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Climate changes and photosynthesis

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ABSTRACT

This paper is a review. According to the latest data issued by the UN, global warming causes danger to human health and well-being, as well as to animals and plants. As global warming is mainly caused by anthropogenic activities, it was considered that emission of the so-called greenhouse gases should be reduced and in some cases even prohibited. Plants are more easily exposed to biological damage than any other living organisms. The paper deals with the biochemical measures that will increase plants' biological potential, in particular, their photosynthetic and energy opportunities and, therefore, will contribute to drought resistance and will prevent increase of carbon dioxide concentrations in the atmosphere.

Solar energy is environmentally friendly and its conversion to energy of chemical substances is carried out only by photosynthesis – effective mechanism characteristic of plants. However, microorganism photosynthesis occurs more frequently than higher plant photosynthesis. More than half of photosynthesis taking place on the earth surface occurs in single-celled organisms, especially algae, in particular, diatomic organisms.

Today, the growing threat of global warming is becoming more and more vivid. The world of plant which is also seriously affected has to play the significant role in the process of surviving humans and the whole ecosystem [1–3]. According to the latest data issued by the UN in 2013–2014, it is confirmed with 95% probability that the global warming is caused by anthropogenic activities and is conditioned by the so-called Greenhouse effect [4].

The table below presents the percentage distribution of the existing gases in the Earth's atmosphere [5–7]. The data corresponds to the sea level (1 atm pressure). The molecular weight of dry air is 28.966.

Table 2 lists the major greenhouse gases, their emission levels and sources, and the approximate amount of time they remain in the atmosphere once they are emitted. It also gives their approximate concentrations 100 years ago, today and projected concentration for the year 2030 [5–7].

Greenhouse effect is called the obstacle that occurs when greenhouse gases emitted in the atmosphere transmit thermal energy from the Earth's surface to the space. In other words, the greenhouse gases which easily transfer the solar energy to the earth, traps longwave thermal energy in the space due to high absorption capacity of infrared rays. This causes planetary (global) warming of the atmosphere and, consequently, oceans, seas and terrestrial planet [8].

Modern atmosphere mainly consists of nitrogen, oxygen and argon (see Table 1). It easily transmits solar light. Earth's surface reflects and absorbs mainly infrared radiation. The flow of infrared radiation of the earth depends on the optical features of the atmosphere. Thus, the atmosphere's reflection

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and absorption ability is determined by the gases exiting in the atmosphere in small portions (carbon dioxide, methane, nitrogen monoxide and aerosols – Freons).

It is estimated that since 1970s, over 90% of the sun energy is absorbed by oceans. The rest heats the earth (9%) and the atmosphere (1%). It has been estimated that 140 trillion tons of carbon dioxide are dissolved in ocean waters what 60 times exceeds the amount of carbon dioxide in the atmosphere. The average temperature of ocean waters is 3.5 °C and that of the land −15 °C. Ocean warming will increase the amount of carbon dioxide in the atmosphere due to reduction of carbon dioxide solubility in the oceans. Generally, it is known that the world ocean is the main accumulator of heat and gases; it accumulates 1000 times more heat than in the atmosphere. So it is considered that significant climate changes in such a complex system can only occur in centuries and millenniums [9].

Nowadays, the main goal is to maximally reduce air pollution caused by greenhouse gases, particularly, by carbon dioxide. In this regard, biological conversion of solar energy by plants is of utmost importance what leads to reducing the amount of carbon dioxide in the atmosphere. As a result, the percentage of the amount of oxygen increases [10].

However, there is an opinion that the greenhouse effect is a natural atmospheric phenomenon. If this phenomenon was completely excluded, our planet's average temperature would be about −21 °C, instead of the current + 14 °C [9]. The same source cites these data: technogenic emission of carbon dioxide in the atmosphere is about 1.8 billion tons per year; plants absorb 43 billion tons of carbon dioxide. However, due to plant respiration, fires and degradation processes, the most part of the absorbed carbon dioxide will again appear in the atmosphere. Only 45 million tons will appear in deposited plant tissues, in the wetlands and oceans depths. Hence, the conclusion is that people have the potential power to positively affect climate change. Moreover, in the process of global warming, particularly in the greenhouse effect, carbon dioxide and water vapor exceed 95%.

For comparison – on the closest planet, Venus the temperature is 500 °C and carbon dioxide comprises 98% of its atmosphere.

At present, humanity annually burns 4.5 billion tons of coal, 3.2 billion tons of oil, oil products and natural gases. All these fuels cause the growth of carbon dioxide in the atmosphere, which from the 50s–90s of the last century rose from 0.031% up to 0.035%. At the same time and the amount of methane increased dramatically [11].

