

TEMPERATURE AND AUXIN TRANSPORT IN
ZEA MAYS L. COLEOPTILES*

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Abstract

Various parameters of auxin transport in *Zea mays* coleoptiles as influenced by change in temperature from 5°C to 30°C was followed. The absorption of ¹⁴C-IAA from apically applied donor blocks by the tissues is a linear function of time and progressively increases with temperature up to 25°C. On the basis of the diffusion constant of 7 in agar for auxin at 20°C it was determined that the major fraction of uptake of ¹⁴C-IAA derives from an active absorption. Both the transport intensity and the velocity were found to be temperature dependent upto 25°C.

Introduction

Van der Weij (1932), after examining auxin movement in sections of the *Avena* coleoptile, concluded that the velocity of basipetal transport was virtually independent of temperature. He also concluded that the transport capacity (amount of auxin translocated per unit time) was temperature dependent. Hertel & Leopold (1963) proposed that the above conclusions also held for the coleoptile of *Zea*, though they did observe a 1.3 fold rise in transport velocity in going from 14° to 24°C. However, other studies with dicotyledonous tissue sections have indicated that polarity (Keitt & Baker, 1967; Pilet, 1968; McCready, 1968) as well as capacity (intensity) and velocity (Gregory & Hancock 1955; Kaldewey, 1963; Naqvi, 1963; Vardar 1963, Hollis & Tepper, 1971) were sensitive to emperature changes. Though Gregory & Hancock (1955) pointed out that the scatter in the data of van der Weij (1932) did not permit the assignment of a common velocity intercept for the transport curves at various temperatures, no unequivocal redetermination of the temperature dependence of auxin transport in monocotyledonous tissue has appeared. We undertook to re-examine the thermal dependence of auxin transport in corn coleoptile segments by the use of ¹⁴C-labelled auxin.

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Materials and Methods

Zea mays L. seeds (Hybrid 64a x 22R University of Wisconsin) were soaked in tap water for 3 hours and planted on moist paper pads (2 Ply "Kimpak") in plastic trays. To inhibit mesocotyl growth the seedlings were exposed to red, light (Wratten filter 1A; irradiance 750 $\mu\text{w}/\text{cm}^2$) between 54 and 70th hour after planting. Otherwise the plants were kept in darkness, at 25°C, till harvest at 96 hours.

Transport determinations were made in rooms maintained at temperatures from 5 to 30 \pm 0.5°C. Before use the seedlings were equilibrated for 0.5 h at the required temperature. From each coleoptile, 4 to 5 cm in length, a 7.0 mm section was cut 2 mm from the tip, using two spaced razor blades. Keeping normal orientation of the segments, it was placed on a 1.5% agar "receiver" block (3.7 x 4x1 mm). A "donor" block (2.7 x 2.7 x 2 mm) containing 0.2 mg/l ^{14}C -IAA (13.3 Ci/M purified by chromatography (Gordon & Paleg, 1957), was mounted on the apical cut surface. A control at 25° accompanied every experiment in order to check the variability of the different planting; there was no material change in transport properties during these experiments.

At the end of every 0.5 h up to 2.0 hours, the donors, tissues, and receivers of 6 assemblies were separately pooled and analyzed for their ^{14}C activity by the liquid scintillation counting (Naqvi, 1963). Each datum given is the mean of three replicates. Analysis of variance was employed to evaluate the significance of differences.

Results and Discussion

In the experimental design here used, the auxin applied must be absorbed by the tissues before it can be transported into the receivers. Therefore, the data have been analysed on the basis of both actual percentage absorbed (tissue + receiver/total applied) as well as the portion of that transported (receiver/absorbed).

