Pattern of ^{14}C -assimilates distribution in relation to their supply and demand in sunflower

Part II

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(Received: March 13, 1971.)

Abstract:

Reduction of photosynthetic activity by 6 or 7 days of preshading increased to some extent migration of ^{14}C -assimilates to the stem and decreased that to the roots. Restriction of roots demand for assimilates by feeding them with sucrose decreased the share of roots in ^{14}C -export from the blades and increased ^{14}C -transport to the other acceptors: stem and apical part, mainly in plants with roots actively accumulating radioactive substances in control plants, in which competition for assimilates was strong. A very small or even no effect of sucrose was observed in seedlings with relatively lower activity of roots as well as in the plants translocating labelled assimilates in darkness.

INTRODUCTION

Experimentally modified (by shading the whole plants and by feeding the roots with sucrose) supply and demand for assimilates influenced the ^{14}C -photosynthates export from the blades and their distribution between particular plant organs in bean plants (Starck 1969, part I).

In suboptimal light conditions, the growth of the whole plant and especially of the roots was greatly reduced in bean seedlings. In most cases after a few days of shading, migration to the roots was less intensive and to the stem — much higher than in control plants immediately after replacing the plants in natural daylight conditions.

The present paper reports some further results of experiments with sunflower. In actively growing sunflower seedlings, the stem is a dominant acceptor (Starck 1966). The plants are supplied with organic substances, accumulated in the cotyledons, much longer than in bean plants. Therefore, it seems to be interesting to compare the effect of shading and exogenous sucrose on the photosynthesis and distribution of assimilates in sunflower with that in bean plants.

MATERIAL AND METHODS

Sunflower var. Borowski Prażkowany was grown in water culture (in modified Hoagland solution, described by Johnson, 1957), out of doors, only during night and rain fall — under greenhouse conditions.

In some experiments the plants were shaded with cheesecloth, which transmitted about 50 percent of natural daylight (50% NL — see table 1). Assimilation experiments were carried out using $^{14}\text{CO}_2$. The plants were exposed to an atmosphere labelled with $^{14}\text{CO}_2$ in plexiglass chamber, in all cases under natural daylight. Two pairs of leaves (expt. No — 2), or two pairs of leaves and also the apical part were exposed to light and $^{14}\text{CO}_2$ (expt. No — 1, 3, 4). All the other plant organs were darkened during exposure.

In some series of all the experiments, sucrose or mannitol were added to the nutrient solution in which the roots were immersed 2 hrs before exposure to $^{14}\text{CO}_2$. Sucrose or mannitol continued to be absorbed to the end of the ^{14}C -translocation period. In experiment No — 2b and 3b roots were immersed in nutrient solution with ^{14}C -sucrose for 2 hrs 30 min (No — 2b) or 2 hrs 45 min (No — 3b).

All the exposures were done in the morning (around 8–9 a.m.) in conditions illustrated in table 1. Harvested plants were immediately frozen in dry ice, cut into particular organs and stored at about -15°C . Total radioactivity of the plant material, homogenised in 80 percent ethanol as well as radioactivity of ethanol-soluble fraction (supernatant) were estimated by means of a thin-end window G-M counter (about 3 percent efficiency) following techniques described before (Starck 1964). Radioactivity of the insoluble fraction was calculated as the differences between total and that of the soluble fraction. In the supernatant, the sugar fraction as well as ionised substances were separated by the use of ions exchangers. The sugar content was estimated by the anthrone method as described in part I (Starck 1969).

The rate of respiration of the whole aerial part was measured by the use of an infrared gas analyzer, and roots respiration — by the Warburg method.

For comparison of the relative values, transformation according to the Bliss table was carried out. The differences between the averages are calculated by Student's *t* test.

RESULTS

In the pilot experiment — No 1, done in one replication, the effects of 6 days preshading and of sucrose supply by the roots on photosynthesis and translocation were studied. Treatment of plants with an isoosmotic concentration of mannitol allowed to check the effect of higher concentrations of nutrient solution on the processes investigated.

