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# THE INFLUENCE OF MULCHATION OF THE SOIL ON THE CARBONIC ACID BALANCE OF COTTON FIELD

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**Abstract**

In a field experiment, located on Old Typical Sierozems, conducted studies to determine the components of the carbon dioxide balance of the "cotton – soil – atmosphere". In a field experiment studied two options: open soil (control) and with perforated polyethylene film mulching of soil. Irrigation of cotton varieties "Navruz" (*G. hirsutum* L.) were carried out with water supply to 50% of cover furrows. On an experimental version in working furrow was packed film with water discharge 6 mm diameter holes and step 1 m. Sampling of soil emitted air was performed using small respirometers installed in ridges furrows.

Determination of $CO_2$ in the soil air was carried out on a gas chromatograph LHM-8M. To determine the mass of $CO_2$ assimilated cotton used the balance equation. Calculations revealed that the cotton field with open soil uses photosynthesis to 4 t/ha field with plastic mulch 8 t/ha. The origins of $CO_2$ from bare soil are 21.5 t/ha of mulch 16.9 t/ha.

**Key words:** balance, furrow, mulching, soil, respirometer, carbon dioxide, photosynthesis, cotton

As it is well known, that as a result of anthropogenic influence the increasing amount of hotbed gases penetrate into the atmosphere, among which the considerable amount comprises carbonic acid gas. It is very important for biosphere owing to its double display. The 1st is that as well as hotbed gas, penetrating into the atmosphere pollutes it, increasing the harmful hotbed effect. The 2nd is that it plays the exceptional role in the process of photosynthesis. In the process of photosynthesis such elements of biosphere as: soil, plants, atmosphere supply the existed population with food products and the industry with raw materials.

Under modern conditions in the connection with the increase of concentration of carbonic acid gas in the atmosphere the acute necessity of decreasing the source of $CO_2$ into atmosphere is rather topicable. Together with strengthening of demands to the industry of developed countries for decreasing of splash of carbonic acid gas into atmosphere, in agriculture there is also developed the trend on reducing the emission of $CO_2$ from the soils of agricultural purpose, which foresees, mainly, the transition from plough tillage of the soil to zero or minimum. The second direction, which is developing in some countries with developed irrigation, foresees an all-year-round employment of irrigated lands for cultivation agricultural crops.

As an example of such trend can serve the experience of Uzbekistan, which means that even under conditions of shortage of irrigated waters it is possible to get high yields of winter wheat, if to sow it on the growing cotton-plant soil at the end of vegetation period without plunging the soil.

As the process of photosynthesis of green plants takes place with participation of carbonic acid gas, it is important to value the possible change of its balance in the system of "cotton – soil – atmosphere" by reducing the share of $CO_2$ imitated by the soil, and increasing the share of $CO_2$ from the atmospheric air. The application of mulchation of the soil with airtight materials gives such an opportunity.

The analysis of the world experience of soil mulchation shows that the most available for reducing $CO_2$ emission from the types of soil mulchation are: from organic group-the straw of winter wheat, rice straw and paper; from mineral group-polyethylene film.

Longstanding researches on the typical greysoils with planted cotton-plant ascertained, that the effectiveness of soil mulchation with craftpaper, the straw of winter wheat, polyethylene film (Bezborodov, 1998; 2005; 2007; 2008) consists in economy of irrigated water (20 – 40%) in the addition to the yield-capacity of cotton plant (15 – 20%).

## MATERIAL AND METHODS

Methodics of determination of mass of emitated carbonic acid from the soil.

For determination of the concentration of carbonic gas, discharged by the soil during the period of cotton vegetation it is necessary to select the probe of soil air and then with the help of chromographical method to determine the content of carbonic acid in it. For selection of soil air there were made small respirometers.

The small respirometer presents the cupola with neck with 0.5 L capacity with diameter of bottom 9 cm, on the neck of respirometer there is installed the cork tap. The respirometer is pressed into the soil on the furrow ridge between cotton-plants, the soil around it is compressed and covered with polyethylene film.

