

Prof. T. Pullaiah,
Professor of Botany,
Sri Krishnadevaraya University,
Anantapur 515003, A.P.

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ROLE OF CARBON ASSIMILATION IN THE PRODUCTION OF DRY MATTER

BY J. J. CHINYOY

(Division of Botany, Indian Agricultural Research Institute, New Delhi)

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As the process of photosynthesis is the main source of dry matter in the plant which ultimately determines its yield a critical survey of its rate under different habitats has considerable ecological significance. The problem is complicated by the fact that the assimilation rate is conditioned by numerous external and internal factors including the catabolic activity, respiration. A consideration of the methods of measuring the assimilatory activity and their value in assessing the production of dry matter is, therefore, necessary.

The methods of investigations readily fall into two groups: (1) the dry-weight methods and (2) the gas-current methods.

In order to obtain a general idea as to the significance of differences in the assimilation rates of plants varying markedly in their internal organisation it would appear important to study the figures for assimilation rates obtained by different workers. Such results have been summarised in Tables I and II. In Table I assimilation rates obtained by dry-weight methods are given together with information regarding temperature source of light and CO₂ concentration. In Table II assimilation rates obtained by gas-current methods have been grouped along with the above information. For the sake of ready comparison the values for assimilation rates are given as milligrams of carbon dioxide per square decimeter per hour. Although the exigencies of space do not permit presentation of a complete list, care has been taken to include almost all the important results.

Dry-weight methods.—Sachs (1884) working with *Helianthus annuus* and *Cucurbita pepo* under natural conditions found by his half-leaf method that the rate of assimilation was on the average 26.4 and 22 mg. CO₂/dm²/hour respectively. Brown and Escombe (1905) have criticised the half-leaf method of Sachs and have tried to determine the rate of photosynthesis by measuring the absorption of CO₂ from

TABLE I

Assimilation rates obtained by dry-weight methods

Investigator	Method	Plant	CO ₂ concentration	Temp. °C.	Light	Assimilation rate mg./CO ₂ /dm ² /hour
Sachs (1884)	Half leaf	<i>Helianthus</i>	Air	25	Sunshine	26.4
do.	Method	<i>Cucurbita</i>	do.	24	—	22.0
Müller (1904)	do.	<i>Nymphaea</i>	do.	—	Illumination changing	36.0
do.	do.	<i>Rumex</i>	do.	—		34.0
do.	do.	<i>Petasites</i>	do.	—	(Natural)	30.0
do.	do.	<i>Helianthus</i>	do.	—		28.0
do.	do.	<i>Nicotiana</i>	do.	—		20.0
do.	do.	<i>Tulipa</i>	do.	—		20.0
do.	do.	<i>Arum</i>	do.	—		16.0
do.	do.	<i>Colchicum</i>	do.	—		18.0
do.	do.	<i>Allium</i>	do.	—		18.0
do.	do.	<i>Helianthus</i>	do.	—		26.0
Thoday (1909, 1916)	do.	<i>Helianthus</i>	do.	27-29	Sunshine	26.0
do.	do.	<i>Catalpa</i>	do.	—	do.	8.0
Weber (1879)	Estimation from the production of dry matter	<i>Tropaeolum majus</i>	do.	—	Illumination changing	6.6
do.		<i>Phaseolus multiflorus</i>	do.	—		4.8
do.		<i>Ricinus communis</i>	do.	—		7.8
do.		<i>Helianthus annuus</i>	do.	—		8.2
Miller (1917)	do.	Dwarf yellow milo	do.	—	Sunshine	26.7
do.	do.	Pumpkin	do.	—	Under field conditions and during the growing season	26.4
do.	do.	Cowpeas	do.	—		12.5
do.	do.	Soybeans	do.	—		11.75
do.	do.	Corn	do.	—		28.0
do.	do.	Kafir	do.	—		22.0
do.	do.	Milo	do.	—	28.0	
Dastur and Chinoy (1932)	Differences in total carbohydrate.	Rice	do.	28-30	Under field conditions	15.6
Chinoy and Sharma (1946)	Half-leaf method	<i>T. vulgare</i> —wheat I.P. 163-4	do.	15-23	Natural illumination of Delhi	22.7
do.	do.	I.P. 52	do.	—		27.7
do.	do.	C. 13	do.	—		24.2
do.	do.	N.S.W. No. C6392	do.	—		34.5
do.	do.	<i>T. Pyramidalis</i> —Buhi	do.	—		35.1
do.	do.	<i>T. vulgare</i> —Greece OC. 7135	do.	—		27.8
do.	do.	Webster	do.	—	do.	29.6