Both 0.075 M sucrose and 0.075 M mannitol reduced in similar degree photosynthesis (expressed in table 2 as radioactivity of total plant), and export of ^{14}C -assimilates from the blades, probably owing to the relatively high value of the osmotic potential, of the nutrient solution which probably influenced the water balance of

Table 1

The conditions during growth and $^{14}\text{CO}_2$ exposure

Expt. No	Conditions during growth	Date of expt.	Age of plants (days)	Replications number	Conditions of $^{14}\text{CO}_2$ exposure		Conditions of ^{14}C translocation		CO_2	
					time (min.)	°C	time (min.)	°C	% v/v	sp. r. $\mu\text{C}/\text{mg}$
1	1) Natural daylight (N.L.) 2) 6 days shaded (50% N.L.)	26.V.1966	19	1 × 4 plants	60	17—19	90	17—15	0.06	4.2
2	Natural daylight (N.L.)	15.VI.1966	20	4 × 2 plants	30	25—27	30 and 60	25—27	0.06	2.4
3	1) Natural daylight (N.L.) 2) 7 days shaded (50% N.L.)	20.V.1967	18	3 × 2 plants	30	28—35	60	22—25	0.05	3.0
4	All the plants 4 days shaded (50% N.L.)	8.VII.1968	21	2 × 2 plants	30	27	A) 30 min. L. B) 30 min. L. + 120 D C) 150 min. L	27—28	0.05	1.5

L — light; D — darkness; sp.r. — specific radioactivity; time of translocation is calculated from the beginning of $^{14}\text{CO}_2$ assimilation

Table 2

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

Plant organs	Distribution of ^{14}C -assimilates												Distribution of ^{14}C -sucrose absorbed by roots (%)	
	Expt. No 1 (1,5 hr. translocation)					Experiment No 2								
	Natural daylight (N.L.)					% of total radioactivity								
	% of total radioactivity					^{14}C -translocation								
	fr. wt. (g)	control	+ma 0,075 M	+sucrose 0,037 M	+sucrose 0,075 M	fr. wt. (g)	% of total radio-activity	fr. wt. (g)	30 minutes control	+sucrose control	60 min. control	+sucrose	Expt. No 2b	Expt. No 3b
Blades	1.95	59.4	69.8	62.4	66.8	1.10	58.0	3.74	80.8	73.7	65.7	60.9	5.8	2.6
Petioles	0.22	2.3	1.8	2.1	2.1	0.12	1.8	0.29	1.6	1.6	1.3	1.2	0.1	trace
Apical part ¹⁾	—	—	—	—	—	—	—	0.34	2.1	3.8*	6.6	9.0	1.7	0.4
Stem	1.27	17.8	15.5	23.5	20.3	1.19	23.7	2.34	12.5	18.9**	19.6	24.5*	7.7	3.6
Roots	3.45	20.2	12.7	11.8	10.6	2.46	16.2	3.06	2.9	1.9	6.6	4.1*	84.0	92.5
Cotyledons	0.75	0.3	0.2	0.2	0.2	0.95	0.3	0.89	0.1	0.1	0.2	0.3	0.7	0.9
Total organs importing assimilates	5.69	40.6	30.2	37.6	33.2	4.72	42.0	6.92	19.2	26.3*	34.3	39.1	16.0	7.5
Radioactivity in 10^3 cpm														
Total plant	—	1524	1215	1440	1231	—	1103	—	1871	1803	1722	1703	21	227

¹⁾ Apical part in experiment No 1 estimated with blades

ma — mannitol

NL — natural light

50% NL — 50 percent natural light

Differences significant at $p = 0.05$ — *,
" " at $p = 0.01$ — **.

Fig. 1. Expt. No. 1. Effect of sucrose and mannitol supplied by roots (A) and 6 days preshading (B) on the distribution of ^{14}C -assimilates in the stem.

