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EFFECT OF UV-A RADIATION ON PHOTOSYNTHETIC PIGMENTS OF SELECTED CROP PLANTS

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ABSTRACT

The present work deals with the effect of UV-A radiation and UV-A along with growth regulators on certain pigments in four crop plants, red gram, groundnut, wheat and ragi. Plants were exposed to UV-A radiation for two hours (2 hr) and four hours (4 hr) daily and UV-A irradiated plants were given chemical treatment, AA, IAA and SA at every fortnight starting from seed stage to yield level. At every fortnight the total chlorophyll content, chlorophyll a (chl-a) and chlorophyll b (chl-b) content were estimated. Treatment with UV-A decreased chlorophyll content. Chlorophyll a was more affected than chl-b. Chlorophylls were found to be more sensitive to UV-A radiation in all the four crop plants studied. The harmful effect of UV-A radiation on pigments was found to be less in AA, IAA and SA treated plants. Ragi plants were found to be more sensitive to UV-A radiation and AA being a powerful antioxidant was found to be an effective possible antidote to UV-A radiation followed by SA and IAA. The present work reveals that UV-A has adverse effects on photosynthetic pigments which ultimately lead to the decrease in the productivity and yield of the crop plants like UV-B radiation.

Key words: UV-A radiation, crop plant, chlorophyll, photosynthetic pigments.

INTRODUCTION

Human activity has greatly altered the concentration of trace gases in the atmosphere like chlorofluorocarbons (CFCs), oxides of nitrogen rocket exhausts which cause depletion of the stratospheric ozone (NASA, 1988). It has been established that depletion of the stratospheric ozone layer is increasing the level of UV-B radiation reaching the earth's surface. There are various reports on the harmful effects of UV-B radiation which effects both physiological and biochemical characters in plants (Bornman, 1989).

In contrast to studies on the effect of UV-B, there are few reports on the effect of UV-A which makes up a large portion of solar UV radiation. Qualitative effects of solar UV-A on higher plants have been reported (Foley, 1965; Krizek et al., 1997). To date, relatively few species have been investigated under UV-A conditions.

UV-A radiation, like UV-B radiation , has many inhibitory effects on plants. It suppresses the pigment synthesis in microorganisms (Hirosawa and Miyachi 1983a, 1983b). The biological effects of UV-A on microorganisms are well known but there are only few reports on higher plants (Klein, 1978 and Tezuka et al., 1994). Voipio and Autio, 1995 reported inhibitory effects of UV-A on lettuce plants. Very limited information is available about the harmful effects of UV-A on tropical plant species, especially the crop plants. UV radiation induces oxidative stress (Elstner, 1982) and enhances accumulation of phenolic compounds (Mc Clure, 1975; Tevini et al., 1981 and Lingakumar and Kulandaivelu, 1993).

The general or specific growth promoting nature of Ascorbic Acid, Indole Acetic Acid and Salicylic Acid has been well established by several workers (Datta et al., 1978; Ajay singh et al, 2013 and Carrington and Esnard, 1988). In the present study the effect of UV-A radiation on photosynthetic and non photosynthetic pigments of certain crop plants under natural levels of PAR and the counteracting effect of AA, IAA and SA on UV-A irradiated plants were observed.

UV- B radiation combined with low PAR growth levels produced singnificant reductions in chlorophyll concentrations (Garrard et al., 1976, and Tevini et al., 1981. Basiouny et al., (1978) found that reductions in total dry weight and net photosynthesis were paralleled by reduction in total chlorophyll concentration in collard, oats and soybean. Krizek et al., 1998 reported reduction in chl a concentration in UV-A exposed plants but there was no effect on chl b concentration. UV-B radiation also causes reduction in carotenoids (Tevini et al., 1981 and Vu et al., 1981; Iwanzik and Tevini, 1982) and induces a class of non photosynthetic pigments flavonoids and anthocyanins (Wellmann, 1982; Caldwell, 1971 and Gausman et al., 1975; Beggs et al., 1986). Voipio and Autio (1995) reported that UV-A radiation significantly increased anthocyanin absorbance in leaves of lettuce.

Relatively very little information is available on the effect of UV-A radiation on pigments compared to that of UV-B radiation. Hence, the present work has been undertaken in order to assess the potential consequence of UV-A radiation on photosynthetic pigments, chlorophylls and carotenoids and non photosynthetic pigments, anthocyanins. Further the effect of certain chemicals, AA, IAA and SA, as possible antidotes on UV-A irradiated plants has also been carried out, as their effect on UV irradiated plants is lacking.

