Chapter 4

# SUSTAINABLE SOLUTIONS FOR CROP CULTIVATION IN THE ERA OF CLIMATE CHANGE

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## INTRODUCTION

The modern world of agricultural production faces unprecedented challenges related to environmental degradation. Historically, the Industrial Revolution marked a surge in fossil fuel use, while the Green Revolution intensified agricultural production through synthetic resources and monocultures, exacerbating pressure on the environment. The growth of industry, agricultural intensification, climate change, and resource pollution have evolved into global threats that impact not only ecosystems but also humanity's ability to feed itself. The effects of negative environmental factors are not merely ecological but also a social issue. Greenhouse gas emissions ($CO_2$, $CH_4$) from energy and agriculture drive global warming, altering precipitation patterns and intensifying extreme weather events. In this context, crop cultivation technologies are no longer just tools for increasing yields but also a key to restoring the balance between humanity's needs and nature's capacity.[1].

Climate change is one of the most significant factors transforming agricultural landscapes. Habitat destruction and land pollution have caused a 69% decline in wildlife populations since 1970[2].

Modern agrotechnologies no longer focus solely on mechanization or selective breeding. They now serve as a bridge between productivity and ecological responsibility. The excessive use of synthetic mineral fertilizers has disrupted nitrogen cycles, causing eutrophication, while over-irrigation depletes aquifers[3]. However, drones equipped with sensors and artificial intelligence can analyze the condition of every square meter of a field,

[1] AR6 Synthesis Report. *Climate Change 2023.* Режим доступу: https://www.ipcc.ch/report/ar6/syr/

[2] Living Planet Report 2022. Режим доступу: https://www.worldwildlife.org/pages/living-planet-report-2022

[3] Rockström J., Steffen W., Noone K., Persson Å., Chapin III F.S., Lambin E., Lenton T.M., Scheffer M., Folke C., Schellnhuber H., Nykvist B., De Wit C.A., Hughes T., van der Leeuw S., Rodhe H., Sörlin S., Snyder P.K., Costanza R., Svedin U., Falkenmark M., Karlberg L., Corell R.W., Fabry V.J., Hansen J., Walker B., Liverman D., Richardson K., Crutzen P., Foley J. Planetary boundaries: Exploring the safe operating space for humanity. *Ecology and Society*, 2009, Vol. 14 (2). P.32.

enabling precise determination of where fertilizer is needed and where natural soil fertility suffices. Such approaches reduce nitrogen emissions into the atmosphere by 20–30%.

Anthropogenic impact demands innovative agricultural technologies, but solutions must balance efficiency with ecological sustainability. Interdisciplinary collaboration encompassing environmental science, policy, and socioeconomics is critical to achieving Sustainable Development Goals (SDGs), such as Zero Hunger (SDG 2) and Climate Action (SDG 13). Future research must prioritize equitable access to technologies and systemic resilience.

The From Farm to Fork (F2F) Strategy, a cornerstone of the European Green Deal, aims to make EU member states' food systems more transparent, environmentally clean, and beneficial for consumer health. It targets 25% of agricultural land to be organic by 2030, incentivizing the adoption of sustainable technologies[4].

## 1. Smart Greenhouse Systems in Modern Tomato Cultivation

Global warming is not an abstract term from textbooks but a reality that already impacts every one of us today. Its main "driver" is human activity, particularly technogenic factors: from $CO_2$ emissions to intensive agriculture. Technogenic factors are not a verdict but a challenge. Today, we already possess technologies to make agriculture an ally in combating global warming.

Tomatoes are one of the most popular vegetable crops worldwide, combining excellent taste, culinary versatility, and significant benefits for human health. According to historical data, tomatoes were introduced to Europe from South America in the 16th century and quickly gained popularity due to their nutritional and medicinal properties. Today, alongside open-field cultivation, increasing attention is being paid to greenhouse tomatoes, which ensure stable yields and year-round availability. This text explores the beneficial properties of tomatoes, the characteristics of greenhouse varieties, and their impact on health[5].

Tomatoes contain a range of vital components:

**Lycopene**: A potent antioxidant that reduces the risk of cardiovascular diseases and certain cancers. Unlike many other foods, its concentration increases during thermal processing (e.g., in tomato paste);

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[4] From Farm to Fork (F2F). Режим доступу: https://www.undp.org/sites/g/files/zskgke326/files/2022-08/3%20Tree%20From%20Farm%20to%20Fork%20Strategy%203%20final_297x210mm_4%2B4_web_180822.pdf

[5] Томат, або Помідор. *Земляк.* 18.10.2023. Режим доступу: https://zemliak.com/kultury/1865-tomat

**Vitamins**: A, C, E, K, and B-group. Vitamin C supports immunity, while vitamin K promotes bone health;

**Minerals**: Potassium, magnesium, iron, and phosphorus. Potassium, for example, regulates blood pressure, and iron prevents anemia;

Organic acids (malic, citric) aid digestion and metabolism. Research shows that regular tomato consumption reduces inflammatory processes in the body and improves skin condition due to their high antioxidant content [6].

According to scientists' estimates, the global population will increase by nearly two billion over the next 30 years, rising from 8 billion to 9.7 billion by 2050 and potentially peaking at 10.4 billion by the mid-2080s. Extreme weather caused by global climate change has significantly reduced crop yields in open fields and led to rising food prices. Greenhouses can serve as efficient systems, as they enable sustainable food production by limiting contact between pollutants and plants and optimizing water, energy, and soil use[7].

Consuming tomatoes, particularly greenhouse-grown ones, is a key element of a healthy diet. They not only provide the body with essential nutrients but also reduce the risk of chronic diseases. Modern greenhouse technologies allow for the production of eco-friendly and nutritious fruits year-round, making them an indispensable component of the diet. To maximize benefits, it is advisable to combine fresh and thermally processed tomatoes, considering their unique properties[8].

Contrary to common stereotypes, greenhouse tomatoes offer several advantages: They ensure a constant supply of vitamins in the diet, which is especially important during winter; Greenhouse protection from industrial emissions and heavy metals reduces the accumulation of harmful substances in fruits; Harvesting occurs at peak ripeness when antioxidant concentrations are highest [9,10].