Radioactivity of total plant assumed as 100 percent. Stem cut as indicated on the picture. Points on the curves present percentage of total radioactivity of particular stem pieces

sunflower. To avoid the effect of relatively high osmotic potential in all the other experiments roots were fed with 0.037 M sucrose. The distribution of assimilates changed in all the plants, treated with sucrose or mannitol; the contribution of roots to total translocation greatly declined, but that of stem—increased only in the sucrose-treated series (Table 2, Fig. 1A).

The growth of plants shaded for six days were reduced and the proportion between the weight of particular organs changed. The weight of blades was most seriously reduced in contrast to the stem. The ratio of *aerial part/root* weight in plants from natural light conditions (NL series) was relatively low — 1.2 and increased slightly, as a consequence of shading—to 1.4.

The photosynthesis of plants preshaded for 6 days was also depressed but in a smaller degree than the reduction of the blades weight. In preshaded seedlings a higher proportion of ^{14}C -assimilates was transported to the stem (Table 2, Fig. 1B), than in the NL series. The reduction of the share of roots in the total export from the blades of ^{14}C -assimilates seems to be proportional to the decrease of the roots weight.

The effect of sucrose applied to roots was examined in more detail in expt No 2 (Table 2) after 30 and 60 min of ^{14}C -translocation. In this experiment the ratio *aerial part/root* fresh weight amounted to 2.5; it was much higher than in the previous experiment (data calculated from Table 2), mainly owing to the higher weight of blades and stem. The content of sugars in the roots absorbing sucrose increased from 1.6 mg to 13.1 mg per 1 g of fresh weight, without changing in all the other organs (data not illustrated in tables).

In control plants after 30 min, as well as after 60 min of ^{14}C -translocation, the highest proportion of ^{14}C -assimilates migrated to the stem and much less, but in almost equivalent proportions to the roots and the apical part in spite of the fact, that the roots were nine times heavier than the latter.

Sucrose absorption by roots caused increase in total export of ^{14}C -assimilates from the blades, which was not observed in the expt 1; ^{14}C -substances were transported to the stem and apical part in significantly higher proportions in sucrose treated plants than in the control ones. The relative amount of ^{14}C -substances which migrated to the roots of sucrose-treated plants was lower, but significantly only after 1 hr period of translocation. The changes in the translocation pattern, as a consequence of sucrose supply, are presented also in table 3, (distribution of labelled substances was calculated in relation of total export from the blades, assumed as 100 percent). The decrease in the proportion of ^{14}C -assimilates transport to the roots and the increase in that to the apical part and the stem are very pronounced. The distribution of labelled assimilates in the stem is illustrated in fig. 2B. The sucrose-treated plants differed from the control ones by a higher share of the particular stem parts in total radioactivity of the whole plant in both harvesting periods.

Table 3

The effect of sucrose supply on the pattern of ^{14}C -assimilates translocation
(total export from the blades assumed as 100 percent)

Plant organs	Experiment 2				Experiment 3			
	30 min. translocation		60 min. translocation		N.L. series		50% N.L. series	
	control	+suc- rose	control	+suc- rose	control	+suc- rose	control	+suc- rose
Petioles	8	6	4	3	11	8	5	6
Apical part	11	15	19	23	—	—	—	—
Stem	65	72	57	63	66	73	74	72
Roots	15	7	19	10	21	16	16	13
Cotyledons	1	tr.	1	1	2	3	5	9

tr. = trace

Since there was no differences in the sugar content in sucrose treated plants (except small in roots), the experiment No — 2b was performed with plants treated with ^{14}C -sucrose (immersion of roots in nutrient solution with uniformly labelled ^{14}C -sucrose). Similar experiment was repeated in the next year, but with higher specific radioactivity of sucrose. All the other conditions were the same as in expts No 2 and 3.