The UN estimates that this century the average temperature will increase from 1.4 up to 5.8 °C. The sea level can rise to several dozens of centimeters what will greatly endanger population of islands and coastal states. Amount of rainfall will be reduced what will result in turning the most part of the terrain into desert; at the same time the number of flood and hurricanes will increase.

A few years later, humanity will appear in unusual and dangerous world where, due to uncontrollable infectious diseases, new lethal epidemics will increase. Warm and humid climate that will be on the planet in 20 years time will further strengthen the relevance of this forecast. Today, [11]:

1. The Arctic ice cover has been decreased by 10–15%.
2. Starting from the midst of the 1950s to 1970, on the Antarctic coast ice retreated 2.8° longitude to the south.
3 Rise of average temperature by one degree caused spreading of Alaska's forests to the north over 1000 km.
4. The ice cover of lakes and rivers on the middle and upper longitudes of the Northern Hemisphere starts melting 2 weeks earlier than in 1850.
5. In Europe, some mountainous plants migrate to upper locations at the speed of 1–4 m per 10 years.

Table 1 – Chemical composition of the atmosphere.

Gas	Chemical symbol	Molecular mass	Percentage by volume	Percentage by weight	Partial pressure, mmHg	Melting point, °C
Nitrogen	N_2	28.016	78.09	75.5	593.4	−195.79
Oxygen	O_2	32.00	20.95	23.15	159.2	−182.95
Argon	Ar	39.944	0.93	1292	7.07	−186
Carbon dioxide	CO_2	44.010	0.0355	0.046	0.23	−78.5
Neon	Ne	20.183	0.0018	0.0014	0.014	−246
Methane	CH_4	16.00	0.0002	0.000084	–	–
Helium	He	4.003	0.000524	0.000073	0.0038	−269
Krypton	Kr	83.80	0.000114	0.0003	0.00084	−153.4
Hydrogen	H_2	2.016	0.00005	0.00008	0.00038	−252.87
Nitrous oxide	N_2O	44.016	0.00005	0.00008	–	–
Xenon	X_e	131.3	0.0000086	0.00004	0.000061	−108.1
Ozone	O_3	48.00	0.000002	0.0000033	–	–

In different parts of the Earth, air composition for each gas may vary within 1–3% (by volume). Air always contains water steam (0–4%). For example, on 0 °C, 1 m^3 air contains ≈5 g of water, + on 10 °C, – ≈10 g of water. Air contains hydrogen peroxide (≈1%), ammonia (≈2.10–6%), sulfur dioxide – 0.0010%, nitrogen dioxide – 0.000002%, iodine – 0.000001%, trace of carbon monoxide and various radioactive emanations (radiation), a total of ≈6 × 10–18%. On the top of the stratosphere, alongside with the increase of altitude, there is a slight reduction in number of relatively heavy gases. For example, at18 km above the Earth's surface, the oxygen concentration is not changed, but at 28–30 km its concentration is 20.39%. The percentage of air composition is not changed at 10 thousand meters above the Earth's surface. The average air temperature is reduced to 0.6 °C per 100 m. Carbon dioxide composition in the air depends on the length of day and night, i.e. on the daily cycle: it is more at night and is significantly reduced during the daytime (due to photosynthesis). The amount of ozone varies according to the seasons and reaches the maximum in the spring.

6. Growing season of garden plants has increased by 11 days in Europe.
7. The migratory birds fly north earlier and come back later.

The question occurs: what measures should states, experts, scientists and each of us take to survive and save our planet?

Firstly, two questions should be answered: 1) What affect can global warming cause to human health and well-being, as well as to animal and vegetable world? 2) What specific physiological and biochemical changes may occur in the process of their growth and reproduction, and why? In other words, what negative consequences can temperature and humidity rise have on physiological-biochemical potential of humans, animals and plants? Any physiological manifestation occurring in any organism depends on the nature, control and regulation of biochemical reactions. To put it shortly, it depends on the rise of biological potential of living organisms and the adaptation ability to new environmental conditions [12,13].

Obviously, the primary concern is a human, but neither humans nor animals can exist without plants. At the same time, people, animals and even plants cannot exist without energy. Energy needs source of feed, i.e. it is just impossible to move, reproduce, breathe, think, store and transmit information without food. In short, life is impossible. People, animals and plants get energy from the sun – plants directly from the sun, people and animals from plants. From the ecological system, i.e. natural food chain: **the sun – plant – animal – people** everything can be excluded except the sun. Experts believe that solar energy will not be exhausted in ≈4.5 billion years. In this regard, practically, there is no danger though, theoretically anything can happen [14].

As it has already been mentioned, the threat of global warming is related to the rise of the average annual air temperature. Solution of this problem requires searching the ways that will save the vegetable and animal world and the humanity. It is clear that the high temperature is disastrous for plants [15–17]. Because of versatile capabilities, a man can be adapted to very high and very low temperature (though, health and economic conditions worsen and working efficiency lowers). The same cannot be said about plants – they cannot "ran away" and survive. Only people can save plants.