After definite time with the help of expositions from respirometer there is carried out the selection of probes of soil air. For this purpose there is prepared 10% solution of boiled water with cooking salt, it is poured into the vessel on the neck of which is put on a supple hose with cork tap. This tap is joint to the suffer of the tap on respirometer. Both taps are opened and the working solution fills the respirometer. And here there occurs the ousting of soil air into the vessel. When there is left approximately 20 – 25 g of solution, the taps are closed and the vessel with soil air is separated from the respirometer.

Then the vessel together with hose and tap is plunged into the bucket with the neck down to the depth of 3 – 4 cm. In this position there is fulfilled the separation of the tap with hose from the neck of the vessel and plastic cork with thread is twisted on it. Then the vessel with soil air in the position "neck down" is transported to the laboratory with gas chromatograph. The content of carbonic acid gas, oxygen and nitrogen is determined on it.

The results of gaschromatographic analysis of $CO_2$ are presented in volumetric per cents. In order to determine the volume of $CO_2$ emission from the soil into atmosphere in conformity with these results it is necessary first to determine the mass of $CO_2$ in respirometer with the volume of 0.5 L. The following ratio is made for that **22.4 L + 44 g/0.5 L – xg**. In which according to the law of Avogadro 1 mol of any gas occupies the volume of 22.4 in this ratio the figure 44 means the mass of 1 mol of carbonic acid gas, in which the atomic mass of carbon (C) molecula equals to 12 g and the mass of oxigen ($O_2$) molecula equals to 32 g. From the given correlation the mass of calculation comprises the following.

After determination of aversive weighed sense of the content of $CO_2$ in the soil surface layer of air equaled to 0.03% is taken for initial sense. According to obtained sense there is determined the mass of emitted $CO_2$ into atmosphere (into the respirometer). The mass of $CO_2$ in the probe is determined from the correlation:

1 g – 100%x – $Cco_2$,

where: $Cco_2$ is the concentration of $CO_2$ in respirometer in volume per cent.

Then there is determined the intensity of discharging of $CO_2$ by the soil with 1 $m^2$ of sowings of cotton-plant. For this purpose there is made such correlation:

**M** *aver/$CO_2$* **G** 0.0064 $m^2$/x – 1 $m^2$,

where: M *aver/$CO_2$* is an average mass of $CO_2$ bet-ween 2 measurements in respirometer; **G** 0.0064 is the area of soil surface of cotton field, covered by respirometer, $m^2$; x is the intensity of discharging of $CO_2$ by the soil g/$m^2$ per an hour. Then there is determined the average weighed sense of intensity of discharging $CO_2$ by the soil during the vegetative period of cotton-plant.

The mass of $CO_2$ emission from the soil into atmosphere is calculated according the dependence

$$M\ CO_{2n} = [Cco_2 \times Tveg \times 24 \times 10^4] : 10^6 = = 0.24\ Cco_2 \times T, \quad (2)$$

where: M $CO_2$ is the mass of discharged $CO_2$ t/ha during the vegetation period of cotton-plant; $Cco_2$ - average weighed intensity of $CO_2$ discharging by the soil g/$m^2$ per an hour during the vegetation period; Tveg - the duration of vegetation period of cotton-plant/a day; 24 - the number of hours a day; $10^4$ - the transferring coefficient from g into ton.

**The methodic of determination of the size of assimilated carbonic acid in the process of photosynthesis**

For determination of the size of $CO_2$ assimilated by cotton-plant during different phazes of growth and development of cotton-plant there were applied materials, given in works of Hodjaev (1983) and Kasparov (2006).

According to one data there is determined the average weighed intensity of absorption of $CO_2$ by cotton plant during vegetation period and then the mass of $CO_2$ absorbed by cotton-plant in the process of photosynthesis according to the dependence

$$M^F_{CO_2} = Y_{CO_2} \cdot Tvegp \cdot \Omega_{x3} \cdot 10^{-9}, \quad (3)$$

where: $M^F_{CO_2}$ is the mass of absorbed $CO_2$, t/ha;$Y_{CO_2}$- the average weighed intensity of absorbation of $CO_2$ by cotton-plant mg/dm$^2$ an hour; Tveg - the duration of sun shining during vegetation period of cotton, an hour; $\Omega_{хл}$- the area of leaf surface of cotton-plant dm$^2$/ha; $10^{-9}$ - coefficient of transmission mg into t according to other data, where the intensity of absorption of $CO_2$ is expressed in mg from 1 bush of cotton-plant for an hour, the mass of absorbed $CO_2$ is determined according to the dependence.