Very few radioactive compounds were transported to the upper part of the plants especially in expt. 3 b (Table 2). A high proportion of ^{14}C -sucrose was incorporated into ethanol-insoluble fraction; in expt 2 b the radioactivity of the insoluble fraction in the roots constituted 54 percent of their total radioactivity detected in roots.

In further investigations the effect of sucrose, supply to the roots, on the photosynthesis and assimilates migration was compared in plants with lower supply of assimilates (plants were grown under low light conditions, expt No — 3), with

Fig. 2. Expt. No. 2. Fresh weight of the particular segments of the stem (A). Points on the curves present fresh weight of particular stem pieces. Distribution of ^{14}C -assimilates in the stem of control plants and that fed with sucrose (B). Points on the curves — as in fig. 1. Expt. No 2b and 3b. Fresh weight of the particular segments of the stem (C). Distribution of ^{14}C -sucrose absorbed by the roots (D).

Points on the curves present radioactivity of particular stem parts: expt. No 2b — in 10^2 cpm, expt. No 3b — in 10^3 cpm

that from natural light conditions. The proportion between the weight of particular organs in experimental plants was similar to that, in expt No — 2; ratio *aerial part*/*roots* fresh weight was 2.6 in NL plants (Table 4).

Shading of the plants for 7 days greatly reduced growth of blades (donor of assimilates) and apical part and also roots in contrast to the stem.

The rate of photosynthesis (measured as total radioactivity of the whole plant — resulting from $^{14}\text{CO}_2$ assimilation by blades and apical part) was reduced proportionally to the decrease in the weight of blades. Preshading did not affect total export of ^{14}C -assimilates from the blades (calculated as percentage of total radioactivity of the whole plant). Suboptimal light conditions changes the pattern of ^{14}C -translocation (Tables 3 and 4) but in lesser degree than in expt 1. The proportion of the available assimilates moved to the stem and cotyledons was relatively higher in preshaded plants, in contrast to the petioles and roots.

Sucrose supply changed very little the general pattern of labelled substances distribution, probably owing to their low absorption (the content of sugars in all the organ did not detectably increase in plants fed with sucrose). The radioactivity gradient in the stem (Fig. 3B) differed in particular plant series. In both NL series, radioactivity decreased gradually towards the roots, but it was not so in the stem of the 50% NL series; (differences in hypocotyls radioactivity between both NL and

Table 4

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

Plant organs	Experiment No 3 (1 hr translocation)					Experiment No 4					
	Natural light			7 days 50% N.L.		fr. wt. (g)	% of total radioactivity				
	fr. wt. (g)	% of total radio- activity		fr. wt. (g)	% of total radio- activity		30 min. L.	150 min. L.		30 min. L.+ +120 min. D	
		control	+sucrose					control	+sucrose		
blades with apical part petioles stem roots cotyledons total organs im- porting assimila- tes	1.55	81.2	82.5	0.77	79.3	3.39	74.8	60.8	60.2	55.8	57.2
	0.08	2.1	1.4	0.03	1.0	0.60	2.7	1.9	2.2	1.7	1.7
	0.71	12.3	12.8	0.51	15.3	5.88	19.6	24.3	27.6	24.0	23.0
	1.13	4.0	2.8	0.51	3.3	2.65	2.7	12.7	9.8	18.3	18.0
	0.62	0.4	0.5	0.58	1.1	0.94	0.2	0.3	0.2	0.2	0.1
	2.54	18.8	17.5	1.63	20.7	10.07	25.2	39.2	39.8	44.2	42.8
Radioactivity in 10 ³ cpm							Radioactivity in 10 ³ cpm				
Total plant	—	1946	1764	—	999	—	1316	1425	1400	1284	1313

L — light

D — darkness

NL — natural light

Differences between roots in both NL and 50% NL — significant at $p = 0.05$ (expt. No 3)Differences between roots in both 150 min. L and 30 min. L + 120 min. D — significant at $p = 0.05$ (expt. No.4)

Fig. 3. Expt. No. 3. Fresh weight of particular segments of the stem (A). The effect of sucrose supply and preshading on the distribution of ^{14}C -assimilates in the stem (B).

