15A.1 GENETIC ASSOCIATION OF UVB IMPACTS ON SOYBEAN

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1. INTRODUCTION

Do similarities exist between the effects of ultraviolet (UV) radiation on soybeans of similar pedigree? Many experiments have investigated the sensitivity of soybeans to enhanced UVB irradiance, in both field and greenhouse. Results of such studies have been contradictory or inconsistent. Two questions were proposed: (1) Is soybean sensitivity related to heliotropic response, and (2) do genetically similar cultivars display comparable characteristics?

The cultivar Bay (Buss et al., 1979) was derived from the York (Smith, 1968) and Essex cultivars (York × R62-550 [Essex × G. Soja]), whereas Williams 82 cv. (Bernard and Cremeens, 1988) is only distantly linked through the CNS cultivar, and therefore was not considered related to the Bay or York cultivars. The data from the Bay and York cultivars were expected to show similarities to each other and differ from that of the Williams 82 cultivar.

2. METHODS

Experiments in the greenhouse at Purdue University, West Lafayette, IN (40.5°N) on three soybean cultivars - Bay, York and Williams 82 - compared the heliotropic movements, leaf area and leaf weight of five replicates of each cultivar in a UV enhanced area with those in a control group to determine the physiological and heliotropic responses of these cultivars to UV. The UV enhancement was approximately 1.3 times that typical for mid-latitude summer. Measurements of leaf orientation were made using a Microscribe 3D-coordinate digitizing system with a laboratory-measured 5° measurement error. The leaf orientation was measured using five points on each leaf of the upper trifoliate together with two points along the petiole. Heliotropic data from each cultivar were averaged into two groups: those with the azimuth of the central leaflet within ±90° of the solar azimuth ("on-sun"), and "off-sun" for the remainder. Data for clear sky and on-sun measurements of leaf orientation are presented.

The leaf orientation measurements were used to predict the UVB dose on the uppermost trifoliates to determine whether the sensitivity was related to their heliotropic response, and whether genetically similar cultivars displayed comparable characteristics. The UVB exposures of the soybean top trifoliates of the three cultivars in the greenhouse study were based on the UVB irradiance being considered all diffuse.

Leaf area data were measured using a LICOR LI-1300 area meter, and leaf weights were obtained from dried samples of each plant.

3. RESULTS

3.1 *Heliotropic response*

Figure 1 illustrates the change in mean leaf angle Ψ_F over the course of the three measurement days in the field for Williams 82, Bay and York cultivars. The leaf angles were not significantly different between cultivars (student's *t*-test, p=0.05) due to the low sample size, particularly for the Williams 82 cultivar (Fig. 1).

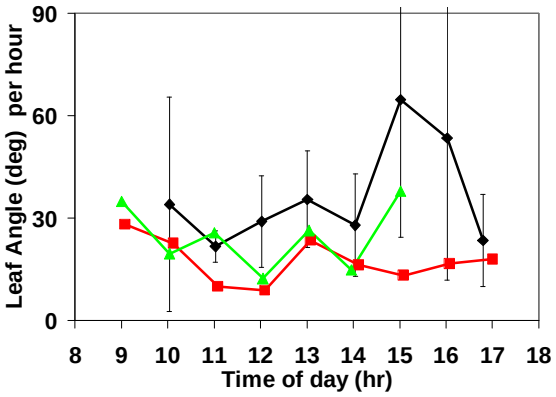

Figure 1. Mean Leaf angles with time for Williams 82 (diamond), Bay (square) and York (triangle) cultivars. The bars indicate the deviation from the mean for the Williams 82

The mean incidence angles similarly showed no significant differences (p=0.05) between cultivars during the course of the day as shown in Figure 2. The standard deviation of leaf angle measurements for the Williams 82 plants show the high variability at large solar zenith angles. The incidence angles show a steady increase over the course of the day for the Williams 82 plants with the minimum occurring in the early morning indicating that the cultivars were reducing the leaf exposure during the course of the day. The minima for Bay and York cultivars occur in the mid- to late-afternoon at 1400 and 1600 hours respectively indicating greater exposure of the leaves to solar radiation at these hours. The incidence angles for all

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three cultivars and particularly Bay and York are 40° higher than those found by Rosa and Forseth (1995) for the genetically similar Essex cultivar. This difference in the measured incidence angles may be partly a result of water stress on the Rosa and Forseth plants as distinct sun avoidance occurred in early afternoon when water stress might be expected.

