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11. Скрипчук П.М. Значення екологічної сертифікації у формуванні менеджменту якості навколишнього природного середовища // Проблеми раціонального використання соціально-економічного потенціалу регіону: фінансова політика та інвестиції. – Рівне : Вид-во НУВГП, 2008. – Вип. XIV, № 4. – С. 50-63.

Скрипчук П.М. Методологические принципы адаптации сельскохозяйственного производства с учетом изменения экономических и экологических факторов

Обоснованно необходимость использования концепции экологической сертификации и ее методологических положений в сфере природопользования с целью рационального использования естественного капитала на примере осушаемых земель сельскохозяйственного назначения.

Ключевые слова: экологические аудит и сертификация, осушаемые земли, лесение, лесные углеродные сертификаты.

Skripchuk P.M. Methodological principles of agricultural production adaptation recognition change of economic and ecological factors

The necessity of the using ecological certification conception is proved and its methodological positions in the field of the natural resources using with the purpose of the rational use of natural capital on the example of the drained earths.

Keywords: audit and certification, drained earths, forests landing, forest carbon certificates.

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MEASUREMENTS OF CARBON DIOXIDE CONCENTRATION [CO₂] IN ATMOSPHERE AND INFLUENCE OF ENHANCED [CO₂] ON PLANTS OF WHEAT (*TRITICUM AESTIVUM* L.)

Trend of atmospheric carbon dioxide concentration [CO₂] in last fifty years, known as 'Keeling curve', and monitoring of CO₂ in Mauna Loa Observatory of Hawaii is described in the paper. Enhanced level of CO₂ affects plants, including wheat, which is one of the most important crop plant species. Some changes caused by this factor are positive, particularly faster growth, development and better photosynthesis of plants. On the other hand, elevated [CO₂] affected lower yield quality. Some results of own experiments on the wheat plants are presented.

Keywords: C₃, C₄, grain quality, Keeling curve, Mauna Loa, photosynthesis.

The rise in atmospheric carbon dioxide concentration [CO₂] is one of the best documented global atmospheric changes of the past half century (Ainsworth & Long 2005, IPCC 2007). Even though measurements of CO₂ level are performed by many observatories in the world, Mauna Loa Observatory on the Island of Hawaii is considered as the most important of them. It is located at an elevation of 3397 m on the northern flank of Mauna Loa volcano at 200 north (Fig. 1). This ob-

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servatory was established in 1957 and since 2008 was determined concentration of atmospheric carbon dioxide. The observatory consists of 10 buildings from which up to 250 different atmospheric parameters are measured.

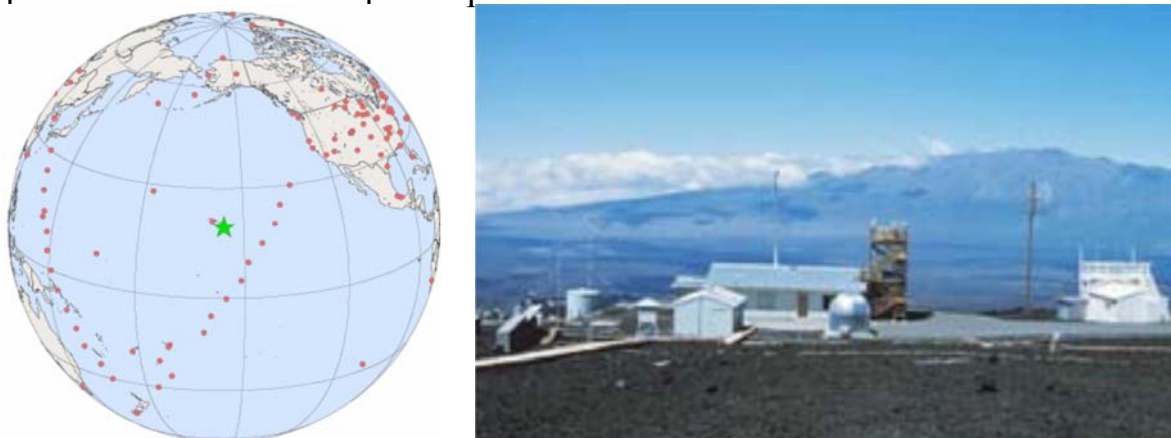


Fig. 1. Mauna Loa Observatory, Hawaii, United States
(<http://www.esrl.noaa.gov/gmd/obop/mlo/index.html>)

