Non-Xtend Soybean Response to Dicamba

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Field experiments were conducted at Manhattan, KS in 2018 and 2019 and at Ottawa, KS in 2019 to evaluate 1) non-Xtend soybean injury and yield loss from dicamba exposure at different growth stages, rates, and multiple exposures, and 2) injury and yield loss from dicamba exposure on different non-Xtend soybean varieties and traits. Soybeans were planted in 30 inch rows following standard agronomic practices at the KSU Ashland Bottoms Agronomy Farm south of Manhattan, KS on May 22, 2018 and June 3, 2019, and at the KSU East Central Kansas Experiment Field south of Ottawa, KS on June 13, 2019. Experiments were maintained weed free by the use of preemergence herbicides and hand-weeding as necessary.

Dicamba Rate, Timing, and Multiple Exposures

Engenia herbicide was applied at 1/100, 1/500 and 1/1000 of the standard use rate of 12.8 oz/a (0.5 lb ae/a dicamba) to 'Credenz 3841 LL' soybeans at the V3, R1, R3, V3+R1, V3+R3, R1+R3, and V3+R1+R3 stages of growth, along with an untreated check. Dicamba injury symptoms were evident within 1 week after treatment at each timing and were visually evaluated at weekly intervals until late in the season. Dicamba symptomology on the non-Xtend soybeans was maximized about 3 to 4 weeks after treatment (Tables 1-6). Soybeans treated with dicamba at the V3 stage expressed early season leaf cupping, but seemed to have recovered fairly well by 8 weeks after treatment, regardless of the application rate (1/100, 1/500, and 1/1000 X). Injury from dicamba applications at the R1 and R3 stages included leaf cupping, stunting, epinasty, and abnormal growing point and pod development. Symptoms from the R1 and R3 applications were more persistent and evident through the remainder of the growing season. The most severe soybean injury generally occurred with treatments at R1, multiple application timings, and at the highest rates (Tables 1-6).

Table 1. Soybean injury from simulated dicamba drift 4 weeks after exposure at Manhattan, KS in 2018.

Application	Dicamba Rate		
Timing	1/1000X	1/500X	1/100X
		(% injury)	
V3	17	23	32
R1	30	39	54
R3	36	49	60
V3/R1	36	45	74
V3/R3	43	49	76
R1/R3	53	63	75
V3/R1/R3	58	64	80

Lsd (5%) = 4

Table 2. Soybean injury from simulated dicamba drift 4 weeks after exposure at Manhattan, KS in 2019.

Application Timing	Dicamba Rate		
	1/1000X	1/500X	1/100X
		(% injury)	
V3	9	14	33
R1	30	36	52
R3	12	16	30
V3/R1	38	43	69
V3/R3	19	33	49
R1/R3	38	46	60
V3/R1/R3	40	49	78

Lsd = 4

Table 3. Soybean injury from simulated dicamba drift 4 weeks after exposure at Ottawa, KS in 2019.

Application Timing	Dicamba Rate		
	1/1000X	1/500X	1/100X
		(% injury)	
V3	11	15	32
R1	36	45	61
R3	32	34	43
V3/R1	38	46	56
V3/R3	28	39	53
R1/R3	48	58	76
V3/R1/R3	48	64	81

Lsd (5%) = 5

Table 4. Soybean injury from simulated dicamba drift at the onset of senescence at Manhattan, KS in 2018.

Application Timing	Dicamba Rate		
	1/1000X	1/500X	1/100X
		(% injury)	
V3	5	5	10
R1	35	50	69
R3	39	46	64
V3/R1	40	51	75
V3/R3	36	40	71
R1/R3	50	64	73
V3/R1/R3	53	64	76

Lsd (5%) = 5

Table 5. Soybean injury from simulated dicamba drift at the onset of senescence at Manhattan, KS in 2019.

Application Timing	Dicamba Rate		
	1/1000X	1/500X	1/100X
		(% injury)	
V3	4	5	5
R1	34	43	56
R3	10	14	31
V3/R1	38	43	68
V3/R3	19	30	46
R1/R3	36	45	61
V3/R1/R3	41	49	78

Lsd (5%) = 4

Table 6. Soybean injury from simulated dicamba drift at the onset of senescence at Ottawa, KS in 2019.

Application Timing	Dicamba Rate		
	1/1000X	1/500X	1/100X
		(% injury)	
V3	5	5	5
R1	36	44	65
R3	26	24	35
V3/R1	31	48	63
V3/R3	20	33	46
R1/R3	46	51	74
V3/R1/R3	40	55	75

Lsd (5%) = 4

Soybean yields and yield loss varied among the site-years, but general trends were similar. Variation among site-years was likely due to different environmental conditions and soils. Soil moisture was limiting through much of the growing season at Manhattan in 2018 until late summer, when excess moisture occurred and delayed soybean harvest. Rainfall patterns were generally favorable at both Manhattan and Ottawa in 2019, resulting in good soybean yields. Soybean yield reduction from dicamba injury was not as great as visual injury ratings (Tables 7-9). Soybean yield loss was minimal from exposure during the V3 stage, regardless of exposure rate, or from the 1/1000X exposure rate, regardless of exposure stage or with multiple exposure timings. The greatest yield loss was from multiple exposure events and at the highest exposure rate of 1/100X dicamba. Soybean yields were generally reduced the most for treatments at R1, especially for the higher yield environments in 2019. Soybean yields were generally lower overall and yield losses from multiple exposures higher at Manhattan in 2018, likely due to drought stress through much of the season.