MATERIALS AND METHODS

Experimental site*:*
Experiments were conducted at the Department of Botany, Osmania University, Hyderabad. Hyderabad is an inland city in the south central part of the country with comparatively mild climatic conditions. Hyderabad is situated on 17^0 22'N and 78^0 above msl.

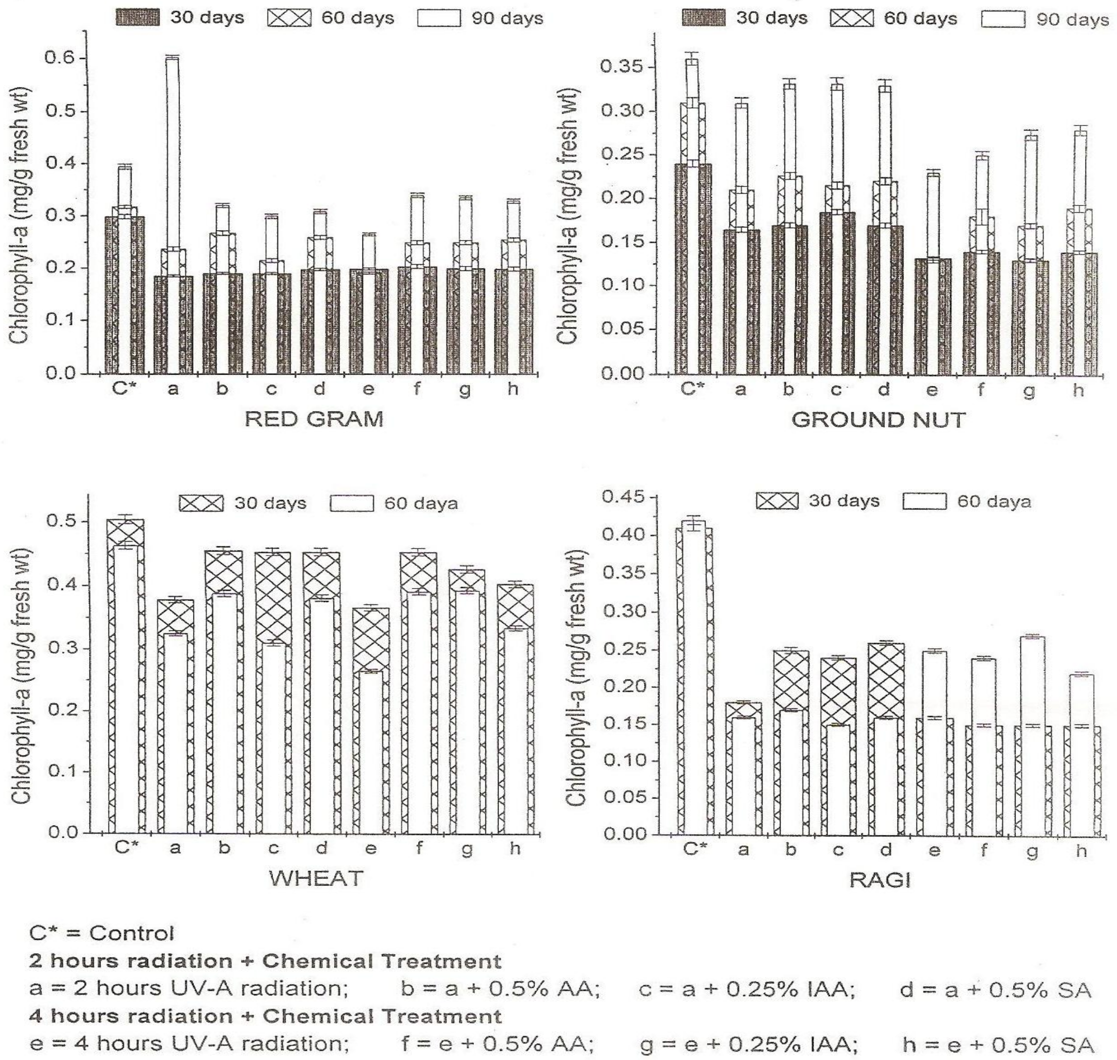
Plant material:
Two leguminous Fabaceae crop plants species Cajanus cajan (L.) Millsp. Var. LRG Palnadu 60 (red gram), Arachis hypogaea L.var. TmV 2 (ground nut) and two Poaceae crop species Triticum aestivum L. var. Sonalika-R (wheat), Eleusine coracana Gaertn. Var. Ratnagiri (ragi) were selected for the study and the seeds of all the four plant species were procured from Andhra Pradesh State Seed Development Corporation (APSSDC), HUDCO Hyderabad.