Greenhouse technologies enable controlled growing conditions, positively impacting fruit quality, yield stability, and environmental

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[6] Томат, або Помідор. *Земляк.* 18.10.2023. Режим доступу: https://zemliak.com/kultury/1865-tomat

[7] Barreca F. Sustainability in Food Production: A High-Efficiency Offshore Greenhouse. *Agronomy*, 2024, Vol. 14, P. 518. https://doi.org/10.3390/agronomy14030518

[8] Насіння томатів для теплиць. *Libraseeds.* 2025. Режим доступу: https://libraseeds.com.ua/plant-type/semena-tomatov-dlya-teplits/

[9] Томат, або Помідор. *Земляк.* 18.10.2023. Режим доступу: https://zemliak.com/kultury/1865-tomat

[10] Насіння томатів для теплиць. *Libraseeds.* 2025. Режим доступу: https://libraseeds.com.ua/plant-type/semena-tomatov-dlya-teplits/

sustainability[11]. Research also shows that greenhouse tomatoes are less prone to rot during storage, preserving their beneficial properties longer[12].

The greenhouse industry is increasingly adopting energy-saving technologies to reduce fossil fuel consumption and its corresponding environmental impact. Most greenhouses are low-cost structures covered with single-layer polyethylene films and lacking active climate control systems[13]. In these greenhouses, the microclimate during winter often falls outside the optimal range, yet active heating systems are rarely used due to being deemed economically impractical[14].

According to the European standard EN 13031-1:2001, a greenhouse is defined as a "structure used for growing and protecting plants and crops, which utilizes the transmission of solar radiation under controlled conditions to enhance the growing environment, and whose dimensions allow people to work inside." The amount of sunlight and heat entering a greenhouse depends on solar radiation, reflection by the Earth, the greenhouse's shape and orientation, structural type, transmittance capacity, absorption and reflection by the covering material, dust, condensation, etc[15]. Minimizing heat loss is necessary to maintain the temperature within optimal ranges. The structural elements of the greenhouse, soil, and crops contribute to solar radiation absorption and influence heat generation[16,17].

Film greenhouses, as an affordable and flexible tool in agriculture, have become a key element in ensuring stable yields under various climatic conditions in recent years. Despite competition from glass and polycarbonate structures, their popularity continues to grow due to low cost, ease of installation, and adaptability. The main advantages of film greenhouses include:

*Economic affordability*: The cost of film is significantly lower than glass or polycarbonate, making it an ideal choice for small and medium-sized farms

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[11] Сумченко В. ТОП-10 хвороб томатів: як врятувати помідори від плям і гнилі. *Zemliak.com* 03.06.2021. Режим доступу: https://zemliak.com/dim-sad-gorod/111-top-10-hvorob-tomativ-yak-vryatuvati-pomidori-vid-plyam-i-gnili

[12] Насіння томатів для теплиць. *Libraseeds.* 2025. Режим доступу: https://libraseeds.com.ua/plant-type/semena-tomatov-dlya-teplits/

[13] Pardossi A., Tognoni F., Incrocci L. Mediterranean greenhouse technology. *Chron. Horticult*., 2004, Vol. 44. P. 28–34.

[14] Bartzanas T., Tchamitchian M., Kittas C. Influence of the heating method on greenhouse microclimate and energy consumption. *Biosyst. Eng.*, 2005, Vol. 91. P. 487–499.

[15] EUROPEAN STANDARD BS EN 13031-1:2019 Greenhouses. Design and Construction Commercial Production Greenhouses 2022. Available online: https://www.en-standard.eu/bs-en-13031-1-2019-greenhouses-design-and-construction-commercial-production-greenhouses/

[16] Ghani S., Bakochristou F., ElBialy E.M.A.A., Gamaledin S.M.A., Rashwan, M.M., Abdelhalim A.M., Ismail S.M. Design Challenges of Agricultural Greenhouses in Hot and Arid Environments -A Review. *Eng. Agric. Environ. Food,* 2019, Vol. 12.P. 48–70.

[17] Papadakis G. Experimental Analysis and Dynamic Simulation of the Greenhouse Microclimate. Ph.D. Thesis, Agricultural University of Athens, Athens, Greece, 1989. 166 p.

(the film's warranty period is 2–3 years, but with proper care, it can last up to 5 years);

*Structural flexibility*: Easy installation allows for greenhouses of various shapes and sizes, including combinations with polycarbonate for end walls, which enhances wind resistance;

*Thermal insulation*: Using a double layer of film or thermal film reduces heat loss by 20–30%, enabling winter use[18,19]. The disadvantages of film greenhouses include: Limited lifespan: The film requires regular replacement, increasing operational costs; Sensitivity to mechanical damage[20].

Film greenhouses remain the most accessible solution for small and medium-sized farms, especially under limited investment conditions. Despite their drawbacks (short lifespan, weather sensitivity), their flexibility, low cost, and potential for modernization make them promising for growing vegetables, green biomass, and seedlings. Technological improvements (double-layer film, IoT, renewable energy sources) allow them to compete with more expensive alternatives like polycarbonate or glass greenhouses. For large farms, a combined approach is optimal, where film is used for temporary or seasonal structures, while permanent complexes rely on polycarbonate. In terms of capital and operational costs, film greenhouses have the lowest initial expenses. For example, the cost of a structure with a galvanized frame and 200-micron film is 3–5 times lower than polycarbonate equivalents. Additionally, government grants promote the development of small farms, covering up to 70% of equipment costs. Film greenhouses with double layers or thermal screens reduce heating expenses by 20–30%, and integrating IoT systems automates temperature and humidity control, lowering energy consumption. However, polyethylene film is less environmentally friendly due to its complex disposal[21,22].

[18] Маковей Ю. Сучасна теплиця: перспективні конструкції, матеріали та технології. *Kurkul.com*. 18.10.2024. Режим доступу: https://kurkul.com/spetsproekty/1650-suchasna-teplitsya-perspektivni-konstruktsiyi-materiali-ta-tehnologiyi

[19] Теплиці під плівку. *Нова Теплиця.* 2025. Режим доступу: https://novateplica.com.ua/uk/tepliczy-pod-plyonku/

[20] Теплиці як бізнес в агросекторі. *Weagro.* 11.11.2024. Режим доступу: https://weagro.com.ua/blog/teplyczi-yak-biznes-v-agrosektori/

[21] Теплиці під плівку. *Нова Теплиця.* 2025. Режим доступу: https://novateplica.com.ua/uk/tepliczy-pod-plyonku/

[22] Теплиці як бізнес в агросекторі. *Weagro.* 11.11.2024. Режим доступу: https://weagro.com.ua/blog/teplyczi-yak-biznes-v-agrosektori/

To properly select a greenhouse, all energy flows within the structure must be considered – soil heat loss, ventilation, thermal radiation, conductivity, etc. (Figure 1)[23].

The "greenhouse effect" occurs when solar radiation enters a greenhouse through a transparent roof, is absorbed inside, and then cannot escape in the form of thermal radiation because the roof is opaque to thermal radiation[24].

