UPTAKE OF SOME NUTRIENTS, TOTAL SUGARS, TOTAL AMINOACIDS AND PROTEIN CONTENTS OF VICIA CULTIVATED UNDER DIFFERENT LIGHT REGIMES

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SUMMARY

1. After 24 hours, the absorption of K, Ca No_3 and Po_4 ions by Vicia plants cultivated under continuous illumination, continuous darkness and alternating light and darkness were investigated. Also the effects of these light regimes on total sugars, total aminoacids and protein contents of plants at the end of the experiment were studied.

2. 6-Hour periods of alternating light and darkness for a total period of 24 hours expressed an effect on uptake of nutrient elements, aminoacid, protein and sugar contents of plants similar to that exerted by exposure to 12 hours light followed by 12 hours darkness. Such effect was an increase in protein content of plants coincident with a decrease in that of sugars and aminoacids as compared with those of plants exposed to continuous darkness for the total 24 hours. In the same time, K, PO_3 and Ca ion uptakes were decreased but that of nitrate was increased.

3. Further elongation of the illumination period increased further the protein contents of Vicia plants with simultaneous further reduction in their sugar and aminoacid contents. Under similar conditions, nitrate absorption was also increased but phosphate, K and Ca uptakes were decreased.

INTRODUCTION

Light affects mineral nutrient absorption only in an indirect manner by way of its direct effect upon such natural processes as photosynthesis, chlorophyll synthesis, morphogenesis, photoperiodism or transpiration (Withrow, 1951). The most conspicuous indirect role of light in mineral nutrient absorption is through photosynthesis (Lundegardh, 1951). When light energy supplied to plants is increased in any way, the rate of photosynthesis increases (Blackman

and Rutter, 1947), total transpiration is greater and the absorption of mineral nutrient is stimulated (Hylmo, 1953 and Lange et al., 1959). With increasing light, the total uptake of minerals is increased.

Humphries (1951 and 1952) has shown that the rate of uptake of N, P and K increase with increasing total sugar content of the roots. A reexamination of his previous results, Humphries (1956) has shown that the positive regression of the nutrient uptake is attributable to the reducing sugar fraction. He concluded that conditions that induce high reducing sugar fraction in barley and pea roots also induce high rates of K, P and N uptake and vice - verse.

Ward (1958) showed that under conditions of reduced light intensity or duration, levels of K and P in wheat seedlings were considerably increased provided that the plants were grown in a medium that contained an adequate supply of the element. This relationship has been previously observed by Miller and Army (1954) but has not been reported for plants grown in a controlled environment.

Trumble (1947) found that the availability of K by herbage plants was in part governed by duration of the daily period of daylight. Hoagland et al., (1927), similarly showed that ion uptake by Nitella was closely related to the daily hours of illumination. Turner and Henry (1939) found that the total daily light radiation for roses and tomatoes determines the proper balance between K and N supply and showed that during the long days of summer, the N must be higher and the K lower than in winter.

In 1965, Nosseir and Spiridinov studied the uptake and release of inoragnic ions by peas and corn plants cultivated in Hoagland solution under different periods of darkness throughout a total period of 72 hours. They also studied the response of total sugar and aminoacid contents of plants to these dark periods at the end of the experiment. They found that elongating the dark period increased Ca, but decreased K uptake by pea plants with simultaneous increase in their sugar and aminoacid contents. In corn plants, however, dark-periods decreased Ca and K absorption with simultaneous reduction in aminoacid and sugar contents of plants. In the present study, further experiments were carried out to study the effect of light regimes on the uptake of K, Ca, No3 and P04 ions by Vicia plants cultivated in Hoagland solution. The light regimes used were : continuous illumination, continuous darkness and 6- and 12-hour periods of alternating light and darkness during a total period of 24 hours. The present study was also extended to include the effect of these light regimes on protein as well as total sugar and aminoacid contents of plants at the end of the experiment.

MATERIAL, METHODS AND EXPERIMENTS

Vicia faba seeds, variety " Giza I " were germinated in the same way as previously described by Nosseir (1968) and 10 days old seedlings were transplanted on nutrient solution in deep glass vessels, 1 L. capacity each. Plants with well developed root systems were selected and one plant was supported in each vessel containing Hoagland solution composed of 2.5mM KN03; 2.5mM Ca (N03)2; 1mM MgS04.7H2 and 0.5mM KH2P04 together with the microelements of Shive and Robbins as cited by Nosseir (1968). The pH of the nutrient solution was kept constant at about 5.8 during cultivation by periodic additions of H2S04 or NaOH. The nutrient solution was also aerated daily and renewed once a week. The plants were cultivated in a specially designed cultivation chamber where the plants were kept under controlled conditions of temperature (27 - 30.C) and continuous light (about 5200 foot candle). After cultivating the plants in the nutrient soultion under the above conditions for 20 days, they were transferred to a normal Hoagland solution. After one week cultivation in this solution under the same couditions, the plants were transferred to a freshly prepared one and then segreggated into 4 groups each composed of 5 comparable seedlings. The plants of the 4 groups were experimented on for 24 hours during which the temperature around the culture vessels was maintained constant at 27 - 30.C while illumination was continuous with the first group, darkness was continuous with the second group; 6 - hour periods of alternating light and darkness with the third group; and 12 - hour illumination period followed by 12 - hour dark period with the fourth group. Darkening of the culture vessels and their seedlings was accomplished by covering the whole system with dark cloth.

