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Research Note

Growth and Proline Content of Germinating Wheat Genotypes under Ultraviolet Light

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Abstract: The effect of ultraviolet light on the growth and proline contents of four wheat cultivars (*Triticum aestivum* L., cvs. Bezostoja-1, Doğu-88, Turkey-13, Yayla-305) was investigated. Ultraviolet light inhibited the growth of all of the four wheat cultivars and increased the daily proline contents of both the radicle and coleoptile. Ultraviolet light is a stress factor in the growth of plants but the wheat cultivars tested produced proline against this stress. From the results obtained, it is suggested that proline can protect cells against damage induced by ultraviolet radiation.

Key Words: *Triticum aestivum* L., Ultraviolet, Proline.

Ultraviyole Işığında Çimlenen Buğday Genotiplerinin Gelişimi ve Prolin İçeriği

Özet: Bu çalışmada, 4-buğday çeşidinin (*Triticum aestivum* L. cvs. Bezostoja-1, Doğu-88, Turkey-13, Yayla-305) gelişimi ve prolin miktarları üzerine ultraviyole ışığının etkisi araştırılmıştır. Ultraviyole ışığı 4 buğday çeşidinde de büyümeyi engelleyip, prolin miktarlarında ise hem radikula hem koleoptilde günlük olarak artışlara neden olmuştur.

Ultraviyole ışığı bitki gelişimi için bir stres faktörü olup bu strese karşı en azından çalışılan buğday çeşitleri prolin biriktirmektedir. Elde edilen sonuçlardan, prolin'in ultraviyole ışığının zararlarına karşı hücreleri koruyabileceği söylenebilir.

Anahtar Sözcükler: *Triticum aestivum* L, Ultraviyole, Prolin.

Introduction

Several biochemical activities in plant cells change drastically as a result of exposure of the plants to supplementary ultraviolet radiation (1). These changes occur at relatively high doses of ultraviolet radiation whereas other effects and responses are manifested at a dose about one magnitude lower (2). In *Pisum sativum* these low-dose effects include increased ion permeability of the thylakoid membrane and alterations in the mRNA transcript levels of photosynthetic and defensive protein components (3). Electromagnetic radiation from the sun contains about 7% ultraviolet at sea level. Ultraviolet radiation is absorbed by plant chromophores, which include nucleic acids, proteins, indole acetic acid, abscisic acid and flavoproteins. The role of chromophores has not been well established and the secondary effects occurring in plants in response to irradiation by ultraviolet have complicated identification. Absorption of UV-light by nucleic acids may alter protein synthesis but proteins are also absorbers of radiation and may react at a primary level. Alteration of protein and lipid membrane components by ultraviolet may alter membrane permeability and ionic balance. Such events also cause an inhibition of photosynthesis and respiration. The most common inactivation of nucleic acids by ultraviolet radiation is through photochemical lesions involving polymers of pyrimidine bases in the deoxyribonucleic acids (DNA). The result is the production of pyrimidine dimers and loss of DNA biological activity. It is evident that ultraviolet absorption can cause acceleration in the mutation rates and aberrations of chromosomes. Repair systems for the DNA molecules have been found in plants, however, and involve the enzymatic splitting of the dimers formed by ultraviolet absorption. Such a repair system has been implicated in repairing epidermal tissue damage, restoration of growth rate and synthesis of chlorophyll and nitrate reductase (3, 4).

In some cases, repair of ultraviolet radiation damage can be accomplished without light activation. The repair system consists of enzymatic reactions in which the DNA lesions are excised from the DNA strand and replaced by newly synthesized preces. Alternatively, undamaged DNA is replicated with gaps in the place of the lesions and a patch is synthesized from information within the cell and spliced into the new DNA strand. Unlike DNA, ribonucleic acid (RNA) and protein have more resistance to ultraviolet rediation damage (5).

Reduced plant growth with exposure to ultraviolet radiation can occur as a result of inhibition of photosynthesis or a reduction in leaf expansion. Since both indole acetic acid and abscisic acid are receptors for ultraviolet radiation, alterations of concentrations of these growth regulators may result in irregular growth. Such irregularities may take the form of depressed flower development, loss of apical dominance, abscission of leaves, and alteration of mineral nutrient concentrations in tissues.

Resistance to ultraviolet radiation damage consists of the ability of a plant to repair the damage to the DNA or to synthesize screening compounds, such as flavanoids and flavones, in the epidermis. Culticular waxes may also be effective in absorbing harmful ultraviolet radiation. Changing the angle of the leaves towards incident radiation or increasing the reflecting properties of leaf surfaces are other mechanisms of resistance (6). The present study was conducted in order to explain the effects of ultraviolet radiation on growth and proline content.

Material and Methods

The seeds of four wheat cultivars (*Triticum aestivum* L. cvs. Bezostoja-1, Doğu-88, Turkey-13, Yayla-305) were used.