Sunlight consists of ultraviolet (UV, 100–400 nm), visible (VIS, 400–780 nm), and near-infrared radiation (NIR, 750–2500 nm). Among these, UV radiation affects film degradation and pollinator behavior, while VIS radiation serves as a heat source. When the greenhouse effect is established, the temperature rises rapidly, creating unfavorable conditions for plant growth, development, and yield formation, plant pollination, and human labor[25,26,27].

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[23] Ravishankar E., Booth R.E., Saravitz C., Sederoff H., Ade H.W., O'Connor B.T. Achieving Net Zero Energy Greenhouses by Integrating Semitransparent Organic Solar Cells. *Joule*, 2020, Vol. 4. P. 490-506.

[24] Papadakis G., Frangoudakis A., Kyritsis S. Experimental Investigation and Modelling of Heat and Mass Transfer between a Tomato Crop and the Greenhouse Environment. *J. Agric. Eng. Res.*, 1994, Vol. 57. P. 217–227.

[25] Wang S., Zhang J., Liu L., Yang F., Zhang Y. Evaluation of cooling property of high density polyethylene (HDPE)/titanium dioxide (TiO 2) composites after accelerated ultraviolet (UV) irradiation. *Sol. Energy Mater. Sol. Cells*, 2015, Vol. 143. P. 120–127.

[26] Abdel-Ghany A.M., Al-Helal I.M., Alzahrani S.M., Alsadon A.A., Ali I.M., Elleithy R.M. Covering materials incorporating radiation-preventing techniques to meet greenhouse cooling challenges in arid regions: *A review. Sci. World J.*, 2012, Vol. 2012, Article# 906360.

[27] Abdel-Ghany A.M., Kozai T., Kubota C., Taha I.S. Investigation of the spectral optical properties of the liquid radiation filters for using in the greenhouse applications. *J. Agric. Meteorol.*, 2001, Vol. 57. P. 11–19.

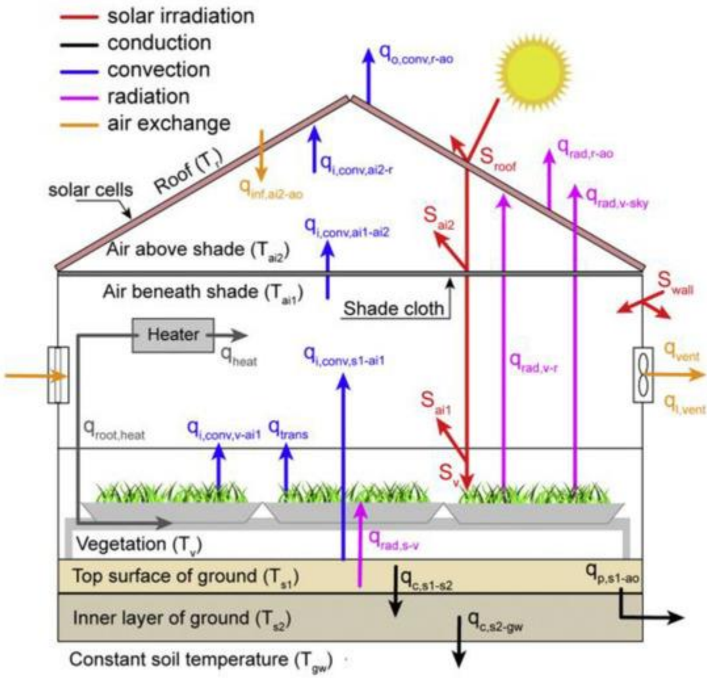


**Fig. 1. Energy flows in a greenhouse[28]**

**Fig. 2. Tomato bush formation in film greenhouses**

[28] Ravishankar E., Booth R.E., Saravitz C., Sederoff H., Ade H.W., O'Connor B.T. Achieving Net Zero Energy Greenhouses by Integrating Semitransparent Organic Solar Cells. *Joule,* 2020, Vol. 4. P. 490-506.

**Fig. 3. Greenhouse shelter designs and heating systems**

Research confirms that greenhouse covering materials influence the microclimate inside the greenhouse. Selecting the appropriate greenhouse covering for a specific region (considering soil-climatic characteristics) promotes stability in the internal environment[29, 30].

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[29] Alsadon A., Al-Helal I., Ibrahim A., Abdel-Ghany A., Al-Zaharani S., Ashour T. The effects of plastic greenhouse covering on cucumber (*Cucumis sativus L.*) growth. *Ecol. Eng.*, 2016, Vol. 87. P. 305–312.

[30] Subin M.C., Karthikeyan R., Periasamy C., Sozharajan B. Verification of the greenhouse roof-covering-material selection using the finite element method. *Mater. Today Proc.*, 2020, Vol. 21. P. 357–366.

Results show[31], that polycarbonate is the most suitable material for heat retention during cold nights, while glass is better for cooling energy savings in hot seasons. Greenhouses with plastic coverings demonstrated the highest variability in indoor air temperature fluctuations, whereas polyethylene-covered greenhouses maintained higher overall indoor air temperatures. Glazed greenhouses exhibited the smallest temperature variation in indoor air. The surface temperature of the covering materials followed a trend similar to indoor air temperature. Relative humidity was very low at noon, ranging from 18.7% to 30.6%, indicating the need to control greenhouse humidity through ventilation. It is also noteworthy that polyethylene transmits infrared radiation more efficiently than glass, meaning greenhouses retain less heat[32].

The correct choice of greenhouse covering determines crop growth, development, and yield formation, particularly for vegetable crops. For example, at temperature regimes below optimal levels, tomato plants alter the duration of interphase periods[33,34], reduce growth rates[35,36,37,38], the number of flowers per cluster[39], and their fruit setting[40].

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[31] Kim H.-K., Lee S.-Y., Kwon J.-K., Kim Y.-H. Evaluating the Effect of Cover Materials on Greenhouse Microclimates and Thermal Performance. *Agronomy*, 2022, Vol. 12. P. 143. https://doi.org/10.3390/agronomy12010143

[32] Nijskens J., Deltour J., Nisen A., Coutisse S. Radiometric and Thermal Properties of Plastic Materials. In Proceedings of the II International Symposium on Plastics in Mediterranean Countries, ISHS Acta Horticulturae 154, Hammamet, Tunesia, 20–25 February 1984. P. 33–42.

[33] Hurd R.G., Graves C.J. Some effects of air and root temperatures on the yield and quality of glasshouse tomatoes. *J. Hortic. Sci.*, 1985, Vol. 60. P. 359–371.