CARBON ASSIMILATION IN PRODUCTION OF DRY MATTER 199

TABLE II

Assimilation rates obtained by gas-current methods

Investigator	Plant	CO ₂ concentration	Temperature °C.	Light	Assimilation rate mg. CO ₂ /dm ² /hour
Giltay (1898)	<i>Helianthus</i> (Wagenigen)	Air	13-27	Illumination changing	5.8
do.	<i>Nicotiana</i> (Wagenigen)	do.	12-29		4.4
do.	<i>Helianthus</i>	do.	28-36	Diffuse light sunlight with canvas screen	7.6-8.0
do.	<i>Cassia</i>		28-35		12.2
do.	<i>Cedrela</i>		28-34		9.0
do.	<i>Nicotiana</i>		31-35		9.0
do.	<i>Acalypha</i>		33-35		7.0
do.	<i>Helianthus</i>		20		6.8
Brown and Escombe (1905)	<i>Tropaecolum</i>	do.	20-25	Intermittent sunshine	3.4
do.	<i>Catalpa</i>	do.	20	Sunlight with screen	6.0
do.	<i>Polygonum weyrichii</i>	do.	20	Excess of light	7.6
Boysen Jensen (1918)	<i>Sinapis alba</i>	0.55 mg. CO ₂ per litre	20	(natural)	12.0
	<i>Senecio silos.</i>		20	..	
	<i>Rumex acetos.</i>		20	9.0	
	<i>Sambucus nigra</i> (Sun leaves)		20	4.6	
Dastur and Chinoy (1932)	Rice	Air	28-30	Artificial illumination	17.58
Blackman and Matthaei (1905)	<i>Helianthus annuus</i>	6.3% CO ₂	30	Strong sunlight	39.0
Willstatter and Stoll (1918)	<i>Helianthus annuus</i>	5% CO ₂	25	48000 lux	55.0 43.0
Dastur and Desai (1933)	<i>Ricinus com.</i>	do.	25	Artificial illumination	19.5
do.	<i>Abutilon asiaticum</i>	do.	36		54.1
do.	do.	do.	25		11.6
do.	do.	do.	34		44.4
do.	<i>Helianthus annuus</i>	do.	31		59.7
do.	<i>Phaseolus vulgaris</i>	do.	36	(1500 watt Osram lamp)	106.7
do.	<i>Phaseolus vulgaris</i>	do.	28		95.9
Chinoy (1935)	Barley (N ₁)	Air	25	Sunlight	25.6
Heinicke and Hoffman (1933)	Apple	Air	..	do.	15.0
Chinoy (1935)	<i>Pelargonium zonale</i>	Air	20	1000 watt Osram bulb	6.82
do.	do.	0.708% CO ₂	do.	do.	36.6
do.	do.	1.03% "	do.	do.	36.0
do.	do.	5.42% "	do.	do.	65.2
Mc Lean (1920)	<i>Musa textilis</i>	Air	do.	Sunlight	1.03
do.	<i>Cocos nucifera</i>	do.	do.	do.	0.67
do.	<i>Sugarcane</i>	do.	do.	do.	5.0
Nutman (1937)	<i>Coffea arabica</i>	do.	do.	do.	4.3
Muller, D. (1932)	<i>Sinapis alba</i>	do.	do.	Artificial light	25.0

TABLE II—(Continued)

Investigator	Plant	CO ₂ Concentration	Temperature °C.	Light	Assimilation rate mg. CO ₂ /dm ² /hour
Lundegardh (1931)	Potato	Air	20	Sunlight	19.1
do.	do.	1.22% CO ₂	30.2	do.	80.1
do.	Tomato	Air	20	do.	16.8
do.	do.	1.22% CO ₂	35.5	do.	60.6
do.	Sugar-beets	Air	20	do.	18.5
do.	Spinach	do.	do.	do.	19.6
do.	<i>Oxalis acetocella</i>	do.	do.	do.	4.8
do.	Cucumber	1.22% CO ₂	36.1	do.	59.8
do. (Walther)	<i>Vicia faba</i>	0.03% CO ₂	20	do.	17.7
do. (Yoshi)	<i>Phaseolus vulgaris</i>	do.	do.	do.	18.5
do. (Johans-son)	<i>Dryopteris austriaca</i>	do.	do.	do.	2.4
do. (Stalfelt)	<i>Picea sylvestris</i>	do.	do.	do.	3.0
do. (Stalfelt)	<i>Picea excelsa</i>	do.	do.	do.	2.0
do. (Burström)	Oats	do.	do.	do.	20.0
Lundegardh (1921)	<i>Oxalis acetocella</i>	0.24% CO ₂	do.	½ Sunlight	12.6
do.	<i>Nemorum</i>	0.03% CO ₂	do.	do.	3.0
do.	do.	0.24% CO ₂	do.	do.	10.6

mg./g. fresh wt.