Expt. No. 4. Effect of light and darkness on the ^{14}C -assimilates distribution in the stem of control and sucrose treated plants (C).

Stem cut as indicated on the picture. Points on the curves present fresh weight (A) and percentage of total radioactivity of particular stem parts (B and C)

both 50% NL plants are significant). The pattern of ^{14}C -distribution in the stem of young sunflower may be influenced by the existence of two donors of organic substances: blades and cotyledons; in the preshaded plants, the content of sugars in the hypocotyl was lower than in the NL series (unpublished data), supposedly owing to the depleted level of mobile substances from cotyledons. Therefore ^{14}C -assimilates in shaded plants, migrated in a higher proportion to the lower part of the stem than in control plants and also, in some extent, to the cotyledons (Table 3); this being rather unusual in sunflower.

In plants treated with suboptimal light conditions, the rate of ^{14}C -incorporation into the ethanol-insoluble fraction changed (fig. 4). In the stem, especially its upper part, as well as in the apical part, a much higher proportion of ^{14}C -assimilates was incorporated into the ethanol-insoluble fraction in preshaded plants (compare Fig. 4A with 4C). In the NL-sucrose series, the rate of ^{14}C -incorporation into insoluble fraction was mostly the same as in the corresponding control plants (Fig. 4A and B). In preshaded and sucrose treated plants the share of the insoluble fraction in the

Fig. 4. Expt. No 3. Effect of preshading and sucrose supply on the contribution of ethanol insoluble fraction as well as sugars, amino acids and organic acids to the total radioactivity in apical part, stem and roots. Plants grown under natural light (NL) — A and B; plants shaded 7 days (50% NL) — C and D.

stem, especially of its younger part, decreased as compared with the corresponding control one (Fig. 4C and D).

The contribution of the ^{14}C -ionizing fraction (mainly amino acids and organic acids) to the total radioactivity was much lower in plants from lower light intensity than in the NL series (compare fig 4A and B with C and D). Also in the roots, a higher proportion of ionizing substances was found in NL plants than in preshaded ones (Fig. 4A, B and C, D).

In view of above mentioned relationship, the degree of sugars labelling, expressed as their specific radioactivity, was also different in the particular series. Preshading caused an increase of specific radioactivity of sugars in the lower part of the stem, where incorporation of ^{14}C into the other fractions was reduced (compare Fig. 4A and C), without detectable effect on that in roots. The same was observed in the lower part of the stem of preshaded plants, treated with sucrose (compare Fig. 4B and D). The specific radioactivity of sugars in roots decreased in both sugar-treated series, as compared with respective control ones.

The above mentioned interaction between the supply of assimilates modified by light intensity and sucrose feeding prompted to further experiment, done on preshaded plants treated with sucrose, but during the ^{14}C -migration, sunflower was kept under light or in darkness following 30 min exposure to $^{14}\text{CO}_2$. The plants used were much larger (Table 4, Expt. 4) than in all experiments previously described, probably owing to higher temperature and better light conditions during their growth (Experiment of July, in contrast to all others, performed in May or June — Table 1). The stem weight dominated over that of all other organs, the ratio of *aerial part/roots* fresh weight was 4. Already after 30 min translocation, under light, about 20 percent of total radioactivity was found in the stem, but very little — in the other organs. In the subsequent period, the rate of translocation depended on the conditions. The data presented in table 4 suggest some promotion of ^{14}C -assimilates transport in darkness and a higher than under light proportion of ^{14}C -assimilates migrated to the roots. In the sucrose-treated plants, transporting ^{14}C -photosynthates under light, some enhancement of ^{14}C -migration to the upper part of stem (Fig. 3C) was observed.

