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Pattern of ^{14}C-assimilate distribution in relation to their supply and demand in bean plants

Part I

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INTRODUCTION

The reported studies are a continuation of previous investigations on the translocation of photosynthates suggesting a close interaction between acceptor-organs and their mobilizing power (S t a r c k 1964, 1967 a, b). This conclusion was drawn from the observations, that removal of one acceptor (roots or inflorescence) reduces the competition for organic substances between the other organs importing assimilates.

In the present experiments the interaction between organs importing assimilates was studied, on intact plants, but with an experimentally modified supply and demand: plants were shaded for a few days — what supposedly leads to depletion in the carbohydrate supply to the sinks or they were supplied with sucrose absorbed by the roots. In both cases, it was studied in how much the different supply and demand for assimilates are factors controling their movement from the blades to the other organs.

MATERIAL AND METHODS

In all experiments, bean plants var. Saxa, grown in water culture, in the nutrient solution described previously (T u r n o w s k a-S t a r c k 1960) were used.

One group of plants were shaded with cheesecloth which transmitted about 50 or 30 percent of natural daylight. When the primary leaves were well expanded, the whole plants of the shaded and control groups were placed in a plexiglass chamber, but only the primary leaves or primary leaves and apical part with a very young trifoliate leaf (as in expt. 3) were exposed to $^{14}CO_2$ under natural daylight. All the other organs were darkened. The roots of plants fed with sucrose were immersed in a nutrient solution with sucrose 2 hrs before exposure to $^{14}CO_2$. Sucrose was still absorbed during the exposure and translocation periods.

Table I

The conditions during growth and $^{14}CO_2$ exposure

Expt. No.	Conditions during growth	Date. of exp.	Age of plants (days)	Replications numbers	Conditions of $^{14}CO_2$ exposure		Conditions of translocation		CO_2	
					time min	°C	time	°C	% v/v	sp. r.** μc/mg
1.	1) Natural daylight 2) 5 days shaded (50% Nl*)	25.V.66	20	1×4 plants	60	17—20	60	17—20	0,07	3.12
2.	Natural daylight	14.VI.66	19	4×2 plants	30	23—24	30	25	0.06	3.57
3.	1) Natural daylight 2) 7 days shaded (50% Nl) 3) 7 days shaded (30% Nl)	19.V.67	17	3×2 plants	30	24—28	60 60	24—26	0.05	1.89
4.	All the plants 10 days shaded (50% Nl)	30.V.68	24	3×2 plants	40	15—17	180	20—25	0.04	1.64

* Nl – natural daylight

** sp.r. – specific radioactivity

Most of the experimental conditions are presented in Table 1. The experiments were done with 4—8 plants in each treatment of uniform length and leaf size.

After various translocation periods (Table 1) all plants were harvested, immediately frozen in dry ice and split into particular organs. Total radioactivity (in plant material homogenised in 80% ethanol) as well as radioactivity of 80% ethanol soluble fraction (supernatant) were estimated by means of a thin end-window G-M counter (about 3 percent efficiency), following the techniques described in the previous paper (S t a r c k, 1964 a). To estimate the radioactivity of sugars, the supernatant was evaporated to dryness at room temperature, the residue was dissolved in water. Amino acids and organic acids were separated on a exchange resins (Dowex 50 and Amberlit IR 45). Besides redioactivity, the amount of sugars was estimated by anthrone method according to P e a c h (1955) in the modification described by D i m l e r (1952) (concerning the heating of solution for 10 min in boiling water and cooling before measuring the optical density), with a Leitz electrocolorimeter. By subtracting the radioactivity of sugars from that of the supernatant, the radioactivity of ionized substances was calculated.

In most experiments statistical analysis of variance was performed. In the case of comparison of the relative values, transformation according to the Bliss table was done. The variances were calculated by Snedecor's F test and differences between the averages — by Student's t test.

RESULTS

A pilot experiment (No. 1) was done on 4 plants in each treatment (analysed together) to observe the effect of sucrose and mannitol absorbed by roots and of preshading the plants 5 days before exposure to $^{14}CO_2$, on the export and distribution of ^{14}C-assymilates from the blades. Neither sucrose (0.075 M and 0.150 M concentrations) nor 0.075 M mannitol did influence the total export of ^{14}C-assimilates from the blades of primary leaves (Table 2). The pattern of ^{14}C-distribution in plants fed with mannitol was mostly the same as in control plants. The increasing concentration of sucrose absorbed by roots, caused a progressive decrease of ^{14}C--translocation to the roots and an increase of translocation to the stem, but almost equal proportions of exported ^{14}C-material were found in the apical part and petioles. The distribution of ^{14}C-substances in the stem is presented in Fig. 1. The highest differences in the translocation were observed in the stem below the labelled leaves, especially in plants supplied with 0.15 M sucrose.

Plants shaded five days exported the same proportion of ^{14}C-assimilates from the blades, as the controls but a greater proportion of labelled

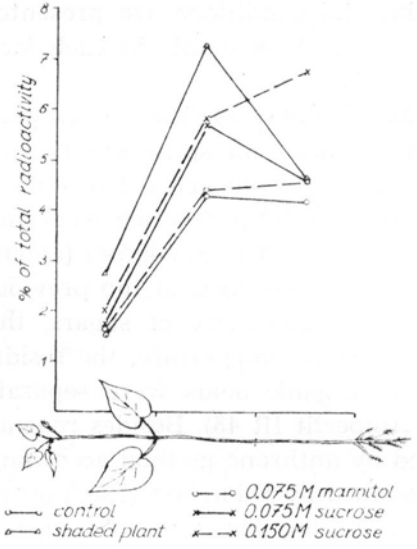

Fig. 1. Effect of sucrose and mannitol supplied by roots and 5 days preshading on the distribution of ^{14}C-assimilates in the stem

c.n. — cotyledon node.