a continuous gas stream. They showed that considerably higher values are obtained by the dry-weight method. They carried out determinations concurrently on the same material by the dry-weight method as well as gas-current method, and showed that with the former method the rate of assimilation for the leaves of *Catalpa bignonioides* was 6.69 mg./dm²/hour, whereas the rate of formation of carbohydrates calculated from the intake of CO₂ was only 2.35 mg./dm²/hour. Thoday (1909, 1910) has, however, carried out a very critical survey of the dry-weight method of Sachs and has also introduced many improvements. He has shown by his improved method that the assimilation rate for *Helianthus annuus* agreed very closely with that obtained by Sachs for the same plant namely 26 mg. CO₂/dm²/hour. For *Catalpa bignonioides*, he found that the rate was much smaller, namely 8 mg./dm²/hour which agreed fairly well with that obtained by Brown and Escombe (1905) using the dry weight method. The very low assimilation rate obtained by these authors with the gas-current method is attributed by Thoday to the wilted condition of the leaves in the chamber under the influence of strong sunlight. Miller (1917) investigated the dry matter variation during day and night in the leaves of Sorghum (Dwarf yellow milo). 11.2 g. of dry matter was manufactured during the day (5 a.m. to 5 p.m.) per square metre of leaf in excess of that which was translocated and used in respiration. 9.4 g. of dry matter disappeared during night (5 p.m. to 5 a.m.) per square

CARBON ASSIMILATION IN PRODUCTION OF DRY MATTER 201

metre of leaf. If the rate of translocation and respiration is considered to be the same during the day as during the night the total amount of substance produced as a result of the photosynthetic activity is 20.6 g. per square metre of leaf which is 17.1 mg. of dry matter per dm^2/hour if the length of assimilation period is taken as 12 hours per day. This is equivalent to 26.7 mg. $\text{CO}_2/\text{dm}^2/\text{hour}$. Miller has also determined the average rate of photosynthesis for corn, Kafir and milo during the growing season and under field conditions in Kansas. The figures are given in Table I.

The average rate of photosynthesis during a 10-hour period for pumpkin, cowpeas and soybeans was found by Miller to be respectively 26.4, 12.5 and 11.75 mg. $\text{CO}_2/\text{dm}^2/\text{hour}$ under field conditions.

Attention must be drawn here to the fact that the difference in some of the results obtained by dry-weight methods are chiefly due to the translocation of materials in the leaves which are allowed to remain on the plant. Thus Sachs (1884) observed that attached leaves of *Helianthus annuus* showed a much smaller rate of increase in dry-weight than detached leaves. This he attributed to translocation of part of the products of photosynthesis from the attached leaves into other parts of the plant. It seems that there is good deal of evidence to show that translocation takes place during the day as during the night. In support of this Thoday (1910) has cited the results of Broocks. The most interesting feature of Broock's curves is that until noon they indicate a rapid increase of dry matter, but after that the curves begin to fall continuously till the following morning. From this Thoday concludes that translocation is taking place at a nearly uniform rate throughout the period in question. Dastur and Chinoy (1932) have also arrived at a similar conclusion from their experiments to determine the progress of photosynthetic activity of the leaves of the rice plant during the day by taking samples of leaves every six hours and analysing their carbohydrate content. A rapid increase in the products of photosynthesis takes place until 12 noon. The carbohydrate content then falls off gradually until the following morning when it presumably reaches the same level as that found at the beginning of the experiment. From the results of the above workers an estimate of the correction for translocation during assimilation may be made. Thus between 6 a.m. and noon the carbohydrate content increases by 3.16 g. per 100 g. of dry weight (Table VIII, Dastur and Chinoy, 1932) and 17.2 g. per 100 g. dry weight (Table IX) whereas between 6 p.m. and midnight a decrease of 1.73 g. and 13.9 g. respectively occurs. The translocation rate is therefore 55% and 87% of the assimilation rate in the two cases. Assuming that translocation is the same during the day as during the night the assimilation must be 75% higher than the value obtained. Therefore the maximum assimilation rate in their carbohydrate experiments will be 15.6 mg. $\text{CO}_2/\text{dm}^2/\text{hour}$ which agrees fairly with the value obtained by the same workers using the gas current method, namely, 17.58 mg. $\text{CO}_2/\text{dm}^2/\text{hour}$.