[34] Sherzod R., Yang E.Y., Cho M.C., Chae S.Y., Kim J.H., Nam C.W., Chae W.B. Traits Affecting Low Temperature Tolerance in Tomato and Its Application to Breeding Program. *Plant Breed. Biotechnol.*, 2019, Vol. 7. P. 350–359.

[35] Venema J.H., Posthumus F., de Vries M., van Hasselt P.R. Differential response of domestic and wild Lycopersicon species to chilling under low light: Growth, carbohydrate content, photosynthesis and the xanthophyll cycle. *J. Physiol. Plant.*, 1999, Vol. 105. P. 81–88.

[36] Chen H., Chen X., Chen D., Li J., Zhang Y., Wang A. A comparison of the low temperature transcriptomes of two tomato genotypes that differ in freezing tolerance: *Solanum lycopersicum* and *Solanum habrochaites*. *BMC Plant Biol.*, 2015, Vol. 15. P. 1–16.

[37] Liu H., Ouyang B., Zhang J., Wang T., Li H., Zhang Y., Yu C., Ye Z. Differential Modulation of Photosynthesis, Signaling, and Transcriptional Regulation between Tolerant and Sensitive Tomato Genotypes under Cold Stress. *PLoS ONE*, 2012, Vol. 7, Article#e50785.

[38] Hoek I., Ten Cate C.H.H., Keijzer C.J., Schel J.H., Dons H.J. Development of the Fifth Leaf is Indicative for Whole Plant Performance at Low Temperature in Tomato. *Ann. Bot.*, 1993, Vol. 72. P. 367–374.

[39] Sherzod R., Yang E.Y., Cho M.C., Chae S.Y., Kim J.H., Nam C.W., Chae W.B. Traits Affecting Low Temperature Tolerance in Tomato and Its Application to Breeding Program. *Plant Breed. Biotechnol.*, 2019, Vol. 7. P. 350–359.

[40] Picken A.J.F. A review of pollination and fruit set in the tomato (*Lycopersicon esculentum* Mill.). *J. Hortic. Sci.*, 1984, Vol. 59. P. 1–13.

## 2. Sustainable corn production in the face of climate change

Agriculture accounts for 24% of global emissions driving global warming. However, new technologies are helping transform it into a tool to combat the crisis. In 2015, member countries of the United Nations (UN) adopted a plan to build a better world for people and the planet by 2030. The plan established 17 Sustainable Development Goals (SDGs) to promote prosperity while protecting the environment and ensuring development balances social and economic interests. These goals defined policies to guarantee safe nutrition, secure land use, and energy efficiency in production[41].

Agricultural production is becoming increasingly energy-intensive compared to the past[42], which is linked to global climate changes. Consequently, food prices are rising, and shortages are growing in domestic and international markets[43,44]. Therefore, modern technological frameworks for cultivating crops are focused on climate-smart technologies that ensure the production of high-quality products rich in nutrients[45,46,47].

The adoption of climate-smart practices in corn production systems is an ideal solution for limiting the impact of agricultural activities on greenhouse gas emissions while enhancing carbon (C) and nitrogen sequestration, restoring soil fertility, and improving soil health[48].

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[41] European Commission. Farm to Fork Strategy, DG SANTE/Unit 'Food Information and Composition, Food Waste'. 2020. Available online: https://food.ec.europa.eu/document/download/472acca8-7f7b-4171-98b0-ed76720d68d3_en?filename=f2f_action-plan_2020_strategy-info_en.pdf

[42] Sims R., Flammini A., Puri M., Bracco S. Opportunities for Agri-Food Chains to Become Energy-Smart, FAO: Rome, Italy, USAID: Washington, DC, USA, 2015. Available online: http://www.fao.org/3/a-i5125e.pdf

[43] Hertel T.W., Burke M.B., Lobell D.B. The poverty implications of climate-induced crop yield changes by 2030. *Glob. Environ. Chang*., 2010, Vol. 20. P. 577–585.

[44] Iizumi T., Ramankutty N. How do weather and climate influence cropping area and intensity? *Glob. Food Secur*., 2015, Vol. 4. P. 46–50.

[45] Barbaresi A., Torreggiani D., Benni S., Tassinari P. Indoor air temperature monitoring: A method lending support tomanagement and design tested on a wine-aging room. *Build. Environ*., 2015, Vol. 86. P. 203–210.

[46] Rey R. New Challenges and Opportunities for Mountain Agri-Food Economy in South Eastern Europe. A Scenario for Efficient and Sustainable Use of Mountain Product, Based on the Family Farm, in an Innovative, Adapted Cooperative Associative System-Horizon 2040. *Procedia Econ. Financ.*, 2015, Vol. 22. P. 723–732.

[47] Mitter, H., Techen, A.-K., Sinabell, F., Helming, K., Schmid, E., Bodirsky, B.L., Holman, I., Kok, K., Lehtonen, H., Leip, A., et al. Shared Socio-economic Pathways for European agriculture and food systems: The Eur-Agri-SSPs. *Glob. Environ. Chang.*, 2020, Vol. 65, Article# 102159.

[48] Della Lunga D., Brye K.R., Mulvaney M.J., Daniels M., de Oliveira T., Baker B., Bradford T.Jr., Arel C.M. Cover Crop Effects on Greenhouse Gas Emissions and Global Warming Potential in Furrow-Irrigated Corn in the Lower Mississippi River Valley. Atmosphere, 2025, Vol. 16(5), Article#498. https://doi.org/10.3390/atmos16050498

Corn is a globally cultivated crop of significant economic importance, primarily due to its high yield potential and versatile use as food, feed, and an energy source[49].

According to data, in 2020, corn was cultivated on 202 million hectares, with global production estimated at 1,162.4 million tons. Compared to 2001, corn cultivation areas increased by 47%, and yields rose by 89%. Similar growth trends were observed in Europe, where cultivation areas expanded from 13.5 to 19.4 million hectares, and production increased by 63%[50].

Corn is the crop most responsive to yield increases when grown under irrigation[51,52,53]. tudies show that combining corn with leguminous crops boosts yields by 20% while simultaneously restoring soils[54].

Corn grain yield (*Zea mays* L.) is influenced by numerous factors, including abiotic and biotic stress, as well as technological aspects of cultivation. Standard farming recommendations often prove insufficient, driving interest in intensive farming strategies within adaptive corn management systems. Research indicates that under non-irrigated conditions, intensive farming methods provided, on average, 5.9% higher yields than standard methods. A stronger yield response to irrigation was observed under standard farming (34%) compared to intensive farming (8.9%). The impact of irrigation on specific plots ranged from 14% to 61%[55].