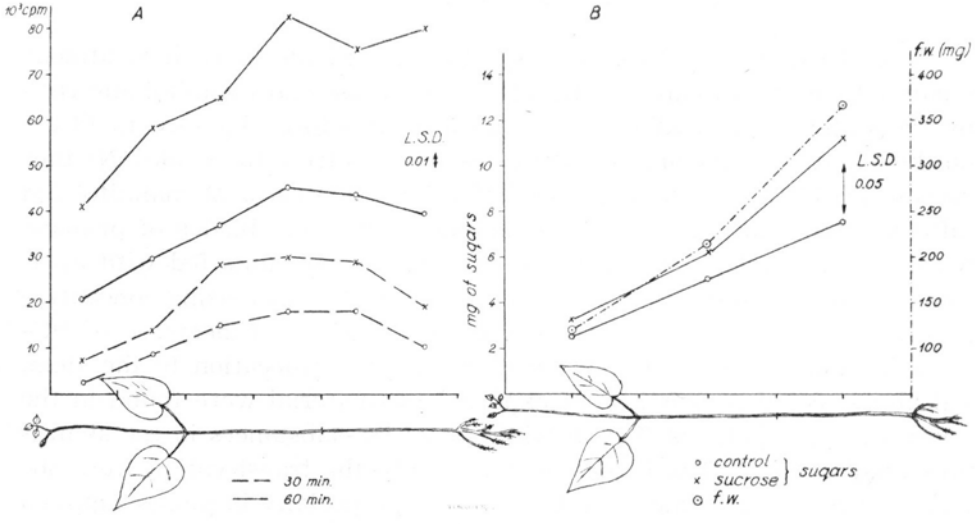

Fig. 2. Effect of sucrose supply on the ^{14}C-distribution and the sugars content in the stem

Table 2

The effect of preshading, sucrose and mannitol supply on the ^{14}C-substances translocation

(Average of all replications expressed as the percentage of total radioactivity)

Plant organs	Distribution of ^{14}C-photosynthates (labelled blades)												Distribution of ^{14}C-C sucrose absorbed by roots	
	Experiment No. 1 (1 hr translocation)							Experiment No. 2						
	Natural daylight					5 days	shaded		30 min. translocation		60 min. translocation			
	fr. wt. g	control	0.075 M mannitol	sucrose 0.075 M	sucrose 0.150 M	fr. wt. g	control	fr. wt. g	control	0.075 M sucr.	control	0.075 M sucr.	Expt. No 2b.	Expt. No. 3b
Blades	1.97	72.9	72.2	74.9	73.5	1.79	71.4	1.91	95.0	91.1	75.8	67.5	7.1	3.1
Petioles	0.42	4.6	4.6	5.9	5.3	0.27	6.0	0.29	1.8	3.1	2.8	4.5*	2.5	0.6
Apical part	0.20	2.8	3.5	1.9	2.9	0.23	3.8	0.27	0.6	1.1	9.0	11.1	1.3	0.4
Stem	0.76	10.1	11.4	12.0	14.5	0.70	14.8	0.70	2.6	4.4*	8.3	13.1**	8.9	2.0
Roots	3.62	9.6	8.3	5.3	3.8	2.77	4.0	1.47	trace	0.3	4.1	3.8	80.2	93.9
Organs importing ^{14}C-substances	5.00	27.1	27.8	25.1	26.5	3.97	28.6	2.73	5.0	8.9*	24.2	32.5**	19.8	6.1

Experiments No.: 1, 2b, 3b not analysed statistically

* differences significant at 5 percent level

** differences significant at 1 percent level

compounds was transported to the stem (Table 2). Much more radioactivity was detected in the epicotyl as well as in the upper part of the stem (Fig. 1). On the other hand a lower percentage of ^{14}C-substances was found in the root system.

The fresh weight of the shaded plants and the weight proportions between the organs changed, but in much lower degree than the distribution pattern of labelled substances as compared with plants, grown all the time under natural daylight. The ratio of shoot/root fresh weight in control plants was 0.9 and in shaded plants, slightly higher — 1.1.

The effect of sucrose absorbed by roots on the translocation of ^{14}C--photosynthates in plants grown under natural daylight was examined in more detail in expt. 2. The plants supplied with sucrose exported a greater proportion of ^{14}C-assimilates from the blades both in 30- and 60-min. translocation period. The ratio of up/down translocation was the same in both treatments (about 0.4 — after 30 min., and about 1.0 after 60 min.).

When comparing the ^{14}C-translocation in the controls with that of plants absorbing sucrose, a much higher proportion of exported material to the stem and petioles was also observed but, in contrary to expt. 1 without differences in the root radioactivity. This may be due to a different proportion between the size of the particular organs in both experiments especially much smaller roots of the plant in expt. 2 than in expt. 1 (fresh weight of roots was in expt. 1 and 2 : 53 and 32% respectively). The shoot/root ratio of fresh weight in expt. 2 was 2. 2. In expt. 2, in control plants the roots accumulated less than half of the ^{14}C-assimilates as compare with roots — in expt. 1, suggesting their lower sink power.