Table 7. Soybean yield and % loss with simulated dicamba drift at Manhattan, KS in 2018.

Application	Dicamba Rate		
Timing	1/1000X	1/500X	1/100X
	Bushel/Acre (% loss)		
V3	40 (14)	42 (10)	46 (2)
R1	43 (9)	42 (10)	35 (25)*
R3	38 (18)	39 (16)	38 (19)
V3/R1	39 (16)	44 (5)	28 (39)*
V3/R3	45 (2)	44 (5)	32 (32)*
R1/R3	39 (17)	35 (25)*	22 (53)*
V3/R1/R3	41 (12)	36 (23)*	15 (68)*

Untreated = 46 bu/acre
* = Significantly different from the untreated check

Table 8. Soybean yield and % loss from simulated dicamba drift at Manhattan, KS in 2019.

Application	Dicamba Rate		
Timing	1/1000X	1/500X	1/100X
	Bushel/acre (% loss)		
V3	68 (4)	65 (8)	64 (10)
R1	66 (7)	67 (6)	54 (24)*
R3	68 (5)	67 (6)	69 (3)
V3/R1	65 (8)	68 (5)	50 (29)*
V3/R3	68 (4)	67 (6)	62 (12)
R1/R3	64 (10)	60 (15)*	43 (39)*
V3/R1/R3	65 (8)	61 (13)*	39 (47)*

Untreated = 71 bu/acre
* = Significantly different from the untreated check

Table 9. Soybean yield and % loss with simulated dicamba drift at Ottawa, KS in 2019.

Application	Dicamba Rate		
Timing	1/1000X	1/500X	1/100X
	Bushel/Acre (% loss)		
V3	61 (0)	63 (-4)	62 (-2)
R1	56 (7)	51 (17)	45 (25)*
R3	59 (3)	61 (0)	58 (5)
V3/R1	57 (6)	51 (16)	34 (43)*
V3/R3	60 (1)	59 (3)	56 (8)
R1/R3	63 (-3)	51 (15)	39 (36)*
V3/R1/R3	54 (11)	49 (19)	34 (43)*

Untreated = 61 bu/acre
* = Significantly different from the untreated check

Soybean Variety/Trait Response

Engenia herbicide was applied at 1/100 of the standard use rate of 12.8 oz/a (0.5 lb ae/a dicamba) to 'Credenz 3841 LL', 'Credenz 4748 LL', 'Asgrow AG 4135 RR2', and 'Stine 40BA02' soybeans at the V3 and R1 stages of growth, along with an untreated check for each variety. Soybean injury was higher from exposure at R1 than the V3 stage of growth, especially with the late season assessment (Tables 10-12). Soybean injury at 4 WAT was similar among varieties for each treatment timing. Visual injury from dicamba tended to be highest on 'Stine 40BA02' and lowest on 'Credenz 4748 LL' at the late season evaluation. Lower injury on 'Credenz 4748 LL' at the onset of senescence may have been partially due to the longer maturity and greater vegetative growth later in the summer than with the other varieties. Maturity appeared to have a greater effect on differences in late season recovery than soybean variety or trait.

Table 10. Soybean variety/trait injury from simulated dicamba drift at Manhattan, KS in 2018.

Variety/Trait	Timing	4 Weeks after Exposure	Onset of Senescence
		(% injury)	
Credenz 3841 LL	V3	31	8
	R1	50	69
Credenz 4748 LL	V3	26	5
	R1	55	51
Asgrow AG 4135 RR2	V3	32	5
	R1	54	66
Stine 40BA02	V3	32	10
	R1	64	74
Lsd (5%)		6	5

Table 11. Soybean variety/trait injury from simulated dicamba drift at Manhattan, KS in 2019.

Variety/Trait	Timing	4 Weeks after Exposure	Onset of Senescence
		(% injury)	
Credenz 3841 LL	V3	33	5
	R1	55	55
Credenz 4748 LL	V3	34	5
	R1	59	48
Asgrow AG 4135 RR2	V3	35	5
	R1	59	60
Stine 40BA02	V3	37	5
	R1	63	63
Lsd (5%)		3	5

Table 12. Soybean variety/trait injury from simulated dicamba drift at Ottawa, KS in 2019.

Variety/Trait	Timing	4 Weeks after Exposure	Onset of Senescence
		(% injury)	
Credenz 3841 LL	V3	34	5
	R1	65	62
Credenz 4748 LL	V3	34	5
	R1	65	50
Asgrow AG 4135 RR2	V3	39	5
	R1	66	66
Stine 40BA02	V3	37	5
	R1	69	70
Lsd (5%)		4	5

Soybean yields varied by site-year (Table 13-15). Significant soybean yield loss from exposure at the V3 stage only occurred with the two LL soybean varieties at Manhattan in 2019, but did not occur with any variety at the other two site-years. Soybean yield was reduced between 8 and 37% across all varieties and site-years and was not consistent across site-years and varieties. 'Stine BA40B2' tended to have the greatest yield loss and 'Credenz 4748' the lowest yield loss from dicamba exposure at the R1 stage. Yield loss most closely correlated to visual injury ratings at the onset of senescence.

