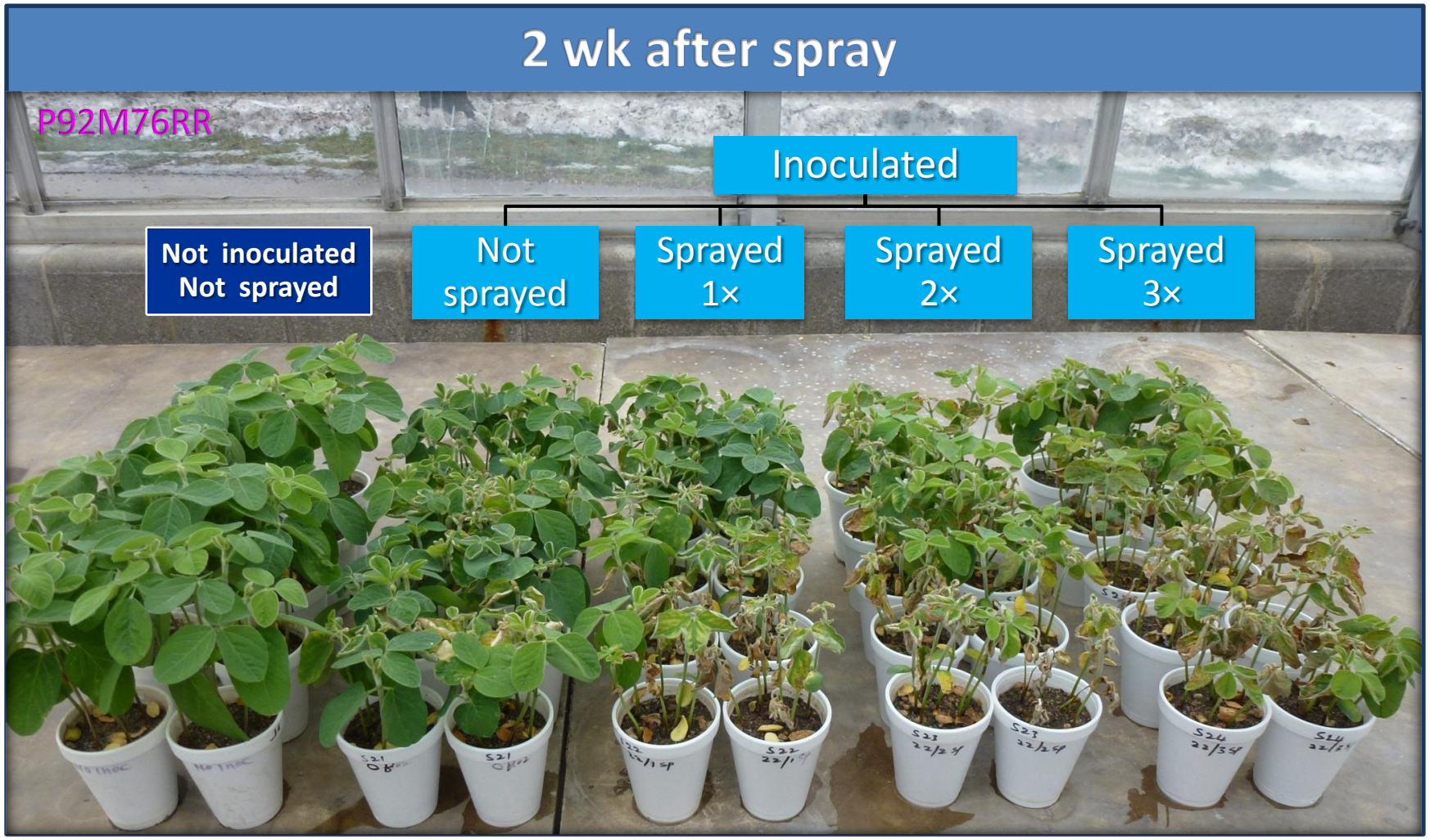
Replications: 4 (5 cups/rep)

Design: RCBD

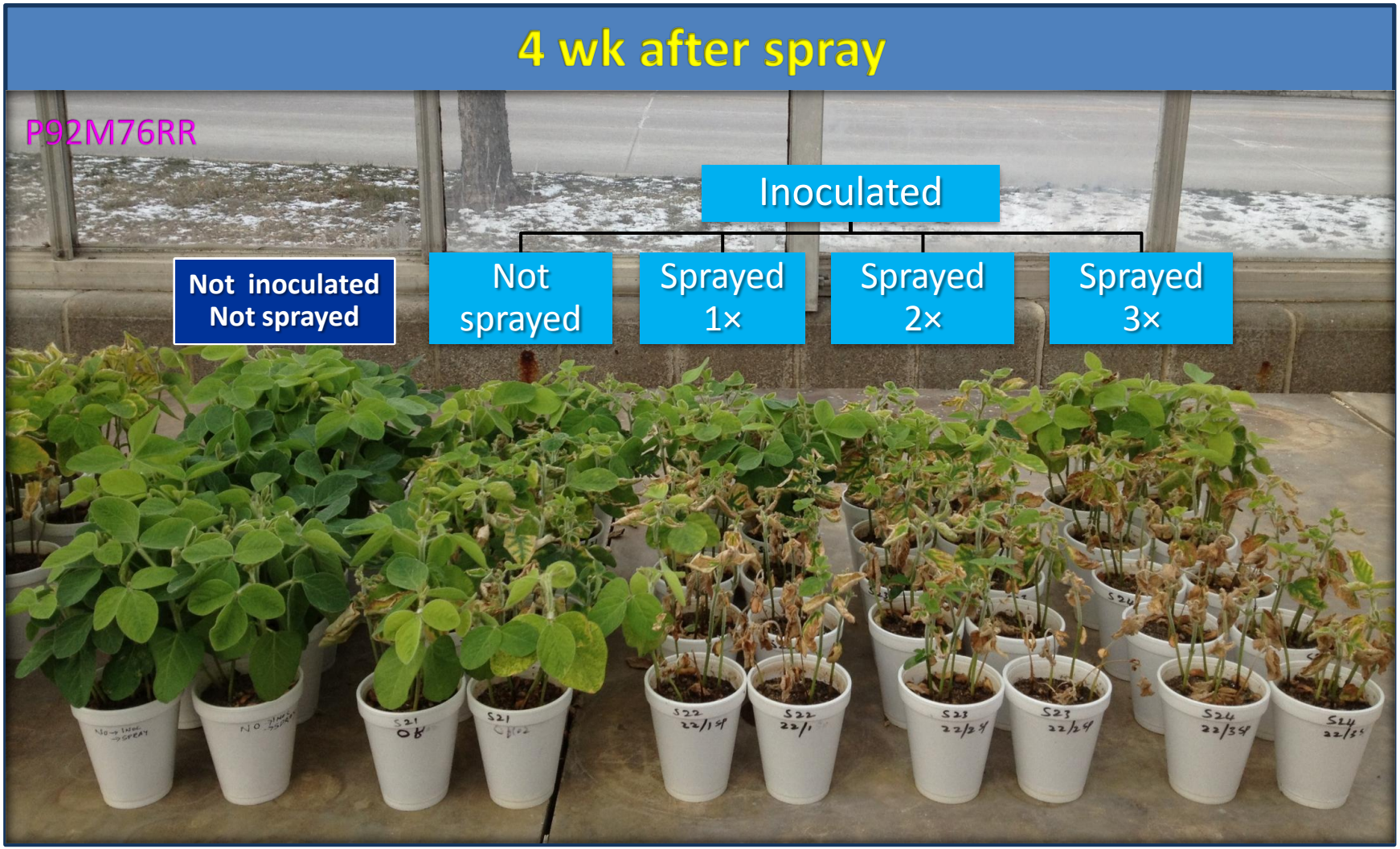
22 fl oz = 650.54 ml = 317.46 ml A.I.