The distribution of labelled substances in the stem in both series is presented in Fig. 2. The effect of sucrose absorbed by roots on the translocation of labelled substances to the stem was rather uniform in the particular segments in both harvesting periods. The amount of sugars in the stem seems to be correlated with their fresh weight. After immersion of the root system in the 0.075 M sucrose solution, the amount of sugars increased especially in the hypocotyl.

In the same conditions as expt. 2 and 3 the migration of ^{14}C-sucrose absorbed by roots within 2.5 hrs was estimated (expt. 2 b and 3 b). The results are shown in Table 2 and Fig. 3. In both experiments ^{14}C-sucrose migrated to all organs of the plant, but in various amounts. About 35—50 percent of ^{14}C-sucrose estimated outside the roots was found in the blades and a much smaller proportion-in the stem and petioles. The labelled substances exhibited a decreasing gradient from the roots to the top of the stem with a similar slope in both experiments (Fig. 3).

The effect of 7-days preshading as well as of 0.075 M sucrose absorbed by roots on the migration of labelled assimilates in control and

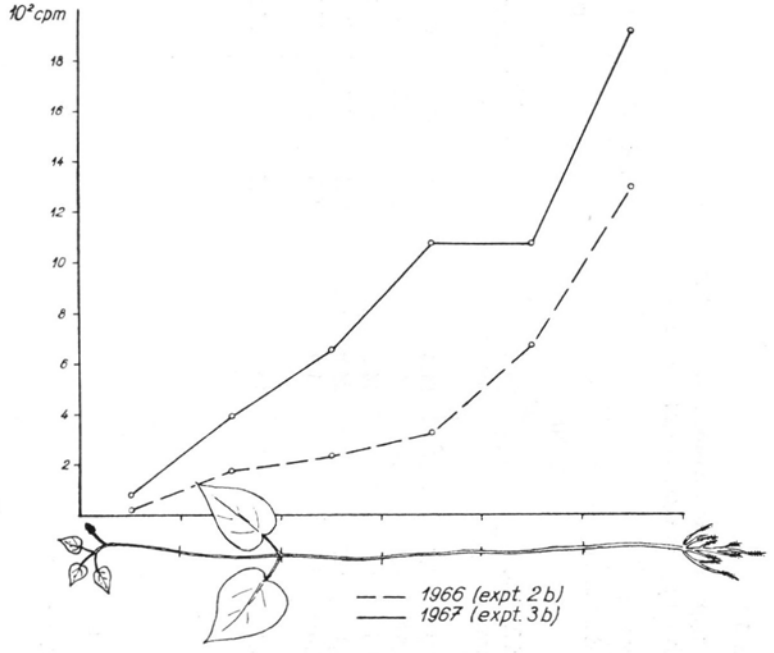

Fig. 3. Distribution of ^{14}C-sucrose absorbed by roots in 2.5 hr period.

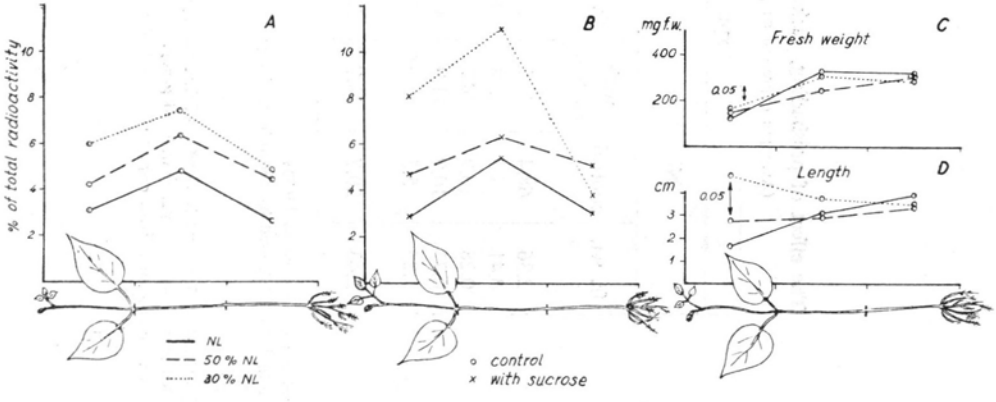

Fig. 4. The interaction between the sucrose supply and preshading effect on ^{14}C-assimilates distribution

A — effect of preshading (control groups); differences between groups N1 and 30% N1 are significant (at 5 percent level); *B* — effect of preshading and sucrose supply; differences between N1 and 50% N1 are significant for stem above primary leaves and hypocotyl (at the 5 percent level); between N1 and 30% N1 are significant for epicotyl and stem above primary leaves (at the 1 percent level) *C* — fresh weight; *D* — length

Table 3

The effect of preshading, darkening and sucrose supply on the translocation of ^{14}C-assimilates

(Averages expressed as percentage of total radioactivity and weight of particular organs)