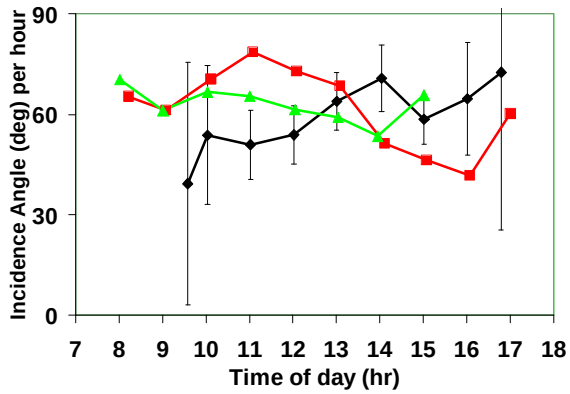

Figure 2. Averaged incidence angles with time of day for Williams 82 (diamond), Bay (square) and York (triangle) cultivars. The bars indicate the deviation from the mean for the Williams 82

The greenhouse UVB exposure for the Bay, York and Williams 82 cultivars were computed to be 98%, 96% and 92% of the horizontal exposure respectively.

3.2 *Physiological characteristics*

The leaf areas and weights for the three cultivars obtained from the UV-enhanced and control plants from the greenhouse are displayed in Table 1. The Williams 82 cultivars exposed to enhanced UV showed leaf weights and areas that were greater than the York-Bay average by 15% and 13% respectively. In comparison, Bay produced the largest leaf weights and areas than either the Williams 82 or York cultivars in the control area. Similarities between the genetically similar cultivars are not evident in the control data: York cv. leaf weights and areas were smaller than Bay cv. by 29.2% and 11.7% for leaf weights and areas. In the UV-enhanced area the data was less dissimilar, York was consistently above Bay by 3.3% in leaf weight and 7.1% in leaf area. Assuming the proportion of heliotropic leaves is constant across cultivars, the Williams 82 cultivar plants had 10% more UVB received than the Bay cultivar (with the greatest proportion of horizontal UV exposure) due to the greater leaf area for exposure (Table 1).

Table 1. Leaf areas and weights for the three cultivars exposed to UV-enhanced and natural lighting.

	UV-enhanced		Control	
Cultivar	**Leaf Weight (gm)**	**Leaf Area (cm^2)**	**Leaf Weight (gm)**	**Leaf Area (cm^2)**
Williams 82	3.93	1448.8	4.36	1138.4
Bay	3.33	1238.3	5.08	1493.9
York	3.44	1326.2	3.93	1338.0

4. CONCLUSIONS

From this early study, there appear to be no statistically different characteristics in heliotropism displayed by cultivars with different genetic pedigree. All three cultivars displayed similar heliotropic responses although the rate of leaf angle change and incidence angles of Bay and York appeared to be more similar to one another than with Williams 82. The estimation of exposures in the greenhouse revealed that Williams 82 had a lower exposure than both Bay and York. It appears that genetic traits of heliotropy may have been retained in the York and Bay lines. Further studies in the field and greenhouse in late summer 2002 will increase the sample set and are expected to improve the *t*-test statistic results.

The physiological data showed that the Williams 82 cultivar produced leaf weights and areas that were greater by an average of 14% than both York and Bay cultivars in the UV-enhanced data, but were lower than Bay cv. for the control area. The genetically similar cultivars, York and Bay, did not show similar characteristics in the leaf areas and weights in the control area but were more similar in the UV area, varying between 3-7%. The Williams 82 cultivar with the positive leaf weight and leaf area response to UVB exposure also received slightly more UVB than the other cultivars.

5. REFERENCES

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