Long before the issues of global warming arose, scientists especially, biologists and ecologists were interested in plant photosynthesis and the problem of respiration energy in the conditions of high temperature. The purpose of the study was to investigate the impact of high temperature on plant growing, its drought resistance, immunity and breeding, photosynthetic ability of carbohydrate biosynthesis, etc. The essence of these two phenomena – photosynthesis and respiration – is well known. We can only add that people cannot exist without plants; though, plants can exist without people. The atmosphere is enriched with released carbon dioxide more by microorganisms and fungi than people.

Starting from the second half of XIX century, separation of oxidation and phosphorylation was considered as the main reason of plant death in unfavorable environmental conditions. Already at that time it was thought that in the breathing process, efficiency of energy change was one of the cardinal issues of biology as it defined the mechanism of plant stability and sustainability [15,18–21].

Alongside with this, intensive study of the impact of environmental factors (especially high and low temperatures) on activity of crop photosynthetic was carried out [22–24]. The experiments carried out in this period created the theoretical and practical base, which served as the basis of research on global warming problems and their solutions.

The impact of very high and low temperatures, light, water, carbon dioxide, mineral salts, stress factors (drought, soil salinity level, nutrient salt deficit), also air pollution (sulfur and nitrogen dioxides) on crop photosynthetic activity was studied [25,26].

Scientists tried to determine how affects of the listed environmental factors were reflected on the first stages of solar energy conversion and dark reactions, also on functional properties and activity of membranes. Great attention was paid to the study of the mechanisms that enabled plants to adapt to adverse environmental conditions; explained those biological resources and potential of plants that ensure migration of crops to relatively undesired zones, for example, from southern to northern regions. It was ascertained that the plant productivity greatly depends on the speed and efficiency of photosynthesis, specific environmental conditions and nutrients essential for plant growth.

The best temperature range for almost all plants is 10–35°C. The photosynthetic activity of the leaves outside these boundaries sharply decreases and is irreversibly lost. As temperature generally affects all photosynthesis reactions, certainly, it is difficult to precisely determine the impact of temperature on CO_2 assimilation level.

In addition, very low lability of other structural units involved in photosynthesis, for example, of certain enzymes, protein-pigment complexes and membranes, complicates determining true rationale reasons which leads to changes in photosynthetic systems. If we consider that the complex photosynthetic system contains a number of sub-systems with its feedbacks and different interrelations, it will be clear how time consuming and difficult it is to find the solution.

As agricultural crops' annual photosynthetic productivity (on unit area) is determined by prolonged active state of photosynthesizing cover, it is necessary to ensure the maximum light absorption by the crops, and (or) to strengthen crops' photosynthesizing ability. Besides, attention should be focused on the orientation of plant leaves that to some extent determines the intensity of photosynthesis. For example, evergreen plants absorb more carbon dioxide, i.e. accumulate more solar energy than cultured plants throughout the year.

Due to the aforementioned, the idea of the vegetable world as a self-regulating system was developed, where the adaptation processes ensure maximum productivity of photosynthesis in the given environmental conditions [27]. It is also interesting that many physiologists choose a cautious approach to the issue of increasing plants' productivity using the methods of genetic engineering.

Starting from the second half of XIX century it was also considered that human existence is ensured by two types of energy: plant biomass and fossil fuel produced as a result of photosynthesis, i.e. newly produced plant biomass and mass

Table 2 – Summary of greenhouse gases.

Gas	Major anthropogenic sources	Amount released per year (millions of tons)	Average time in the atmosphere	Global warming potential-GWP (over 100 years)	Preindustrial concentration (around 1860), ppb	Average concentration now, ppb	Expected concentration in 2030, ppb
CO_2	Burning of fossil fuels	5500	100 years	1	290,000	350,000	500.00
CH_4	Fossil fuel production, rice fields	500	10 years	21	850	1700	2300
N_2O	Fertilizers, deforestation, burning biomass	30	days	310	·0001 to 7	·001 to 50	·001 to 50
CFCs	Aerosol sprays, refrigerants	1	60 to 100 years	1500–8100	0	about 3	2.4 to 6

Methane is present in the atmosphere at less than 1% of the levels of carbon dioxide; however, it is 25 times more efficient as a greenhouse gas. The primary anthropogenic sources are combustion of fossil fuel and decomposition of organic materials associated with wetlands, rice paddies, and livestock manure.
Nitrous oxide is 230 times more efficient as a greenhouse gas. The primary anthropogenic sources are fossil fuel combustion, fertilizers, and deforestation.
CFCs – Chlorofluorocarbons – are major greenhouse gases that are not naturally occurring. They are present at an extremely low concentration in the atmosphere; however, they are 15, 000 times more efficient as a greenhouse gas relative to carbon dioxide.
Concentrations are given in parts per billion (ppb). For example, the concentration of CO_2 today is 350,000 ppb, meaning that for every billion molecules in the atmosphere, there are 350,000 molecules of CO_2. 350,000 ppb corresponded to 0.0350 percentage by volume.
GWP – greenhouse gases are often assigned a value for Global Warming Potential. This value is simply a comparison of the gas relative to CO_2 over a time span of 100 years. Therefore, a gas with a GWP of 20 is 20 times more efficient of retaining heat the CO_2 over a 100 years time period.