Results – objective 2

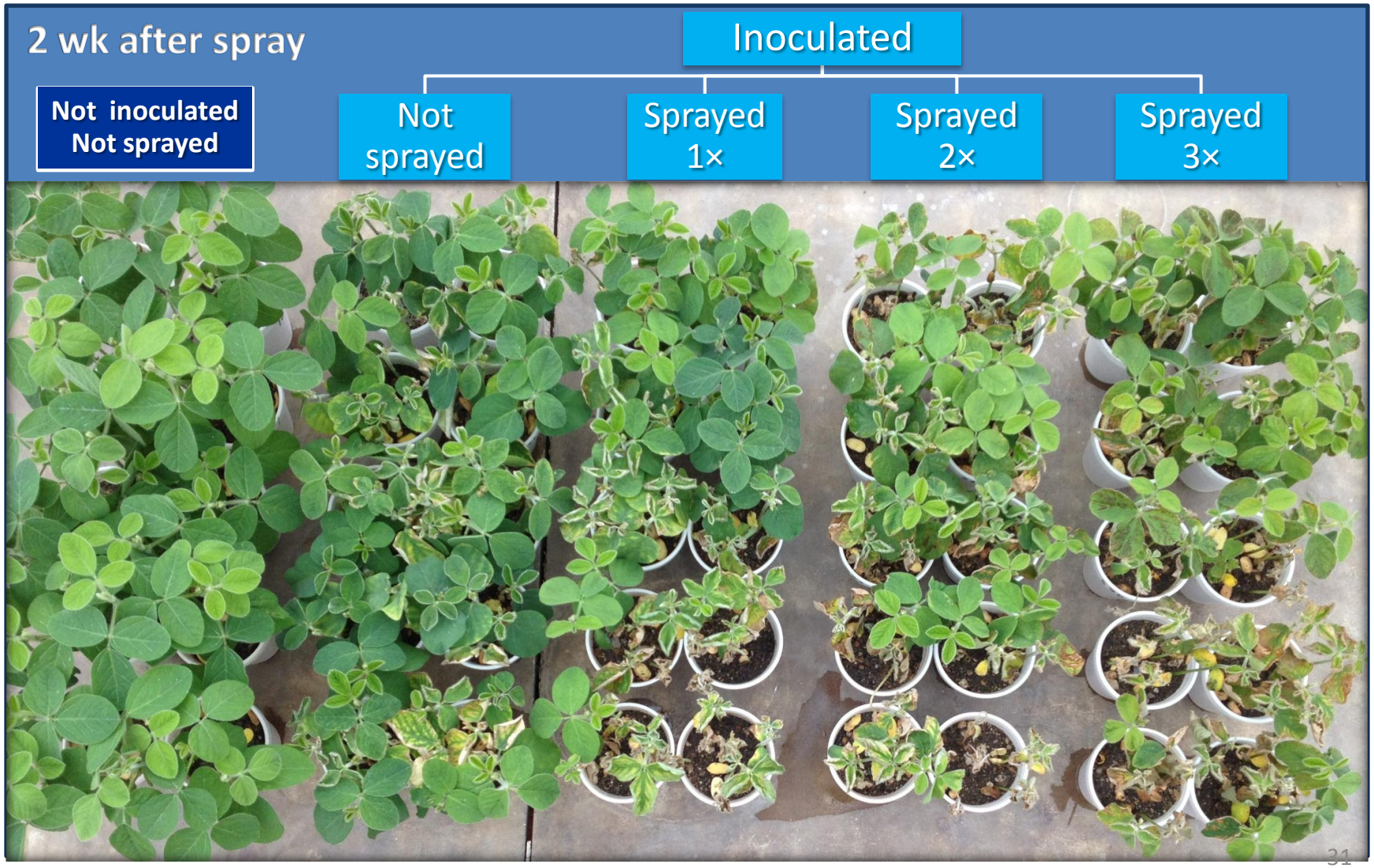
Spray frequency of Roundup WeatherMax® @ 22 fl oz/Ac on SDS



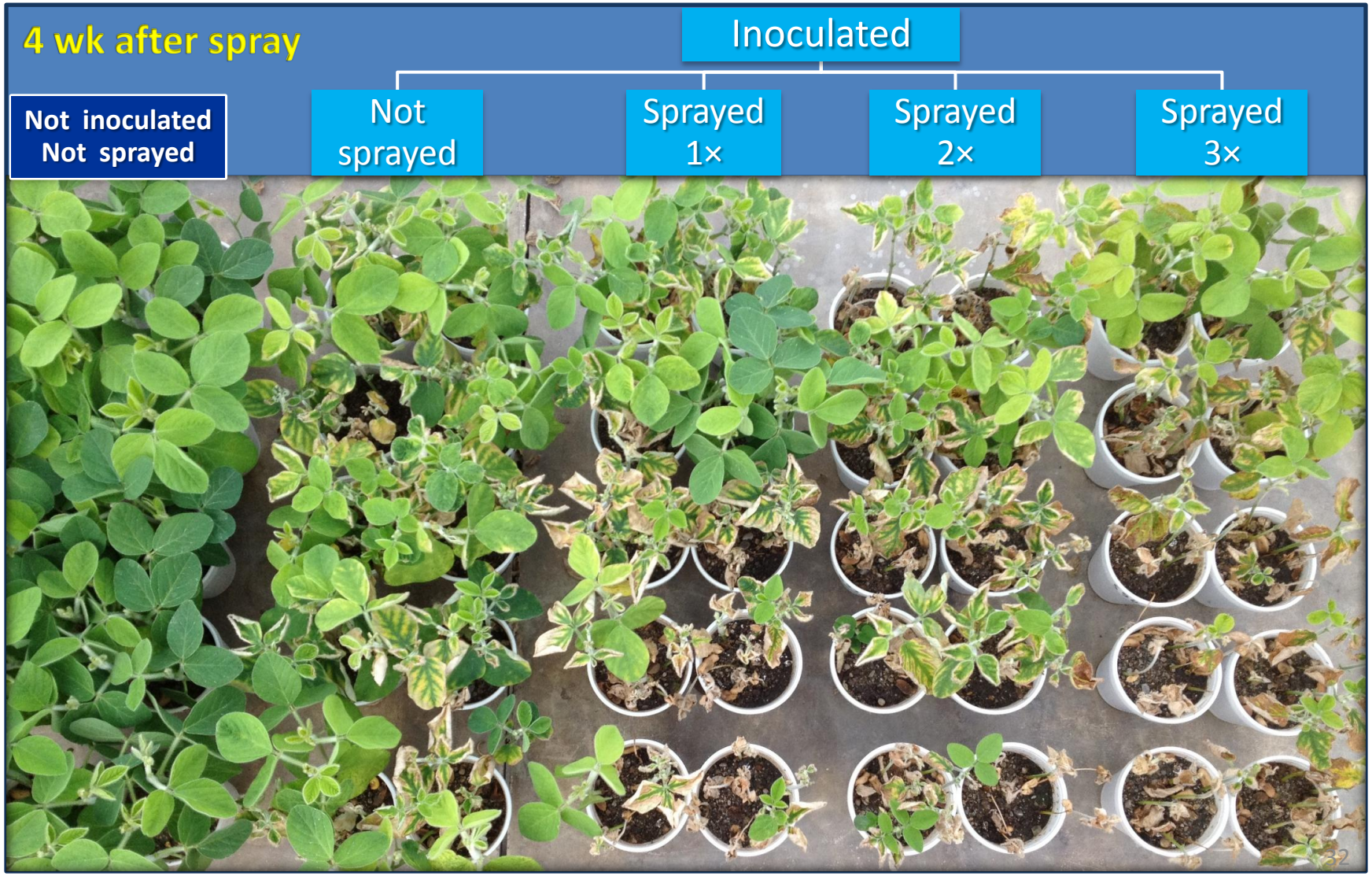
Spray frequency of Roundup WeatherMax® @ 22 fl oz/Ac on SDS