The seeds were surface sterilized with 1.0% sodium hypochloride. 25 seeds were placed in 12 cm petri dishes, furnished with 2 sheets of Whatman No.1 filter paper moistened with 10 ml of distilled water, and they were left to germinate in an incubator at 25°C under continuous ultraviolet light for seven days. The coleoptile and radicle lengths of the seedlings were measured in mm at the end of the experiment. Furthermore, every day the proline contents in the radicle and coleoptile were determined using the acid-ninhidrin method (7).

Results and Discussion

Ultraviolet light had adverse effects on the coleoptile and radicle growth of the germinating wheat genotypes. The physiological and developmental processes of plants are affected by ultraviolet radiation, even by the amount of ultraviolet present in sunlight (8). The most negative effect of the stress was observed on the radicle and coleoptile tissues of the Doğu-88 genotype (Table 1). The most resistant genotype was Bezostoja-1. In all the genotypes, the coleoptile was generally affected more than the radicle. Response to ultraviolet also varies considerably. Cucumber and tomato seedlings have been found to show appreciable and rapid inhibition of hypocotyl elongation in response to ultraviolet radiation exposure (9, 10). Reduced plant growth by exposure to ultraviolet radiation can occur as a result of a reduction in leaf expansion or inhibition of photosynthesis. This is the reason for the decrease in radicle and coleoptile growth (6).

Ultraviolet light caused an increase in the proline content of the radicle and coleoptile tissues in all the genotypes. Similar results have been observed by other researchers (11). The daily proline contents increased in both the control and ultraviolet-treated plants (Table 2). Similarly, seedlings of rice and mung beans have been reported to accumulate proline in the shoots when exposed to ultraviolet radiation, and the presence of exogenous proline decreased the increase in the malondialdehyde content of linolenic acid micelles caused by ultraviolet radiation (12, 13). In addition, it has been suggested that exposure to ultraviolet radiation reduces plant growth, vigour, the contents of chlorophyll, carotenoids, amino acids, proteins, total sugars and starch, and increases the composition of anthocyanin and proline (14, 15). The accumulation of free proline in the

Table 1. Effect of ultraviolet light on the length of the radicle and coleoptile in seedlings from germinating wheat seeds at the 7th d.

	Radicle (mm/seedling)		Coleoptile (mm/seedling)	
	Control	UV	Control	UV
Bezostoja-1	102	68	75	47
Doğu-88	121	68	72	41
Turkey-13	134	79	81	54
Yayla-305	127	75	75	41

LSD (0.05): 6

Table 2. Proline content (µM/fresh weight) in the radicle and coleoptile in seedlings from germinating wheat seeds at the 7th day under ultraviolet light. Radicle (R), Coleoptile (C).

	5th day				6th day				7th day			
	Control		UV		Control		UV		Control		UV	
	R	C	R	C	R	C	R	C	R	C	R	C
Bezostoja-1	12.4	5.7	15.4	9.4	17.9	9.2	27.0	18.2	21.6	14.3	26.3	17.7
Doğu-88	11.8	5.2	17.2	16.1	10.8	4.7	25.4	23.0	10.3	8.5	21.0	16.4
Turkey-13	16.2	8.7	14.8	9.0	22.4	10.8	24.3	18.6	14.0	7.8	34.0	31.8
Yayla-305	17.2	11.8	15.6	17.1	27.3	13.6	30.0	30.2	19.6	13.0	22.1	16.1

LSD (0.05): 2.4

tissue of several plant species is regarded as a general response to stress from different origins (16). Thus, the free proline increases under water and osmotic stress (17) as well as under salt and cold stress (18). There are three possible causes of the free proline accumulation under stress: first, stimulation of proline synthesis from glutamic acid (19, 20), which has been found to be dependent on the abscissic acid concentration (21); second, inhibition of proline oxidation to other soluble compounds; and, third, inhibition of protein synthesis (22). In contrast to its metabolism, the physiological significance of proline accumulation has not yet been completely clarified.

Hanson, Nelson & Everson (23) considered proline accumulation to be a symptom of damage. However, many researchers have ascribed to proline a positive role associated with some sort of adaptive response. According to Stewart and Lee (24), proline is a substance inducing osmotic adjustment. Other researchers have suggested that proline is a source of energy, carbon and nitrogen for the recovering tissues (25, 26). From the results obtained, it is suggested that proline can protect cells against damage induced by ultraviolet radiation.