Water is a critical factor in corn development, with its deficiency being one of the main causes of reduced productivity[56]. Water requirements, temperature, and solar radiation are variables that directly affect the growth

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[49] Żarski J., Kuśmierek-Tomaszewska R. Effects of Drip Irrigation and Top Dressing Nitrogen Fertigation on Maize Grain Yield in Central Poland. *Agronomy*. 2023, Vol. 13(2), Article#360. https://doi.org/10.3390/agronomy13020360

[50] FAOSTAT. Food and Agriculture Data. Available online: https://www.fao.org/faostat

[51] Liu Y., Yang H.S., Li J.S., Li Y.F., Yan H.J. Estimation of irrigation requirements for drip-irrigated maize in a sub-humid climate. *J. Integr. Agric.*, 2018, Vol. 17. P. 677–692.

[52] Wang Y., Li S., Cui Y., Qin S., Guo H., Yang D., Wang C. Effect of drip irrigation on soil water balance and water use efficiency of maize in Northwest China. *Water*, 2021, Vol. 13, Article#217.

[53] Irmak S., Mohammed A., Kukal M. Maize response to coupled irrigation and nitrogen fertilization under center pivot, subsurface drip and surface (furrow) irrigation: Growth, development and productivity. *Agric. Water Manage.*, 2022, Vol. 263, Article#107457.

[54] UNEP IN 2022. https://www.unep.org/annualreport/2022

[55] Arinaitwe U., Thomason W., Frame W.H., Reiter M.S., Langston D. Optimizing Maize Agronomic Performance Through Adaptive Management Systems in the Mid-Atlantic United States. *Agronomy*, 2025, Vol. 15(5), Article#1059. https://doi.org/10.3390/agronomy15051059

[56] Cavalcante E.S., Lacerda C.F., Costa R.N.T., Gheyi H.R., Pinho L.L., Bezerra F.M.S., Oliveira A.C., Canjá J.F. Supplemental irrigation using brackish water on maize in tropical semi-arid regions of Brazil: Yield and economic analysis. *Sci. Agric.*, 2021, Vol. 78, Article#e20200151.

period, which peaks when these variables are optimally available, enabling the crop to achieve maximum yields[57].

Corn consumes an average of 400 to 700 mm of water during its full cycle, depending on climatic conditions. The period of maximum water demand coincides with grain formation and filling, during which water deficiency causes the greatest decline in productivity[58].

In climate zones where water is the primary determinant of corn yield, modern technologies focus on deficit irrigation strategies[59,60].

Irrigation plays a vital role in corn cultivation, particularly in arid and semi-arid climatic zones, as it is the main factor influencing yield under persistent or periodic rainfall shortages, ensuring optimal growth, development, and satisfactory crop harvests. In such conditions, food production without irrigation would be impossible. Globally, irrigated corn occupies 31.5 million hectares, accounting for 15.6% of total global cultivation areas. The largest irrigated corn areas are in China (13 million ha), the USA (4.8 million ha), and India (2.2 million ha). In Europe, corn is irrigated on 2.4 million ha, primarily in France, Italy, and Spain[61].

***Sprinkler irrigation***

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[57] Cruz J.C., Pereira Filho I.A., Alvarenga R.C., Gontijo Neto M.M., Viana J.H.M., de Oliveira M.F., Matrangolo W.J.R., de Albuquerque Filho M.R. EMBRAPA Milho e Sorgo: Cultivo do Milho, Sistemas de Produção, v. 2 (6). 2010. Available online: https://ainfo.cnptia.embrapa.br/digital/bitstream/item/27037/1/Plantio.pdf

[58] Cavalcante E.S., Lacerda C.F., Costa R.N.T., Gheyi H.R., Pinho L.L., Bezerra F.M.S., Oliveira A.C., Canjá J.F. Supplemental irrigation using brackish water on maize in tropical semi-arid regions of Brazil: Yield and economic analysis. *Sci. Agric.*, 2021, Vol. 78, Article#e20200151.

[59] Tarighaleslami M., Zarghami R., Mashhadi A.B.M., Oveysi M. Effects of drought stress and different nitrogen levels on morphological traits of proline in leaf and protein of corn seed (*Zea mays* L.). *Am.-Eurasian J. Agri. Environ. Sci.*, 2012, Vol. 12, Article#49.

[60] Kresović B., Gajić B., Tapanarova A., Dugalić G. How irrigation water affects the yield and nutritional quality of maize (*Zea mays* L.) in a temperate climate. *Pol. J. Environ. Stud.*, 2018, Vol. 27. P. 1123–1131.

[61] AQUASTAT. Global Information System on Water and Agriculture. Available online: https://www.fao.org/aquastat

***Drip irrigation***

***Subsurface irrigation***

**Fig. 4. Different irrigation methods for corn**

Cultivating corn for grain under global warming requires integrating modern technologies that combine efficient water use, adaptation to temperature stress, and soil resource conservation. Drip irrigation, monitoring systems, water condensation, and stress-resistant hybrids are key elements of sustainable agriculture. Global leaders’ experience proves that innovations can not only offset losses from climate change but also deliver record harvests[62,63].

Drip irrigation plays a critical role in enhancing crop productivity through precise water delivery[64], reducing production costs and crop

[62] Сучасна технологія вирощування кукурудзи на зерно. Режим доступу: https://uapg.ua/blog/suchasna-tehnologiya-viroshhuvannya-kukurudzi-na-zerno/

[63] Глобальне потепління змушує добувати воду з повітря. *Пропозиція*, 10.10.2017. Режим доступу: https://propozitsiya.com/news/hlobalne-poteplinnya-zmushuye-dobuvaty-vodu-z-povitrya

[64] Chen M., Gao Z., Wang Y. Overall introduction to irrigation and drainage development and modernization in China. *Irrig. Drain*., 2020, Vol. 69. P. 8-18.

evapotranspiration[65]. Resource efficiency: Drip irrigation cuts water use by 30–60% compared to flood methods[66].

The adoption of drip irrigation methods for corn has significantly reduced costs and improved water-use efficiency in northeastern China. Optimizing supplemental and drip irrigation are highly effective methods with substantial potential for increasing crop yields[67].

Nighttime irrigation using subsurface drip systems can help lower soil temperature in the root zone, improving plant growth and yields in regions where high-temperature stress limits crop development. This is crucial for mitigating the negative impacts of warming trends on agriculture[68].

In recent years, the contribution of simulation models to studying vital processes between soil, water, atmosphere, and plants has grown significantly[69]. Several computer simulation models based on calculating root-zone water content to assess crop needs have already been developed[70,71]. Farmers' adoption of simulation models for irrigation planning remains gradual due to two main reasons: model interfaces are not user-friendly, and the lack of localized reference values for crop evapotranspiration (ETo)[72].