$M^F_{CO_2} = Y_{CO_2} \cdot Tveg.p \cdot 10^{-9}$, where N is the number of plants of cotton-plant per 1 ha.

## RESULTS AND DISCUSSION

### *The discharging of carbonic acid gas by the soil*

The participation of carbonic acid gas in the system of soil-plant-atmosphere is described by the following balance equation.

$$M^F_{CO_2} = m^{resp}_{CO_2} + m_{CO_2} + M^{atm}_{CO_2} \quad (1)$$

$M^F_{CO_2}$- the mass of carbon acid gas by the soil and assimilated by cotton-plant in the process of photosynthesis, t/ha;

*$CO_2$* - the mass of carbon acid gas, assimilated by cotton-plant in the process of photosynthesis from atmospheric air t/ha;

$M^{resp}_{CO_2}$- the mass of carbon acid gas, emitated by the soil into atmosphere in process of air exchange t/ha;

$m^{FD}_{CO_2}$ - the mass of carbon acid gas, spent for photorespiration of cotton-plant t/ha.

For determination of $CO_2$ emitated by the soil of cotton field in 2012 there was laid the field experiment, situated on oldly irrigated heavy loamy typical grey soils on experimental farm of scientic research institute of cotton-growing (Kibray district of Tashkent region of the Republic of Uzbekistan). During the field experiment the dinamics of $CO_2$ in the process of soil respiration was studied in 2 variants from the open soil and from the soil 50% covered with dark polyethylene film with the thickness of 10 mkm. The film with water-discharging holes with diameter of 6 mm and pace of 1 m is layed in the interrows of cotton-plant with the wideth of 60 cm on every other interrow, fully covering it. The watering of cotton-plant in both variants was carried out in every other interrow and so, approximately 50% of crop area is moistened. The experiment was conducted in 3 times repeatedness. The size of plot of each variant included 8 rows of cotton plant with the length of 50 m the area of one plot comprised 120 $m^2$.

The waterings were carried out up to the humidity of soil 70-70-60% NA.

The selection of soil air probes with small respirometers was conducted every hour (at 12 o'clock of local time) and in 23 hours also at 120 o'clock in the afternoon. The results of the measurement of the content of carbonic acid gas, discharged by the soil in the process of respiration are given in the Table 1.

As it is seen the content of $CO_2$ in soil air of experimental variant decides the first initial determination is higher than control.

According to the data of Table 1 there was made the calculation of mass of carbonic acid gas, emitated to the atmosphere by the soil in the process of air exchange.

According to data of Table 2 there are calculated average weighed senses of emitated carbonic acid gas into atmosphere from the soil of controlled variant – 0.53 g/m$^2$ an hour and experimental – 0.76 g/m$^2$ an hour according to these senses there was determined the mass of carbonic acid gas, emitated into atmosphere from 1 ha of crop area of cotton-plant during 130 days for the control variant it comprised $M_{CO_2}^{resp}$ = 16.5 t/ha. Taking into consideration that in the second variant half of the surface is covered with air impenetrable film, the mass of emitated $CO_2$ will comprise 11.9 t/ha. Thus, from the soil, covered with mulchated polyethylene film the carbonic acid gas goes up to the atmosphere 4.6 t/ha (27.9%) less, than from the open soil. It is possible to calculate the mass of $CO_2$ absorbed by cotton-plant during the vegetation period with the data of measuring of intensity of photosynthesis during of the content of carbon in all the plant (land surface and underground parts) in the mass of assimilated carbonic acid gas.

