Title: Controlling weeds in soybean

Principal investigators and collaborators: S.A. Clay, P.O. Johnson, D. Deneke, S. Subramanian, D.E. Clay

Plant Science Dept. SDSU

Email: Sharon.clay@sdstate.edu

2014-2015 Final Report -

Objective 1

SDSU WEED Project Report

The information from the sponsored soybean plots is used in a lot of WEED project field schools, meetings, and seminars that are conducted around the state. This past year 2000 pest Management guides were printed and handed out around the state. We ran out of copies before April 1 so more will need to be produced next year. Thanks to your help the guide was given out free of charge and also was put on line and available to look at or be downloaded free of charge. We also handed out 1250 copies of the 2014 Weed Control Field Test Data and also run out of them by April 1.Below are summaries of some of the events that were done by the WEED project were the information was used this past year

The sixth annual SDSU IPM Field School for Agronomy Professionals was held at the Volga SDSU Research Farm on July 29 & 30, 2014. The school was co-hosted with the South Dakota Agri-Business Association and SDSU Extension Plant Science. Attendance for the event included 72 professional agronomists. Seven topic areas featuring wheat, corn, and soybeans were covered over the two days by SDSU Extension Plant Science Specialists, Extension Filed Specialists and NRCS personnel. Each participant received a notebook containing session handouts, reference materials, scouting clipboard, and a hand-lens. A pre and post-test was given asking questions on material covered in the sessions. The pre and post-test showed an average increase of 39 % correct answers after completing the two days of sessions.

The SDSU WEED project participated in several SDSU Plant Science Research Farm Grower tours. Topics were included in the programs which centered around weed control in crops. SDSU Research Farm Tours: July 8, SE South Dakota Research Farm Tour July 9, NE South Dakota Research Farm Tour and August 5, Volga Research Farm Field Tour. Weed stops included discussions on herbicide resistance management options, Palmer Amaranth identification and IPM topics included utilizing IPM practices in pest management plans to reduce the incidence of pesticide resistance in the state. Sponcered plots were viewed at all three locations.

A traveling display was put together by the SDSU WEED project and set up for the South Dakota State Fair, Dakota Fest Ag Show. The display features a live weed plant display. In addition posters to help identify Palmer Amaranth were part of the display. Annually over 7,500 people visit the displays.

SDSU Extension Weeds presented talks at 11 Commercial Pesticide Recertification Meetings with weed control topics. There were over 1950 commercial applicators trained. In addition seven Private Applicator Training meetings had 316 private applicators trained.

SDSU Extension Weeds helped lead spring and summer weekly conference calls for Extension agronomy field specialists and extension state specialists on pest and crop updates and alerts. A weekly newsletter has been established to inform clientel of current agronomic concerns. The newsletter goes out by e-mail subscription to over 800 growers, agronomists, crop advisors, crop consultants and agency personnel on a weekly basis.

SDSU Extension IPM Program and the SDSU WEED Project sponsored the annual Extension Plant Science Update Workshop for South Dakota Independent Crop Consultants on March 31, 2015. This provides a time for SDSU Extension State Specialists and Regional Field Specialists to meet with area crop consultants prior to the growing season. There were 45 crop consultants attending in 2015. All attending received copies of the 2015 SD Pest Management Guides for corn, soybeans, small grains, alfalfa, and oil seed crops.