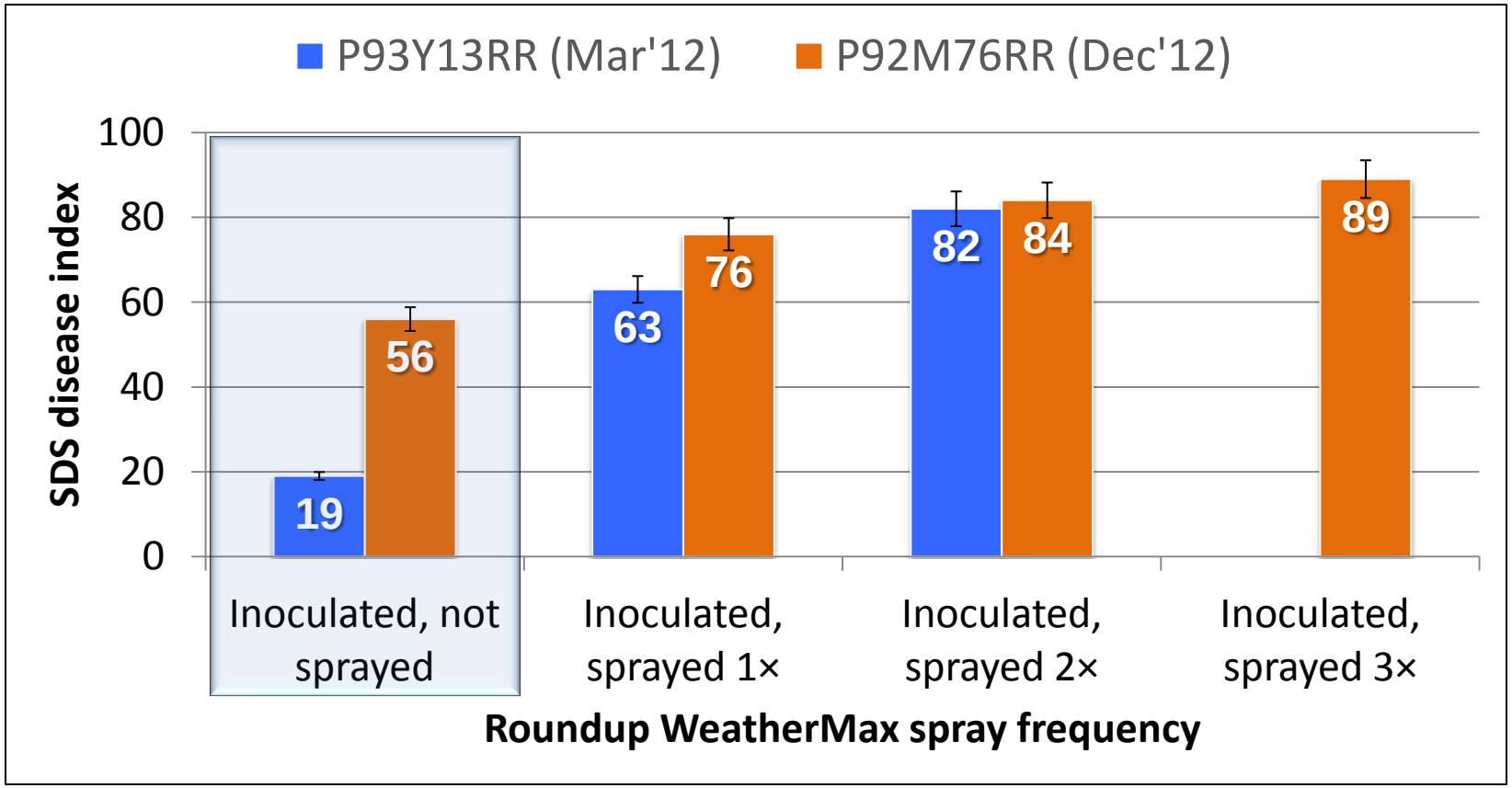
Spray frequency of Roundup WeatherMax® @ 22 fl oz/Ac on SDS