The mass of absorbed carbonic acid gas by cotton-plant is determined according to data of Hodjaev (1983), according to which the cotton-plant of early ripening sort C4727 absorbs $CO_2$ during the phase of bud formation with the intensity of 13 mg/dm$^2$ an hour, during the phase of flowering – 22 mg/dm$^2$ an hour, during the phase of fetus formation – 20 mg/dm$^2$ an hour. According to these data, taking into consideration the duration of vegetation of absorption of $CO_2$ by cotton-plant equal to 15.4 mg/dm$^2$ an hour.

Taking into consideration FAO-56 there is determined the duration of sun radiance during period of vegetation of cotton-plant equal to 1420 hours.

According to the results of analysis of the dinamics of leaf surface of cotton-plant under conditions of field experiment there was determined the area of leaf surface of cotton field of 1.3 ha.

Using the formula of calculation of absorbed carbonic acid gas by cotton-plant in the process of photosynthesis there was determined the mass of absorbed $CO_2$ equal to 26 t/ha.

As is seen, in the calculation of phase and average weighed intensity of photosynthesis there was used the indicator of leaf surface on the area of 1 ha.

In the researches of Kasparov (2006) there was used the indicator of photosynthesis of one bush of cotton-plant. The author carried out researches on photosynthesis on the example of late ripening cotton-plant of 108-7 sorts out early ripening lines.

The dynamics of photosynthesis during different phases of development of cotton-plant is presented by mathematical models in the form of dispetional equation with high sense of coefficient of authenticity (Table 3) hot hours of the day whole, one size numbers from 8 till 20 the intensity of photosynthesis of one bush of cotton-plant mg $CO_2$ h.

As it is seen, the intensity of photosynthesis of late ripening high-needed cotton-plant of 108-F sort during all the phases of development is higher than that of early ripening cotton-plant.

For cotton-plant of 108-F sort there is calculated the average weighed intensity of photosynthesis, equal to 2145 mg $CO_2$ from 1 bush an hour. At the thickness of standing of cotton-plant of 90 thousand/ha the mass of assimilated $CO_2$ during 130 days will comprise 25.1 t/ha. Thus, the determined the mass of physiologists comprises 25 – 26 ha. For calculation of absorbed $CO_2$ by cotton-plant there was used the method based on the content of carbon in the dry mass of the whole plant.

According to data of Belousov (1964), the dry mass of onland part of one bush of cotton-plant comprises 257.8 g, among them stems and branches – 31.6 g, leaves 40.4 g, leaflets 49.0 g fallen fruit elements – 18.6 g, raw cotton-plant – 118.3 g. So, the correlation between productive part of plant (raw cotton-plant) and unproductive ones (all other organs) comprise 0.85%, which means the prevalence of unproductive mass of the bush over productive to 15%.

The energy expended by the plant is also spent for the development of root system. Therefore, according to data of Ashraliev, Karimov (1988), the dry mass of root system of cotton-plant depends on agrotechnics, at standard in the soil layer of 0 – 60 cm it comprises 18 g per one plant.

It should be marked that the depth of spreading the root system of cotton-plant is not limited by 60 cm, taking into consideration, that in amorphous soils it reaches 1 m, and in hydromorphous ones even 1.5 – 2.0 m. 26.44/12 = 9.5 t/ha

For Typical Grey Soil Mukhamedjanov, Suleymanov (1978) bring forward diffent contradicting facts.

Table 1. The content of $CO_2$ in discharged air by the soil

| Variants | Dates of taking probes from soil air | | | |
|---|---|---|---|---|
| | 4.06 | 4.07 | 4.08 | 7.09 |
| Control (1 hour) | 0.03 | 0.73 | 0.09 | 0.44 |
| Control (24 hours) | 0.16 | 0.73 | 0.13 | 0.35 |
| Experimental (1 hour) | 0.16 | 0.79 | 1.86 | 0.19 |
| Experimental (24 hours) | 0.09 | 1.07 | 0.13 | 0.47 |
| Average weighed | | | | |
| Control | 0.15 | 0.71 | 0.13 | 0.37 |
| Experimental | 0.09 | 1.06 | 0.20 | 0.46 |