Plant organs	Expt. No. 3 (1 hr translocation)									Expt. No. 4 (3 hrs translocation)				
	Nl			7 days shaded						fr. wt.	Light		Darkness[2])	
				50% Nl			30% Nl							
	fr. wt.	control	with sucrose	fr. wt.	control	with sucrose	fr. wt.	control	with sucrose		control	with sucrose	control	with sucrose
Blades	2.36	68.4	71.1	2.15	66.0	61.0	1.72	60.7	51.4	2.04	58.3	57.8	48.5	50.9
Petioles	0.41	4.3	3.8	0.36	3.1	5.3*	0.38	7.1*	7.4	0.26	5.0	5.2	4.7	6.1
Apical part[1])	0.28	10.9	10.2	0.22	8.4	12.6	0.18	10.7	14.5	0.65	11.5	14.9	10.2	11.0
Stem	0.77	10.9	11.9	0.71	15.3**	18.1	0.75	19.8**	24.8*	1.33	15.4	16.7	19.9*	25.2*
Roots	1.25	5.5	3.0*	0.99	7.2	3.0**	1.12	1.7**	1.9	2.15	9.8	5.4**	16.7*	6.8**
Organs imparting ^{14}C-assimilates	2.43	20.7	18.7	2.06	25.6*	26.4	2.25	28.6**	34.1*	4.39	41.7	42.2	51.5	49.1

1) in expt. No. 3 — apical part exposed to $^{14}CO_2$

2) 40 min. of exposure in $^{14}CO_2$ followed by 150 min of darkness

Nl — natural daylight

fr. wt. — fresh weight (g)

* — differences significant at 5 percent level ** — differences significant at 1 percent level.

Control plants of shaded groups were compared with Nl group.

Sucrose supplied groups were compared with respective control plants grown in the same light conditions.

Table 4

The contribution of ^{14}C-assimilates into 80% ethanol soluble fraction and ^{14}C-sugars- into ethanol soluble fraction as well as sugars content and their specific radioactivity

	Expt. No.:	2		3						4			
		60 min.		Nl		50% Nl		30% Nl		L		D	
		C	+S	C	+S	C	+S	C	+S	C	+S	C	+S
Blades	% of sol. fr.	70	71	65	68	68	70	65	68	71	71	85	90
	% of ^{14}C-sug. in sol. fr.	67	73							81	67	70	84
	sugars mg/g fr. wt.	8.3	9.1							6.1	6.6	3.4	3.6
	sp. r.	28.0	36.0							35.5	31.5	26.9	32.9
Petioles	% of sol. fr.	99	74	43	—	41	83	86	70	85	89	100	100
	% of ^{14}C-sug. in sol. fr.	79	83	48	—	64	92	84	84	88	85	89	85
	sugars mg/g fr. wt.	6.9	8.4	2.1	1.0	1.4	4.1	3.3	2.8	3.8	3.8	1.6	1.4
	sp. r.	21.0	29.0	7.2	5.5	14.9	23.0	30.8	28.3	29.6	32.3	32.1	45.0
Apical part	% of sol. fr.	81	71	92	52	100	100	91	100	77	84	90	98
	% of ^{14}C-sug. in sol. fr.	58	82	83	63	88	79	85	81	65	93	78	76
	sugars mg/g fr. wt.	9.2	13.9	10.2	6.7	8.5	14.7	12.8	7.5	7.9	14.7	5.2	5.5
	sp. r.	32.0	41.0	21.9	13.6	32.8	27.8	41.1	45.1	50.0	54.9	43.7	49.6
Stem	% of sol. fr.	97	72	56	73	97	100	94	100	88	93	100	100
	% of ^{14}C-sug. in sol. fr.	85	90	66	77	84	91	82	92	80	76	93	89
	sugars mg/g fr. wt.	11.5	14.6	3.6	5.7	6.1	8.0	4.6	5.9	6.7	8.1	5.4	4.7
	sp. r.	15.0	20.0	12.0	13.5	13.5	23.4	32.0	33.1	21.8	21.8	21.2	33.9
Roots	% of sol. fr.	100	98	74	77	86	85	83	86	96	100	100	100
	% of ^{14}C-sug. in sol. fr.	77	93	74	80	88	73	100	69	63	79	75	76
	sugars mg/g fr. wt.	2.4	16.3	4.0	3.6	2.5	2.6	3.7	4.9	2.7	5.8	1.9	5.4
	sp.r.	10.6	1.9	6.2	3.8	13.5	3.4	4.1	1.5	30.4	10.8	43.3	7.1
Roots absorbed ^{14}C-sucrose	% of sol. fr.	—	56	—	46								

Nl — natural dyalight
sp.r. — specific radioactivity
sol.fr. — ethanol soluble fraction
fr.w. — fresh weight

L — light group
D — darkness group
C — control
+S — sucrose supplied plants

shaded plants is illustrated in Table 3. It was found that preshaded plants from more severly preshading conditions exported more ^{14}C-assimilates from the blades exposed to $^{14}CO_2$ under natural daylight. The proportion of ^{14}C-assimilates in the roots in plants of the natural daylight (Nl) groups was slightly higher than in expt. 2 (after 1 hr of translocation), in spite of their relatively smaller size (25% of total fresh weight). The proportion of root's radioactivity in the total ^{14}C-translocation was not affected by the weaker preshading (50% Nl), but decreased in more shaded plants (30% Nl). With increasing severity of shading, there was a progressive increase of the radioactivity exported from the blades to the stem especially, in the 30% Nl groups, with longer upper internodes, (Fig. 4). Sucrose absorbed by roots enhanced ^{14}C-translocation to the stem significantly especially in more shaded plants.

In Nl plants and those treated with 50% daylight, but not less, the proportion of ^{14}C-assimilates exported to the roots decreased as a consequence of sucrose supply.