Table 13. Soybean variety/trait yield and yield loss from simulated dicamba drift at Manhattan, KS in 2018.

Variety/Trait	Timing	Yield	Yield loss
		(Bushel/acre)	(%)
Credenz 3841 LL	Untreated	43	--
	V3	46	-5
	R1	35*	20*
Credenz 4748 LL	Untreated	51	--
	V3	53	-4
	R1	43	5
Asgrow AG 4135 RR2	Untreated	44	--
	V3	50	-15
	R1	35*	20*
Stine 40BA02	Untreated	43	--
	V3	45	-5
	R1	27*	37*

* = Significantly different than the untreated check

Table 14. Soybean variety/trait yield and yield loss from simulated dicamba drift at Manhattan, KS in 2019.

Variety/Trait	Timing	Yield	Yield loss
		(Bushel/acre)	(%)
Credenz 3841 LL	Untreated	68	--
	V3	55*	18*
	R1	46*	32*
Credenz 4748 LL	Untreated	67	--
	V3	55*	18*
	R1	44*	35*
Asgrow AG 4135 RR2	Untreated	70	--
	V3	64	9
	R1	45*	36*
Stine 40BA02	Untreated	65	--
	V3	67	-4
	R1	43*	34*

* = Significantly different than the untreated check

Table 15. Soybean variety/trait yield and yield loss from simulated dicamba drift at Ottawa, KS in 2019.

Variety/Trait	Timing	Yield	Yield loss
		(Bushel/acre)	(%)
Credenz 3841 LL	Untreated	55	--
	V3	54	2
	R1	43*	23*
Credenz 4748 LL	Untreated	57	--
	V3	59	-3
	R1	55	8
Asgrow AG 4135 RR2	Untreated	57	--
	V3	57	0
	R1	41*	29*
Stine 40BA02	Untreated	57	--
	V3	57	0
	R1	39*	32*

* = Significantly different than the untreated check

Impact of Dicamba Exposure on Harvested Seed Germination and Early Season Growth

Grain harvested from both experiments at Manhattan in 2018 had extremely poor seed quality due to early season drought stress and delayed harvest as a result of excess moisture in the fall at harvest time. Consequently, seed viability was very low, highly variable, and not different among treatments. Germination tests and early growth assessments on seed harvested from all experiments in 2019 indicated minimal impact of dicamba exposure during the growing season on the germination and early growth of offspring. These results may differ from previous research due to differences in exposure rates and timings of the treatments.

Summary

All dicamba treatments caused significant visual injury to non-Xtend soybeans, especially within the first few weeks after exposure. Soybean injury from dicamba was lower and less persistent when exposed during the V3 than the R1 or R3 growth stages. Symptoms became more severe as dicamba rates increased and with multiple exposures. Soybean injury was most severe at 4 weeks after treatment and was highest with the 1/100X rate applied at all three timings with 78% to 81% injury. Yield reductions were not directly correlated to visual injury and were substantially less than most injury ratings. The highest soybean yield reduction occurred from the 1/100X rate of dicamba applied at V3+R1+R3, which resulted in a 43 to 68% yield loss across the three site-years. Soybean yield loss was minimal from a single dicamba exposure at the V3 stage regardless of exposure rate, or from the 1/1000X rate, regardless of timing or number of exposures. Multiple exposures and exposure of non-Xtend soybeans to dicamba at the R1 growth stage pose the greatest risk of soybean yield loss.

Soybean injury was higher from exposure at R1 than the V3 stage of growth for all varieties evaluated, especially with the late season assessment. Soybean injury at 4 WAT was similar among varieties and traits within each exposure timing. Visual injury from dicamba exposure at R1 tended to be highest on ‘Stine 40BA02’ and lowest on ‘Credenz 4746 LL’ at the late season evaluation. Lower injury on the ‘Credenz 4746 LL’ at the onset of senescence may have been partially due to the longer maturity and greater vegetative growth later in the summer than with the other varieties. Soybean yields varied by site-year. Significant soybean yield loss from exposure at the V3 stage only occurred with the two LL soybean varieties at Manhattan in 2019, but did not occur with any variety at the other two site-years. Soybean yield was reduced between 8 and 37% from dicamba exposure at the R1 stage across all varieties and site years, but was not consistent across site-years and varieties. ‘Stine BA40B2’ tended to have the greatest yield loss and ‘Credenz 4748 LL’the lowest yield loss from dicamba exposure at the R1 stage. Yield loss from dicamba exposure was most closely correlated to visual injury ratings at the onset of senescence. Soybean maturity appeared to have a greater effect on late season recovery to dicamba than soybean trait.

Dicamba exposure to soybeans had no significant effect on germination or early season growth of offspring grown from the seeds harvested from the plots.