## CONCLUSIONS

1. Global warming, caused by anthropogenic factors, poses significant challenges for humanity, particularly in the realm of food security. However, agriculture, being one of the key sources of $CO_2$ emissions, can become an ally in combating climate change through innovative approaches. Greenhouse technologies, particularly tomato cultivation, demonstrate how ecological sustainability, economic efficiency, and public health support can be combined.

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[65] Wang Z., Gao J., Ma B. Concurrent Improvement in Maize Yield and Nitrogen Use Efficiency with Integrated Agronomic Management Strategies. *Agron. J.*, 2014, Vol. 106. P. 1243-1250.

[66] FAO, 2020. https://www.fao.org/interactive/state-of-food-agriculture/2020/en/

[67] Wang Z., Jin M., Šimůnek J., van Genuchten M.T. Evaluation of mulched drip irrigation for cotton in arid Northwest China. *Irrig. Sci.*, 2014, Vol. 32. P. 15–27.

[68] Dong X., Xu W., Zhang Y., Leskovar D.I. Effect of Irrigation Timing on Root Zone Soil Temperature, Root Growth and Grain Yield and Chemical Composition in Corn. *Agronomy*, 2016, Vol. 6(2), Article#34. https://doi.org/10.3390/agronomy602003

[69] Jones J.W., Antle J.M., Basso B.O., Boote K.J., Conant R.T., Foster I., Godfray H.C.J., Herrero M., Howitt R.E., Janssen S., et al. Brief history of agricultural system models. *Agric. Syst*., 2017, Vol. 155. P. 240–254.

[70] Abd El Baki H.M., Fujimaki H. An Evaluation of a New Scheme for Determination of Irrigation Depths in the Egyptian Nile Delta. *Water*, 2021, Vol. 13, Article#2181.

[71] Pereira L.S., Teodoro P.R., Rodrigues P.N., Teixeira J.L. Irrigation Scheduling Simulation: The Model Isareg. In Tools for Drought Mitigation in Mediterranean Regions, Springer: Dordrecht, The Netherlands, 2003. P. 161–180.

[72] Sadsad J.S., Ella V.B., Lampayan R.M., Sta. Cruz PC. A VBA-Based Field Water Balance Model for Efficient Irrigation Water Management of Corn (Z*ea mays L*.). Agronomy, 2023, Vol. 13(3), Article#751. https://doi.org/10.3390/agronomy13030751

Tomatoes, rich in antioxidants, vitamins, and minerals, are not only a valuable component of diets but also a promising crop for greenhouse production. Modern greenhouses ensure stable yields regardless of external climate fluctuations, reduce the impact of pollution, and optimize resource use (water, energy, soil). Special attention is given to film greenhouses, which, due to their low cost, flexibility, and potential for modernization (double-layer film, IoT, solar energy), serve as an accessible solution for small and medium-sized farms. Despite the limited lifespan of their coverings, their role in ensuring food stability and reducing environmental footprints remains pivotal.

Research emphasizes that the choice of greenhouse materials (polyethylene, polycarbonate, glass) directly affects microclimate, energy efficiency, and crop yields. The integration of automation and renewable energy sources opens new opportunities for reducing costs and enhancing system resilience.

Thus, greenhouse tomato cultivation is not only a response to the challenges of a growing population and extreme weather conditions but also a pathway to healthy nutrition and an ecologically balanced future. To maximize effectiveness, a combined approach is necessary: merging traditional methods with modern technologies, state support for small farms, and active implementation of energy-saving solutions. This will transform greenhouses from ordinary agricultural structures into tools for combating climate change, promoting health, and ensuring food security.

2. Agriculture, accounting for 24% of global greenhouse gas emissions, simultaneously holds the potential to become a tool in addressing the climate crisis. The implementation of the UN Sustainable Development Goals (SDGs) by 2030, particularly those related to safe nutrition, efficient land use, and energy efficiency, has become critically urgent against the backdrop of rising energy intensity in agro-production, food shortages, and intensifying climate change. Corn, as one of the world’s most vital agricultural crops, illustrates this dynamic: its production is growing rapidly, yet it demands innovative approaches to reduce environmental impact and adapt to extreme conditions.

Climate-smart technologies have proven effective in increasing yields by 20–60%, reducing water consumption by 30–60%, and restoring soil fertility. The experience of leading countries (China, the USA, the EU) highlights that integrating advanced irrigation methods and related practices not only compensates for drought-related losses but also ensures production stability under global warming. However, large-scale adoption of these practices requires overcoming barriers. Striking a balance between production intensification, ecological sustainability, and socio-economic needs remains decisive.

Thus, the transition to climate-smart agriculture, particularly in the context of corn cultivation, is a necessary step toward achieving global sustainable development goals, safeguarding food security, and mitigating the consequences of climate change.


## SUMMARY

Agriculture, a major contributor to greenhouse gas emissions, holds dual potential as both a driver of climate change and a solution through sustainable innovation. Two key crops, tomatoes and maize, exemplify this duality. Greenhouse technologies for tomato cultivation demonstrate how controlled environments enhance food security by ensuring stable yields, optimizing water and energy use, and reducing environmental impact. Innovations enable farms to adopt eco-efficient practices while improving dietary health through nutrient-rich produce. Similarly, climate-smart practices in maize production, such as advanced irrigation and soil management, boost yields, cut water use, and restore soil health. However, scaling these methods requires balancing agricultural intensification with ecological and socio-economic needs. This underscores the necessity of integrating automation, renewable energy, and adaptive technologies with traditional methods. Achieving global sustainability requires investment in energy-efficient infrastructure and systemic collaboration to transform agriculture into a climate-resilient sector. This transition is critical for mitigating climate impacts, safeguarding food security and aligning with the UN's Sustainable Development Agenda.