preserved in fossil remains. The first is regularly updated, the second – exhaustive. It was thought that the use of fossil fuels would reach maximum around 2100 and would end in 2400; that the mankind would face the threat of global warming caused by the accumulation of carbon dioxide in the Earth's atmosphere. Though, the possibility of partial self-regulation of carbon dioxide could not be excluded.

Notwithstanding the fact that the total area of seas and oceans 2.5 times exceeds the land area (149 km^2), its straight primary product (dry biomass or total weight of carbon) comprises 1/2–1/3 of terrestrial products (it is recognized that 1 g dry mass contains 0.45 g of carbon and during full combustion of 1 g of biomass $\approx$19 kJ heat is emitted).

In the process of formation of straight primary products (expressed in gigatons) is necessary to consider the relationship between light and nitrogen impact. These factors determine assimilation of carbon dioxide – light as the energy source, nitrogen, as the main element of the enzyme ribulose bisphosphate carboxylase (the largest part of all active protein of the world) synthesis. This direction of research has to consider the difference between the C_3- and C_4- plants. In C_3-plants, in the first reaction of carboxyls, 3-carbonic intermediate product 3-phosphoglycerate is produced. In C_4-plants, in the first reaction of carboxyls, 4-carbonic intermediate product oxaloacetic acid is produced. In the first case ribulose bisphosphate carboxylase is involved in the reaction, in the second case – phosphoenolpyruvatecarboxylase [12]. C_4-plants are the most important part of the global phytomass; they are not found in woody plants.

As a result of breathing or biological (cellular) oxidation, every living aerobic organism produces energy mainly in the form of ATP (by cybernetic direct and feedback mechanisms). Only vegetable world (terrestrial plants, algae, blue and red bacteria), influenced by the sunlight, produces much more carbohydrates and energy from atmospheric carbon dioxide and water than people or animals do.

It turns out that a plant provides itself with oxygen (as a result of photosynthesis in the daytime), and with carbon dioxide (as a result of breathing in the daytime and at night). Thus, a plant can exist without any kind of aerobic organisms what is conditioned by two radically different and independent processes – breathing and photosynthesis. However, the overall reactions of these processes are contradictory, inverse processes at the first glance.

$$C_6H_{12}O_6 + 6O_2 \underset{\text{photosynthesis}}{\overset{\text{respiration}}{\rightleftarrows}} 6CO_2 + 6H_2O$$

We will not go into details of photosynthesis but we will note only that as a result of a plant's own carbohydrate combustion it takes extra energy. The interesting thing is that breathing is a more stable process towards high temperatures than photosynthesis, i.e. high temperatures first of all damage plants' photosynthetic apparatus. It is known that photosynthesis is stopped completely, but breathing goes on normally [28–30].

It is clear that raising the temperature up to a certain level will enable plants to produce more energy, raise their biological potential, increase vitality, immune capacity, yield and nutritional value. But what should be done in order to “force” the plant to withstand the high temperature? What feeding regime, which mineral and physiologically active substances, and what percentage, what kind of soil and environmental conditions should be maintained for plants, how to change agro-chemical, agricultural and land-reclamation measures to make plants normally develop in the changed conditions? What genetic-selective measures should be taken in order to facilitate the task? Methodological side of this and other similar researches should be identified by scientists. In general, the approach is as follows: firstly, it should be determined how different plants react to growing temperature and how their physiological, morphological, anatomical characteristics and development are changed accordingly. Alongside with this, the basic biochemical parameters of plants (e.g. features of respiration and photosynthesis) should be studied: breathing coefficient of efficiency, amount of emitted heat, intensity of oxidative and photosynthetic phosphorylation, breathing energy effects, ADP/ATP and respiration ratio, synthesis of proteins, fats, carbohydrates and other important compounds (for example, chlorophyll, vitamins), etc. In each separate case it is essential to determine whether the temperature impact on the object lies in the zone of tolerance, or causes damage. Obviously, different plants respond diffently to certain temperature. Therefore, only setting the temperature points will not be enough. Other features should also be pointed, for example, air humidity, lighting, atmospheric pressure, etc. It is known that plants are significantly affected not only by high temperature, but also by the degree and duration of lighting.

