EFFECT OF 2, 4-DINITROPHENOL AND ATP ON UPTAKE, TRANSLLOCATION AND DISTRIBUTION OF $^{32}$P IN COTTON PLANTS UNDER DIFFERENT LIGHT CONDITIONS

N. I. ASHOUR, R. BARAKAT AND T. A. NOUR

National Research Centre, Dokki, Cairo, Egypt

ABSTRACT

Cotton seedlings were subjected, in light and darkness, to DNP, ATP or both for 3 hours, then allowed to remain in contact with $^{32}$P for further 6 hours. Darkness decreased phosphorus uptake and its translocation. In the light, DNP decreased the uptake of $^{32}$P, but enhanced its translocation to the shoot. ATP did not affect $^{32}$P uptake but enhanced its translocation. ATP could not overcome the negative effect of DNP on $^{32}$P uptake. In the dark, neither DNP nor ATP exerted significant effect on $^{32}$P uptake, yet accelerated its translocation. Under both light conditions, DNP accumulated most of the translocated $^{32}$P in the stem, while ATP moved it further to the leaves. The enhancement of $^{32}$P translocation was accompanied by the presence of higher percentage of $^{32}$P in an organic form. It was concluded that high energy compound formed during photosynthesis may play a role in the metabolic active uptake of phosphorus.

INTRODUCTION

The uptake of phosphorus and its translocation in plants were suggested to be metabolic active processes (Brower, 1965 and El-Fouly and Ashour, 1969). The energy required for such a process is supplied from the adenosine-triphosphate (ATP) deposited in the cells (Weigh, 1963). The high energy compound (ATP) is produced during the process of oxidative phosphorylation (Jackson et al., 1962). Thus, 2,4-dinitrophenol (DNP), an inhibitor of oxidative phosphorylation was found to decrease the uptake of phosphorus by plant roots (Stenlid, 1959).

The uptake of phosphorus by roots and its translocation to the shoot are higher in the light than in the dark (Linser, 1965), and increase with increasing light intensity (Ashour et al., 1968). Raven (1969) suggested that the ATP required for regulation of ion pump can be produced in the light by cyclic photosynthetic phosphorylation.

The aim of this work was to investigate the effect of DNP and ATP on $^{32}$P uptake, translocation and distribution in the cotton seedlings in light and in darkness.

MATERIALS AND METHODS

One month old, uniform cotton seedlings (G. baradense) cv. Ashmouni grown in water culture were selected. The plants were rinsed in large test tubes (2.5 cm dia and 20 cm long) filled with distilled water and left over-night. On the second day, the distilled water in each test tube was replaced by 50 ml of 1/4 strength complete Hoagland’s nutrient solution containing $10^{-4}$ M 2,4-dinitrophenol (DNP), $10^{-3}$ M ATP (the dipotassium salt of ATP) or both and left for 3 hours. Then 8$\alpha$ Cl of $^{32}$P as KH$_2$PO$_4$ supplied from the Egyptian Atomic Energy Establishment was injected in the nutrient solution in each tube, and the plants were allowed to remain in contact with the $^{32}$P for 6 hours at 21°C. This experiment was conducted under conditions of both light (20,000 Lux) of fluorescent lamps, and darkness. Each treatment under both conditions had seven replicated tubes, thus each treatment included seven plants. At the end of the incubation period, the plants of four replicates were harvested, and the roots were washed carefully with running water for 2 min. then the plants were divided into roots,
Effect of 2, 4-Dinitrophenol and ATP in Cotton Plants

RESULTS

Under light conditions, DNP significantly decreased the uptake of $^{32}P$, whereas ATP was without significant effect (Table I). The addition of ATP together with DNP did not change the uptake of $^{32}P$ more than that induced by DNP alone. In darkness, cotton plants absorbed much less amount of $^{32}P$ than in light. Under dark conditions, neither DNP nor ATP had any significant effect on the uptake of $^{32}P$ by plant roots as compared with the control plants. Combined treatment with DNP + ATP in the dark did not affect the uptake of $^{32}P$.

Table I also shows that the darkness markedly retarded the translocation of absorbed $^{32}P$ from the root to the shoot of cotton plants. All treatments of metabolically active substances enhanced the translocation of the absorbed $^{32}P$ from the root to the shoot under both light conditions, the combined treatment of DNP + ATP was the most effective one.

In Table II it is clear that in the light DNP and ATP retained more or less an equal percentage of $^{32}P$ in the roots. However, much more of the $^{32}P$ that moved out of the roots in DNP-treated plants remained in the stems in comparison with the ATP-treated plants, where, further moving of $^{32}P$ towards the leaves was observed. In the dark, most of the absorbed $^{32}P$ was retained in the roots, while only traces were found in the stem and the leaves as compared with that in the light. However, the change in $^{32}P$ distribution among different plant organs in the dark due to DNP or ATP treatments was the same as observed in the light. When DNP and ATP were applied together most of the translocated $^{32}P$ under light conditions was accumulated in the leaves; whereas in darkness it was retained mainly in the stem.