The pretreatment of plants by 7 days under suboptimal light conditions caused their weaker growth especially of the blades. Neverthless the $^{14}CO_2$ assimilated by leaves under natural daylight (calculated per 1 g of their fresh weight) was the lowest in control plants (313.10^3 cpm). and higher in preshaded plants 50% Nl groups — 403.10^3 and in the 30% Nl groups — 380.10^3 cpm). The same is true for the apical part. It seems to be the response of preshaded plants to the increase of light intensity during exposure to $^{14}CO_2$.

The ratio of shoot/root fresh weight slightly increased only in the 50% Nl plant group (3.1 in control and 3.5 in 50% Nl) but is much higher than in expts 1 and 2 probably owing to the fact that these plants were the youngest, (see Table 1). Various meteorological conditions during the growth period in particular experiments, mainly temperature, would have greatly effect the value of this ratio (see B r o u v e r 1964).

Another aspect of the same problem was to compare the influence of sucrose absorbed by roots, on the translocation pattern but in plants kept 150 min. in dark chamber following 40 min exposure to $^{14}CO_2$ with that in a plants translocating ^{14}C-substances all the time under light. All the plants of expt. 4 were treated for 10 days by 50% natural daylight. In darkness relatively more ^{14}C-substances were exported from the blades. A greater proportion of ^{14}C-assimilates exported from the blades was detected in the roots and in the stem. The sucrose supplied plants exported much less ^{14}C-substances to the roots both under light and in darkness. Higher percentage of labelled substances was found only in the stem in the dark group supplied with sucrose (Fig. 5), especially in the stem parts above the cotyledon node. On the contrary, an increase of sugars in the stem of darkened plants, with roots immersed in nutrient solution with sucrose was not detected but some increase was observed

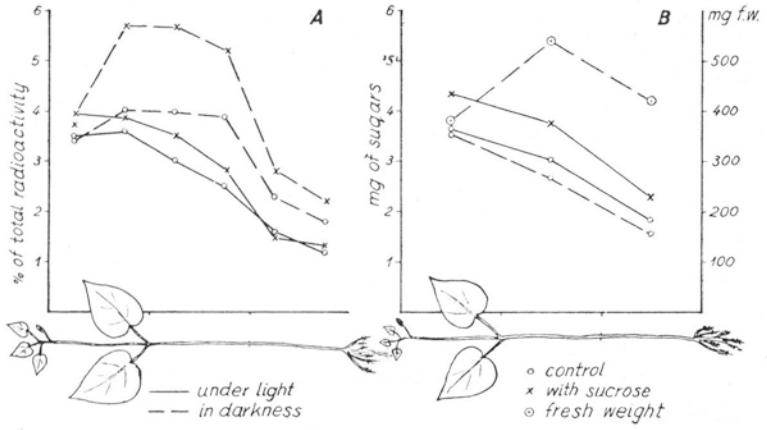

Fig. 5. Effect of light and darkness on the ^{14}C-distribution in the stem (*A*) and fresh weight and content of sugars (*B*)

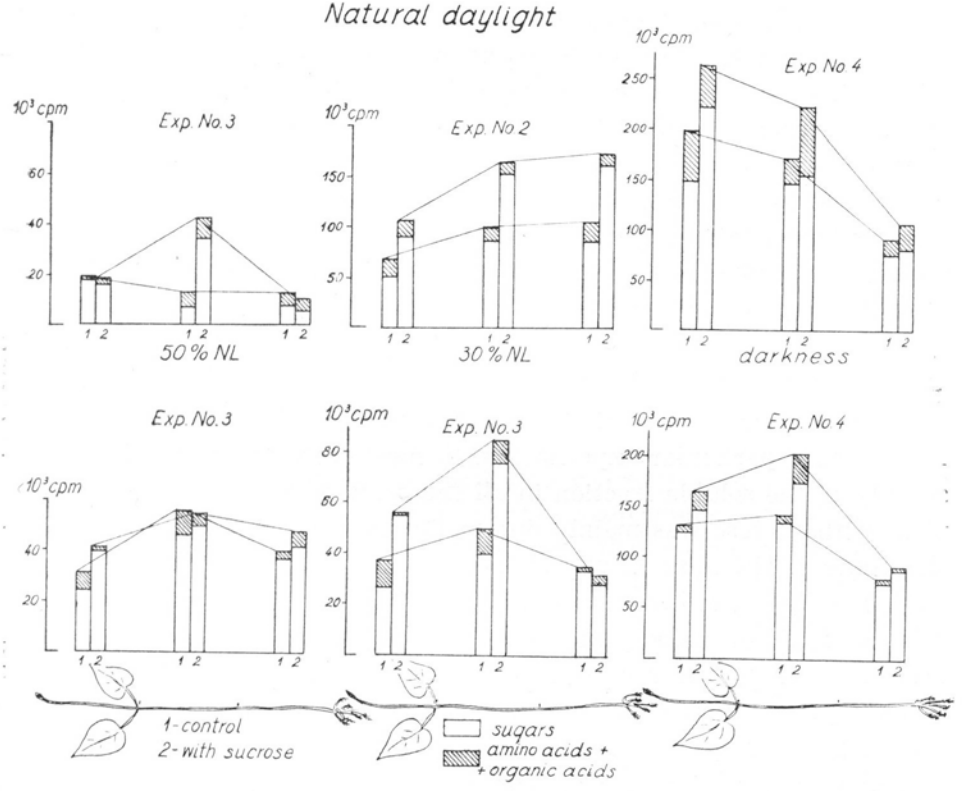

Fig. 6. Effect of preshading, darkening and sucrose supply on the contribution of labelled: sugars, amino acids and organic acids to the radioactivity of the 80 percent ethanol soluble fraction in the stem

in the stem of the light group. ^{12}C-sucrose absorbed by plants of the light groups was translocated also to the apical part (Table 4, expt. 4) but no differences in the sugar content were found either in petioles or in the blades. In plants darkened during ^{14}C-translocation, the increase of sugars was found only in the roots. It did not indicate a lack of sucrose absorption, because sucrose would have been incorporated into the insoluble fraction, as it was observed in the cases of ^{14}C-sucrose absorption (see Table 4).