Radical points should necessarily be determined – at what temperature photosynthesis and respiration start and stop, at what temperature they reach maximum values, i.e. temperature, exposition and validity period should be changed while carrying out the research.

It is known that the solar luminosity and spectrum, in other words, the solar activity is periodically changed within a certain time intervals, including several millennia. Especially prevalent is 11-year solar activity cycle, the so-called Schwabe Cycle (German astronomer and botanist, pharmacist by education. In 1826–1843 he was watching sunspots. In 1843 he found out that the number of sun spots changed according to the particular pattern – approximately every 10 years, the minimum and maximum number of spots recurred. Rudolf Wolf (1816–1893), Swiss astronomer and mathematician, Bern Observatory Director, specified that in fact, the timing of the cycle included 11.1 years. Word collected the data since 1610). However, non-periodic changes also occur. It is considered that the intensity of solar radiation that reaches the earth during the last 2000 year period has been relatively constant, with the fluctuations of 0.1–0.2% [31–33]. These variations are weak to explain modern climate – on the contrary, in recent decades, a slight freezing is observed [34]. The second argument of the fact that the sun is a possible cause of the current warming is temperature distribution in the atmosphere. In other words, observations and modules show that strengthening of warming with greenhouse effect leads to warming of lower layers of the atmosphere (troposphere) and simultaneous cooling of its upper layers (stratosphere). This means that if the sun were the main cause of warming, the temperature should be risen in troposphere and stratosphere [35,36].

In the last decades of XX century, scientists suggested that Earth's absorbed and dispersed throughout atmosphere the part of the solar energy, namely $\approx 3 \cdot 10^{24}$ J per year. Maximal energy production on the Earth is $= 3 \cdot 10^{21}$ J per year what is approximately 0.1% of the solar energy. It is probable that a critical situation occurs in the nearest future, when increase of energy production on the Earth will not be possible, as it will be extremely close to the permitted value. Obviously, this is directly related to increase of gas concentrations and global climate warming in the atmosphere [3,37].

Now, about photosynthesis, i.e. the biological conversion of solar energy. Solar energy is environmentally friendly and it is converted to energy of chemical substances by natural and effective mechanism – photosynthesis. It is known that plants use no more than 0.1% of solar energy for photosynthesis. The calculations, however, show that plants can use up to 30% of the energy absorbed by them. Obviously, in such cases, plant biomass and its nutritional value will dramatically increase. At the end of the last century, the portion of plant biomass in the world consumption of energy did not exceed 14%. In developing countries, the plant biomass (wood) covered the half of energy needs, while in developed countries, for example, in the US – only 3%. Brazil received 28% of all energy produced from plant biomass, mainly from sugar cane, which was used to produce microbiological ethyl alcohol (mainly used as fuel – 6–7 billion liters per year).

Study of still unknown biochemical mechanisms of photosynthesis will lay the ground for an ideal, inexpensive and environmentally friendly fuel, such as hydrogen. So, nature protection alongside with maintaining peace is the primary task of the humanity. It is noteworthy that a tree provides 5 people with oxygen (a healthy adult breathes in $\approx 10 \times 103$ L of air per day, i.e. $\approx 2 \times 103$ L of oxygen).

Environmental and natural long-term cycles, including biorhythms are still poorly understood. However, knowledge of these cycles is essential to merge our life cycle with the nature's time flow.

The stream-line with non-waste production and closed production cycle exits due to the solar energy and is the environment of our life. To break such "power cycle" we have to spend additional energy supply. All living organisms are genetically distinct from each other – some relatively easily adapt to changes in environmental parameters, while others – more heavily. So, the natural survival process continues. On the other hand, there a lot of self-regulation processes with feedbacks in the biosphere, due to which organisms can easily maintain necessary conditions.

The climate system includes a number of feedbacks which respond to external pressure. Positive feedbacks strengthen the response of the climate system to the initial pressure, while negative feedbacks – reduce. For example, water vapor, due to its feature to strengthen greenhouse effect, contributes to additional warming. The main negative feedback is reducing infrared radiation in the space as a result of warming the Earth's surface. But due to ambiguity of some feedbacks, it is impossible to predict the exact outcomes, i.e. according to the existing modules, only possible ranges of warming can be foreseen. IPCC (Intergovernmental Panel Climate Change, set up in 1998) predicted that the probability of determining such boundaries is no less than 66%. In 2014, IPCC stated that to reduce global warming by 2 °C, it will be necessary to reduce emission of greenhouse gasses by 40–70% by 2050 and reduce them to zero by the end of the century [38].