UV–A irradiation system:
UV–A irradiation (320 – 400nm) was artificially supplied in artificial radiation chamber specially designed for the purpose (6'x3'x5'). Flourescent UV – A tubes (Philips 40 W) were suspended above and perpendicular to the plants. The plants were irradiated for two different durations, two hours per day and four hours per day, in the middle of the photoperiod, 11 O' clock to 1 O' clock and 11 O' clock to 3 O' clock respectively daily starting from seed level to yield level.

UV-A radiation and chemical treatment:
Along with UV-A radiation chemical substances, possible antidotes, were added to 2 hr and 4 hr UV-A irradiated plants individually at every fortnight to all the four crop plants studied. The chemicals used where as follows:

Ascorbic Acid	(AA)	0.5%
Indole Acetic Acid	(IAA)	0.25%
Salicylic Acid	(SA)	0.5%

Figure 1: Effect of UV-A radiation and along with chemical treatment on Chlorophyll-a of four different crop plants



Sampling Of Plants:
Three plants were sampled randomly from each replicate treatment pots as well as from control pots for pigment analyses at every fortnight.

Pigment Analysis:
Photosynthetic pigments, chlorophylls were estimated at every fortnight. Chlorophyll content was estimated by Arnon method (1949).

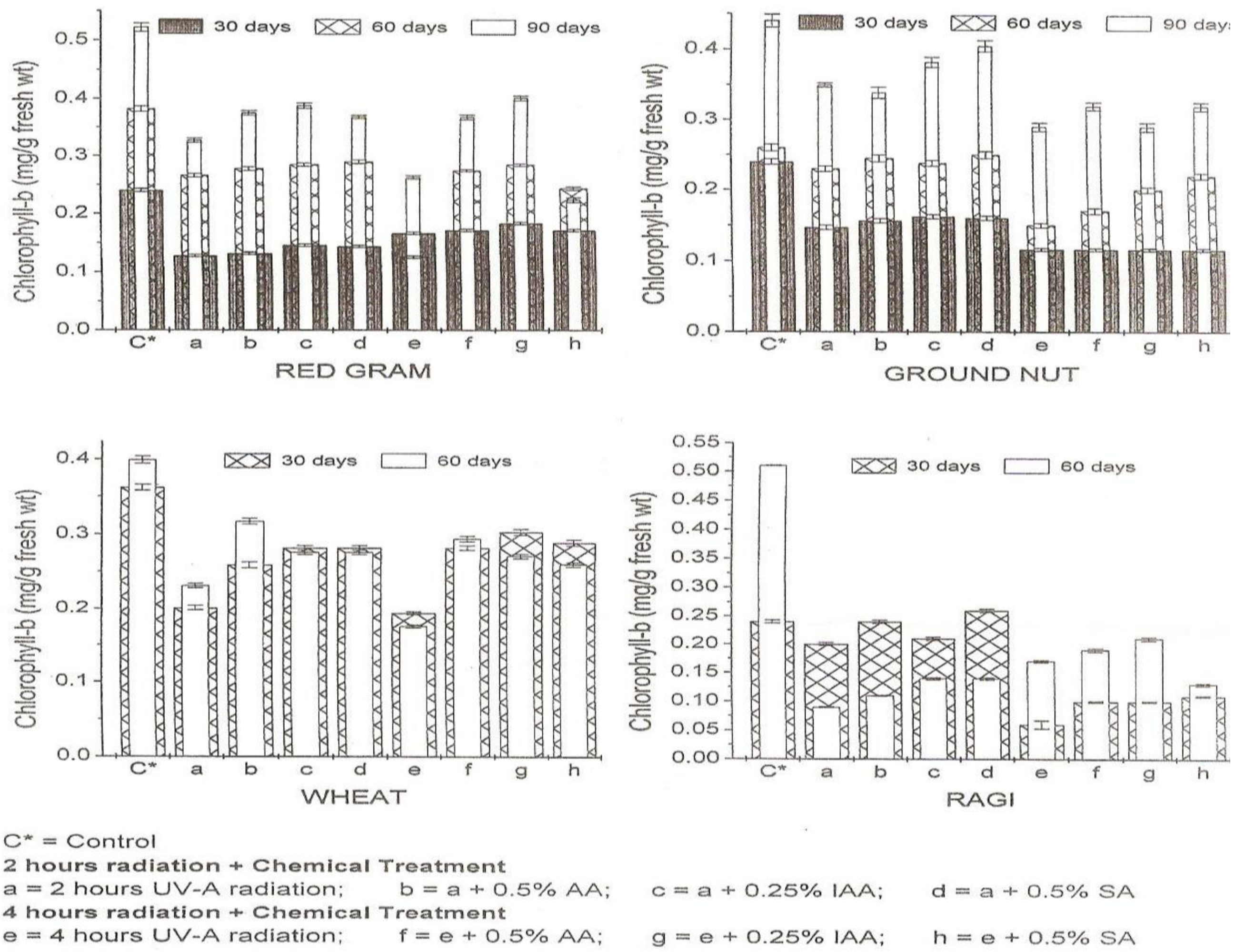
Stastical Analyses:
Data are expressed as mean +_ standard error from 4 to 6 independent experiments. Standard error is mentioned along with the mean value. Values are compared by applying t-test.