It seems, therefore, that the lower results for assimilation rates in attached leaves as compared with detached ones obtained by the dry-

weight method are mainly due to the translocation of the products of photosynthesis especially in plants where the water supply is abundant and as a result of which stomata can remain open to their fullest extent. In the case of plants such as *Catalpa* it seems that the water content of the attached leaves is lower than the detached ones and therefore the partial closure of the stomata might influence the assimilation. Thus Brown and Escombe (1905) observed that much more CO_2 diffused into detached leaves of *Catalpa* than into leaves which were allowed to remain on the tree. Thoday (1910) has carried out observations with the horn hygroscope and observed no differences between the stomatal apertures of attached and detached leaves of *Helianthus*, while on the other hand quite marked differences were observed in the case of *Catalpa bignonioides*.

Gas-current method.—The assimilation rates measured by gas-current methods are generally lower than those obtained by dry-weight methods. Thus McLean (1920) working with the leaves of sugarcane obtained a very low rate of assimilation (about $5.0 \text{ mg. CO}_2/\text{dm}^2/\text{hour}$) by the gas-current method under field conditions using atmospheric air. Other Investigators such as Giltay (1898), Brown and Escombe (1905) and Boysen Jensen (1918) have measured the assimilation rates in sunlight by the gas-current method and have found very low rates ranging from 3 mg. to $12 \text{ mg. of CO}_2/\text{dm}^2/\text{hour}$.

In cases where care has been taken to pass the gas at a fairly rapid rate higher rates have been obtained by the gas current method. Dastur and Chinoy (1932) working with Rice have measured assimilation by the gas-current method using atmospheric air and also by estimating the increase in the total carbohydrates of the plant during a 10-hour period of illumination. The maximum apparent assimilation by the gas current method was found to be 17.58 mg. CO_2 per hour per dm^2 . By the dry-weight method the maximum rate was $8.9 \text{ mg. of CO}_2/\text{dm}^2/\text{hour}$ taking the average dry weight of one square decimeter of leaf surface as 0.4 g. The figure when corrected for translocation became $15.6 \text{ mg. CO}_2/\text{dm}^2/\text{hour}$. Chinoy (1935), Müller (1932) and Lundegårdh (1928) have found even higher rates of assimilation for different plants using CO_2 of the air under natural illumination.

Still higher assimilation rates than those already mentioned above have been obtained by the gas-current method using higher concentrations of CO_2 . Blackman and Mathaei (1905) working with 6.3% CO_2 concentration obtained a rate of $39 \text{ mg./dm}^2/\text{hour}$ for *Helianthus annuus* at 30°C. in strong sunlight. Willstätter and Stoll (1918) however obtained a rate of $55 \text{ mg./dm}^2/\text{hour}$ for the same plant in a 5% CO_2 concentration and at 25°C. with a light intensity of 48000 lux. Working under the same conditions but with an atmosphere of 4% CO_2 they obtained a rate of $43 \text{ mg./dm}^2/\text{hour}$ for *Cucurbita pepo*. Dastur and Desai (1933) have measured the assimilation rates of some tropical plants using a 5% concentration of CO_2 and a 1500 watt gas filled lamp as the source of illumination and obtained even higher rates (Table II).

CARBON ASSIMILATION IN PRODUCTION OF DRY MATTER 203

Chinoy (1935) working with different concentrations of CO_2 and 1000 watt Osram bulb succeeded in increasing the rate of assimilation in *Pelargonium zonale* to 65 mg. $\text{CO}_2/\text{dm}^2/\text{hour}$.

Discrepancies in the gas-current method.—Before discussing the role of assimilation in the production of dry matter attention may be drawn to some of the difficulties involved in the estimation of assimilation rate by the gas-current method. The divergence between the results obtained by some workers such as McLean, Boysen Jensen, Brown and Escombe and others on the one hand and those obtained by Dastur and Chinoy, Lundegårdh, Chinoy and others on the other may perhaps be attributed to the failure on the part of the former to realize the importance of certain experimental conditions, such as (i) the size of the assimilating leaf surface, (ii) the rate of gas flow, and (iii) morpho-physiological status of the leaf.