Because of the favorable site location, continuous monitoring, and careful selection and scrutiny of the data, the Mauna Loa record is considered to be a precise record and a reliable indicator of the regional trend in the concentrations of atmospheric CO₂ in the middle layers of the troposphere. On the basis of flask samples collected at Mauna Loa, the annual average of the fitted concentrations of CO₂ rose from 315.98 ppmv in 1959 to 385.34 ppmv in 2008. This represents an average annual growth rate of 1.4 ppmv per year in the in situ values at Mauna Loa (Fig. 2).

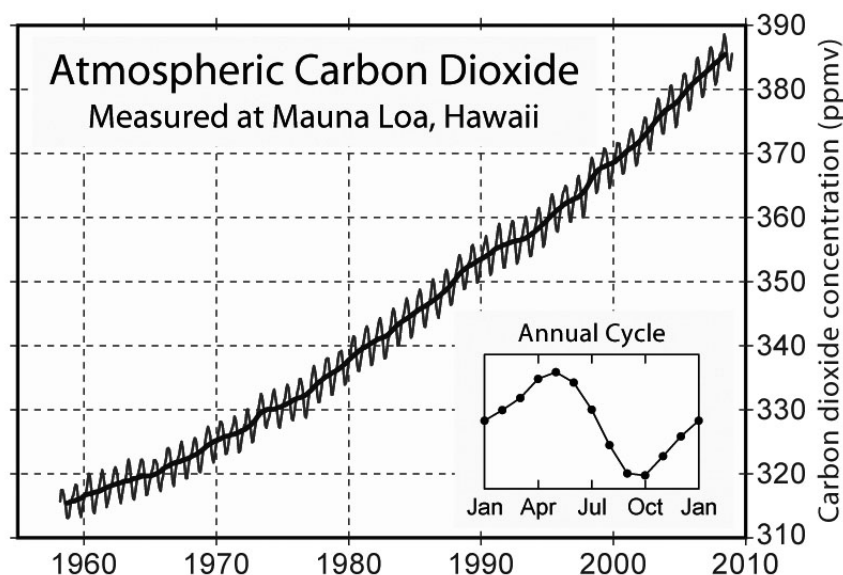


Fig. 2. Atmospheric CO₂ concentration measured since 1958. Data are reported as the number of molecules of carbon dioxide divided by the number of molecules of dry air multiplied by one million by volume (ppmv)
(http://www.en.wikipedia.org/wiki/Charles_David_Keeling)

This data are providing dramatic evidence of that: they show amounts more than 35 % over amounts recorded before the Industrial Revolution, and a rise of 6 % in the last 19 years alone. This graph showing changes of atmospheric

CO₂ concentration measured since 1958 is named as "Keeling curve", because Charles David Keeling of Scripps Institution of Oceanography as the first researcher observed changes of atmospheric carbon dioxide concentration in this observatory. Hourly averages of atmospheric CO₂ concentration, wind speed, and wind direction are plotted as a basis for selecting data for further processing. Data are selected for periods of steady hourly data to within ~0.5 ppmv; at least six consecutive hours of steady data are required to form a daily average (Keeling 1976). National Oceanic and Atmospheric Administration started its own CO₂ measurements in May of 1974, and they have run in parallel with those made by Scripps since then (Thoning, 1989). Keeling curve shows also cyclic seasonal variations by ca. 5 ppmv every year connected to a vegetation period (Fig. 2). Peak levels reached in the late northern hemisphere winter. A reduction in carbon dioxide followed during spring and early summer each year as plant growth increased in the land-rich northern hemisphere.