Spray frequency of Roundup WeatherMax® @ 22 fl oz/Ac on SDS

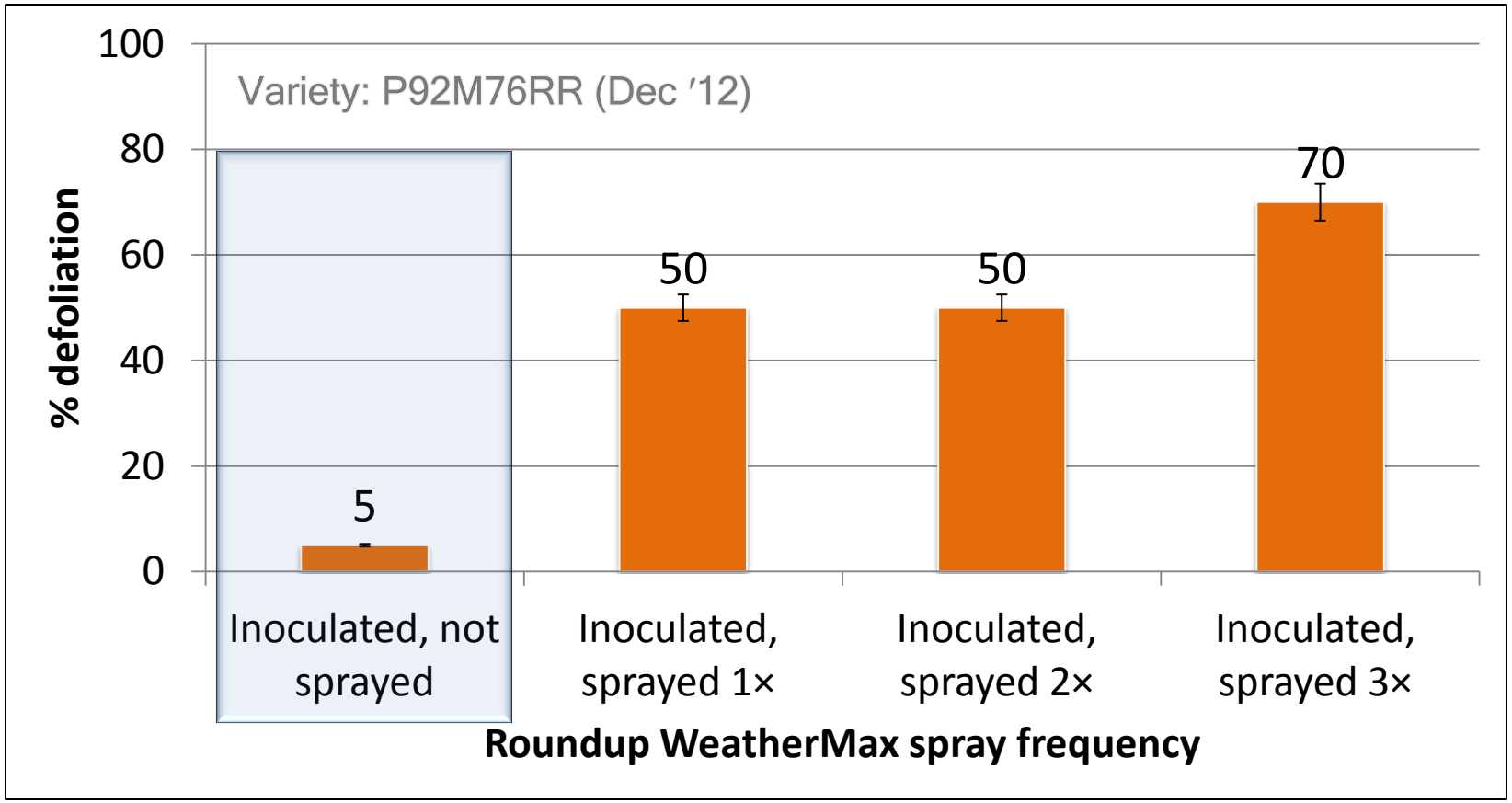


Spray frequency of Roundup WeatherMax® @ 22 fl oz/Ac on SDS*



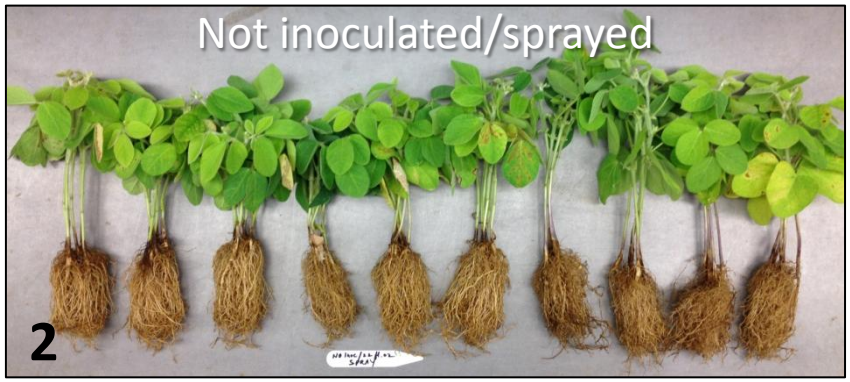
*Disease index based on final reading of 4 week after 1st spray. SDS rating of P93Y13RR is 5 and P92M76RR is 4 on 1-9 scale where, 1= poor and 9= excellent

Spray frequency of Roundup WeatherMax® @ 22 fl oz/Ac on % defoliation*



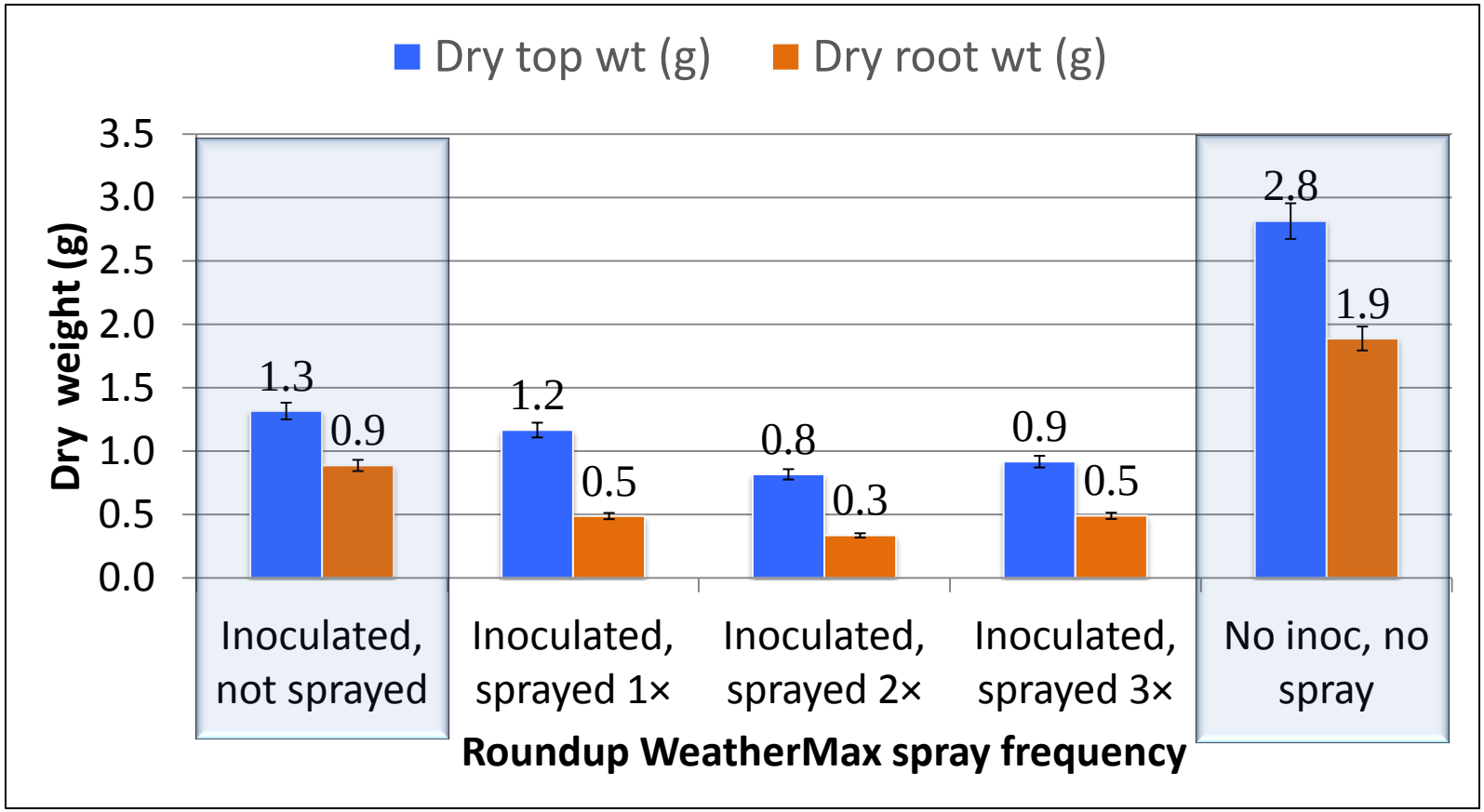
*Readings 4 week after Roundup spray

Spray frequency of Roundup WeatherMax® @ 22 fl oz/Ac on biomass



Biomass readings were taken 5 weeks after the first spray (Variety: P92M76RR)

Spray frequency of Roundup WeatherMax® @ 22 fl oz/Ac on dry biomass*



*Average of 50 plants/treatment

Methods – objective 3

The varietal response to SDS in Roundup WeatherMax® sprayed @ 22 fl oz/Ac and unsprayed treatments.

