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The Effect of Ultraviolet Light on Plant Development & Fruit Production

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Abstract:

UV-C radiation is efficient in reducing the development of diseases in many species, including fruit production(Fragaria x ananassa). Several studies suggest that UV-C radiation is effective not only because of its disinfecting effect but also because it may stimulate plant defenses. In this study, the effect of pre-harvest UV-C radiation applied during fruit production and plant growth, fruit quality and susceptibility to major fungal diseases, as gray mold, powdery mildew and soft root, was evaluated. UV-C treatments had an impact on flowering initiation and fruit development. Flowering occurred earlier for UV-C-treated plants than for non-treated plants. At harvest, a larger amount of fruit was produced by treated plants despite their slight decrease in leaf area. UV-C treatment did not improve fruit production shelf life but did not alter the physical integrity of fruit production. Natural infection of leaves to powdery mildew and of fruit to Rhizopus was strongly decrease in response to UV-C treatment.

Keywords:- : Crop yield; Leaf pigments; Leaf wax; Phenology; Photosynthesis; Plant development.

Introduction

This paper provides an overview of existing literature on the ultraviolet-B (UV-B) radiation effects on field crops. Earlier reviews on field crop responses to UV-B considered few physiological processes or crops. For this review, we easily located about 129 studies on 35 crop species published since 1975. Here, we report the effects of UV-B radiation on visual symptoms, leaf ultra-structure and anatomy, photosynthetic pigments, UV-B absorbing compounds, photosynthesis, growth and development, yield, genotypic differences, and finally, interactions of UV-B with abiotic and biotic factors of crop plants. Experiments conducted in glasshouses, in closed and open top chambers, and under field conditions, with varying source (solar or artificial) and intensity of photosynthetically active radiation (PAR, 50–1800mol m^{-2} s^{-1}) and UV-B (0–50 kJ m^{-2} per day) are included. It is easy to conduct experiments that purport to evaluate the effects of projected UV-B intensities on crop species by providing supplemental irradiance with lamps or by reducing UV-B with filters; however, it is very difficult to simulate UV-B irradiance spectral changes that are likely to occur in nature. Collated results for each process are presented as percent change from control along with the experimental conditions in tabular format. Many of the studies showed dramatic effects of UV-B radiation, but under conditions with supplemental UV-B irradiance that was higher than would ever occur outside experimental conditions or in which the longer wavelengths in the PAR and UV-A, which moderate UV-B effects, were greatly reduced. Only 25 of the studies reviewed used experimental conditions and supplemental UV-B irradiance that approached realism. However, unrealistic the experimental conditions might be, an increase in understanding of basic plant physiology was gained from most of the studies. Visual symptoms consisting of chlorotic or necrotic patches on leaves exposed to

UV-B were not unique. Both vegetative and reproductive morphology were altered by UV-B radiation. Leaf anatomy was altered due to changes in thickness of epidermal, palisade, and mesophyll layers. Enhanced UV-B generally decreased chlorophyll content (10–70%), whereas it increased UV-B absorbing compounds (10–300%) in many crops. Decrease in photosynthesis (3–90%), particularly at higher UV-B doses, was due to both direct (effect on photosystem) and indirect (decrease in pigments and leaf area) effects. The decreases in chlorophyll pigments and photosynthesis resulted in lower biomass and yield of most crop plants. Genotypes of crop species exhibited variability in leaf wax layer thickness, loss of chlorophyll, and increase in phenolics as mechanisms of tolerance to enhanced UV-B radiation resulting in changes in biomass/yield. Results from the few studies on interaction of UV-B with other abiotic and biotic factors did not lead to useful conclusions. Studies are needed to quantify the effects of UV-B radiation on crops in order to develop dose response functions that can facilitate development of dynamic simulation models for use in UV-B and other environmental impact assessments.

Data Analysis

All statistical analyses were performed with the software Statistica. First, analysis of data normality was performed using the Shapiro test. If the data were normal, an analysis of variance (ANOVA) was performed. In the case of a significant effect of the test factor, a comparison of means was made with Duncan's test or Newman-Keuls test. In contrast, if the data were not Gaussian, non-parametric tests were used, such as the Kruskal-Wallis test. For each test, a threshold of $p\text{-value} < 0.05$ was used. All statistical analyses were performed on all results obtained in both 2020 and 2021 years.

Impact of UV-C treatments on fruit quality

The colour and firmness of fruit production were analyzed (Table 1). During storage, the hue angle and chroma of groups treated with UV-C were lower than those of the control group. The groups "AFTER" and "DURING" had lower hue angles and chroma values than the control group beginning at two days of storage. After three days of storage, the groups "AFTER", "DURING" and "BEFORE" had a lower hue angle and chroma than the control group.The firmness slightly decreased during storage for all the samples. Sensory evaluation on fruit production the day before was carried out by blind tests with 30 consumers (Data not shown). UV-C treated fruit from both the "BEFORE" group and the "DURING" group were appreciated at the same level (21 % for each group). The UV-C treated fruit from the "AFTER" group were appreciated by 11 % of consumers. And 47 % of consumers prefer fruit no treated with UV-C radiation.

Conclusions-

In conclusion, pre-harvest UV-C treatments had some significant effect on plant and reduced the natural occurrence of diseases, such as powdery mildew on leaves. Concerning fruit, pre-harvest UV-C treatments had some significant effect on colour and there was a strong significant reduction in natural infection with pathogens, such as Rhizopus sp. Additional experiments will be done to confirm this encouraging result with artificial inoculum of Rhizopus and P. aphanis. It seems difficult to find only one UV-C treatment that would be optimal for all parameters measured, such as disease resistance of plants, of fruit or fruit quality. In our study, we showed that it is preferable to apply UV-C treatments before flowering to increase flowering and plant yield but it is preferable to apply UV-C after flowering to reduce the susceptibility of leaves to infection by B. cinerea. In addition, UV-C treatments applied pre-harvest seem to be promising in terms of crop quality, but further evaluation is needed to find optimal UV-C treatments that can also have an impact on fruit production.

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