The increase of sugars content as a consequence of sucrose supply varied in particular experiments. The highest increase in the sugars level was observed in the plants of expt. 2. In expt. 3 the differences between the content of sugars in control plants and those which absorbed sucrose were variable.

Shaded plants had in some cases a higher content of sugars as compared with that in controls. Shading of the plants decreased the incorporation of ^{14}C-substances into the ethanol — insoluble fraction (calculated from the percentage of soluble fraction) (Table 4, expt. 3) in the stem, roots and petioles of severely shaded plants, without effect on that in $^{14}CO_2$ assimilated organs: blades and in apical parts. Plants kept in darkness (expt. 4) following $^{14}CO_2$ assimilation, incorporated into the insoluble fraction a much lower proportion of ^{14}C-substances (or even none in a 3-hr period). In plants which absorbed sucrose, the same proportion of ^{14}C-substances was incorporated into the ethanol — insoluble fraction in the roots, but the effect was variable in other organs. Sucrose supply increased the contribution of ^{14}C-sugars to the radioactivity of the supernatant in the plants of expt. 2, and also in those from natural daylight conditions in expt. 3 (except for the ^{14}C-labelled apical part), but only in the roots and apical part of the light groups of expt. 4. The same is true for the stem (expt. 2 and 3).

On Fig. 6, the radioactivity of the soluble fraction in the stem is illustrated for particular experiments. In most cases the increase of radioactivity of the soluble fraction in all the parts of the stem in plants supplied with sucrose was mainly due to the increase of the ^{14}C-sugar fraction content. The radioactivity of the fraction separated on ion exchangers (amino acids and organic acids) increased slightly in the stem of plants of both the light and dark group (expt. 4). This fraction did not differ in the groups of plants under natural daylight of expt. 2 and 3, and decreases in some part of stem — in shaded plants (expt. 3). Therefore the percentage of the nonsugar fraction usually decreased.

The specific radioactivity of sugars decreased significantly in the roots of all the plants supplied with sucrose (Table 4), and in the dark group increased in all the plant organs except roots. No differences were ob-

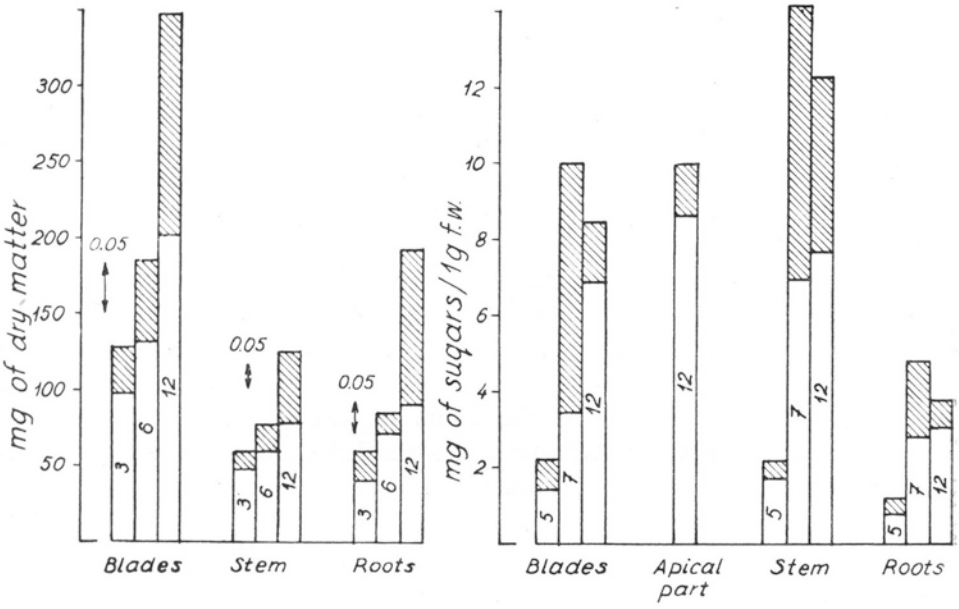

Fig. 7. Effect of shading on the increment of dry matter and on the sugars content: higher bars — organs of control plants; hatched part — differences between control and shaded plants; numbers — days after differentiating light intensity

served in severely shaded plants and variable differences-in all the other groups.

Comparison of the groups of plants from natural daylight conditions with that preshaded, shows that sugar specific radioactivity increased in the apical part ($^{14}CO_2$-assimilated) and the petioles as well as in the more shaded stem. In the 30% Nl group the specific radioactivity of roots decreases as a result of great reduction of ^{14}C-translocation to this organ.