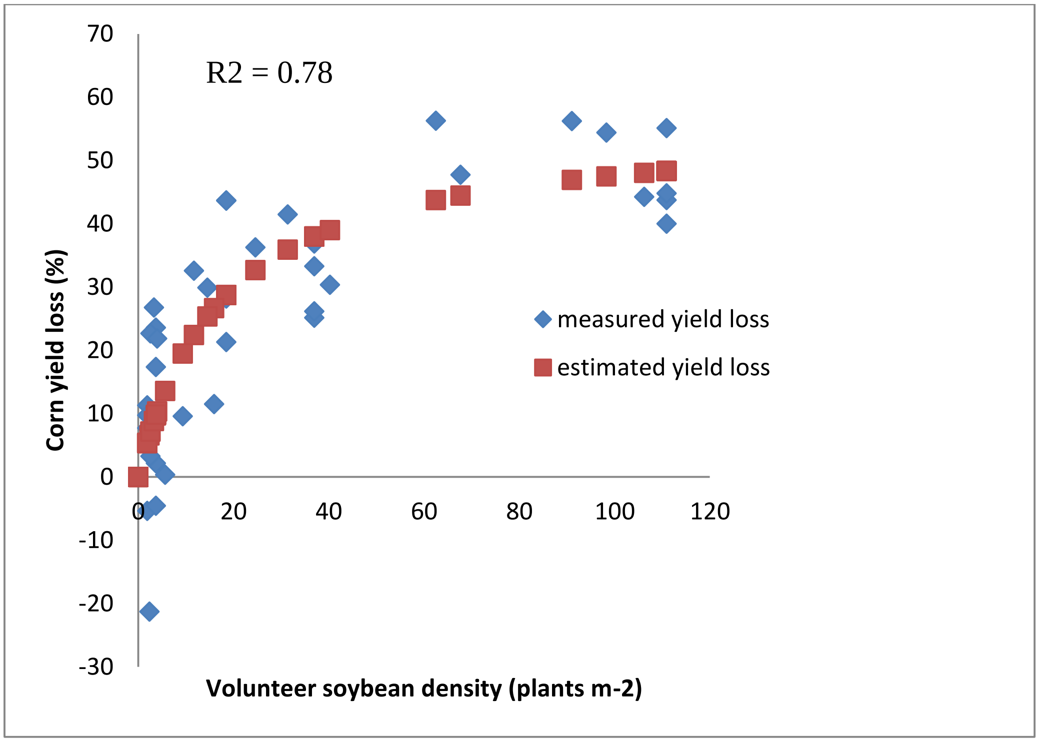
Results from a past grant that supported the Weed Project (M. Moechnig PI, Jill Alms grad student) (2011-2012)

Summary of Volunteer corn in soybean – Yield loss and Control (Submitted for publication, Weed Technology, June, 2015)

Volunteer corn is often overlooked as a weed in soybean. Defining yield loss in soybean contributed specifically to volunteer corn may aid in management decisions. The objectives of this study were to determine soybean yield loss at volunteer corn densities as single, rather than multiple, plants, and volunteer corn control and soybean yield with herbicides applied at various rates and timings. A hyperbolic equation estimated ($R^2 = 0.88$) incremental yield loss (I) of 39.7% at low density when maximum yield loss (A) was constrained to 71%, the highest yield loss observed in these trials, which indicated that volunteer corn was more competitive than many common Midwestern weedy species. Clethodim applied at V4 soybean resulted in 12 - 16% control and decreased yield loss by 32- 61% when applied at 12.7 g ai ha^{-1}, whereas 51 g ai ha-1 had > 90% control and < 5% yield loss, suggesting that partial control of volunteer corn reduced soybean yield loss. Glufosinate alone provided acceptable control of susceptible volunteer corn in glufosinate-tolerant soybeans, but control improved with later application times and/or tank mixing with grass herbicides. Early postemergence (EPOST) applications (15 – 36 cm tall corn) provided 33 – 73% control, whereas late postemergence (LPOST) applications (30 – 91 cm tall corn) provided 79 – 83% control, with concomitant yield increases. Results demonstrate that volunteer corn can substantially reduce soybean yield at low densities. Yield increases offset the additional herbicide cost.

Summary of volunteer soybean in corn – Yield loss and control

The continuous use of glyphosate-resistant crops has caused volunteer crops, which have the same resistance mechanism as the cash crop, to become an increasing weed problem. There has been little research on the effect of volunteer soybeans in corn. Several volunteer soybean densities were established to determine the extent of corn yield loss. Using these data, the hyperbolic yield equation indicated the incremental yield loss (I value) to be 3.2 for volunteer soybeans in corn when maximum yield loss (A) was constrained to 55.9% (highest observed loss). Densities of 13 soybean plants m^{-2} (about 1.5 plants ft^{-2}) or greater resulted in >10% corn yield loss. Based on these data, volunteer soybeans in corn was more competitive than common lambsquarters and low densities of yellow, green, and giant foxtail, and barnyardgrass.