Table 2. The mass of the average

| Date of measurement | The interval of time between measurements a day | Average weighed $CO_2$ in concentration, % | The concentration of emitated $CO_2$, % an hour | Emitated $CO_2$, g | Sense of $CO_2$, mass g | The intensity of discharging of $CO_2$ by the soil, g/m an hour |
|---|---|---|---|---|---|---|
| Control variant | | | | | | |
| *4. VI* | | 0.15 | 0.12 | 0.0012 | | |
| | 30 | | | | 0.0040 | 0.63 |
| *4. VII* | | 0.71 | 0.68 | 0.0068 | | |
| | 31 | | | | 0.0039 | 0.61 |
| *4. VIII* | | 0.13 | 0.10 | 0.0010 | | |
| | 30 | | | | 0.0022 | 0.34 |
| *7. IX* | | 0.37 | 0.34 | 0.0034 | | |
| Experimental variant | | | | | | |
| *4. VI* | | 0.09 | 0.06 | 0.0006 | | |
| | 30 | | | | 0.005 | 0.86 |
| *4. VII* | | 1.06 | 1.03 | 0.0103 | | |
| | 31 | | | | 0.0060 | 0.94 |
| *4. VIII* | | 0.20 | 0.17 | 0.0017 | | |
| | 30 | | | | 0.0030 | 0.47 |
| *7. IX* | | 0.46 | 0.43 | 0.0043 | | |

Table 3. Mathematical models of the day dynamics of photosynthesis of cotton-plant

| Genotype of cotton-plant | Phenophase | Mathematical model | Coefficient of authenticity |
|---|---|---|---|
| 108-F | bud formation | $y = 3.90x^2 + 110.4x – 596.4$ | $R^2 = 0.96$ |
| Line-3 | | $y = -3.51x^2 + 96.2x – 509.3$ | $R^2 = 0.94$ |
| 108-F | flowering | $y = -7.53x^2 + 209.6x – 1085$ | $R^2 = 0.99$ |
| Line-3 | | $y = -6.25x^2 + 166.8x – 805.7$ | |
| 108-F | fetus formation | $y = -9.26x^2 + 246.8x – 1222$ | $R^2 = 0.98$ |
| Line-3 | | $y = -5.62x^2 + 149.6x – 723.2$ | $R^2 = 0.95$ |

Table 4. The mass of dry matter and carton in organs of cotton-plant, g/plant

| The organ of cotton-plant | Dry mass* | The content of carbon | |
|---|---|---|---|
| | | %** | G |
| Stem | 31.6 | 27 | 8.5 |
| Leaf | 40.0 | 30 | 12.0 |
| Leaves | 49.0 | 19 | 9.3 |
| Fallen organs | 18.6 | 27 | 5.0 |
| Raw cotton-plant | 118 | 40 | 47.2 |
| Root system | 18 | 40 | 7.2 |
| Sum total | 275.2 | 32.5*** | 30.9*** |

Data Belousov (1964); Data of M. Wasti (2011).

Thus, according to their data, the weight of root system of one plant (it is meant cotton-plant) in the layer of 0 – 70 cm by the end of vegetation period comprises about 7 – 9 g of air-dry mass. At the dampness of the soil of 75-80-65% NV and 9 watering at 2 plants of cotton-plant in one nest the root system comprised 1.83 t/ha at the dampness of the soil of 60-65-65% NV – 1.25 t/ha. The average sense of this indicator comprises 1.54 t/ha, which is in conformity with data Ashraliev and Karimov (1988). On the base of adduced data there was determined the content of carbon in organs of cotton-plant (Table 4).

As it is seen, the average sense of the content of carbon in one plant of cotton-plant comprises 30.9g. On the base of this sense it is possible to determine the mass of carbonic acid gas, assimilated by cotton-plant in the process of photosynthesis. Thus, at yield-capacity of cotton-plant of 3 t/ha the dry mass of unproductive organs of cotton-plant will comprise 3: 0.85 = 3.5 t/ha, and total onland and underground parts-the mass will comprise 3 + 3.5 + 1.5 = 8 t/ha. Then the content of carbon in this mass will be equal to 8 x 0.325 = 2.6 t/ha. Taking into consideration the mass of carbonic molecules (12 a.c.m) and carbonic acid gas (44 a.c.m) the equivalent content of carbonic acid gas will comprise

$$26 \cdot \frac{44}{12} = 9.5 t / ha$$

The photosynthetic process, as any other one, is characterized by definite coefficient of efficiency at photosynthesis. According to data of Nechiporovich et al. (1961) it equals to 0.5 according to data of Voznesenkiy (1977) – (0.5 – 0.68), according to data of Maximov (1958), under normal conditions the plants spend 15 – 20% of carbon and energy for breathing, according to data of Naumov (1988), in plants of steppe zones the expenditure for breathing reaches 40 – 60% of total photosynthesis.