Treatments: **16**

- FV inoculated, roundup sprayed -- 4
- FV inoculated, roundup not sprayed -- 4
- Not inoculated but roundup sprayed -- 4
- Not inoculated and not sprayed -- 4

(RR varieties: P92Y20, P92Y51, P92M40, P93Y13)
(RR varieties: P92Y20, P92Y51, P92M40, P92M76)

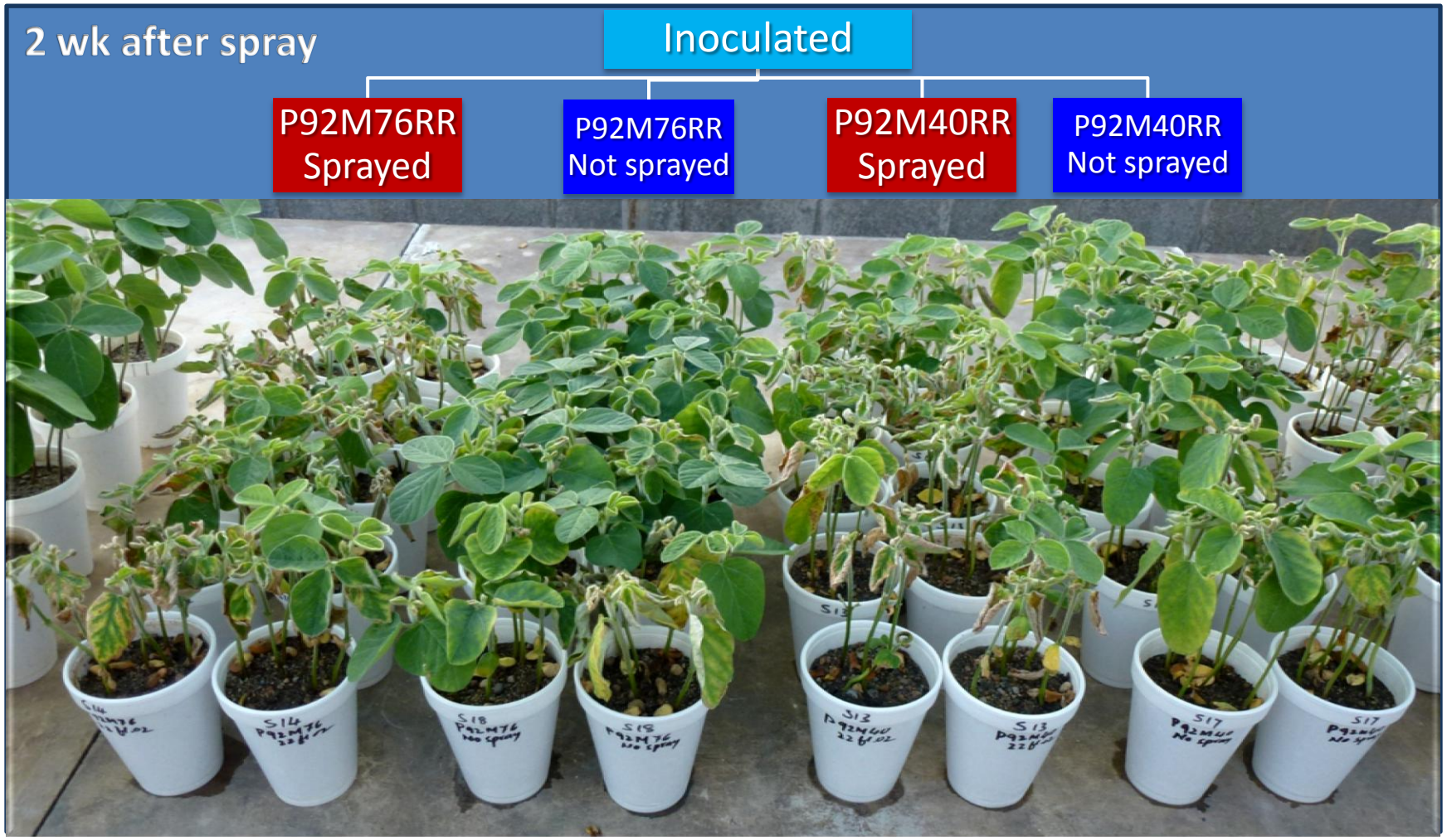
Replications: **4** (5 cups/rep)

Design: RCBD

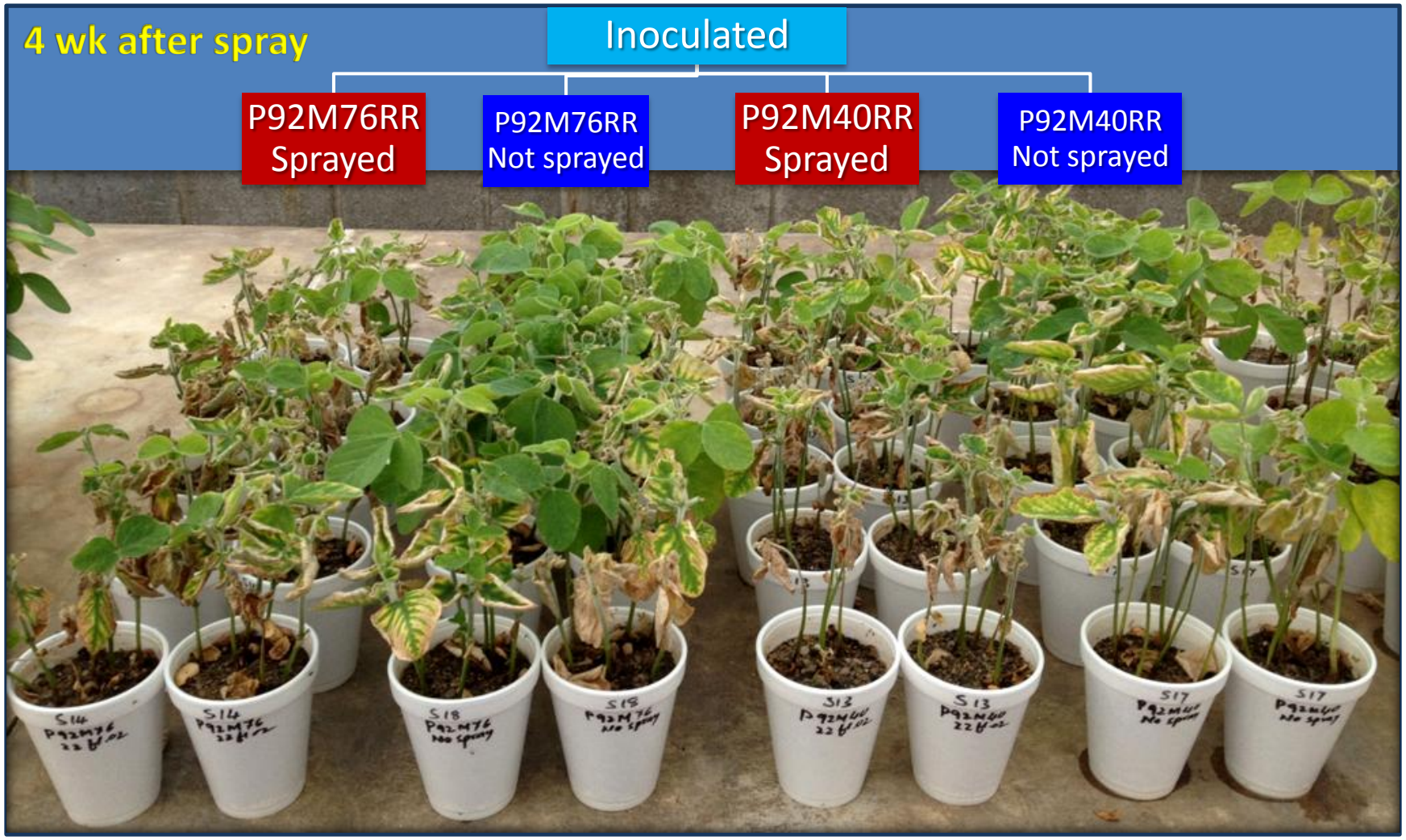
22 fl oz = 650.54 ml = 317.46 ml A.I.