Several post-emergence herbicides tank-mixed with glyphosate provided good (70 - 80%) to excellent (>90%) control of volunteer glyphosate-resistant soybeans in glyphosate-resistant corn (Table 2). Better control was observed in 2011 when treatments were applied to V-2 soybeans compared with 2012 when applications were applied to V3-V4 soybean stage. Herbicide applications provided 65-99% control in 2011. Best control was observed with full rates of tembotrione (Laudis) and rimsulfuron (Resolve). In 2012, control ranged from 48-96% control in 2012 with dicamba (Clarity) and dicamba + diflufenzopyr (Statues) providing the best control. Atrazine treatments resulted in the poorest volunteer soybean control (48-59%) in 2012. The herbicide treatments cost about $5-20 per hectare ($2-8 per acre) in addition to the glyphosate application. Based on the estimated loss of $272-556 per hectare ($110-225 per acre) when > 13 soybean plants m^{-2} (~1.3 plants ft^{-2}) are observed and control obtained with the herbicide treatments, it would be profitable to include most of the tested herbicides in a tank-mix to control volunteer soybeans. For example, if corn price was $0.16 kg^{-1} ($4/bu) a yield loss of only 126 kg ha^{-1} (2 bu per acre) would balance out the additional herbicide cost.

#	Treatment Chemical name	Trade Name	Rate (g ai/ha)	Volunteer Soybean Control (%) 2011		2012	
1	Check			0	d	0	f
2	Tembotrione+NIS	Laudis	30.6	94	ab	89	bc
3	Tembotrione+NIS	Laudis	15.3	84	b	87	c
4	Dicamba+difluenzopyr	Status	78.5	99	a	94	ab
5	Dicamba+difluenzopyr	Status	39.2	98	a	92	abc
6	Atrazine+NIS	Atrazine	1120	98	a	59	d
7	Atrazine+NIS	Atrazine	560	91	ab	48	e
8	Dicamba	Clarity	280	99	a	96	a
9	Rimsulfuron+NIS	Resolve	8.8	65	c	88	bc
	LSD			9.0		4.5	

Table 2. Volunteer soybean control in 2011 near Brookings, SD and in 2012 near Volga, SD. Visual observations for % control where 0 is no control and 100 is complete control. Applications were applied to V2 soybeans (June 25) in 2011 and V3-V4 soybeans (June 12) in 2012. Control ratings were recorded 8 weeks after application (August 23) in 2011 and 4 weeks after application (July 11) in 2012. All treatments included glyphosate (870 g ai/ha) and AMS (470 g ai/ha).

Objective 3. Summary of Palmer Amaranth biology (emergence, flowering, and growth characteristics) in SD

Some of this information was reported on in the 1st quarter report. In 2014, Palmer amaranth was planted in the field from greenhouse germinated seedlings at one planting time. No seed was obtained due to early frost which killed plants in the vegetative stage. Variation in plants included variegation (white; purple; purple AND white; none) (see images below) and leaf margins (highly undulated to entire). The very long petioles of primary older leaves was common to all of the Palmer amaranth plants. Leaves of redroot pigweed were ovate and hairs are present on the stem. Flowers of redroot pigweed are perfect with male and female in the same inflorescence and appearance much shorter and bristly compared to the elongate inflorescences of Palmer amaranth. Common waterhemp has narrower leaves that are less undulated leaf margins.

Two SD areas had confirmed Palmer amaranth in sunflower fields. This portion of the study was funded for 2015. The person at Swet, SD has planted millet in these areas and a grad student has been in contact with the producer and has small areas set up for observation. We have been in contact with the crop consultant who is helping manage two farms in Chamberlain where Palmer amaranth was confirmed last year. The producers have no interest in cooperating for research on this plant. However, in discussions with the consultant in July of 2015, he told us that all plants were destroyed last year and the area is being closely monitored. As of July, 2015, no escape plants were noted. In June, 2015, reports of suspicious plants from the Corsica area have been reported. To date, PA has not been confirmed in the area, but the project is in contact with crop consultants to keep informed about these infestations (Gary Larson will be consulted when plants have flowers and seed for confirmation).