As in the arid zone during vegetation period of cotton-plant the daily temperature of air reaches $+45^0$ and higher, the discharging of carbonic acid gas begins to

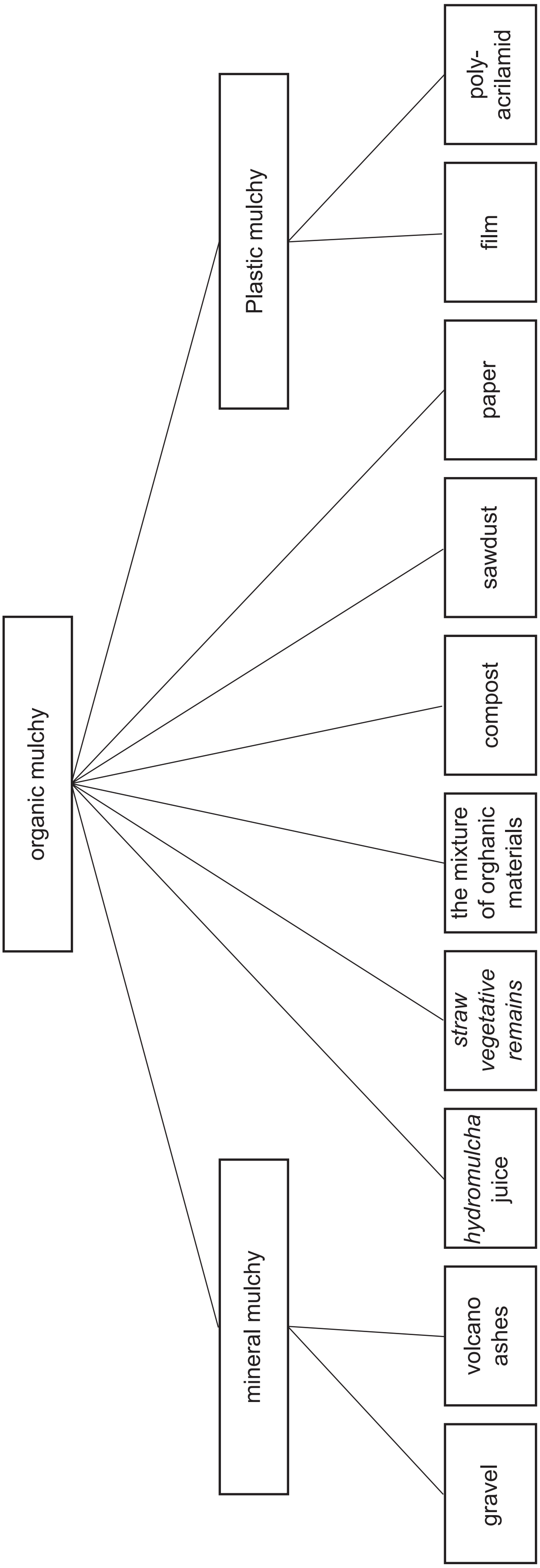


*Fig. 1. In the blocks there are shown the tried types of mulchy by italics*

exceed its assimilation and it makes it possible to consider that about 40% of assimilated $CO_2$ is converted into organic matters of plant tissues. On this base there was determined the mass of carbonic acid gas, assimilated by cotton-plant in the process of photosynthesis, equal to 9.5: 0.4 = 23.7~24 t/ha. At the yield-capacity of raw cotton-plant of 3.5 t/ha, the dry mass of bush organs will comprise – 3.5 + 4.1 + 1.5 = 9.1 t/ha, carbon 9.1 x 0.325 = 2.96 t/ha, carbonic acid gas – 10.9 t/ha NETTO, 27.3 t/ha BRUTTO (true photosynthesis) thus, the mass of $CO_2$, assimilated by cotton-plant, depends on the size of yield of onland mass.