Results – objective 3

Varietal response to SDS in Roundup un/sprayed treatments



Varietal response to SDS in Roundup WeatherMax® un/sprayed treatments



2 wk after spray

P92M76RR Sprayed

P92M76RR Not sprayed

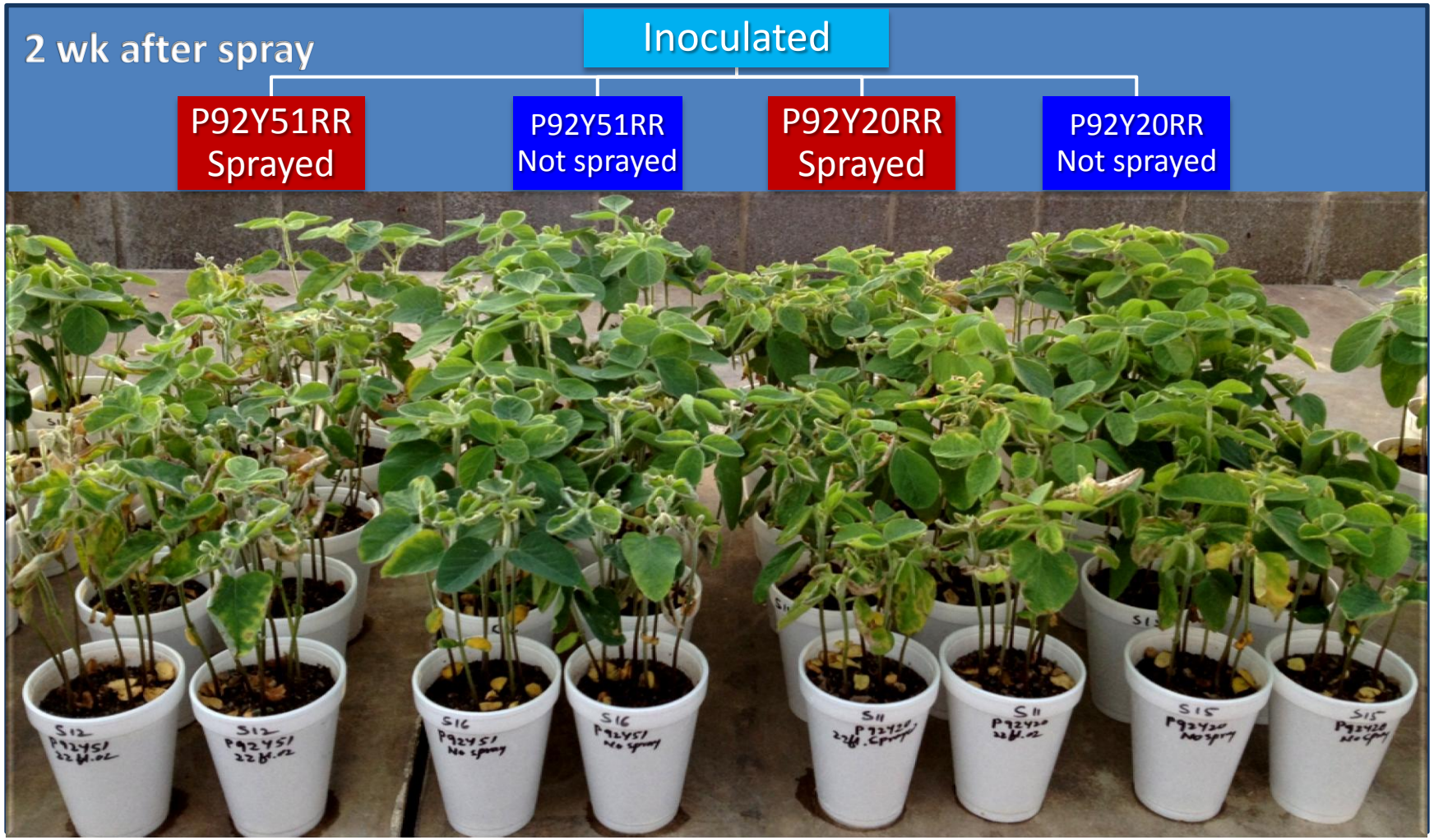
P92M40RR Sprayed

P92M40RR Not sprayed

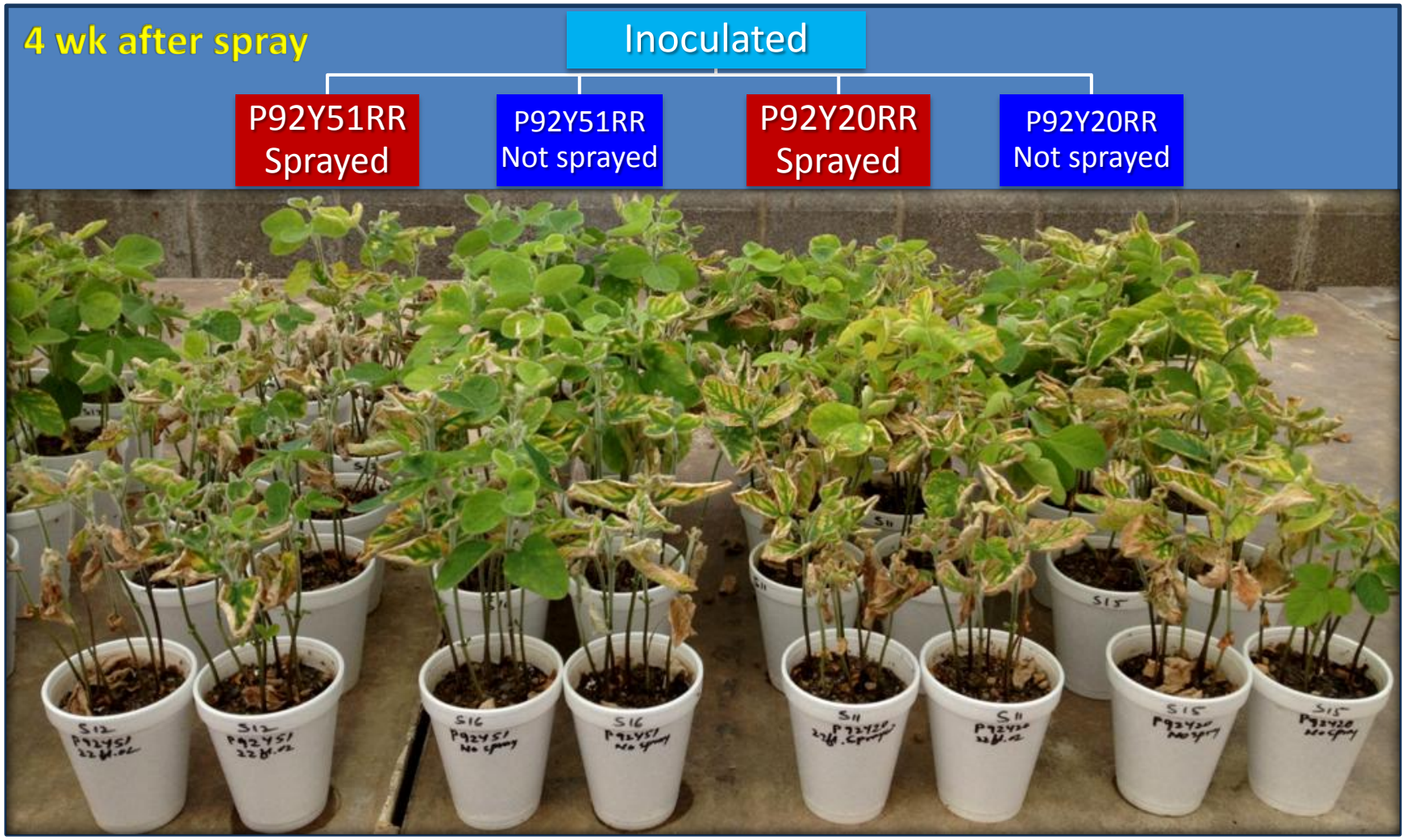
4 wk after spray

P92M76RR Sprayed | P92M76RR Not sprayed | P92M40RR Sprayed | P92M40RR Not sprayed