To get a more general picture, as regards the influence of prolonged shading on the growth rate of particular plant organs independently on the other variable conditions in particular years, the increment of dry matter and the content of sugars in plants grown under natural daylight conditions and under low light intensity (30% Nl) was measured. The results illustrated in Fig. 7 are averages of 9 plants (3 replications including 3 plants per each) in the case of dry matter and 6 plants (2 replications $\times$ 3) in the case of sugars. There is a progressive decrease of the increment in all the organs, especially pronounced for the roots, as a consequence of shading of the plants.

All the organs of shaded plants had a lower sugar content, particularly after 7 days of shading. These differences are slightly lower, when calculated per 1 g of dry matter, because the percentage of dry matter in shaded plants was also lower.

DISCUSSION

The comparison of ^{14}C-distribution in preshaded plants and those under natural daylight conditions is rather difficult, owing to changes in many processes (for instance: photosynthesis, respiration and in consequence — growth). The plants, shaded for few days had developed smaller leaves (as regards their weight and area), smaller roots and longer stems, especially in their upper part. The proportion between the weights of organs changed — the shoot/root ratio usualy increased. Taking this into account it seems to be more reasonable to compare the ^{14}C-translocation in experimental groups as the relative values (percentage) simultaneously with the relations between the weight of particular plant organs or the length, in the case of the stem. A distinction must be drawn between changes in the distribution of assimilates exported from the blades and the change in the total amount of exported assimilates.

From the data of the reported experiments it seems clear, that preshading of the bean plant influences translocation of photosynthates under natural daylight in dependance on the duration and degree of pretreatment with suboptimal light conditions. In preshaded plants exposed to $^{14}CO_2$ under natural daylight a smaller proportion of assimilates was transferred to the roots, but ^{14}C-translocation to the stem and sometimes to the apical part increased.

The reduction of assimilate migration to the roots of shaded plants was also observed by Shiroya at al. (1962) and Nelson (1964), on pine seedlings. In Kudryavtsev's experiments (1964) the shaded tomato plants supplied generative organs rather well but the decrease of dry matter and of the carbohydrates content were especially pronounced in the roots. This would have been a consequence of the competition between sinks of various mobilizing power. In many papers it was reported, that shoots have priority over root growth under conditions of assimilate deficiency (Wardlow's rieview, 1968).

Ford and Thorn (1967) observed in shaded plants of several species an increase of top/root dry matter ratio mainly owing to decreasing root growth. A close relation between the light intensity and the rate of root growth was observed on the tree seedlings (Wassink 1967; Eliasson 1968).

Humphries (1967) whereas studied transport of photosynthates in rooted bean leaves, observed that in shaded leaves greater proportion of assimilates was transferred to the roots, especially in conditions of low root temperature and noticed less accumulation of dry matter in the lamina.

In my own experiments, preshading also increase, in some cases, export of assimilates from the blades; they were, however, translocated in a

greater proportion not to the roots, but to the other acceptors, mainly the stem. Humphries's observations do not seem to contradict those to mentioned above, because the interactions between organs would have been different in intact plants than in rooted leaves.

In darkness a greater proportion of labelled assimilates was exported to the roots than in light group as shown by the presented experiments and those on soybean in Nelson and Gorham's investigations (1967). Darkness changed distinctly the translocation pattern in many other experiments too, but the results were often contradictionary (Hartt 1965; Bielenko 1963; Eschrich 1966, and many others).

In the experiments reported darkness decreased ^{14}C-incorporation to the ethanol insoluble fraction as well as into the non-sugar compounds (mainly amino acids and organic acids). The same is reported in Hodghinson's paper (1966) with lucerne. It may be one of the reason of a greater proportion of mobile assimilates exported from the blades of darkened bean plants.

In contrast to the shading effect — decreasing the level of assimilates in plants, the aim of sucrose supply to the roots was to reduce the roots demand for assimilates, exported from the blades. It was expected to diminish the competition between acceptors, mainly: stem, apical part and roots. Indeed exogenic introduced sucrose decreased the share of roots in the assimilates exported from the blades especially in the case of their high mobilizing power. In some cases when the roots were a less active sink, sucrose supply increased ^{14}C-exported from the blades to the stem. This effect was not the same in individual experiments, probably owing to the variations in the amount of sucrose absorption by the roots and the proportion of its translocation to the upper part (see experiments 2b and 3b with ^{14}C-sucrose). Sucrose absorbed by roots seems to influence translocation of ^{14}C-assimilates probably in connection with the competition between particular acceptor-organs. An argument in this supposition is the fact that an interaction was observed between the preshading (or darkening) and sucrose-feeding effects. The influence of exogenic sucrose on the translocation of labelled compounds was more pronounced in severely shaded and darkened plants, in which the competition between organs seems to be stronger.

The fact, that in some cases plants receiving sucrose, exported more ^{14}C-assimilates from the blades, may be connected with the direct or indirect effects of exogenic sucrose on the amount of mobile ^{14}C-sugars in the particular organs, miainly in the blades. It is obvious, that conversion of sugars to starch and other immobile compounds, respiration and all the other metabolic pathways which would have been changed in plants fed with sucrose, may have altered the ^{14}C-translocation. This suggestion is based on the observation that almost in all organs and in most

experiments, the contribution of ^{14}C-sugars to ^{14}C-assimilates was not the same in the sucrose supply and control groups. Usually the fraction of ^{14}C-sugars increased as a consequence of sucrose absorption. On the other hand, sucrose absorbed by roots could have been incorporated in a high degree into the ethanol insoluble fraction, as it was observed in the case of ^{14}C-sucrose absorbed by roots (Table 4). When exogenous sucrose become mixed with endogenous labelled and unlabelled assimilates, the utilization of these substances in particular pools might have also been not the same, ^{12}C-sucrose could have been utilised in respiration in a higher proportion than ^{14}C-assmilates, but this would have to be experimentally proved.