The comparison of obtained marks of the mass of assimilated carbonic acid gas by cotton-plant (25 – 26 t/ha) and emitated by the soil $CO_2$ shows, that in the variant of experiment with the open soil the share of $CO_2$ comprises about 65% and in the variant with mulchation of the soil is about 77%. The results of conducted researches make it possible to make and approximate balance of carbonic acid gas in the system *soil – cotton field atmosphere*.

In the adduced above balance equation of carbonic acid gas there are 2 unknown values: $MCO_2^{atm}$ and $MCO_2^{F9}$. The mass of expended for photorespiration of plants is valued differently. According to data of Maximov (1958), the respiration of plants comprises no more than 50 – 10% of photosynthesis. According to data of Naumov (1988) in vegetable association of steppe zone the expenditures for respiration comprise 40 – 60% of total photosynthesis. Voznesenskiy (1977) considers that some desert plants discharge 40% of assimilated $CO_2$ by respiration. Nichiporovich (1961) together with his colleagues affirm that the expenditure of photosynthesis products for respiration can reach 15 – 20% and even more. According to data of Bikhele et al. (1980) the respiration of agricultural plants (cotton-plant, sugar beet) in darkness and lightness comprises about 40% of photosynthesis, according to data of Nasirov (1982), the losses of assimilated carbon at photorespiration reach 50% of pure productivity of photosynthesis.

**CONCLUSIONS**

Taking the photorespiration in the volume of 20% of photosynthesis, the mass of carbonic acid gas, expended by cotton field for this process will comprise 5 t/ha. Then the total mass of the source of $CO_2$ (the right part of balance equation) will comprise:
for open soil 16.5 + 5 = 21.5 t/ha;
for mulchated one – 11.9 + 5 = 16.9 t/ha.

The unknown value of balance equation $MCO_2^{atm}$ the mass of carbonic acid gas, assimilated by cotton-plant from atmospheric air will be determined according to difference:

$$MCO_2^{atm} = MCO_2^{F} - MCO_2^{resp} - mCO_2^{FD} \quad (4)$$

and will comprise: for open soil 4 t/ha:
for mulchated – 8 t/ha.

So, as a result of photosynthesis cotton-plant uses most part of carbonic acid gas from the soil air, and mostly from the open soil, than from mulchated correspondingly mostly cotton plant uses carbonic acid gas from atmospheric air, which contributes to reducing from atmospheric air, which contributes to reducing of the concentration of carbonic acid gas in atmosphere.

One more important dignity of such agrotechnical method is mulchation of the soil with air impenetrable material at cultivation.

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## Влияние на мулчирането на почвата върху въглероднокиселинния баланс в памуково поле


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**Резюме**

За определяне на въглероднокиселинния баланс на системата „почва – памук – атмосфера” е проведен полски опит с памук сорт „Навруз” на почвен тип Old Typical Sierozems. Изпитвани са два варианта – с открита почвена повърхност (контрола) и мулчиран участък с перфорирана полиетиленова лента. Поливането на памуковия сорт е извършвано с подаване на вода в 50% от браздите. При опитния вариант в работните бразди е полагана лента с водоизпускащи отвори с диаметър 6 mm, разположени на разстояние 6 m. Вземането на проби от отделения от почвата въздух е извършвано с помощта на малки респирометри, поставени в гребена на браздата. Определянето на съдържанието на $CO_2$ в почвения въздух е извършвано с газов хроматограф ЛХМ-8М. За определяне масата на асимилирания от памука $CO_2$ е използвано балансово уравнение.

Установено е, че памуковото поле с открита почвена повърхност използва за фотосинтеза 4 t/ha $CO_2$, а полето с полиетиленов мулч – 8 t/ha. Изнесеният $CO_2$ от откритата почвена повърхност е 21,5 t/ha, а от мулчираната е 16,9 t/ha.