RESULTS & DISCUSSION

At every fortnight day pigment analysis studied in all the four crop plants revealed significant decrease in chlorophyll a (chl a), chlorophyll b (chl b) and total chlorophylls in 2 hr and 4 hr irradiated plants and also in corresponding chemical treated plants. 4 hr irradiated and treated plants showed maximum reduction in chlorophyll content compared to 2 hr exposed plants (Fig. 1 and 2).

Red gram and ground nut 2 hr and 4 hr irradiated plants showed maximum reduction in chl a, chl b and total chlorophylls at 75 days, 60 days and 90 days, 45 days age respectively. In wheat and ragi 2 hr and 4 hr UV-A irradiated plants the reduction in chl a, chl b and total chlorophylls was maximum at 45 to 60 days age (Fig. 1 & 2).

Figure 2: Effect of UV-A radiation and along with chemical treatment on Chlorophyll-b of four different crop plants



Increase in chl a, chl b and total chlorophylls have been observed in all the four irradiated chemical treated plants (Fig. 1 & 2). Groundnut and red gram plants showed maximum recovery than wheat and ragi plants. This increase in chlorophyll content was correlated with increase in leaf area and total dry weight of the leaf in irradiated chemical treated plants.

Chlorophyll b was found to be more sensitive to UV-A radiation than chl a in all the four crop plants studied. Maximum reduction in total chlorophylls was found in ragi followed by rd gram, ground nut and wheat. The sensitivity of plants to UV-A radiation in terms of total chlorophylls may be expressed as ragi > red gram > ground nut > wheat.

SA treated 2 hr and 4 hr red gram and ground nut plants showed more improvement in total chlorophylls than IAA and AA. Similarly SA was found to be more effective in bringing recovery than IAA and AA in 2 hr wheat and ragi plants whereas IAA was found to be more effective in bringing recovery in 4 hr UV-A irradiated wheat and ragi plants instead of SA and AA. Of the three chemicals used SA was found to be more effective antidote followed by IAA and AA.

The chl a/b ratio also varied with species and growth conditions. Linga kumar and Kulandaivelu (1993) found an increase in chl a/b ratio of *Vigna unguiculata* leaves exposed to UV-B radiation, Tevini et al., (1981) have reported an increase in chl a/b that was due to the preferential damage of chl b levels rather than to chl a was supported by the observed low levels of cab mRNA transcripts under UV-B treatment (Jordan et al., 1992). However, in the present study a greater reduction has been observed in chl a rather than chl b in UV-A irradiated crop plants. Chl a is reported to be more sensitive than chl b to external stress especially salt stress (Strogonov, 1970 and Krishna Murari Kumar, 2013). Krizek et al., (1998) also reported reduction in chl a in UV-A irradiated lettuce plants but there was no effect of UV-A on chl b concentration.

CONCLUSION

In the present study the levels of photosynthetic pigments, chlorophylls are unfavourably affected due to UV-A radiation in all the four crop plants. The level of response varied with plant species, exposure length of UV-A and growth stage of the plants. Chlorophyll a was more affected than chl b. Changes in photosynthetic pigments may affect the photosynthetic capacity and consequently yield of the plant. However, except in red gram non photosynthetic UV absorbing pigments were found to increase to a slight extent which may be an adaptive measure and act as a protective screen to inner cell organelles from adverse effect of UV-A radiation. The increase in non photosynthetic pigments is likely to reduce the photosynthetic yield of the crop plants. The present studies demonstrate that UV-A has harmful effects on photosynthetic pigments which ultimately effect the yield and productivity of the plant species. This indicates that the effects of UV-A radiation also need to be considered especially as they show harmful effect in relatively high intensities as in case of UV-B. Even though large changes in UV-A radiation are not projected to occur as a consequence of stratospheric ozone reduction, a realistic assessment of the effects of current levels of solar radiation should include examination of both UV-A and UV-B compounds.

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