(1) The assimilating leaf surfaces in experiments with gas current methods have been generally too large for the rate of supply of air so that gas coming into contact with the leaf has been almost depleted of CO_2 . Thus in Boysen Jensen's work as Kostychev (1931) has pointed out the air leaving the leaf chamber was almost entirely free of CO_2 . To obviate this difficulty it would be necessary to pass an extremely rapid flow of air which in its turn raises the problem of complete absorption of CO_2 after its passage through the leaf chamber. This discrepancy can, however, easily be removed by reducing the assimilating leaf surface.

(2) Kostychev and his collaborators (1927, 1928) state that the rate of supply of air should be at least one litre per square centimetre of the leaf surface per hour to obtain maximal assimilation rate. Boysen Jensen and Müller (as quoted by Nutman, 1937) suggest that the outgoing air should have at least two-thirds of the normal carbon dioxide content. Heinicke and Hoffman (1933) found a reduction of about 15% in the carbon dioxide content of air when an air-flow of 2.51/sq. cm./hour was used. Under these conditions he obtained a rate of 15 mg. $\text{CO}_2/\text{dm}^2/\text{hour}$ for apple leaves. Nutman (1937) used very low rates of supply of air in his experiments on *Coffea arabica*, viz., 0.25 litre/sq. cm./hour and obtained very low rates of assimilation averaging only about 2.0 mg. $\text{CO}_2/\text{dm}^2/\text{hour}$.

In the experiment recorded by Chinoy (1935) the supply was somewhat less on the average than the limit suggested by Kostychev, *et al.* and although an assimilation rate of 25.6 mg. $\text{CO}_2/\text{dm}^2/\text{hour}$ was obtained it is doubtful whether the maximum assimilation rate was reached.

(3) The leaf chamber used by many investigators have often been disproportionately large and deep so that much of the air entering the chamber failed to come into contact with the assimilating leaf surface and consequently passed out without its CO_2 having been utilised for assimilation. This in effect comes to the same thing as passing the stream of air at a very slow rate over the leaf and thus reducing assimilation.

(4) Last but not the least the morpho-physiological status of the assimilating leaf is very important in determining the level of assimilation. Failure to realize the importance of this condition very much reduces the value of results obtained by many of these workers. Discussing this question at length Richards (1934) has pointed out that many workers have made the assumption that "the successive leaves produced by a plant, if taken at corresponding stages, form a uniform population whose distribution is determined entirely by chance causes and that there are no general drifts dependent on the time during the life-history of the plant at which the individual organs are produced". This assumption, he says is unwarranted in the light of results obtained by Gregory and his collaborators (Gregory and Richards, 1929; Richards, 1932; Mathur, 1932; Chinoy, 1935; Verma, 1935).

DISCUSSION

The foregoing survey of results obviously raises questions of fundamental and practical significance which may be stated thus: (1) Is there a real difference in the inherent capacity of plants growing in different habitats for assimilating carbon dioxide? and (2) Is the assimilatory capacity of different crop plants so different as to cause difference in the rate of production of dry matter? Boysen Jensen (1918), Lundegårdh (1931) and others have ascribed differential efficiency of carbon assimilation to sun and shade plants at comparable light intensity and CO₂ concentration. Lundegårdh (1931) observed in the case of shade plants, *Oxalis acetosella*, *Melandrium rubrum*, *Circea alpina* and *Stellaria nemorum*, that the assimilation rate was proportional to the light intensity about 1/10 that of a clear day in July. In the case of sun plants, *Nasturtium palustre* and *Atriplex liastatum*, on the other hand the proportionality between the rate of photosynthesis and light intensity was maintained upto a much higher level of the latter (0.7 that of full sunlight). Lubimenko (as quoted by Miller, 1938) also found greater efficiency in the case of shade plants compared to sun plants at lower intensity of illumination. Lundegårdh (1931) has even made a mention of intermediate grades between typical shade and sun plants. The same worker, however, working with a higher concentration of CO₂ and $\frac{1}{4}$ intensity of sunlight has obtained very much higher assimilation rates for the shade plants, *Oxalis* and *Stellaria* (quoted from Spoehr, 1926, pp. 126), viz., 12.6 and 10.6 mg. CO₂/dm²/hour respectively. It, therefore, appears that even in the case of shade and sun plants the difference in the assimilation rates can be reduced considerably under a suitable combination of environmental factors.