## Bibliography


1. AR6 Synthesis Report. *Climate Change 2023.* Режим доступу: https://www.ipcc.ch/report/ar6/syr/
2. Living Planet Report 2022. Режим доступу: https://www.worldwildlife.org/pages/living-planet-report-2022
3. Rockström J., Steffen W., Noone K., Persson Å., Chapin III F.S., Lambin E., Lenton T.M., Scheffer M., Folke C., Schellnhuber H., Nykvist B., De Wit C.A., Hughes T., van der Leeuw S., Rodhe H., Sörlin S., Snyder P.K., Costanza R., Svedin U., Falkenmark M., Karlberg L., Corell R.W., Fabry V.J., Hansen J., Walker B., Liverman D., Richardson K., Crutzen P., Foley J. Planetary boundaries: Exploring the safe operating space for humanity. *Ecology and Society*, 2009, Vol. 14 (2). P.32.
4. From Farm to Fork (F2F). Режим доступу: https://www.undp.org/sites/g/files/zskgke326/files/2022-08/3%20Tree%20From%20Farm%20to%20Fork%20Strategy%203%20final_297x210mm_4%2B4_web_180822.pdf
5. Томат, або Помідор. *Земляк.* 18.10.2023. Режим доступу: https://zemliak.com/kultury/1865-tomat
6. Насіння томатів для теплиць. *Libraseeds.* 2025. Режим доступу: https://libraseeds.com.ua/plant-type/semena-tomatov-dlya-teplits/
7. Сумченко В. ТОП-10 хвороб томатів: як врятувати помідори від плям і гнилі. *Zemliak.com* 03.06.2021. Режим доступу:

https://zemliak.com/dim-sad-gorod/111-top-10-hvorob-tomativ-yak-vryatuvati-pomidori-vid-plyam-i-gnili
8. Маковей Ю. Сучасна теплиця: перспективні конструкції, матеріали та технології. *Kurkul.com*. 18.10.2024. Режим доступу: https://kurkul.com/spetsproekty/1650-suchasna-teplitsya-perspektivni-konstruktsiyi-materiali-ta-tehnologiyi
9. Теплиці під плівку. *Нова Теплиця.* 2025. Режим доступу: https://novateplica.com.ua/uk/tepliczy-pod-plyonku/
10. Теплиці як бізнес в агросекторі. *Weagro.* 11.11.2024. Режим доступу: https://weagro.com.ua/blog/teplyczi-yak-biznes-v-agrosektori/
11. Що вигідно вирощувати у теплиці? *Agroplast*. 2024. Режим доступу: https://agroplast.kiev.ua/index.php?route=blog/article&article_id=148
12. UNEP IN 2022. https://www.unep.org/annualreport/2022
13. FAO, 2020. https://www.fao.org/interactive/state-of-food-agriculture/2020/en/
14. Barreca F. Sustainability in Food Production: A High-Efficiency Offshore Greenhouse. *Agronomy*, 2024, Vol. 14, P. 518. https://doi.org/10.3390/agronomy14030518
15. Pardossi A., Tognoni F., Incrocci L. Mediterranean greenhouse technology. *Chron. Horticult*., 2004, Vol. 44. P. 28–34.
16. Bartzanas T., Tchamitchian M., Kittas C. Influence of the heating method on greenhouse microclimate and energy consumption. *Biosyst. Eng.*, 2005, Vol. 91. P. 487–499.
17. Ghani S., Bakochristou F., ElBialy E.M.A.A., Gamaledin S.M.A., Rashwan, M.M., Abdelhalim A.M., Ismail S.M. Design Challenges of Agricultural Greenhouses in Hot and Arid Environments -A Review. *Eng. Agric. Environ. Food*, 2019, Vol. 12.P. 48–70.
18. Papadakis G. Experimental Analysis and Dynamic Simulation of the Greenhouse Microclimate. Ph.D. Thesis, Agricultural University of Athens, Athens, Greece, 1989. 166 p.
19. Ravishankar E., Booth R.E., Saravitz C., Sederoff H., Ade H.W., O'Connor B.T. Achieving Net Zero Energy Greenhouses by Integrating Semitransparent Organic Solar Cells. *Joule,* 2020, Vol. 4. P. 490-506.
20. Wang S., Zhang J., Liu L., Yang F., Zhang Y. Evaluation of cooling property of high density polyethylene (HDPE)/titanium dioxide (TiO 2) composites after accelerated ultraviolet (UV) irradiation. *Sol. Energy Mater. Sol. Cells*, 2015, Vol. 143. P. 120–127.
21. Abdel-Ghany A.M., Al-Helal I.M., Alzahrani S.M., Alsadon A.A., Ali I.M., Elleithy R.M. Covering materials incorporating radiation-preventing techniques to meet greenhouse cooling challenges in arid regions: *A review. Sci. World J.*, 2012, Vol. 2012, Article# 906360.
22. Abdel-Ghany A.M., Kozai T., Kubota C., Taha I.S. Investigation of the spectral optical properties of the liquid radiation filters for using in the greenhouse applications. *J. Agric. Meteorol*., 2001, Vol. 57. P. 11–19.

23. Kim H.-K., Lee S.-Y., Kwon J.-K., Kim Y.-H. Evaluating the Effect of Cover Materials on Greenhouse Microclimates and Thermal Performance. *Agronomy*, 2022, Vol. 12. P. 143. https://doi.org/10.3390/agronomy12010143

24. Nijskens J., Deltour J., Nisen A., Coutisse S. Radiometric and Thermal Properties of Plastic Materials. In Proceedings of the II International Symposium on Plastics in Mediterranean Countries, ISHS Acta Horticulturae 154, Hammamet, Tunesia, 20–25 February 1984. P. 33-42.

25. Papadakis G., Frangoudakis A., Kyritsis S. Experimental Investigation and Modelling of Heat and Mass Transfer between a Tomato Crop and the Greenhouse Environment. *J. Agric. Eng. Res.*, 1994, Vol. 57. P. 217–227.

26. Alsadon A., Al-Helal I., Ibrahim A., Abdel-Ghany A., Al-Zaharani S., Ashour T. The effects of plastic greenhouse covering on cucumber (*Cucumis sativus L.*) growth. *Ecol. Eng.*, 2016, Vol. 87. P. 305–312.

27. Subin M.C., Karthikeyan R., Periasamy C., Sozharajan B. Verification of the greenhouse roof-covering-material selection using the finite element method. *Mater. Today Proc.*, 2020, Vol. 21. P. 357–366.

28. Hurd R.G., Graves C.J. Some effects of air and root temperatures on the yield and quality of glasshouse tomatoes. *J. Hortic. Sci.,* 1985, Vol. 60. P. 359–371.

29. Sherzod R., Yang E.Y., Cho M.C., Chae S.Y., Kim J.H., Nam C.W., Chae W.B. Traits Affecting Low Temperature Tolerance in Tomato and Its Application to Breeding Program. *Plant Breed. Biotechnol.*, 2019, Vol. 7. P. 350–359.

30. Hoek I., Ten Cate C.H.H., Keijzer C.J., Schel J.H., Dons H.J. Development of the Fifth Leaf is Indicative for Whole Plant Performance at Low Temperature in Tomato. *Ann. Bot.*, 1993, Vol. 72. P. 367–374.

