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EFFECTS OF UVB ON SORGHUM WAX PRODUCTION AND REFLECTANCE

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1. INTRODUCTION

Epicuticular waxes on crop plants have been shown to influence crop development and yield by reducing evapotranspiration, insect damage and pathogen infestation, and influence the optical properties of the leaves and stalks. Part of the variability found in the reflectance of leaf tissues appears related to the epicuticular wax distribution and wax abundance on the leaf. The aim of this study is to further characterize the effects of ultraviolet (UV) radiation on epicuticular wax formation and determine the effect of the epicuticular waxes on leaf and canopy reflectances.

2. METHODS

Two laboratory approaches were made to determine the influence of epicuticular waxes on the optical properties of *Sorghum bicolor* varieties: the wild type P954035 and two mutants h7-1 and h10-1 (Jenks et al., 1992). The first method used a Lambda 19 spectrophotometer to measure the optical reflectances of adaxial surfaces of stalk and leaf samples for the three sorghum varieties before and after wax removal to determine the interaction of wax amount and wax structure on the optical properties of sorghum tissues. The second method related UV and wax amount to stalk and leaf reflectance using the colorimetric method from Ebercon et al. (1977) and modified as given in Smoczyk (2000) to obtain the wax amounts. This would establish whether higher UV levels produced more wax that in turn produced a higher reflectance in the leaves and stalks.

3. RESULTS

3.1 *Wax removal*

The measured reflectances averaged over the UVB region (280-320nm) for the UV-enhanced plants compared with the control plants are set out in Table 1. The reflectance of the control plants was also measured before and after the wax was removed. The h7-1 and h10-1 mutants show a 4-5% reflectance for both the stalks and leaves, and little to no difference in reflectance before and after wax removal for both stalk and leaf reflectances. There were no observed differences in stalk reflectance between the UV and control plants for these two mutants and small differences in the leaf reflectances of up to 2%. The P954035 data show a 9% decrease in the stalk reflectance between the control and UV-enhanced plants, but a 3.3% higher leaf reflectance in the UV above the control. The P954035 stalk reflectance data shows a 10.5% reduction with the removal of the wax.

Table 1. Comparison between the reflectance (%) for the sorghum stalks and leaves before and after wax removal and between control and UV-enhanced plants

Sorghum bicolor	**Before**		**After**
STALKS	**Control**	**UV**	**Control**
P954035	16.0	7.0	5.5
h7-1	4.5	4.5	4.5
h10-1	4.3	4.3	4.5
LEAF			
P954035	5.7	9.0	5.2
h7-1	5.2	4.5	5.2
h10-1	5.0	3.0	5.0

3.2 *Wax amount and reflectances*

Figure 1 shows the dependence of wax amount on reflectance for the P954035 data (diamond), h7-1 data (square) and h10-1 data (triangle). As indicated in Table 1 where the reflectance in the UVB region from the h7-1 and h10-1 mutants showed little to no difference with wax removal, Figure 1 shows that the stalk wax amount is not dependent on reflectance for these two mutants. The possible cause of this low reflectance may lie with the type of cuticle and cell waxes found on the stalks. Jenks et al. (1992) indicated that the abaxial stalk surfaces were comprised of long and short filaments for the h7-1 and h10-1 mutants respectively whereas the cuticle waxes were comprised of thin to normal plates. From visual observation of low wax amounts on the adaxial surfaces, the cuticle waxes were assumed to predominate and account for the low reflectance values.

The study of Jenks et al (1992) reported that the cell waxes for P954035 were comprised of long filaments, and visual observations confirmed the high wax load on these plants. As shown in Figure 1, the wax amount for the P954035 is dependent on reflectance and this linear dependence can therefore be used to determine wax amounts from reflectance data. From this relation, the reflectance calculation for a wax amount of zero produces a value near 5% which is the standard reflectance value for most vegetative surfaces.

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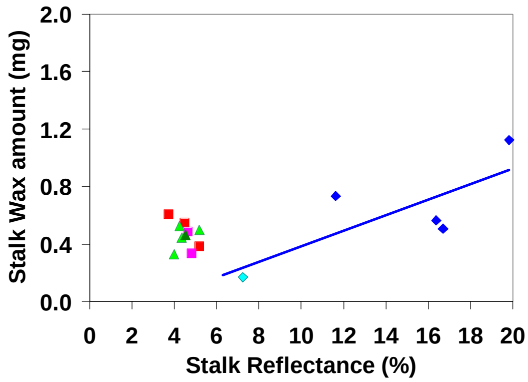

Fig. 1. Dependence of stalk wax amount (in mg) with stalk reflectance (%) for the three sorghum varieties

In Figure 2, the leaf wax amounts for the mutants h7-1 and h10-1 again show no dependence on reflectance, but there is also no dependence evident in the P954035 data. This is perhaps indicative of the type of wax found on the leaves. Jenks et al. (1992) examined the abaxial surfaces of these three sorghum varieties and showed that the cuticle and cell waxes on the leaf surfaces are comprised of thin plates and short filaments respectively. It is possible that the thin plates have little or no reflectance and if dominant would produce low reflectances and low wax amounts. Further studies are required to show the types of waxes present on the adaxial surfaces of both the sorghum leaves and stalks.

4. CONCLUSIONS

Higher UV levels on three sorghum varieties produced a 4.5% increase in reflectance on the leaves of the wild-type P954035 but 9% less reflectance on the stalks. There was little difference between the reflectances for the UV and control plants for both leaves and stalks for the two mutant varieties h7-1 and h10-1. It is possible that the increased wax amount on the P954035 leaves in the UV area can be attributed to the overhead orientation of the UV lamps, and the reduction in P954035 stalk reflectance from the increased shading of the stalks from the shielding of the UV experimental area and therefore reduced sunlight on the stalks. Conversely, in the control area, the stalks receive radiation from a large portion of the sky and hence the increased reflectances and wax amounts seen on the stalks of the control plants. Further studies in the fall of 2002 will examine the effects of UV light on the sorghum stalks. The interrelation between wax amount and reflectance was evident only for the stalks of the P954035 plants. There was no dependence for the h7-1 and h10-1 mutant varieties for either stalks or leaves.

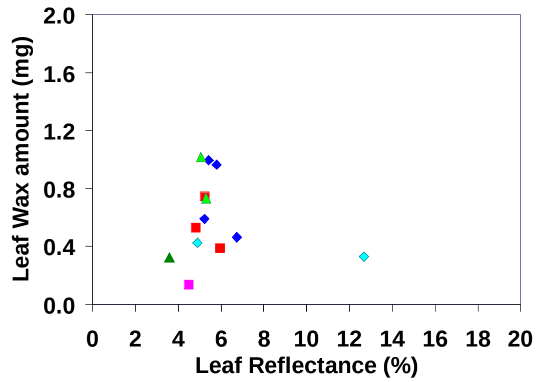

Fig. 2. Dependence of leaf wax amount (in mg) with leaf reflectance (%) for the three sorghum varieties

This study further characterizes the effects of epicuticular waxes on canopy and leaf reflectance, in particular, the leaf characteristics that cause UVB leaf reflectance, and assists in understanding how *Sorghum bicolor* thrives in low latitude-high UVB irradiance regions.

5. REFERENCES

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