In small plot research starting in May, 2015 Palmer amaranth seed was planted in the greenhouse in small pots with cohorts started 2 weeks apart for 3 planting dates. Plants were thinned to one plant per pot and 36 plants for each date were planted in the field at the Aurora experiment Station. The field planting started in mid-May and ended in mid-June. In addition to the Palmer plants, a few redroot pigweed plants were planted for comparison. Plant height and width are being taken weekly to examine growth rates. Palmer plants from the earliest cohort started flowering around July 8th with male plants the first to flower and females flowering 5 to 8 days later. The other cohorts will be monitored to determine how emergence timing influences flowering. GDD days from emergence to flowering will be calculated for each cohort. Female plants are being bagged to stop seed development and dispersal. Plants will be destroyed later in the season by removing plant material and burning.

Images depicting vegetative diversity among individual Palmer Amaranth plants grown at Aurora, SD experiment Station in 2014 are shown below. Seeds were obtained from Kansas State University and started as seedlings under greenhouse conditions. About mid-July a single cohort of about 30 plants was planted in field. Images were taken September 2, 2014. All plants were frozen out before reaching maturity in a mid-September freeze.

Purple variegation noted on upper leaves. Lower leaves have white variegation. Note the long petioles on the leaves at the base of the plant.

Highly colored purple variegation noted on upper leaves. Lower leaves have white variegation. Note inflorescence just starting to emerge.

Whiite variegation on all leaves.

White variegation on some leaves. Male inflorescence elongating. Note the long petioles of the oldest leaves at the base of the plant and the branching of the plant from the base.

Leaves with slight variegation. Male inflorescence just starting to elongate.

Objective 4. Nodulation in auxin drift-treated plants (Sharon Clay and Sen Subramanian)

Introduction and methodology:

Significant yield losses occur in soybean from undesirable exposure to auxin herbicides. Such exposures are commonly due to wind drift, post application volatility and deposition, or tank contamination. Leaf damage, such as leaf rolling, blistering, or strapping, plant stunting, and other shoot symptoms in response to auxinic herbicide exposure have been well documented (Figure 1), but no remedial measures have been suggested to mitigate yield losses. We recently discovered that auxin can inhibit soybean nodule formation in laboratory studies. Based on this we ***hypothesized*** that exposure to auxinic herbicide can reduce nodulation and nitrogen (N) fixation resulting in lower plant N status and end-of-season yield loss. If true, exogenous N application or reducing endogenous auxin levels might be a management strategy to mitigate yield losses due to a reduction in nodule formation caused by herbicide injury.

The goal here was to test the effect of drift-level application of two common auxinic herbicides, 2,4-D and dicamba at different growth stages of soybean at two different locations in SD. Plants were treated with either Dicamba or 2,4-D at V1, V3, V+V3, V5, or V3+V5 and nodules counted at R1. The experiment was conducted at Beresford and Aurora. Total nodules count data were analyzed using one-way ANOVA to identify the effect of herbicide and herbicide+vegetative stages combined.

Results:

1. At Aurora, 2,4-D application caused a 19% reduction in total nodule numbers (statistically significant at P<0.1; 10% error).