References

1. Bronman, J. F. and Teramura, A. H. Effects of UV-B radiation on terrestrial plants. In: Young A. R., Björn L. O., and Nultsch W. (eds.). Environmental UV photobiology. 427-471.-Plenum Publishers, New York. 1993.
2. Strid, A., Chow W. S. and Anderson J. M., UV-B damage and protection at the molecular level in plants-Photosynth. Res. 39: 475-489, 1994.
3. Kalbin, G., Ohlsson, A. B., Berglund, T. Rydström, J. and Strid, A. UV-B radiation causes changes in intracellular levels of Nicotinamide, Trigonelline and Glutathione in *Pisum sativum* leaves. Phyton (Austria) Special issue: 'Free Radicals' Vol. 37 Fasc. 3 115-124, 1997.
4. Lainsen, L. and Micheal, J. W. Ultraviolet-B responses of nuclear genes encoding light-harvesting complex II proteins in pea *(Pisum sativum)* are altered by norflurazon- and photobleaching-induced chloroplast changes. Phsiologia Plantarum 102: 128-138, 1998.
5. Lewitt, J. Responses of Plant to Environmental Stress. Vol. 2 Academic, New York, pp. 283-364, 1980.
6. Maynard, G. Hale and David, M. Orcutt. The physiology of plants under stress, 111-112, 1987.
7. Bathes, L. S., Waldren, R. P. and Teare, I. D., Rapid determination of free proline for water-stress studies. Plant and Soil 39, 205-207, 1973.
8. Caldwell, M. M., Teramura, A. H., Tevini, M., Bornman, J. F. Bjorn, L. D. and Kulandaivalu G. Effects of increased solar ultraviolet radiation on terrestrial plants. Special issue. Environmental effects of ozone depletion: 1994 assessment. Ambio. 24: (3) 166-173, 1995.
9. Barnes, P. W., Ballare, C. L. and Caldwell, M. M. Photomorphogenic effects of UV-B radiation on plants: consequences for light competition. J. of Plant Physiology., 148: (1-2) 15-20, 1996.
10. Hao, H., Hele B. A., Ormrod, D. P. and Hao, X. M. The effects of ultraviolet-B radiation and carbon dioxide on growth and photosynthesis of tomato. Canadian Journal of Botany. 75: (2), 213-219, 1997.

11. Chai, T., Didierjean, L., Burkard, G., Genot, G. and Chai, T. Y. Expression of a green tissue-specific 11 kDa proline-rich protein gene in bean in response to heavy metals. Plant Science. Limerick. 133: (1) 47-56 1998.

12. Saradhi, P. P., Alia, Sandeep, A., Prasad, K. and Arora, S. Proline accumulates in plants exposed to UV radiation and protects them against UV induced peroxidation. Biochemical and Biophysical Research Communications. 209: (1), 1-5 1995.

13. Alia, P., Saradhi, P., Prassana, M. and Mohanty, P. Involvement of proline in protecting thylakoid membranes against free radical-induced photodamage. J. of Photochemistry and Photobiology.-B, Biology. 38: (2-3), 253-257 1997.

14. Britto, A. J-de and De-Britto, A. J. Impact of ultraviolet radiation on the pulse Phaseolus mungo. J. of Ecotoxicology and Environmental Monitoring. 5: (2), 113-117 1995.

15. Musil, C. F. Accumulated effect of elevated ultraviolet-B radiation over multiple generations of the arid-environment annual *Dimorphothec sinuata* DC. (Asteraceae). Plant Cell and Environment. 19: (9), 1017-1027 1996.

16. Sumaryati, S., Negruti, I. and Jacobs, M. Salt and water stress resistant mutants isolated from protoplast of ss *Nicotiana plumbaginifolia* (Viviani). Mededelingen-van-de faculteit Landbouwwetenscappen, Universitiet-Gent 1992, 57. 4a, 1507-1516; Proceedings, part I. Sixth forum for applied biotechnology, Bruges, Belgium, 24-25 September 1992.

17. Karamanos, A. J. Drosopoulus, J. B. and Niavis, J. B., Free proline accumulation during development of two wheat cultivars with water stress. J. Agric. Sci. 100, 429-439. 1983.

18. Chu, T. M. Aspinall, D. & Paleg, L. G., Stress metabolism. VII. Salinity and proline accumulation in barley. Aust. J. of Plant Physiology. 3, 219-228. 1976.

19. Barnett, N. M. and Naylor, A. W., Amino acid and protein metabolisms in Bermuda grass during water stress. Plant Physiol. 11, 1222-1250. 1966.

20. Boggess, S. F. Stewart, C. R. Aspinall, D. & Paleg, L. G., Effect of wateR stress on proline synthesis from radioactivity precursors. Plant Physiology. 58, 398-401 1976.

21. Stewart, C. R., The mechanism of ABA-induced proline accumulation in barley leaves. Plant Physiology. 66, 230-233 1980.

22. Stewart, C. R., The effect of wilting on proline metabolism in excised bean leaves in the dark. Plant Physiology. 51, 508-511 1973.

23. Hanson, A. D., Nelson, C. E. and Eversen, E. H., Evolution of free proline accumulation as an index of drought resistance using two contrasting barley cultivars. Crop. Sci. 17, 720-726 1977.

24. Stewart, G. R. and Lee, J. A., The role of proline accumulation in halophytes. Planta. 120, 279-289 1974.

25. Singh, T. N., Aspinall, D., Paleg, L. G. and Boggess, S. F., Stress metabolism. II Changes in proline concentrations in excised plant tissues. Aust. J. of Biol. Sci. 26, 57-63 1973.

26. Blum, A. & Ebercon, A., Genotypic responses in sorghum to drought stress. III. Free proline accumulation and drought resistance. Crop Sci. 16, 428-431 1976.