Table III shows that in the light, all treatments increased the percentage of organic-$^{32}P$ in the root

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**Table I**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>The uptake of $^{32}P$</th>
<th>Transport index $^{a}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\times 10^3$</td>
<td>$\times 10^3$</td>
</tr>
<tr>
<td>Light Dark</td>
<td>Light Dark</td>
<td>Light Dark</td>
</tr>
<tr>
<td>Control</td>
<td>326 213</td>
<td>1270 620</td>
</tr>
<tr>
<td>DNP</td>
<td>275 201</td>
<td>631 732</td>
</tr>
<tr>
<td>ATP</td>
<td>306 189</td>
<td>1062 599</td>
</tr>
<tr>
<td>DNP + ATP</td>
<td>237 208</td>
<td>787 702</td>
</tr>
</tbody>
</table>

$^{a}$Transport index $= \frac{^{32}P \text{ in shoot}}{^{32}P \text{ in whole plant}} \times 100$

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**Table II**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Roots $\times 10^3$ counts/30 sec/organ</th>
<th>Stem Light Dark</th>
<th>Light Dark</th>
<th>Leaves Light Dark</th>
<th>Light Dark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>221 185</td>
<td>92 26</td>
<td>12·3 1·5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DNP</td>
<td>98 137</td>
<td>163 64</td>
<td>13·8 0·8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATP</td>
<td>106 129</td>
<td>117 46</td>
<td>83·2 5·4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DNP + ATP</td>
<td>32 65</td>
<td>84 100</td>
<td>121·6 42·3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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**Table III**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Organic-$^{32}P$ (Light, Dark)</th>
<th>Inorganic-$^{32}P$ (Light, Dark)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>49·7 68·6</td>
<td>50·3 31·4</td>
</tr>
<tr>
<td>DNP</td>
<td>69·2 84·3</td>
<td>30·8 15·7</td>
</tr>
<tr>
<td>ATP</td>
<td>79·3 66·0</td>
<td>20·7 34·0</td>
</tr>
<tr>
<td>DNP + ATP</td>
<td>79·6 91·3</td>
<td>20·4 8·7</td>
</tr>
</tbody>
</table>
exudate at the expense of the inorganic fraction. Darkness showed similar effect. Under such dark conditions, DNP also increased the percentage of organic $^{32}$P in the root exudate, ATP was uneffective, while DNP + ATP appreciably increased it as compared with that in the control plants.

**DISCUSSION**

The results indicate that light enhances the uptake of phosphorus by the roots of cotton plants and its translocation towards the stem thus confirming the results obtained by others (Linser, 1965 and Ashour et al., 1968). Such effect was suggested by McEvoy (1967) to be due to the increased supply of the photosynthate under light conditions. In the light, the decrease in the uptake of $^{32}$P after treatment with DNP, may be due to the inactivation of the phosphorylation processes in plant tissues. Under such conditions the formation of ATP was found to be partially blocked (Jachson et al., 1962). However, in the dark, when only the oxidative phosphorylation was acting and not the photosynthetic phosphorylation, the DNP and the ATP were without effect on the uptake of $^{32}$P. Thus, it seems that the high energy compounds formed during photosynthesis alongside with the downwards photosynthate may take part in the metabolic active uptake of phosphorus. On the other hand, when ATP is present in the root medium, the uptake of $^{32}$P was not activated, but on the contrary, may be slightly retarded. A competitive effect between the molecule of ATP or its derivatives and the ion of phosphorus for a certain carrier was suggested for the explanation of such phenomenon (Vakhmistrov and Listova, 1967).

The translocation of $^{32}$P from the root to the shoot was enhanced under both conditions of light due to DNP or ATP treatments, while DNP + ATP seemed to have an additive effect. It seems that high energy phosphorus compound is required for translocation. Randal and Vose (1963) found that DNP had a major positive effect on the translocation of phosphorus to the shoots. In addition, it seems that when the translocation of phosphorus from the root was enhanced, the organic fraction of the translocated phosphorus was increased indicating a change in phosphorus metabolism. Further studies are needed to clarify the problem of translocation of phosphorus compounds in connection with the role of DNP, ATP and light.


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**PROPOSITION OF DIOSCOREA FLORIBUNDA FROM IN VITRO CULTURE OF SINGLE-NODE STEM SEGMENTS**

**H. C. CHATURVEDI**

*Tissue Culture Laboratory, National Botanic Gardens, Lucknow*

**ABSTRACT**

*Dioscorea floribunda* plants were established in aseptic cultures from surface-sterilized single-node stem segments of field-grown vines. Axillary buds of nodal segments proliferated in the presence of 6-benzylaminopurine (2 mg/l) unaccompanied by root formation. Whereas, shoot apices and single-node leaf cuttings rooted 100% in the presence of NAA (0.5 mg/l), resulting into plantlets, 100% of which were successfully grown in potted soil. It took about 40 days to obtain a 5-6 leaved plantlet in potted soil from single-node cutting taken from a plant grown in aseptic culture.

**INTRODUCTION**

*Dioscorea floribunda* Mart. and Gal. is one of the three *Dioscorea* spp. (the other two are *D. composita* Hemsl. and *D. deltoides* Wall.) commercially yielding diosgenin, a main precursor, from plant source, for the synthesis of steroidal drugs, namely, cortisone, sex hormones, oral contraceptive pill, etc., which are so important in