In order to elucidate the second question a mention must be made here of the method of estimating net assimilation rate first suggested by Gregory in 1917 (quoted from Gregory, 1926). It is analogous to the unit leaf rate of Briggs Kidd and West (1920, 1920 a) and is calculated by dividing the difference in total dry weights of two consecutive samples by the average leaf area (or leaf weight) during the period and correcting for time.

CARBON ASSIMILATION IN PRODUCTION OF DRY MATTER 205

A reference may also be made here to the work of Boysen Jensen (1918), Müller (1932) and others on "Trockensubstanz production". Heath and Gregory (1938) have pointed out the inadequacy of using "Substanzquotient" as an index for the estimation of dry weight accumulation for ecological studies, and this for two reasons, one of which, *viz.*, the conditions operative in the determination of assimilation rate by CO_2 uptake has already been discussed above. The second objection as pointed out by these authors is dependent on two factors: (a) net assimilation rate and (b) the rate of growth of the leaf surface. In the determination of the "Substanzquotient" the second aspect of dry weight increase is overlooked. Gregory (1926) has shown in the case of barley plant that increase in dry weight accumulation on nitrogen manuring is not due to an increase in net assimilation rate but is brought about by an increase in leaf surface. Gregory and Richards (1929) and Chinoy (1935) have corroborated this fact by observing that assimilation rate in barley grown even under extreme nitrogen deficiency was not lower than that found for the fully manured plant.

From the point of view of the production of dry matter it would be of interest to compare net assimilation rate with assimilation rates obtained by other methods. From the data presented by Chinoy (1935) it is seen that the average assimilation rate for fully manured barley plant is $19.85 \text{ mg. CO}_2/\text{dm}^2/\text{hour}$. 13.54 mg. of carbohydrates are therefore formed per hour per dm^2 , *i.e.*, by 0.361 gm. dry weight of leaf. During the course of the day therefore one gm. of dry leaf material would produce 0.602 gm. of organic matter if the average period of illumination is taken as 16 hours during the summer in Great Britain. From this figure losses due to respiration during the 8 hours of darkness should be deducted to obtain the value for net gain per day. There is no correction to be made for respiration during the 16-hour assimilation period as the figure taken for calculation is that of apparent assimilation. The average temperature during the night is $15\text{--}17^\circ \text{C.}$ and the average respiration rate at that temperature works out to be approximately 5 mg. per hour per gm. dry weight from the data given by Gregory and Sen (1937). The total loss therefore, during the 8-hour period, is 40 mg. On the basis of these calculations the real gain in the organic matter is 56.04% of the dry weight of the leaf per day. At this rate, therefore, it seems that the plant would add three or four times its own weight during the course of a week. On examining the growth data of barley collected over a number of years by Gregory and his collaborators (Gregory, 1926, 1937; Mathur, 1932; Verma, 1935) this is found to be the case in the first 2 or 3 weeks of growth.

The mean value of net assimilation rate over a period of four years obtained by Gregory (1926) for barley growing out of doors in pots at Rothamsted is 0.546 gm. dry matter per square decimeter of leaf surface per week. The percentage production of dry matter in this case works out to be 21% per day. In other words, at this rate the barley plants adds about one and a half times its weight of dry matter

during a week. Working out the hourly rate of assimilation from the above net assimilation data figure of about 5 mg. CO₂/dm²/hour is obtained which is about one-fourth the value obtained by the gas-current method.

It would be well to remember at this stage the fact that values obtained by the gas-current method would tend to be higher than those of net assimilation rates because the assimilation rate of a selected part of the leaf is measured during the period of maximum light intensity in the former case, while in the latter, the calculations are based on the average performance of all leaves, young, mature and senescent. Again in the former case the air is passed over the leaf at a very rapid rate, whereas the net assimilation data are derived from leaves supplied by diffusion and convection air currents under natural conditions.

Heath and Gregory (1938) have recently reviewed the work done on net assimilation rate and have come to the conclusion that "it is a remarkable fact which needs further investigation that plants as different as are barley, mangolds, cotton, and tomato, and in such diverse environments as out of doors in England and in Africa and under glass in England should all have the same mean net assimilation rate during their vegetative phase". They consider this constancy of net assimilation rate as of fundamental significance.

Considering the above fact and re-valuating the data given in Tables I and II in the light of what has been already discussed it appears that the inherent capacity for carbon assimilation of different plants (especially of crop plants) is of such an order that it can rarely become a limiting factor in the production of dry matter.

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CARBON ASSIMILATION IN PRODUCTION OF DRY MATTER 207

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