Varietal response to SDS in Roundup WeatherMax® un/sprayed treatments



Varietal response to SDS in Roundup WeatherMax® un/sprayed treatments



2 wk after spray

P92Y51RR Sprayed

P92Y51RR Not sprayed

P92Y20RR Sprayed

P92Y20RR Not sprayed

4 wk after spray

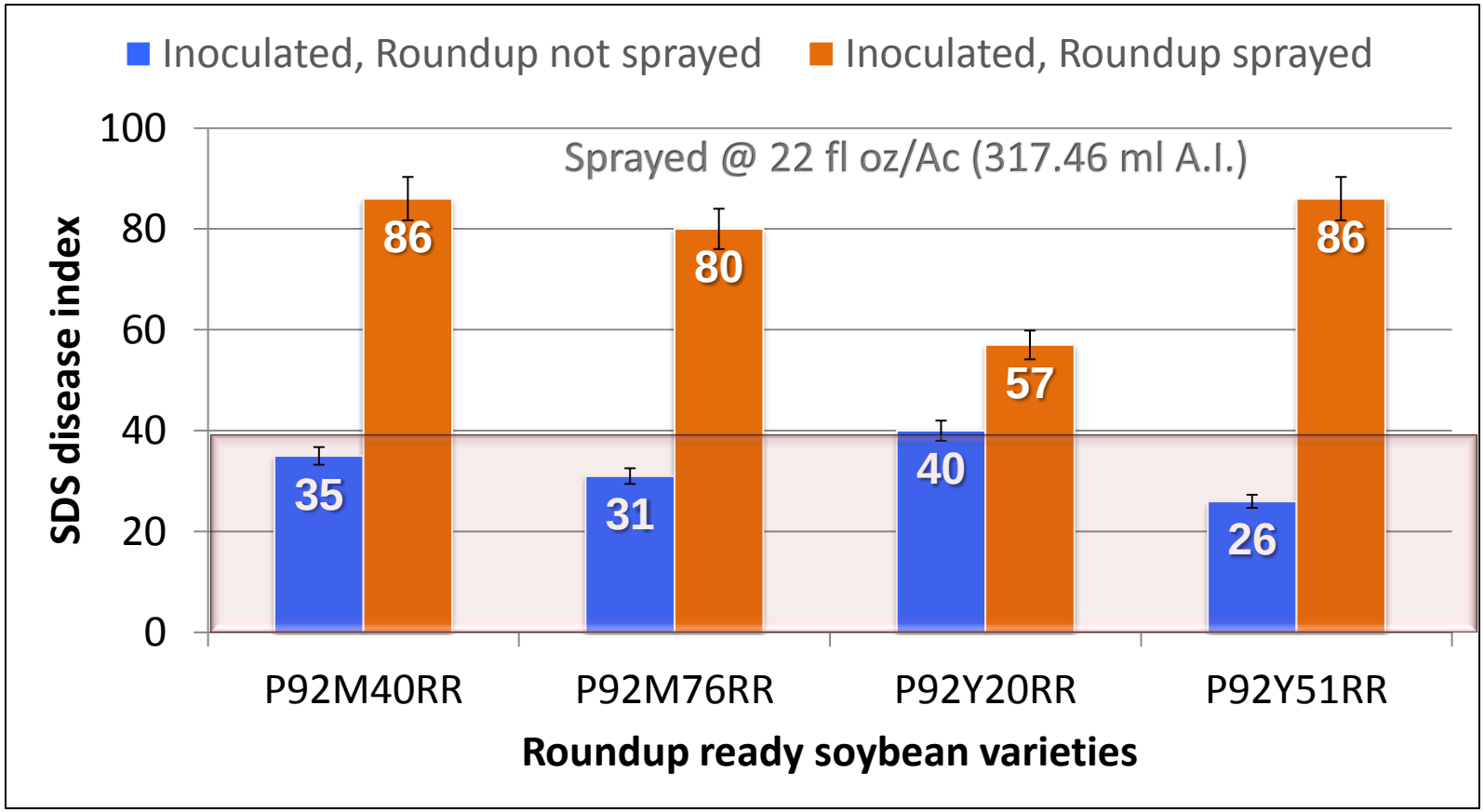
P92Y51RR Sprayed

P92Y51RR Not sprayed

P92Y20RR Sprayed

P92Y20RR Not sprayed

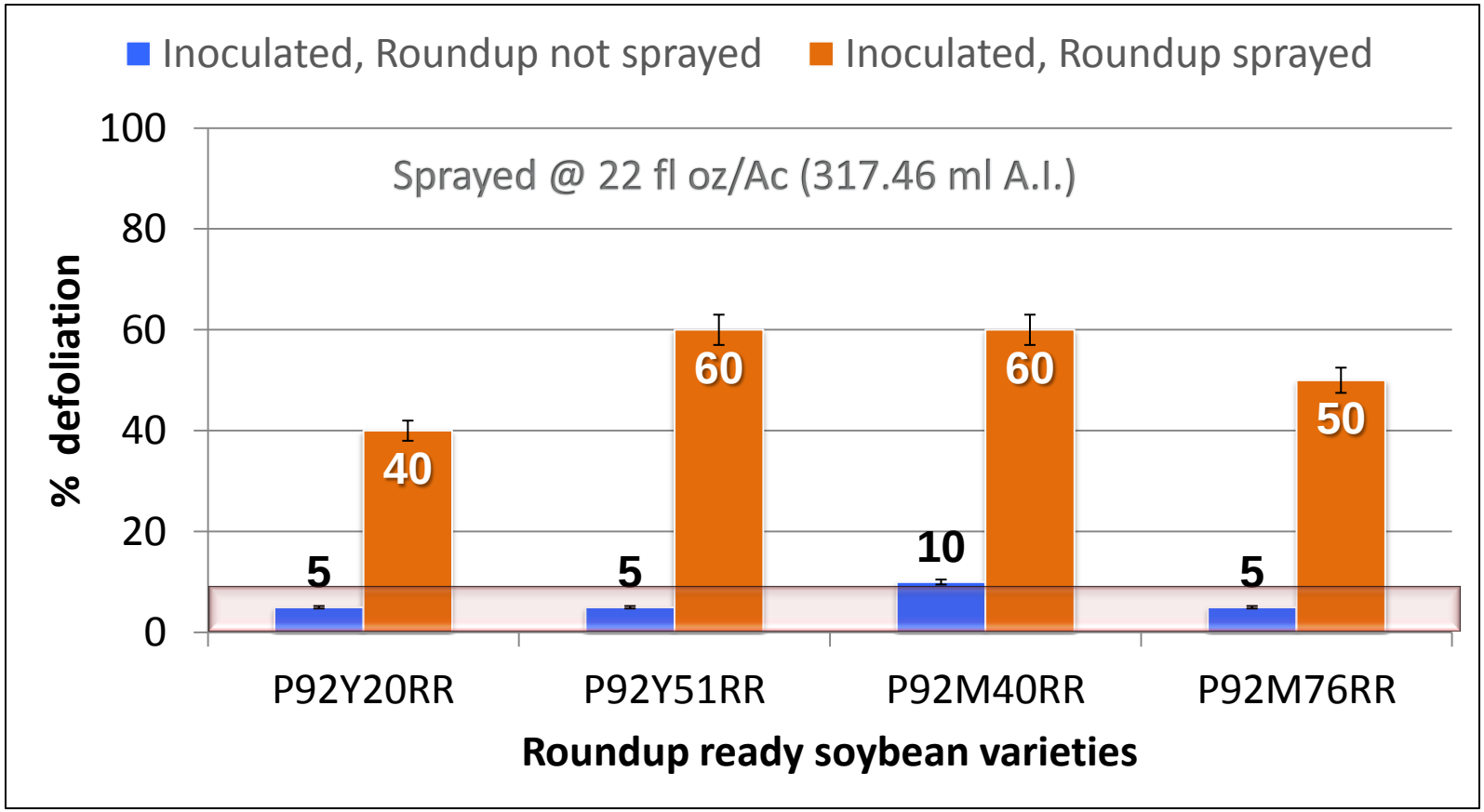
Varietal response to SDS* in Roundup WeatherMax® sprayed and unsprayed treatments (Dec 2012)



*Disease index based on final readings of 4 week after spray

Company ratings for P92M40RR, P92M76RR, P92Y20RR and P92Y51RR are 7, 4, 6 and 6 respectively on 1-9 scale. where, 1= poor and 9= excellent

% defoliation* in Roundup WeatherMax® sprayed and unsprayed treatments.