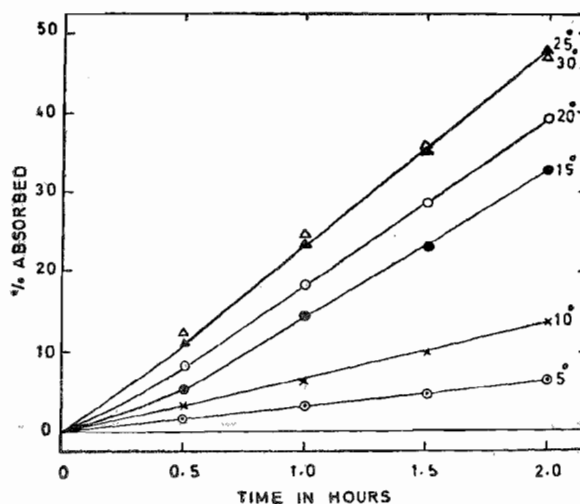


Fig. 1. The effect of temperature on the absorption of C^{14} -IAA from donor blocks by 7.0 mm corn coleoptile sections.

Figure 1 shows that absorption is progressively enhanced as the temperature rises to 25°C. No significant increase was observed between 25°C (closed triangles) and 30°C (open triangles).

Assuming the percentage absorbed at 5°C on a purely diffusion phenomena we can determine the anticipated values at different temperature if it were not an active process. Following EINSTEIN-STOKES LAW:

$$D_2 = D_1 \frac{T_2 n_1}{T_1 n_2}$$

the values of D_2 at various temperatures can be computed (Larsen, 1955). The reported diffusion constant in agar at 20°C of ca. 7 for the auxin (Larsen, 1955) and the viscosity of water at different temperatures (Handbook of Chemistry and Physics 1962 p. 2257) has been used to obtain the D_2 values. The anticipated data were thus obtained by dividing the D_2 values at each temperature by D_5 and multiplying them by the observed data at 5°C. The difference between the observed and calculated values is the portion which is due to an active process. Data based on these considerations have been presented in Figure 2, where A represents the calculated slope from the observed data and B the amount of auxin moving into the tissue as a strictly diffusive phenomena. The differences between the two curves (C) show that the major portion of the uptake of the auxin is derived from an active absorption.

The curves in Figure 3 represent the recovery of radio-activity from the receiver blocks. The intercepts (estimated velocity) and the slopes (intensity) for the linear regression were fitted by least square and are given in Table 1. No. ^{14}C -activity was detected in the receiver blocks when the transport temperature was 5°C. The calculated velocities were found to be significantly different from each other

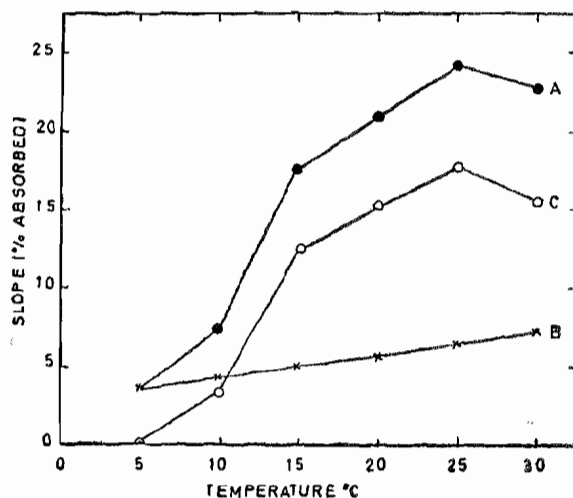


Fig. 2. Estimation of the amounts of the applied auxin absorbed per hour (slope from Fig. 1), at different temperatures, by an active process (see text for explanation of A, B and C).

TABLE 1. Thermal dependency of auxin transport velocity and intensity in *Zea* coleoptile sections.

Temperature (°C)	10	15	20	25	30
Velocity mm/h	5.3a	8.8b	14.5c	17.1d	18.5d
Intensity cpm/h	74a	359b	369b	479c	482c

Means not followed by same subscript in each row is significant at $p=0.01$ or less.

except between 25 and 30°C. Similarly the various transport intensity are also significantly different from each other, except between 15-20 and 25-30°C.