Fortunately or not, many scientists do not share the inevitability of global warming. As a result of processing the latest data obtained on the bass of satellite images, the prospect of global scourge, which pessimistic scientists anticipate, is excluded. This provides hope that mankind will be able to cope with the threat. Moreover, there is a radically different opinion, according to which global warming is not caused by carbon dioxide release into the atmosphere, but on the contrary, an increase of carbon dioxide concentration is conditioned by global warming. A certain group of scientists believe that increase of the air temperature causes growth of the amount of carbon dioxide and emission of carbon dioxide does not cause any danger to the Earth. If the Earth's atmosphere is entirely changed into carbon dioxide, the air temperature will even reduce to 5 °C, rather than rise. This consideration is confirmed by the IPCC which notes that in 1998–2012, higher tendency of warming was anticipated in 111 climatic models out of 114; but actually it turned out to be lower. In 1984–1998, the majority of the models predicted warming at a low rate, but in reality it was higher. According to the IPCC, in 1998–2012, the Earth's average temperature rose by 0.2 °C, though, according to other data temperature rise, in general, did not take place [39,40].

On November 26, 2014, international group of scientists, Allatra Science presented the paper on "Earth's global climate change problems and results and the effective ways of soling them". The paper rejects the opinion on the crucial role of a human's anthropogenic activities in global warming, and, therefore, doubts the Kyoto, Montreal and other similar agreements forecasts [41]. The report clearly states that global climate change is mainly conditioned by astronomical processes and their cyclical nature. The planet's geological history shows that the Earth has many times faced cataclysms similar to global climate change. Nevertheless, every effort should be taken to maximize the reduction of GHG emissions in the atmosphere, even if they do not bring the desired result. If not anything else, global disasters will be reduced. Many scientists think, and we share their opinion, that right now, all the necessary measures should be taken in compliance with the current weather conditions in Georgia.

It is necessary to create forest protective strips and rows of trees everywhere where it is possible – around fields, pastures, rivers, lakes, reservoirs, ponds, roads, settlements, cattle farms, large and small cities, in fords and ravines, on arid mountain slopes, along railroads, highways and irrigation canals. It should be done not only because of fear of global warming, but in order the living world to survive. Only thus it will be possible to reduce (at least partly) concentrations of emitted carbon dioxide to the air.

Though, some scientists do not consider deposition of carbon dioxide with the help of deforestation to be the effective way as a great amount of carbon is still returned to the atmosphere by forest fires and transformation of organic substances [9].

In 2013, emission of carbon dioxide from fossil fuels and cement production amounted to 36.1 gigatons – where the United States had 14%, the European Union – 10%, and China – 28%. It is estimated that by 2019 China will have more percentage than the United States, the European Union and India taken together.

It is interesting to stress that although the carbon dioxide emitted to the atmosphere as a result of fossil fuel combustion increases, the ratio of the emitted carbon dioxide and its unused remainings does not change. This means that all photosynthesizing organisms still are able to absorb more and more amount of carbon dioxide. This perspective is encouraging because the increase of vegetation and strengthening of the potential capacity of plants will significantly reduce the temperature rise. However, it will not last forever. Today, the fact is that absorption of carbon dioxide by oceans is almost completely ceased. The data appeared that terrestrial plants absorb less and less amount of carbon dioxide. It is noteworthy that life expectancy of carbon dioxide in the atmosphere lasts over centuries.

Finally, as global warming is followed by long aridity, it is essential to immediately start cultivation of drought resistant plants. Drought resistant plants can easily stand dehydration and overheating. Normally, long-term aridity (because of low humidity of soil and air) badly affects most of the plants: water regime and root feeding are changed, more moisture is evaporated from leaves than it is absorbed by roots; photosynthetic activity, breathing, as well as synthesis of primary (protein, fat, carbohydrate) and secondary metabolites (volatile oils, polyphenols, steroids, alkaloids, etc.), caused by temporary growth of the catalyst enzyme action and then its inactivation, is broken; regulations based on direct linkage and feedback are violated; nitrogen-containing compounds – amino acids, proteins, nucleic acids – are degraded that is followed by accumulation of ammonia in tissues and cells, intoxication, decomposition of subcellular structures and death of plants.

Drought resistance of plants is conditioned by their physiological and anatomic-morphological peculiarities what is reflected in reduced demand for water, ability of cell compression and water absorption from the soil. Their main ability is that they can easily stand the lack of water due to high hydrophilic nature of colloidal compounds of their cytoplasmic structures and the existing sugar and mucous fluids.

Among different morphological peculiarities, scarcity of leaf surface and the ability of the root system to deepen into the soil are most noteworthy. Anatomically drought resistant plants are characterized by small cells and a dense network of vascular bundles. They have a well-developed cuticle (Latin: thin shell that covers epidermis of leaves and stems with a thin film), few small-sized stomata which prevents extra water evaporation and protects plants from overheating.