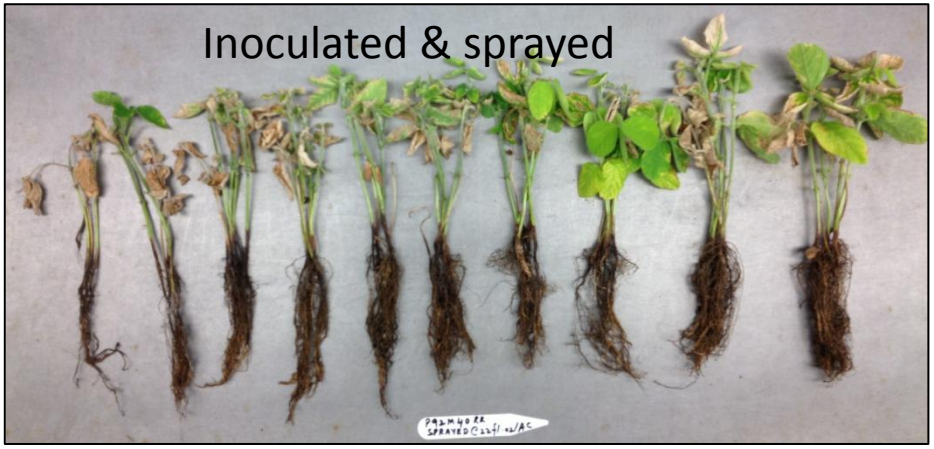
*Readings of 4 week after Roundup spray

Biomass* in Roundup WeatherMax® sprayed[1] and unsprayed treatments.

P92M76RR (SDS rating 4)[2]

[1]Sprayed @ 22 fl oz/Ac (317.46 ml A.I.)

P92M40RR (SDS rating 7)



*Biomass readings were taken 5 weeks after the spray

[2]= Company rating on 1-9 scale where 1=poor and 9= excellent

Biomass* in Roundup WeatherMax® sprayed[1] and unsprayed treatments

P92Y51RR (SDS rating 6)[2]

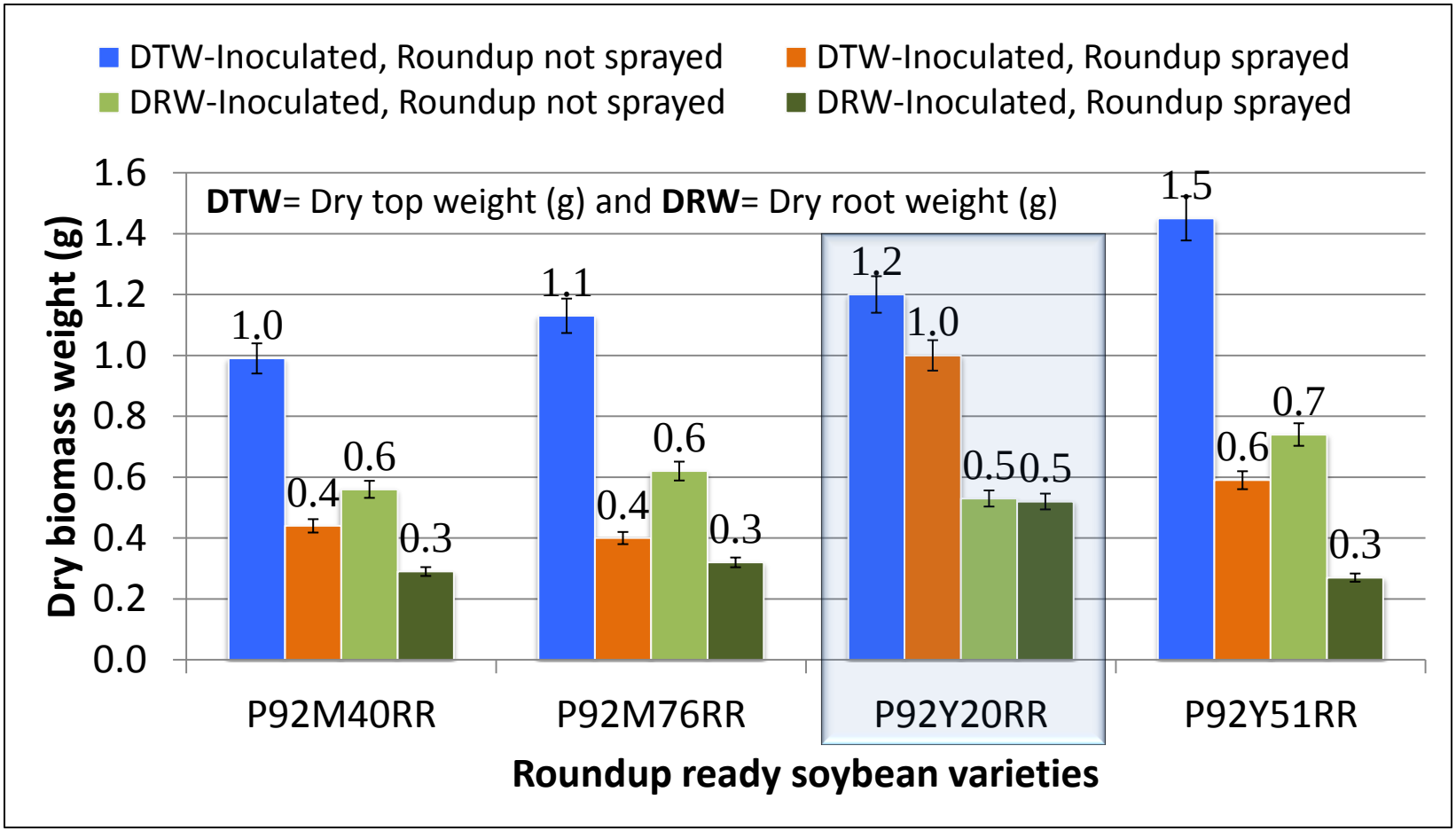
[1]Sprayed @ 22 fl oz/Ac (317.46 ml A.I.)

P92Y20RR (SDS rating 6)

*Biomass readings were taken 5 weeks after the spray

[2] = Company rating on 1-9 scale where 1=poor and 9= excellent

Biomass* in Roundup WeatherMax® sprayed[1] and unsprayed treatments



*Average of 50 plants/treatment;

[1]Sprayed @ 22 fl oz/Ac (317.46 ml A.I.)

Remarks

Greenhouse results showed that .....

- The inoculated, and Roundup sprayed varieties showed higher SDS than the unsprayed.
- The inoculated, and 1 or >1 spray @ 22 fl oz/Ac increased SDS compared with the unsprayed.
- The inoculated, and sprayed with higher rates had higher SDS in MR, and higher SDS with lower spray rates in MS varieties.

Remarks

- The inoculated and sprayed plants showed significantly lower biomass values than the unsprayed.
- These studies are to be conducted in field conditions to compare the current greenhouse results at least two growing seasons.

Thanks