At the end of the experiment, the plants grown under every light regime, after washing and drying their roots gently between blotting paper, were divided into 2 batches. One batch was cut into small pieces, killed with boiling water and finally extracted. The protein content of the extract was then, coagulated with acetic acid and chilling treatment. Then the residue containing protein was separated by filtration, dried, weighed, powdered and finally its protein content was determined using the methods described by El-Shishiny (1955). The second batch of the same light regime was dried at 105.°C until a constant weight. After its dry weight was determined, the dry matter was powdered and then samples from the powder were taken and treated with 70% alcohol for extracting total sugars and aminoacids, the separation and determination of which were as previously described by the author (1968). Separation of sugars from aminoacids was done using the ion exchange resin (Ky-2); sugar

estimation was done using the anthrone method while aminoacids were estimated by means of the ninhydrin method.

After removing the plants from their culture media, the vulume of the latters were adjusted to the original volume for correction of the residual concentrations of the nutrient ions. Absorption of these ions during the experimental period under different light regimes were computed from the change in their conceutrations in the nutrient media. Ca was estimated by titration against trilon, K by flame photometer, nitrate and phosphate by colorimetric methods using the technique already described by the author

The data concerning the total sugars, total aminoacids and protein content of Vicia plants cultivated at different light regimes for 24 hours together with the total uptake of K, Ca, N03 and P04 ions during this period under the same conditions are presented in table (1).

RESULT AND DISCUSSION

A glimpse to table (1) shows that, Vicia plants grown in Hoagland solution under different light regimes absorbed K, Ca, N03 and P04 ions at different rates during 24 hours. Plants exposed to continuous illumination during that period absorbed the least amounts of K, Ca and P04 ions. Decreasing the illumination period to the half by exposing the plants to 6- and 12-hour periods of alternating light and darkness enhanced the absorption of K and Ca but was without a re-remarkable effect on P04 absorption. Further, Vicia plants exposed to continuous darkness during the whole experimental period absorbed the highest amounts of K, Ca and P04 ions. Under all light regimes adopted, K was always absorbed in excess over Ca.

Johnson and Hoaglaud (1929) working with tomato plants showed that the actual percentage of K in the tissues of the shaded plants were higher than in the corresponding unshaded ones. Similarly, Ward (1958) working with wheat seedings found that under conditions of reduced light duration, levels of K were considerably inercased provided that the plants were grown in a medium containing an adequate supply of the element. Increased exposure to light depressed the relative uptake of this element with resulting lower percentages in all parts of the plant.

As regards the effect of light on Ca absorption by plants, Nightingale et al. (1931) in his studies of the chemical composition of Marglobe tomato plants grown in quartz sand supplied with nutrient solutions found that shading resulted in an increase in Ca absorption by plants and hence its higher accumulation in them. Recently, Nosseir and Spiridinov (1965) found that dark periods increased Ca absorption by pea plants grown in Hoagland solution and that the increase in Ca absorption was further enhanced by elongating the dark period.

Again, Tanada (1946) showed that chemical analysis of coffee plants grown without shade and under $\frac{1}{2}$ shade and $\frac{3}{4}$ shade revealed that K and Ca tended to increase with shading. Moreover, Phillis and Mason (1942) found in cotton plants that the percentage content of most of the minerals they studied decreased by day but increased during the night.

The results obtained by the previously mentioned authors were in quite agreement with those obtained with Vicia plants under the present study since absorption of K and Ca by Vicia plants exposed to continuous darkness were relatively higher than those absorbed by plants exposed to half light and half darkness, and the latters being higher than those absorbed by plants exposed to continuous illumination, table (1).

On the other hand, the effect of light on phosphate absorption by plants seems to be variable. Tanada (1946) has shown that P uptake by coffee plants and hence its accumulation in tissue was reduced by shading. In contrast Ward (1958) found that increased exposure to light depressed the relative uptake of P and hence its lower percentages in all parts of wheat seedlings. Hanson and Biddulph (1953), however, found that the absorption of P32 by kidney bean plants from their utrient media was the same in day and night but its distribution between aerial organs and roots was different. With Vicia plants under study, continuous light for 24 hours decreased phosphate uptake by about 50% below that of plants exposed to continuous darkness for the same period. In this respect Vicia plants behaved similar to wheat seedlings as found by Ward (1958).