The most drought resistant plants are xerophytes (Greek: xero – dry, piton – plant). Cultural plants growing in desert, semi-desert and dry steppes and lichens (lower plants – fungi and algae, grow on rocks, bark and soil) belong to xerophytes. Among cultural plants should be noted, for example, sorghum, millet, sunflower, pumpkin, watermelon, Sudan grass, alfalfa. Dry watering – soil harrowing, soil mellowing, and timely fertilizing soil with potassium and phosphate fertilizers – contributes to drought resistance of plants. Generally, plants, which once suffered from drought, easily overcome it for the second time. Plant drought resistance is mainly conditioned by their hereditary characteristics.

Thus, terrestrial ecosystems, due to absorption and emission of greenhouse gases, not only to participate in the global carbon cycle, but also significantly affects the climate. Climate, on its turn, influences the processes taking place in ecosystems. In 2008, Martin Haiman and Marcus Raichshtain, scientists of the Max Planck Institute for Biotechnology (Jena, Germany) published the article in the Journal "Nature". They noted that the relationship between climate and the inner processes of ecosystems is not yet clear. It means that the effects of global warming can be reduced as well as enhanced by ecosystems. For example, if the number of plants increases in any of the ecosystems or organic matter stocks – in the soil, absorption of carbon dioxide (photosynthesis) is higher than its allocation (breathing). In such a case, ecosystem will act as a carbon dioxide holder, and vice versa – if carbon dioxide allocated while breathing exceeds the amount of carbon dioxide absorbed during photosynthesis, such an ecosystem will become a source of atmospheric carbon dioxide. Although the main principles of these two processes are clear, some details of these processes are still to be studied – their quantitative characteristics and mechanisms of some environmental factors. Such uncertainty, of course, greatly reduces the possibility of the correct prediction. Often such an example is taken: according to the experimental data, intensity of photosynthesis increases alongside with the growth of carbon dioxide in the atmosphere and reaches maximum when concentration of carbon dioxide is 0.8–1.0%. As the current concentration of carbon dioxide in the atmosphere is ≈ 0.038%, plants have more potential for absorption, i.e. it can effectively resist to accumulation of carbon dioxide in the atmosphere.

As the average temperature increases simultaneously with the growth of the amount of carbon dioxide in the atmosphere and the respiratory rate of any organism rises exponentially with temperature increase (Arrhenius law), the total breath of ecosystems will certainly increase. As a result, the most productive ecosystems, i.e. forests, will be the most effective holders of atmospheric carbon dioxide, but only in wet years. In dry years, the same systems will start emitting more carbon dioxide. This means that the amount of carbon dioxide in the atmosphere will strongly fluctuate annually. This fluctuation is related to the climatic peculiarities of the year.

In spite of diversity of opinions concerning the major issues of global warming, there is a hope that in European and Asian countries, as well as in the United States, the whole humanity will do its utmost to prevent the impending disaster. In particular, people will reduce greenhouse gas emission. This can be done by using energy resources more effectively, reducing heat and fuel leakage, renewing energy complexes, using safer types of fuel, creating alternative environmentally friendly technologies of energy production, taking care and paying more attention to flora.

REFERENCES

[1] G.Sh. Tkemaladze, BioChemical fundamentals of protecting the world from global warming. Proceeding of the International Scientific Conference "Global Warming and Agrobiodiversity, Tbilisi, Georgia, pp.32–41 (in Georgian).

[2] G.Sh Tkemaladze, K.A. Makhashvili, Biological conversion of the sun's energy, in: Proceedings of the International Scientific Conference Dedicated to Academician I. Prangishvili 85th Anniversary – "Information and Computer Technologies, Modelling, Control", 2016, pp. pp.303–309 (in Georgian).

[3] https://en.wikipedia.org/wiki/Global_warming.

[4] https://en.wikipedia.org/wiki/Kyoto_Protocol.

[5] http://environ.andrew.cmu.edu/m3/s2/atmos.pdf.

[6] https://en.wikipedia.org/wiki/Atmosphere_of_Earth.

[7] https://ru.wikipedia.org/wiki/воздух.

[8] http://earthobservatory.nasa.gov/Features/GlobalWarming/page2.php.

[9] www.Priroda.SU/item/389.

[10] Photosynthesis, in: Govindjee (Ed.), Development, Carbon Metabolism and Plant Productivity, vol. 2, Mir, Moscow, 1987 (in Russian).

[11] http://www.ecosystema.ru/07referats/warming.htm.

[12] G.Sh Tkemaladze, Principles of Biochemistry, Meridiani, Tbilisi, 2013 (in Georgian).

[13] John Whitmarsh, Govindjee, The photosynthetic process, in: G.S. Singhal, G. Renger, S.K. Sopory, K.-D. Irrgang, Govindjee (Eds.), Concepts in Photobiology: Photosynthesis and Photomorphogenesis, Narosa Publishers/New Delhi; and Kluwer Academic/Dordrecht, 1999, pp. 11–51.

[14] G.Sh Tkemaladze, Encyclopedical Dictionary of Biochemistry and Molecular Biology, Meridiani, Tbilisi, 2013 (in Georgian).

