Using UASs to Assess Dicamba Injury to Non-dicamba Tolerant Soybeans in a Drift Simulation Study

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In 2017, when Xtend soybean were brought into the market, it was estimated that nationwide, around 3 million acres of non-dicamba tolerant soybeans were injured by off-target dicamba. From that acreage, around 150,000 acres were located in North Dakota. One the main issues in fields affected by dicamba off-target movement is the difficulty in assessing the extent of a field affected by dicamba and subsequent loss in seed yield. Sensors mounted on a UAS (unmanned aerial system) can quickly provide information to support that assessment. By overlaying a yield map over the imagery, one can assess how the yield changes in areas impacted by dicamba compared to those not affected by it. During the past growing season, we carried out a study primarily designed to answer questions regarding the effect of multiple dicamba exposures on non-dicamba tolerant soybean yield during reproductive stages, and the suitability of the use of a UAS fitted with different sensors (cameras) to make an assessment of the crop response to those exposures. Due to space constraints, this report will focus on the suitability of an off-the-shelf, ready-to-fly UAS to assess the effect of dicamba rates, alone and mixed with glyphosate, on non-dicamba tolerant soybean.

Material and Methods

In 2018, a study was established at the Carrington REC to identify injury threshold to soybeans from simulated dicamba and glyphosate drift. Most of the treatments were applied at the R1 growth stage (July 2), with exception of some medium-rate treatments, which were applied at R2 (June 11) and at R2 and R3 (July 11 and July 23). The later applications simulated multiple exposures to dicamba drift. The low, medium, and high dicamba (Clarity) rates were combined with low, medium, and high glyphosate (RoundUp Powermax) rates to assess possible interaction of those products on non-dicamba tolerant soybeans. A detailed list of the treatments is presented in Table 1. Visual injury scores were collected from each plot at 10, 20, 30, and 40 days after treatments (DAT). For imagery collection, we used a DJI Phantom 4 Pro (P4P) equipped with a 20MP RGB camera. We flew several missions at different altitudes (100, 250, and 350 ft AGL [above ground level]) to investigate the impact of flight altitude on our ability to detect differences among treatment. Since we were able to detect such differences from all flight altitudes tested, we will focus on the imagery collected on July 25 and August 15, which were collected two days after the second and fourth visual injury rating evaluations, respectively.

Table 1. List of treatments and plant injury ratings on non-dicamba tolerant soybeans at different days after application of the treatments.

Treatment	Rate	---------- Plant injury rating, % ----------			
	fl oz/ac	10 DAT	20 DAT	30 DAT	40 DAT
Check		0.00 g	0.00 f	0.00 g	0.00 e
DicM_R1-R2	0.14	25.0 d	26.3 c	23.8 cd	26.3 c
DicM_R1-R3	0.14	26.3 d	27.5 c	25.0 cd	28.8 c
DicM+Adj	0.14	35.0 c	30.0 c	27.5 cd	30.0 c
DicL	0.014	5.00 f	6.30 e	5.00 f	2.50 e
DicM	0.14	27.5 d	28.8 c	25.0 cd	26.3 c
DicH	1.4	46.3 b	58.8 b	62.5 b	68.8 b
GlypL+DicL	0.025 + 0.014	12.5 e	16.3 d	13.8 e	11.3 d
GlypM+DicM	0.25 + 0.14	33.8 c	30.0 c	28.8 c	27.5 c
GlypH+DicH	2.5 + 1.4	61.3 a	68.8 a	71.3 a	73.8 a

DAT = days after treatment; Dic = dicamba; M = median; R1, R2, R3= soybean reproductive growth stages; Adj.= adjuvant; L = low; H = high; and Glyp = glyphosate. Means followed by the same letter within each DAT are not significantly different.

Images collected during flights were processed with Pix4Dmapper by Pix4D to produce georeferenced orthomosaics (Figure 1). We used ArcGIS software paired with Python scripts to calculate and extract the average “Excess Green” index (ExGr) value for individual plots, which then were correlated with the visual injury scores collected on the field.

Results and Discussion

Figure 1 shows an aerial view from the study area collected on July 15, with the ExGr index layer masked to each plot extension. That layer clearly shows the differences among the check plots and those that received the highest rates of dicamba. A more detailed inspection of the imagery allows one to visually identify most of the plots that received the medium dicamba rate.

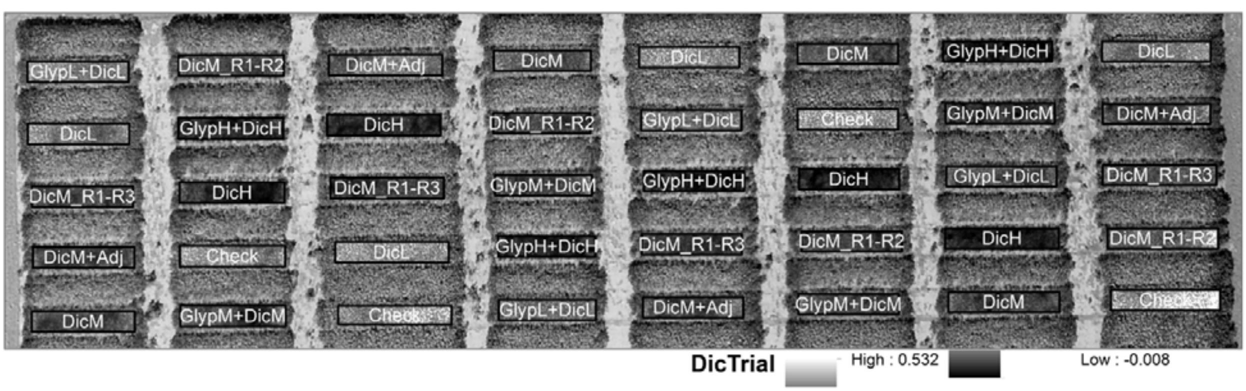

Figure 1. Dicamba drift study at the Carrington REC. RGB imagery (August 15, 2018, Phantom 4 Pro, 350 ft AGL) on the background with the Excess Green index layer masked to each plot extension.