Conditions favouring the assimilation of nitrate by pine-apple plants as illustrated by Sideris and Young (1950) are light prasumably via combination with carbohydrates or photochemical reduction. The effect of light on nitrate intake by pine-apple plants shows that the plants exposed to light absorbed greater amaints of nitrate than the shaded ones. With Vicia plants used in the present study, the nitrate absorption by plants exposed to continuous light for 24 hours was 13.0 mgm./plant. By reducing the illumination period to the half, the nitrate absorption was also reduced by about 30% and reached a reduction of about 60% in plants exposed to continuous darkness for the same period.

It has been mentioned before that Ca, K and P04 uptake by Vicia plants were increased progressively by increased exposure to darkness. In the same time, sugar and aminoacid contents of plants were also increased, table (1). Similar results were obtained by Nosseir and Spiridinov (1965) who found that Ca uptake by pea plants increased progressively by elongating the dark period with simultaneous increase in their sugar and aminoacid contents. These

results might indicate that conditions, reasonably the metabolic acitivity of the tissues, that induced higher sugar content of Vicia plants, induced also their uptake of Ca, K and P. In this case, sugars may be the parent substance for the formation of a chemical compound capable of combining with the absorbed elements as suggested by Humphries (1952) for barley and pea roots.

On the other hand, nitrate absorption by Vicia plants during 24 hours was increased by elongating the illumination period. In the same time, protein contents of plants were also increased but those of sugars and aminoacids were decreased. These results might indicate the dependence of protein synthesis on sugars and nitrate through aminoacid formation. Under such conditions, sugars produce energy required for protein synthesis from aminoacids and form the C skeleton of the aminoacids and proteins which are built up from nitrate. The importance of carbohydrates or its derivatives and nitrate for protein synthsis has been emphasized by many workers, Sideris et al (1937 and 1938), Said and El-Shishiny (1948) and Nightingale (1948).

REFERANCES

Blackman, G.E. and Butter, A.I. (1947); Anal. Bot., 11, 126-158.

El-Shishiny, E.D.H. (1955); J. Exp. Bot., 6, 6-16.

Hanson, L. and Biddulph, G. (1953); Plant Physiol., 28, 356.

Hoagland, D.R., Hibbard, P.L. and Davis, A.R. (1927); J. of General Physiol 10, 121-146.

Humphries, E.C. (1951); J. Exp. Bot., 2, 344-349.

———————— (1952); Ibid, 3, 291-309.

———————— (1956); Anal. Bot., 20, 411-417

Hylmo, B. (1953); Physiol. Plantarum; 6, 333-405.

Johnson, E.S. and Hoagland, D.R. (1929); Soil. Sci., 27, 89-109.

Lange, A.H., Ehrler, W.L. and Hamner, K.C. (1959); Proc. Amer. Soc. Hort. Sci., 73, 349-354.

Lundegardh, H. (1951); Leaf analysis, translated by R.L. Mitchell. Hilger and Watts Ltd London.

Miller, E.V. and Army, T.J. (1954); U.S.D.A. Southern coperative series Bulletin, 36, 118-154.

Nightingale, G.T. (1948); Bot. Rev., 14, 185,.

———————— Addoms, R.M., Robbins W.R. and Shermerhorn, L.. (1931); Plant Physiol., 6, 605-630.

Nosseir, M.A. (1968); Ind Adv. Front. Plant Sci., 21, 103-115.

——————— and Spiridinov, P.A.E. (1956); J. Agric. Acad. Moscow, 1, 59-70.

Phillis, E., and Mason, T.G. (1942); Anal. Bot., 6,t437-442.

Said, H. El-Shishiny, K.D.H. (1948); Bull. Fac. Sci. Cairo Univ., No. 27.

Sideris, C.P., Krauss, B.H. and Young, H.Y. (1937); Plant Physiol., 12, 899.

———————, ——————— and ——————— (1938); ibid, 13, 489.

———————, and Young, H.Y. (1950); Plant Physiol., 25, 594.

Tanada, T. (1946); J. Agric. Res., 72, 245-238.

Trumble, H.C. (1947); J. Austr. Inst. Agric. Sci., 13, 198.

Turner, N.J. and Henry, V.M. (1939); John Willey, N.Y. and Chapman and Hall, London.

Ward, G.M. (1958); Canad. J. Plant Sci., 28, 292-292.

Withrow, R.B. (1951); Mineral nutrition of plants. Univ. Wis. Press, Madison, Wis. Emil Truog, ed. P. 389-410.

Table (1)

Total uptake of individual nutrient elements, total sugars, total aminoacids and protein contents of Vicia plants cultivated at different light regimes for 24 hours. The data are given as mgm./plant/24 hours.

Light regime	Total uptake of untrients				Total sugars	Total aminoacids	Protein
	K	Ca	N03	P04			
Continuous illumination	9.1	7.3	13.0	8.6	41.7	24.6	90.1
6 — Hour periods of alternating light and darkness	33.2	12.1	9.6	8.9	60.1	32.8	70.8
12 — Hour periods of alternating light and darkness	34.0	13.3	9.2	9.3	63.3	31.9	68.2
Continuous darkness	53.1	20.2	5.1	16.8	70.2	40.2	50.5