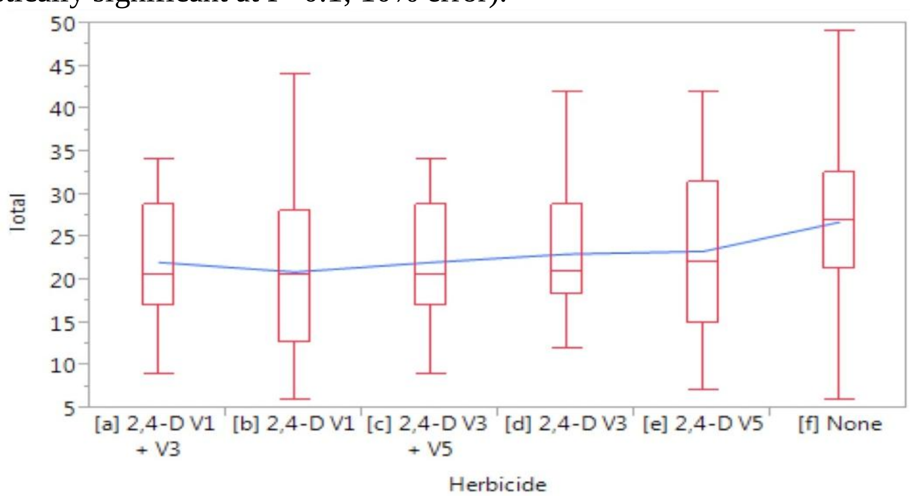


Figure 1. *Total nodules, Aurora (2,4-D)*

2. At Aurora, when all dicamba applications were analyzed together there was no significant change in nodule number. The likely reason is that several of the Dicamba treated plants and the control plants had significant plant to plant variation in nodule numbers.

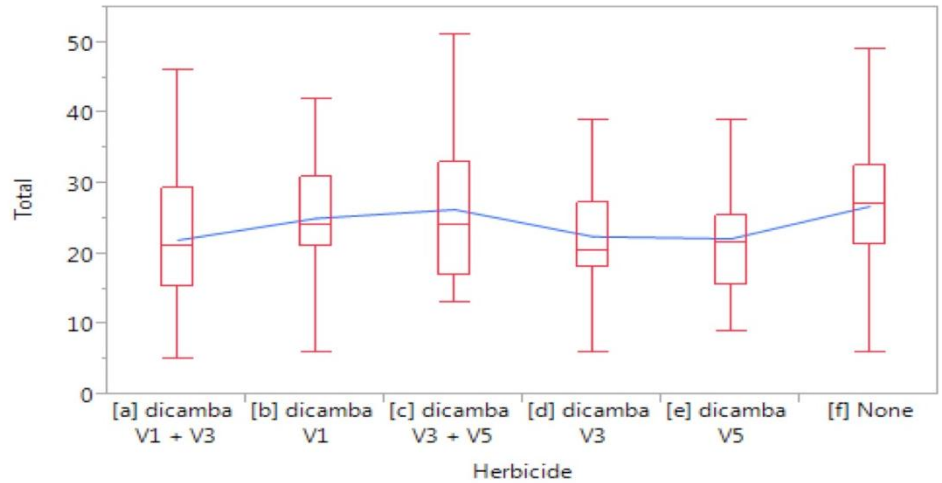


Figure 2. *Total nodules, Aurora (Dicamba)*

3. At Beresford, when herbicides were analyzed independently there was not significant effect on nodule numbers

4. At Beresford, combined analysis of all applications indicated a significant reduction in nodule numbers, especially due to 2,4-D application at V1+V3 and at V5.