Considering the amounts of auxin absorbed as 100%, the percentage transported to the receiver blocks was calculated. These percentages, for a transport time of 2.0 h, are given in Table 2. It can be concluded that an increase in temperature, up to 25°C, significantly enhances both the absorption and the transport intensity of auxin. Both phenomena saturate at 25°.

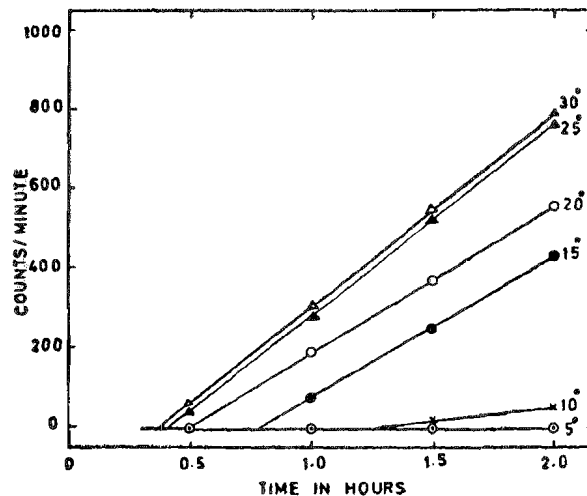


Fig. 3. Effect of temperature increase on the amount of radioactivity recovered from the receiver at different intervals of transport time.

We find, therefore, that the absorption of auxin by *Zea mays* L. coleoptile sections, and the subsequent intensity and velocity of basipetal transport, are temperature dependent. Therefore, the present work as well as those mentioned earlier indicates that as regards to the transport intensity and velocity, there appears to be no qualitative difference between the monocot and dicot.

TABLE 2. Thermal dependency of absorption of auxin from the donor, and amount of auxin translocated as a percentage of that absorbed (time 2.0 hr.)

Temperature (°C)	5	10	15	20	25	30
Percent of applied						
In tissue	6.70a	11.73b	13.79c	16.20d	14.94d	14.05cd
In receiver block	0.00a	2.09b	18.04c	23.12d	32.27e	32.36d
Total	6.70a	13.82b	31.83c	39.32d	47.21e	46.41e
Percent of absorbed						
In receiver blocks	0.00a	15.11b	56.65c	58.82d	68.31e	69.73e

Means not followed by same subscript in each row is significantly at $p=0.01$ or less.

The Q_{10} value at 2.0 h for absorption is observed to be that of a metabolically dependent reaction up to 20°C (Table 3). Though the intensity and velocity of auxin transport seems to be dependent on metabolism up to 20°C above that the Q_{10} values suggest an involvement of a physical phenomena. These observations are in agreement with our earlier conclusion that auxin transport in *Zea mays* coleoptile was not affected by anoxia at 25°C (Naqvi et al. 1965). Morris (1977) using intact pea seedlings has also concluded that the transport requires metabolic energy and is strongly dependent on temperature in the range 5°–35°C. The reported Q_{10} values for transport intensity between 0–30°C is of the order of 3 (van der Weij, 1932) and about 2 for velocity (Gregory & Hancock, 1955). The discrepancies, in the literature, with regard to the thermal dependency of velocity are mainly due to the scatter in data (van der Weij, 1932) and low Q_{10} values (Hertel & Leopold, 1963).

TABLE 3. The calculated values of Q_{10} at different temperature for 2 hours of auxin transport.

Temperature (°C)	5—15	10—20	15—25	20—30
Absorption	4.8	2.8	1.5	1.2
Intensity	—	5.0	1.3	1.3
Velocity	—	2.7	1.9	1.3

It is, therefore, concluded that auxin absorption and its subsequent translocation (intensity and velocity) are metabolically dependent on temperature increase, probably upto 20°C. The transport of auxin then appears to depend on a physical transfer of the molecule from one site to another inside the coleoptile tissues.

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