The metabolic pattern of labelled assimilates also changed. In darkness the rates of ^{14}C -assimilates incorporation into the ethanol-insoluble as well as into the ionizing fraction were reduced as follows:

migration:	under light			in darkness		
fraction:	insoluble	ionizing	sp.r.	insoluble	ionizing	sp. r.
blades	67	63	6.6	60	56	17.1
apical part	55	39	14.3	46	33	18.8

(percentage of insoluble fraction calculated assuming total radioactivity in particular organs as 100 percent; ionizing substances are referred respectively to the supernatant). The sugar's specific radioactivity (sp.r.) both in the apical part and in blades was higher in the darkened series.

Table 5

The effect of preshading and sucrose supply on the rate of respiration

Plant organs	N.L.		50% N.L.	
	control	+sucrose	control	+ sucrose
Aerial part ¹⁾	8.6	8.4	7.1	6.5
Roots ²⁾	7.3	8.2	4.2	4.7

¹⁾ Estimation as ml CO₂/g d.m. Average of 3 replications L.S.D = 1.24 (p = 0.05) (IRGA apparatus)²⁾ Estimation as ml O₂/g d.m. Average of 2 replications (no statistical analyse was done, Warburg apparatus)

Sucrose treatment did not significantly influenced the above mentioned metabolism of ¹⁴C-assimilates (data not reported).

To gain a more complete picture of the balance of ¹⁴C-substances in control and preshaded plants, the rate of respiration was estimated in plants grown for 11 days under modified light conditions (the same series which was used in expt. 4). The rate of roots respiration (expressed as oxygen absorption), was measured by Warburg method and respiration of all the aerial parts of intact plants — by the use of an infrared gas analyser (CO₂ evolution). The data presented in table 5 indicate a significant reduction of the dark respiration's rate in the aerial parts, and even more pronounced in the roots of shaded plants. Sucrose did not affect the rate of respiration of the aerial part (differences within the limits of error) in contrast to the roots, where sugar treatment slightly increased respiration.

DISCUSSION

In sunflower a more drastic response to shading was observed than in bean plant. The growth of the sunflower stem was less sensitive than that of the other organs. The sink power of the acceptors also changed, and in preshaded plants, competition between organs was stronger than in plants from natural light conditions owing to reduction of photosynthetic activity. In plants grown a few days under low light intensity, the ratio of blades (donors) to acceptors weight declined, especially in expt No 1. In that experiment reduction of photosynthetic activity was lower than reduction of blades weight probably owing to the fact, that proportionally larger acceptor organs exhibit a higher demand for assimilates, which promote the rate of photosynthesis (see Neals 1968). In sunflower seedlings stem — the most actively growing organ at the stage of development under investigation (Starck 1966) actively competes for assimilates with the roots, especially for the limited supply in plants from low light conditions, similarly like in bean plants (part I, Starck 1969). In sunflower this competition may have been connected partly with the lateral transport in the stem and accumulation of ¹⁴C-assimilates outside the translocation stream, mainly as ethanol insoluble substances (Whittle 1970).

In plants with roots accumulating a high proportion of ¹⁴C-assimilates this competition was more pronounced. The effect of preshading limited ¹⁴C-translocation

to the roots (expt No 1), similarly as it has been observed in tomato plants (Kudravec 1964), in bean plants (Starck 1969) and wheat (Wardlaw 1970), but increased migration of assimilates to the stem.

In the case, when in the NL series the activity of roots, as a sink of assimilates was relatively low (as compared with the other experiments), preshading decreased very little ^{14}C -migration to the roots but also increased little that to the stem (like in expt No — 3).

In plants from suboptimal light conditions, the results obtained with labelled substances, may be modified by differences in the rate of respiration which was lower in shaded plants; thus their loss of $^{14}\text{CO}_2$ was probably also lower. Therefore, the differences in migration of ^{14}C -assimilates, in comparable series, are supposedly wider than it results from radioactivity measurement (lower $^{14}\text{CO}_2$ loss in preshaded plants). On the basis of approximative estimations of $^{14}\text{CO}_2$ respired by the roots of NL and shaded plants, the suggestion may be advanced that this error is not so large (the loss of labelled compounds constitutes not more than 1 percent of total radioactivity of the whole plant and about 10 percent of roots radioactivity in the 1 hr period of respiration).