The last four complete years of the Mauna Loa CO₂ record plus the current year are shown on Fig. 3. The dashed red line with diamond symbols represents the monthly mean values, centered on the middle of each month. The black line with the square symbols represents the same, after correction for the average seasonal cycle. The latter is determined as a moving average of seven adjacent seasonal cycles centered on the month to be corrected, except for the first and last three and one-half years of the record, where the seasonal cycle has been averaged over the first and last seven years, respectively.

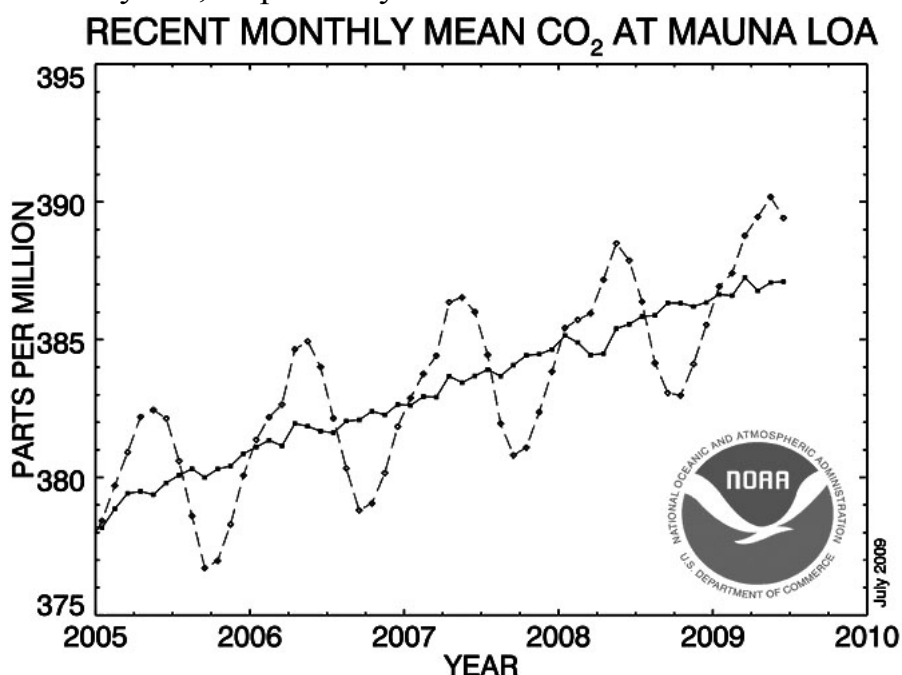


Fig. 3. Last trend of atmospheric CO₂ concentration
(www.esrl.noaa.gov/gmd/ccgg/trends/)

Levels of atmospheric CO₂ are anticipated to double by the end of the 21st century (IPCC 2007). How crop plants are going to respond to such change in higher CO₂ concentration? Elevated CO₂ concentrations enhance the growth rate of many plant species, including grass, owing to an increase in photosynthesis, decrease in photorespiration and increase of tillering (Manderscheid & Weigel 1997, Ulman et

al. 2000, Pandurangam et al. 2006, Del Pozo et al. 2007). Maciorowski et al. (1995) described growth of spring wheat plants grown at different concentration of CO₂ (350 and 700 ppm) using logistic function. They observed faster growth of assimilation area (leaves, stems, whole plants) as well as dry matter, on average by 18 %.