At this stage of knowledge the problem of control and regulation of transport between donors and acceptors still remains unclear. Shading effects the growth, and growth itself effects photosynthesis and also translocation of assimilates as suggested by many authors. It seems to be reason why it is so difficult to find the causes of the decrease in export of assimilates mainly to the roots which in young bean seedlings are one of the most active sinks.

SUMMARY

The influence of 5- and 7-day preshading and of sucrose supply by roots on the translocation of ^{14}C-assimilates in bean plants was examined with references to the concept of the competition for assimilates between acceptor-organs. The results support the well known fact that root growth is inhibited to a greater extent than shoot growth by reduction of natural daylight. In preshaded bean plants transferred to the natural daylight, the proportion of ^{14}C-assimilates translocated to the roots was in most cases lower, and to the stem much higher, than in control plants. In plants from suboptimal light conditions, unsuficiently supplied in carbohydrates the translocation is restricted mainly to the roots. Return to the natural daylight conditions of severely shaded plants caused an increase of ^{14}C-export from the blades. Plants kept in darkness exported relatively more ^{14}C-assimilates from the blades, which migrated in higher proportion to the roots.

Sucrose supplied to the roots migrated to all the plant organs, but in variable amounts and changed the proportion between the ^{14}C-ethanol soluble and insoluble fraction as well as the incorporation of labelled substances into amino acids and organic acids. The sucrose absorbed by roots reduced the competition for ^{14}C-assimilates, decreasing the proportion of labelled substances translocated to the roots or increasing that transferred to the stem. The effect of exogenic sucrose on ^{14}C-distribution was mostly of the same character, but more pronounced in the preshaded and darkened plants, in with the competition between organs seems to be stronger.

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Rozmieszczenie ^{14}C-asymilatów w zależności od zaopatrzenia siewek fasoli w cukrowce

STRESZCZENIE

W celu bliższego scharakteryzowania interakcji pomiędzy organami-akceptorami, badano rozmieszczenie ^{14}C-asymilatów w przypadku obniżonego poziomu zaopatrzenia w cukrowce i inne produkty fotosyntezy (rośliny ocieniano w ciągu pięciu lub siedmiu dni) lub też w przypadku, gdy korzeniom, które u młodych siewek są głównym akceptorem asymilatów, dostarczano egzogennie sacharozę.

Uzyskane wyniki potwierdziły znany fakt, że w suboptymalnych warunkach świetlnych wzrost korzeni był hamowany w większym stopniu niż części nadziemnej.

Rośliny ocienione (50% Nl lub 30% Nl) eksponowano jednocześnie z serią kontrolną (Nl) (rosnącą cały czas w warunkach naturalnego oświetlenia) w atmosferze $^{14}CO_2$, w kamerze oświetlonej naturalnym światłem dziennym. U roślin ocienianych przez 5—7 dni, udział radioaktywności korzeni (wyrażony w % radioaktywności całej rośliny) był znacznie niższy w przeciwieństwie do zwiększonego udziału łodygi, w porównaniu z roślinami serii Nl.

U roślin ocienianych lub umieszczonych po ekspozycji na okres 150 min. w ciemności, stwierdzono większy eksport ^{14}S-asymilatów z blaszek liściowych w porównaniu z roślinami kontrolnymi. W ciemności stwierdzono większy transport ^{14}C-asymilatów do korzeni w porównaniu z roślinami przebywającymi cały czas na świetle.

Po umieszczeniu korzeni na 2,5 godz. w pożywce zawierającej ^{14}C-sacharozę, radioaktywne związki stwierdzano we wszystkich nadziemnych organach. Tylko po-

łową znakowanych substancji, stwierdzonych pod koniec doświadczenia w korzeniach, stanowiły związki rozpuszczalne w 80% etanolu.

U roślin, którym dostarczono ^{12}C-sacharozy przez korzenie, stwierdzono w wielu przypadkach mniejszy stopień inkorporacji ^{14}C-asymilatów do frakcji związków nierozpuszczalnych w 80% etanolu, jak również większy udział ^{14}C-cukrów w supernatancie.

Sacharoza wprowadzana egzogennie wpływała też na rozmieszczenie ^{14}C-asymilatów w różny sposób, zależnie od aktywności korzeni jako okceptorów. W przypadku, gdy korzeń był aktywnym akceptorem (gromadził u roślin kontrolnych duży procent ^{14}C-asymilatów eksportowanych z liści), egzogenna sacharoza obniżała eksport znakowanych związków do korzeni, natomiast przy niższej aktywności korzeni u tej samej serii roślin obserwowano większy transport ^{14}C-asymilatów do łodygi.

Stwierdzono, że efekt sacharozy wprowadzonej przez korzenie miał taki sam charakter, lecz był spotęgowany u roślin uprzednio ocienianych oraz u tej serii roślin, która w czasie przemieszczania ^{14}C-asymilatów umieszczona była w ciemności. Fakty te zdają się wskazywać na zmniejszenie konkurencji o asymilaty w przypadku, gdy oprócz liści — głównych ich donorów — cukry wprowadzono do roślin egzogennie, przez korzenie.