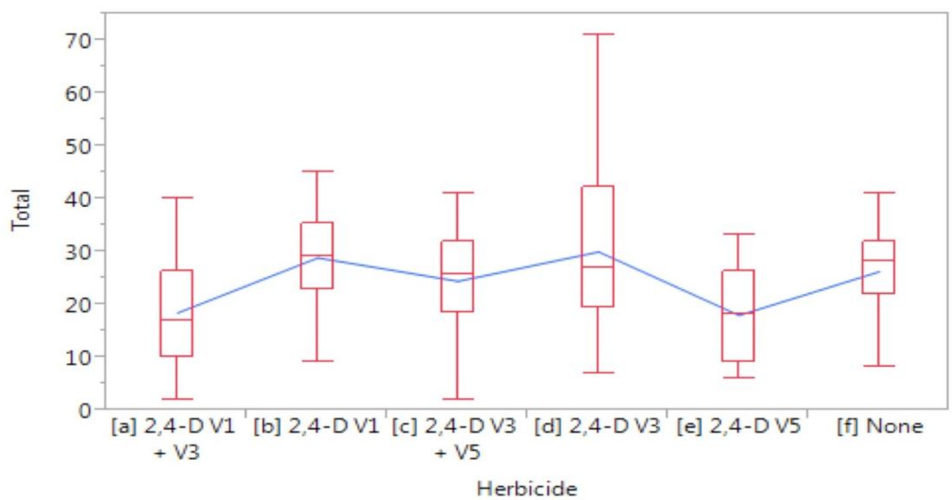


Figure 3. *Total nodules, Beresford (2,4-D)*

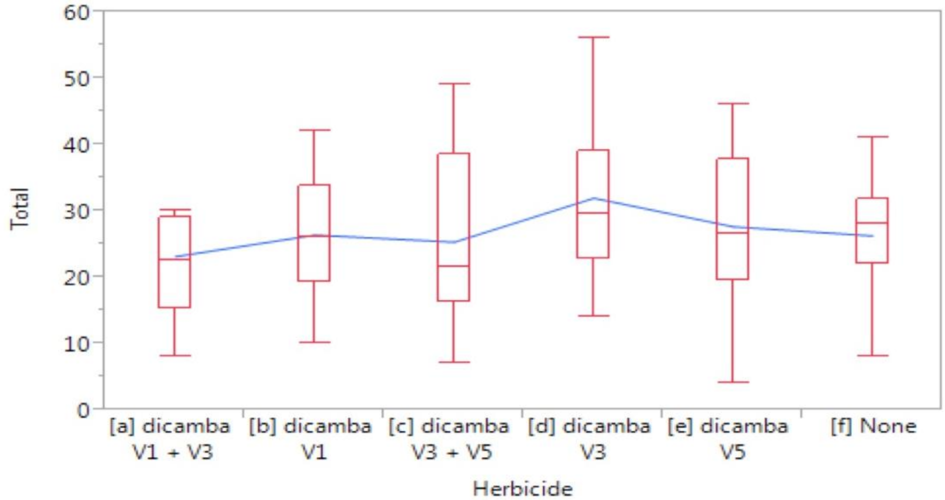


Figure 4. *Total nodules, Beresford (Dicamba)*

5. Detailed analysis of fixing and non-fixing nodules were performed by staining for the presence of rhizobium bacteria and pink coloration.

6. In Aurora, 2,4-D was more inhibitory than Dicamba resulting in reduced number of fixing nodules, but emerging nodules were unaffected.

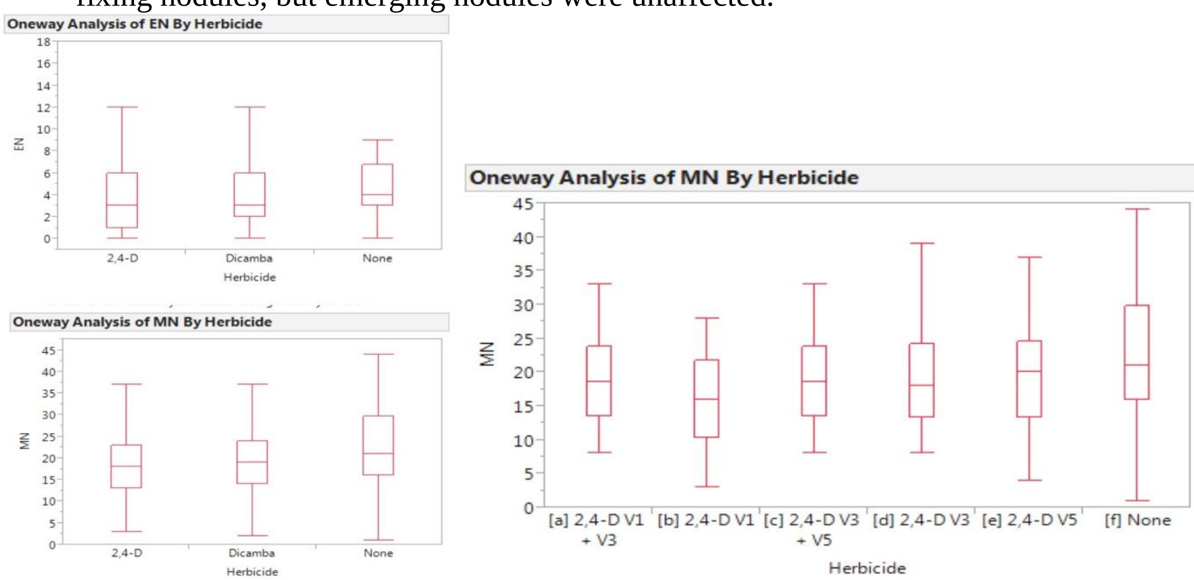


Figure 5. *Top Left – Emerging nodules, Aurora (2,4-D vs Dicamba); Bottom Left – Mature/Fixing nodules, Aurora (2,4-D vs. Dicmaba); Right – Mature/Fixing nodules, Aurora (2,4-D)*