The different amount of $^{14}\text{CO}_2$ expired in the particular experimental series, makes it more difficult to draw conclusions from the results of experiments in the case of sucrose-fed plants.

The effect of sucrose treatment depends probably on the amount of its absorption by the roots and translocation to the upper part. Considering the high rate of ^{14}C -sucrose incorporation into the ethanol-insoluble fraction (expt. 2b), the fact that in most experiments, in the sucrose-treated series, no increase in the content of sugars was found, is not a proof of any sucrose absorption. Taking into account the higher sensitivity of sunflower to the increase of osmotic potential of the nutrient solution, than it was observed with bean plant, some indirect effect of sucrose on the translocation may interfere with the decreased demand for assimilates of roots immersed in sucrose solution.

Supply of sucrose to the roots, especially when they were active sinks, diminished their demand for assimilates from the blades and therefore reduced the competition as it was observed in bean plant. Consequently ^{14}C -migration both to the stem and apical part increased only in some experiments; it may be caused partially by the fact, that the sunflower seedlings in contrast to bean plants, were still partly supplied with organic substances from the cotyledons. In general the reaction of bean plants to sucrose application was more pronounced (part I), but sucrose was supplied them in two times higher concentration (0.075 M instead of 0.037 M). Darkness during ^{14}C -translocation period slightly intensified export of assimilates from the blades, especially to the roots. Also darkening of the whole plant, except the treated with $^{14}\text{CO}_2$ on leaf, increased the export of assimilates from the blade of tomato plant (Khan, Sagar, 1969). The greater proportion of ^{14}C -assimilate migration to the roots in darkness was already observed in soybean (Nelson, Gorham 1957) and in bean plants (Starck 1969).

Habeshow (1970) and Plaut (1969) established that darkening of the whole

plant decreases export of sugars from leaves, but illumination of the source leaf increases the translocation rate of exogenously introduced sucrose. Plaut concluded that light, could regulate the rate of loading of sugars into the phloem tissues and influence the "push" of organic substances from the leaf.

In present experiments after 30 min exposure to light (expt. 4) the photosynthates were probably already loaded into the veins of blades and into the petioles; in the subsequent period (light or dark conditions) the "pull" forces may decide of the migration of assimilates.

The photosynthates export in darkness would be facilitated by the reduction of ^{14}C -incorporation into the ethanol-insoluble fraction in the blades (more ^{14}C -assimilates were mobile).

The changes in ^{14}C -photosynthates metabolism, as a consequence of preshading and sucrose treatment probably also interfere with the translocation process directed, to some extent, by the demand of acceptors, as it has been mentioned in discussion of part I.

SUMMARY

Supply and demand of assimilates in sunflower were modified by 6 and 7 days of shading or by feeding the plants with sucrose through roots. Low light intensity (50% natural light) restricted seriously the growth of the apical part, blades and roots, but much less that of the stem.

Assimilation of $^{14}\text{CO}_2$ was investigated under natural light conditions and ^{14}C -transport—under natural light conditions or in darkness. Reduction of photosynthetic activity in preshaded plants in some experiments influenced the competition for assimilates, and migration to the roots decreased in contrast to that to the stem, similarly as it was observed in bean plants; in others, where roots did not exhibit so strong mobilizing power, the changes in the pattern of ^{14}C -distribution in preshaded plants (as compared with those grown all the time under natural light conditions) were not so strong. In darkness the labelled assimilates migrated in a higher proportion to the roots.