Rising CO₂ has the potential to stimulate yield in crops, including wheat (Amthor 2001). Wheat is one of the oldest and most widely cultivated cereals across the globe. Wheat yield has been projected to rise by up to 15 % under enhanced CO₂ concentration (Amthor 2001; Sinha et al. 2009). Several studies authors reported an increase in the leaf area and total plant biomass in wheat plants grown under enhanced [CO₂]. Stomatal limitation of photosynthesis as affected by enhanced CO₂ concentration was observed (Janacek 1997, Pandurangam et al. 2006, Uddling et al. 2008). Since CO₂ is a substrate limiting photosynthesis in C₃ plants in the present atmosphere, the impact of elevated CO₂ would depend mainly on how photosynthesis acclimates or adjusts in long-term high CO₂ environment. Pandurangam et al. (2006) in experiment on wheat and sunflower plants grown in field under atmospheric and elevated CO₂ concentrations (650 ppm) in open top chambers for entire period of growth and development till maturity showed that wheat accumulated in leaves mostly sugars, whereas sunflower accumulated mainly starch. Pérez et al. (2007) observed differences in acclimation to elevated growth CO₂ of 700 ppm in successive leaves of wheat investigated in field chambers. At elevated [CO₂] photosynthesis and the quantum yield of electron transport were increased, and contents of chlorophyll, ribulose-1,5-bisphosphate carboxylase/oxygenase, and total soluble protein were lower. In the experiment Sharma-Natu et al. (1997) enhanced CO₂ decreased RuBPCO protein content relative to soluble protein and chlorophyll contents throughout the development of penultimate leaves, and increased allocation of resources to photon harvesting in the penultimate leaves, but to increased allocation to carboxylation early on in growth, and to light harvesting subsequently, in the flag leaves

C₃ crops are generally considered more sensitive than C₄ crops to the elevated CO₂ (Rudorff et al. 1996, Li et al. 2008). Enrichment experiment with open-top chamber was conducted to examine the effects of elevated CO₂ on the contents of total phenolic compounds and flavone in the leaves of spring wheat (C₃ crop) and maize (C₄ crop). The results showed for spring wheat, the total phenolic content in its leaves at jointing stage was significantly higher under elevated CO₂. The total phenolic content in maize leaves at jointing stage had the similar variation trend with that for wheat, but at grain-filling stage, the total phenolic content was slightly affected by elevated CO₂. The flavone content in spring wheat leaves was significantly lower under CO₂ at jointing stage, but had lesser difference at grain-filling stage under the stress.

Apart from photosynthesis and respiration, studies have been carried out to observe the effect of elevated [CO₂] on morphology and ultrastructure of leaf in a wide range of plants. Gutiérrez et al. (2009) concluded that in addition to photosynthesis and stomatal aperture, leaf morphology of wheat is also changed by high-growth CO₂. Their results shown that future increase in atmospheric CO₂ and temperature will decrease leaf dry mass per unit area and the former also leaf den-

sity, although the CO₂ effect may be masked by opposing effects on leaf primordia. Morphologic modifications of leaves in high CO₂ and temperature are due to lower amounts of structural compounds. The functional significance of these changes is probably a decrease in photosynthetic capacity per unit leaf area.

On the basis of many comparisons it was argued that model projections of future food supply may have significantly overestimated the positive effect of elevated CO₂ concentration on crop yields and, by extension, food security of wheat (Ziska & Bunce 2007). However, several studies have indicated that yield stimulation by elevated CO₂ is associated with a reduction in grain protein concentration and Zn concentrations of wheat grain, thus reducing the nutritional quality (Pleijel & Danielsson 2009). The continuing increase in atmospheric CO₂ concentration 550 ppm is predicted to enhance biomass production and to alter biochemical composition of plant tissues of winter wheat cv. 'Batis'. Also results of our earlier experiments on spring wheat cv. Minaret plants subjected to enhanced CO₂ concentration showed decrease of protein and gluten content by ca. 25 % compared to the control plants grown at ambient [CO₂] 320 ppm (Table). Valorimeter value of flour was reduced by 35 %, and dough resistance – 77 %. It showed negative effect of elevated CO₂ as well on grain as flour quality. Reduction of protein content, dough resistance and valorimeter value caused by CO₂ enrichment was much bigger under the condition of 150 than 75 of nitrogen dose (Stankowski & Mortensen 1997).