7. Subsequent analysis indicated that 2,4-D had an overall significant effect on the number of fixing nodules.
8. The overall trend was that early applications or dual applications had a more inhibitory effect.
9. In Beresford, 2,4-D was more inhibitory than Dicamba, but here the number of fixing nodules were unaffected where as the number of emerging nodules was reduced.

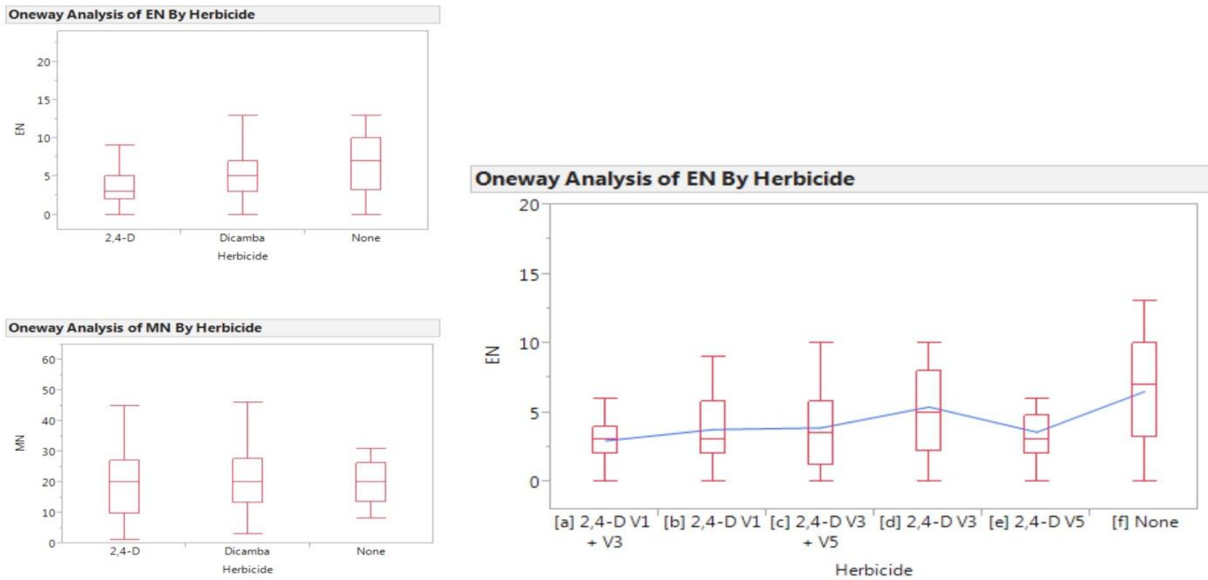


Figure 6. Top Left – Emerging nodules, Beresford (2,4-D vs Dicamba); Bottom Left – Mature/Fixing nodules, Beresford (2,4-D vs. Dicmaba); Right – Mature/Fixing nodules, Beresford (2,4-D)

10. The overall trend was similar to that in Aurora that early applications or dual applications had a more inhibitory effect.

Summary and Conclusions:

1. Summarized analysis indicated that 2,4-D had a much more significant effect on nodulation compared to Dicamba.
2. Application of herbicide at V1+V3 had the most significant negative effect on nodulation.
3. In Aurora, 2,4-D application significantly reduced the number of fixing nodules and thus likely the nitrogen status.
4. In Beresford, 2,4-D application significantly reduced the number of emerging nodules (and not fixing nodules at R1), but overall nitrogen status might still be impacted throughout the life of the plant.
5. The initial results strongly indicated that herbicide injury due to minor exposures resulting from tank contamination or actual drift can significantly impact nitrogen fixation and thus soybean yield.
6. Detailed evaluation of plant responses and yield in a larger study especially with multiple applications and multiple samplings is likely to provide sufficient data to predict possible causes of yield losses and appropriate mitigation strategies.