In plants with roots actively accumulating radioactive substances a reduction of their demand for assimilates (by feeding them with sucrose) decreased the share of roots in ^{14}C -transport from the blades, but increased the transport to the stem and apical part as it was observed in bean plant. A very small or even no effect was observed in seedlings with relatively lower activity of the roots as an acceptor of photosynthates as well as in the plants translocating labelled assimilates in darkness. The variable results in the series with sucrose-treated plants may be also due to the sensitivity of sunflower to the increased osmotic potential of the nutrient solution.

REFERENCES

- Habeshaw D. 1969, J. expt. Bot. 20: 64-71.
Johnson C. M. et al. 1957, Plant and Soil. 8: 337-357.
Khan A. A., Sagar G. R., 1969, Ann. Bot. 33: 753-762.
Kudryavtsev V. A., 1964, Fizj. Rast. 11: 409-416.
Nelson C. S., Gorham P. R., 1957, Can. J. Bot. 35: 339-347.
Neales T. F., Incoll L. D. 1968, Bot. Rev. 34: 107-125.
Plaut R. 1969, Aust. J. Biol. Sci. 22: 1105-1111.
Starck Z. 1964, Acta Soc. Bot. Pol. 33: 427-449.
Starck Z. 1966, Bull. Acad. Polon. Sci. Ser. sci. biol. 14: 359-366.

- Starck Z. 1969, Acta Soc. Bot. Pol. 38: 583–600.
Wardlaw J. F. 1970, Austr. J. Biol. Sci. 23: 765–774.
Whittle C. M. 1970, Planta, 95: 247–263.

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

Streszczenie

Przedstawiono wyniki badań, prowadzonych na siewkach słonecznika, dotyczących współzależności pomiędzy zaopatrzeniem roślin w asymilaty a ich dystrybucją.

Zaopatrzenie słonecznika w substancje organiczne modyfikowano poprzez ocienianie roślin w ciągu 6–7 dni, w warunkach 2-krotnie zmniejszonego natężenia światła, (50% NL) lub też poprzez dostarczenie siewkom sacharozy przez korzenie. Asymilację $^{14}\text{CO}_2$ badano w warunkach naturalnego oświetlenia (NL) natomiast transport asymilatów w warunkach NL lub też w ciemności.

W efekcie ocienienia obserwowano bardzo silne zahamowanie wzrostu wierzchołkowej części pędu, blaszek i korzeni, natomiast w najmniejszym stopniu ocienienie wpłynęło na wzrost łodygi, która w tym okresie rozwoju słonecznika jest najaktywniejszym akceptorem asymilatów. Jako efekt ocienienia malała też aktywność fotosyntetyczna słonecznika. Wytworzone w wyniku 30–60 min. fotosyntezy ^{14}C -asymilaty przemieszczały się u roślin ocienionych w mniejszym stopniu do korzeni natomiast w większym — do łodygi, w porównaniu z roślinami serii NL. Ciemność nieznacznie stymulowała eksport ^{14}C -asymilatów z blaszek liściowych, które w stosunkowo większym stopniu były transportowane do korzeni. Mogło to wynikać z obniżenia stopnia ^{14}C -inkorporacji do frakcji związków nierozpuszczalnych w 80% etanolu, co obserwowano w blaszkach i wierzchołkowej części pędu u roślin umieszczonych w ciemności w czasie transportu znakowanych asymilatów.

Efekt egzogennie wprowadzonej sacharozy nie był jednakowy i najprawdopodobniej zależał od wielkości jej absorpcji przez korzenie, jak również od wzajemnego stosunku aktywności poszczególnych akceptorów. W siewkach, w których korzenie wykazywały małą „aktywność mobilizującą” asymilaty, dostarczenie do pożywki sacharozy nie wpływało w zasadniczy sposób na rozmieszczenie znakowanych substancji. Reakcja roślin na egzogennie wprowadzoną sacharozę, w przypadku gdy korzenie były aktywnymi akceptorami asymilatów, polegała na zmniejszeniu transportu znakowanych związków do korzeni i zwiększeniu do łodygi, co najprawdopodobniej spowodowane było zmniejszeniem konkurencji o produkty fotosyntezy.