[15] O.A. Semichatova, Energetics of Plants Respiratory at the Elevated Temperature, Nauka, Leningrad, 1974, p. 112 (in Russian).

[16] A.W. Galston, P.D. Davies, R.L. Satter, The Life of the Green Plant, Mir, Moscow, 1983, p. 549 (in Russian).

[17] A.B. Rubin, Biophysics, vol. 2, Mir, Moscow, 1987 (in Russian).

[18] A. Benzioni, Ch Itai, Short and longterm effect of high temperatures (47-49) on tobacco leaves, plant Physiol. 28 (3) (1973) 493–497.

[19] J. Geronimo, H. Bevers, Effect of aging and temperature on respiratory metabolism of green leaves, Plant Physiol. 39 (5) (1964) 786–793.

[20] T. Koichi, Effect of temperature on the acivity of respiratory enzymes and oxidative phosphorylation in crop leaves, Proc. Crop Sci. Jap. 40 (3) (1971) 261–266.

[21] M.J. Merreet, D.W. Sunderland, Respiration rate and adenosine triphosphate formation in tissues infected by tobacco mosaic virus, J. Exp. Bot. 20 (65) (1969) 717–733.

[22] J.A. Berry, J.S. Downton, Dependence of photosynthesis on environment factors, in: Photosynthesis, vol. 2, Mir, Moscow, 1987, pp. 273–364 (in Russian).

[23] R.M. Gifford, C.L.D. Jenkins, Use of achievements of sciences about photosynthesis for the purpose of increasing efficiency of cultural plants, in: Photosynthesis, vol. 2, Mir, Moscow, 1987, pp. 365–410 (in Russian).

[24] R.M. Gifford, Global photosynthesis and the problem of food and energy resources, in: Photosynthesis, vol. 2, Mir, Moscow, 1987, pp. 411–453 (in Russian).

[25] W.E. Winner, H.D. Mooney, Ecology of SO2 resistance: III. Metabolic changes of C3 and C4 Atriplex species due to SO2 fumigation, Ecologia 46 (1980) 49–54.

[26] J.N. Bull, T.A. Mansfied, Photosynthesis in leaves exposed to SO2 and NO2, Nat. Lond. 250 (1974) 443–444.

[27] H. Tooming, Mathematical model of plant photosynthesis considering adaptation, Photosynthetica 1 (3–4) (1967) 233–240.

[28] https://en.wikipedia.org/wiki/Photosynthetic_efficiency.

[29] https://en.wikipedia.org/wiki/Photosynthesis.

[30] S.S. Medvedev, Plant Physiology. Saint Petersburg, 2004 (in Russian).
[31] Committee on Surface Temperature Reconstructions for the Last 2,000 Years, Board on Atmospheric Sciences and Climate, Division on Earth and Life Studies, National Research Council of the National Academies. Climate Forcings and Climate Models//Surface Temperature Reconstructions for the Last 2,000 Years, National Academies Press, 2006, ISBN 0-309-10225-1.
[32] Judith Lean, Evolution of the Sun's spectral irradiance since the maunder minimum, Geophys. Res. Lett. 27 (16) (2000) 2425–2428.
[33] N. Scafetta, B.J. West, Phenomenological solar signature in 400 years of reconstructed Northern Hemisphere temperature records since 1600, J. Geophys. Res. 112 (D24S03) (2007) 1–10.
[34] Changes in Solar Brightness Too Weak To Explain Global Warming (UCAR). *http://www.ucar.edu/news/releases/2006/brightness.shtml*.
[35] Hegerl, et al., Chapter 9: Understanding and Attributing Climate Change, Frequently Asked Question 9.2: Can the Warming of the 20th Century Be Explained by Natural Variability?, in IPCC AR4 WG1, 2007. http://www.ipcc.ch/publications_and_data/ar4/wg1/en/faq-9-2.html.
[36] J. Randel William, et al., An update of observed stratospheric temperature trends, J. Geophys. Res. 114 (D2) (2009). http://onlinelibrary.wiley.com/doi/10.1029/2008JD010421/abstract.
[37] http://www.climatechange2013.org/images/report/WG1AR5_SPM_FINAL.pdf.
[38] http://www.un.org/russian/news/story.asp?NewsID=22606#.Vp93-pp96M8.
[39] http://inosmi.ru/world/20140828/222641787.html.
[40] O. Sorokin, Is it worth being afraid of greenhouse effect and ozone gaps? Ind. Gaz. 1–12 (2014) (in Russian).
[41] Report of International Group of Scientists of the International Social Movement, About the problems and consequences of global climate change on the Earth. The Ways of Solution of the Terrestrial Problems, Allatra, November 26, 2014 (in Russian), http://allatra-science.org/publication/globalnoe-poteplenie.