Table. Some quality traits of grain and farinogram evaluation flour of spring wheat cv. Minaret subjected to different level of CO₂ during growth

Feature	320 ppm [CO ₂]	640 ppm [CO ₂]	LSD
Protein content [%]	9.5	7.5	0.75
Gluten content [%]	25.6	19.2	3.7
Valorimeter value	71	46	6
Dough resistance [min]	8.36	1.87	0.99

Similar results of inferior grain quality are described by Pozo et al. (2007). Effects were more pronounced in wheat samples supplied with normal amounts of N fertilizer. Crude protein was reduced by 14 %, gliadins by 20 %, glutenins by 15 % and glutenin macropolymer by 19 %. According to these results, flour from high CO₂ grown grain will have a diminished baking quality. Also Högy et al. (2009) in the field experiment on spring wheat cv. Triso observed increase of 13.5 % in grain yield, and decrease of total grain protein concentration by 3.5 % affected by elevated [CO₂] of 526 ppm. Elevated CO₂ caused significant reductions in crude protein and all protein fractions and types except albumins and globulins (Wieser et al. 2008).

Taub et al. (2008) described meta-analysis techniques used to examine the effect of elevated atmospheric carbon dioxide [CO₂] on the protein concentrations of major food crops, incorporating 228 experimental observations on barley, rice, wheat, soybean and potato. Each crop had lower protein concentrations when grown at elevated (540-958 ppm) compared with ambient (315-400 ppm) CO₂. For wheat, barley and rice, the reduction in grain protein concentration was 10-15 % of the value at ambient CO₂. The magnitude of the CO₂ effect on wheat grains was

smaller under high soil N conditions than under low soil N. There was also indication of a possible pot artifact as, for both wheat and soybean, studies performed in open-top chambers showed a significantly greater CO₂ effect when plants were rotated in pots rather than in the ground. Studies on wheat also showed a greater CO₂ effect when protein concentration was measured in whole grains rather than flour. These findings suggest that the increasing CO₂ concentrations of the 21st century are likely to decrease the protein concentration of many human plant foods.

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Скурська Е., Башуцька У., Станковські С. Дослідження концентрації діоксиду карбону [CO₂] в атмосфері та вплив збільшення [CO₂] на пшеницю (*Triticum aestivum* L.)

Описано тренд концентрації в атмосфері діоксиду карбону [CO₂] за останні п'ятдесят років, відомий як "крива Кілінга", та моніторинг CO₂ в обсерваторії Мауна-Лоа на Гавайях. Збільшення рівня CO₂ впливає на рослини і на пшеницю зокрема, яка є одним із найважливіших видів зернових культур. Окремі зміни, спричинені цим чинником є позитивними, особливо пришвидшений ріст, розвиток і кращий фотосинтез рослин. З іншого боку, підвищення вмісту [CO₂] спричинює погіршення якості та зниження врожайності. Наведено деякі результати власних досліджень із пшеницею.

Ключові слова: C₃, C₄, якість зерна, крива Кілінга, Мауна-Лоа, фотосинтез.

Скурська Е., Башуцька В., Станковски С. Дослідження концентрації діоксида карбона [CO₂] в атмосфері та вплив збільшення [CO₂] на пшеницю (*Triticum aestivum* L.)

Описан тренд концентрации в атмосфере диоксида карбона [CO₂] за последние пятьдесят лет, известный как "кривая Килинга", и мониторинг CO₂ в обсерватории Мауна-Лоа на Гавайях. Увеличение уровня CO₂ влияет на растения и на пшеницу в частности, которая является одним из важнейших видов зерновых культур. Отдельные изменения, вызванные этим фактором, являются позитивными, особенно ускоренный рост, развитие и лучший фотосинтез растений. С другой стороны, повышение уровня [CO₂] влечет снижение качества урожайности. Приведены некоторые результаты собственных исследований с пшеницей.

Ключевые слова: C₃, C₄, качество зерна, кривая Килинга, Мауна-Лоа, фотосинтез.