Average visual field injury ratings for the treatments are presented in Table 1. There were significant differences among treatments at every evaluation date, and those differences were consistent across time. Based on plant injury ratings, treatments can be ordered as GlypH+DicH>DicH>all DicM treatments>GlypL+DicL>DicL>Check. All the treatments involving medium rates of dicamba, independent of the number of applications (R1, R1+R2, R1+R2+R3), with or without glyphosate, showed similar injury levels. Although there were some significant differences among the DicM treatments on the first two flight dates, data extracted from UAS imagery collected on August 15, showed similar results (GlypH+DicH=DicH>all DicM treatments>GlypL+DicL>DicL>Check; Table 2).

Table 2. Non-dicamba tolerant soybean average excess green index values calculated from RGB imagery collected at 350 ft above ground level during three flight dates.

Treatment	---------- Excess Green Index ----------		
	25-Jul	30-Jul	15-Aug
Check	0.271 a	0.298 a	0.153 a
DicM_R1-R2	0.188 d	0.178 de	0.082 d
DicM_R1-R3	0.192 d	0.174 e	0.072 d
DicM+Adj	0.208 c	0.204 cd	0.085 d
DicL	0.236 b	0.254 b	0.131 b
DicM	0.201 c	0.187 cde	0.082 d
DicH	0.139 e	0.117 f	0.042 e
GlypL+DicL	0.213 c	0.212 c	0.106 c
GlypM+DicM	0.192 d	0.177 de	0.074 d
GlypH+DicH	0.125 e	0.102 f	0.042 e

Dic = dicamba; M = median; R1, R2, R3 = soybean reproductive growth stages; Adj. = adjuvant; L = low; H = high; and Glyp = glyphosate. Means followed by the same letter within each flight date are not significantly different.

Figure 2 shows the correlations between field visual injury rating data at 20 DAT (July 23) and ExGr values (July 25), and injury rating at 40 DAT (August 13) and ExGr values (August 15). Although the flights were carried out two days after the field evaluations, the high R^2 (above 0.96 in both cases) show good agreement between field- and imagery-collected data. In addition, one can notice that the treatments were separated out closely following the order listed above for data on Tables 1 and 2.

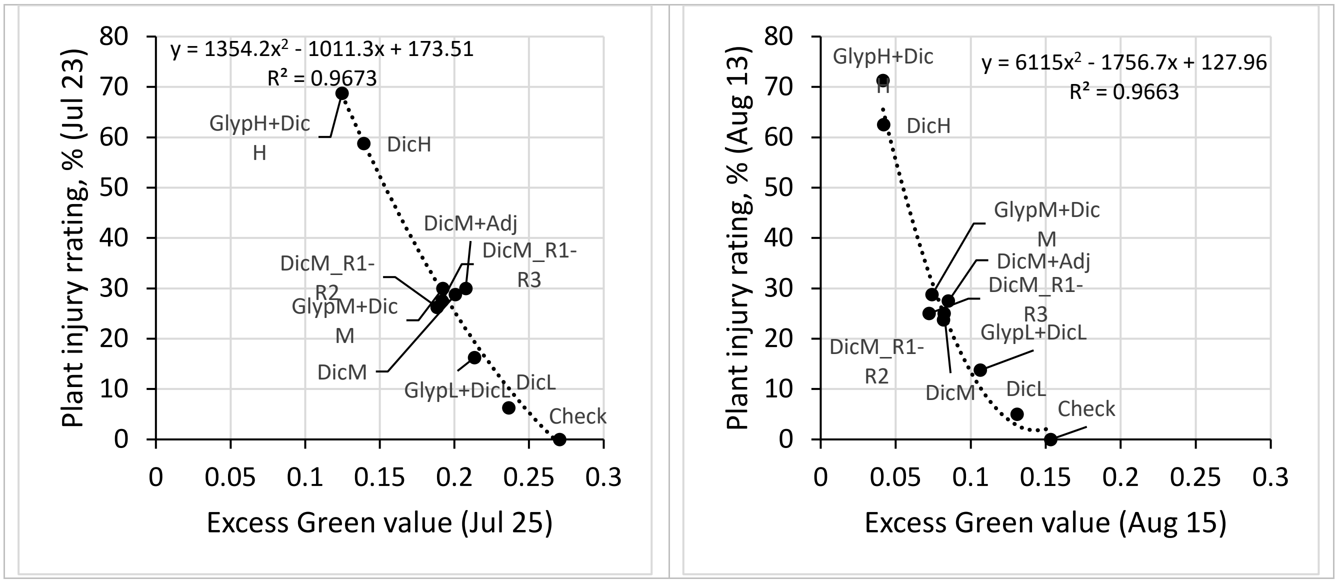

Figure 2. Correlations between visual plant injury ratings and excess green index at 20 days (left) and 30 days (right) after treatment applications.

Based on our results, we can conclude that the UAS used in this study (Phantom 4 Pro), flying at 350 ft above ground level, was able to capture imagery that allows one to identify soybean areas affected by dicamba off-target movements. In addition, the imagery collected allows one to discern the level of injury caused by different rates of dicamba on non-dicamba tolerant soybeans.