31. Venema J.H., Posthumus F., de Vries M., van Hasselt P.R. Differential response of domestic and wild Lycopersicon species to chilling under low light: Growth, carbohydrate content, photosynthesis and the xanthophyll cycle. *J. Physiol. Plant.*, 1999, Vol. 105. P. 81–88.

32. Liu H., Ouyang B., Zhang J., Wang T., Li H., Zhang Y., Yu C., Ye Z. Differential Modulation of Photosynthesis, Signaling, and Transcriptional Regulation between Tolerant and Sensitive Tomato Genotypes under Cold Stress. *PLoS ONE*, 2012, Vol. 7, Article#e50785.

33. Chen H., Chen X., Chen D., Li J., Zhang Y., Wang A. A comparison of the low temperature transcriptomes of two tomato genotypes that differ in freezing tolerance: *Solanum lycopersicum* and *Solanum habrochaites*. *BMC Plant Biol.*, 2015, Vol. 15. P. 1–16.

34. Sherzod R., Yang E.Y., Cho M.C., Chae S.Y., Kim J.H., Nam C.W., Chae W.B. Traits Affecting Low Temperature Tolerance in Tomato and Its Application to Breeding Program. *Plant Breed. Biotechnol.*, 2019, Vol. 7. P. 350–359.

35. Picken A.J.F. A review of pollination and fruit set in the tomato (*Lycopersicon esculentum* Mill.). *J. Hortic. Sci.*, 1984, Vol. 59. P. 1–13.

36. European Commission. Farm to Fork Strategy, DG SANTE/Unit 'Food Information and Composition, Food Waste'. 2020. Available online: https://food.ec.europa.eu/document/download/472acca8-7f7b-4171-98b0-ed76720d68d3_en?filename=f2f_action-plan_2020_strategy-info_en.pdf

37. Sims R., Flammini A., Puri M., Bracco S. Opportunities for Agri-Food Chains to Become Energy-Smart, FAO: Rome, Italy, USAID: Washington, DC, USA, 2015. Available online: http://www.fao.org/3/a-i5125e.pdf

38. Hertel T.W., Burke M.B., Lobell D.B. The poverty implications of climate-induced crop yield changes by 2030. *Glob. Environ. Chang*., 2010, Vol. 20. P. 577–585.

39. Iizumi T., Ramankutty N. How do weather and climate influence cropping area and intensity? *Glob. Food Secur*., 2015, Vol. 4. P. 46–50.

40. Rey R. New Challenges and Opportunities for Mountain Agri-Food Economy in South Eastern Europe. A Scenario for Efficient and Sustainable Use of Mountain Product, Based on the Family Farm, in an Innovative, Adapted Cooperative Associative System-Horizon 2040. *Procedia Econ. Financ.*, 2015, Vol. 22. P. 723–732.

41. Barbaresi A., Torreggiani D., Benni S., Tassinari P. Indoor air temperature monitoring: A method lending support tomanagement and design tested on a wine-aging room. *Build. Environ.*, 2015, Vol. 86. P. 203–210.

42. Mitter, H., Techen, A.-K., Sinabell, F., Helming, K., Schmid, E., Bodirsky, B.L., Holman, I., Kok, K., Lehtonen, H., Leip, A., et al. Shared Socio-economic Pathways for European agriculture and food systems: The Eur-Agri-SSPs. *Glob. Environ. Chang.*, 2020, Vol. 65, Article# 102159.

43. Żarski J., Kuśmierek-Tomaszewska R. Effects of Drip Irrigation and Top Dressing Nitrogen Fertigation on Maize Grain Yield in Central Poland. *Agronomy*. 2023, Vol. 13(2), Article#360. https://doi.org/10.3390/agronomy13020360

44. Сучасна технологія вирощування кукурудзи на зерно. Режим доступу: https://uapg.ua/blog/suchasna-tehnologiya-viroshhuvannya-kukurudzi-na-zerno/

45. Глобальне потепління змушує добувати воду з повітря. *Пропозиція*, 10.10.2017. Режим доступу: https://propozitsiya.com/news/hlobalne-poteplinnya-zmushuye-dobuvaty-vodu-z-povitrya

46. FAOSTAT. Food and Agriculture Data. Available online: https://www.fao.org/faostat

47. AQUASTAT. Global Information System on Water and Agriculture. Available online: https://www.fao.org/aquastat

48. Arinaitwe U., Thomason W., Frame W.H., Reiter M.S., Langston D. Optimizing Maize Agronomic Performance Through Adaptive Management

Systems in the Mid-Atlantic United States. *Agronomy*, 2025, Vol. 15(5), Article#1059. https://doi.org/10.3390/agronomy15051059

49. Liu Y., Yang H.S., Li J.S., Li Y.F., Yan H.J. Estimation of irrigation requirements for drip-irrigated maize in a sub-humid climate. *J. Integr. Agric.,* 2018, Vol. 17. P. 677–692.

50. Wang Y., Li S., Cui Y., Qin S., Guo H., Yang D., Wang C. Effect of drip irrigation on soil water balance and water use efficiency of maize in Northwest China. *Water,* 2021, Vol. 13, Article#217.

51. Irmak S., Mohammed A., Kukal M. Maize response to coupled irrigation and nitrogen fertilization under center pivot, subsurface drip and surface (furrow) irrigation: Growth, development and productivity. *Agric. Water Manage.,* 2022, Vol. 263, Article#107457.

52. Tarighaleslami M., Zarghami R., Mashhadi A.B.M., Oveysi M. Effects of drought stress and different nitrogen levels on morphological traits of proline in leaf and protein of corn seed (*Zea mays L.*). *Am.-Eurasian J. Agri. Environ. Sci.*, 2012, Vol. 12, Article#49.

53. Kresović B., Gajić B., Tapanarova A., Dugalić G. How irrigation water affects the yield and nutritional quality of maize (*Zea mays L.*) in a temperate climate. *Pol. J. Environ. Stud.*, 2018, Vol. 27. P. 1123–1131.

54. Chen M., Gao Z., Wang Y. Overall introduction to irrigation and drainage development and modernization in China. *Irrig. Drain*., 2020, Vol. 69. P. 8-18.

55. Wang Z., Gao J., Ma B. Concurrent Improvement in Maize Yield and Nitrogen Use Efficiency with Integrated Agronomic Management Strategies. *Agron. J.*, 2014, Vol. 106. P. 1243-1250.

56. Wang Z., Jin M., Šimůnek J., van Genuchten M.T. Evaluation of mulched drip irrigation for cotton in arid Northwest China. *Irrig. Sci.,* 2014, Vol. 32. P. 15–27.

57. Dong X., Xu W., Zhang Y., Leskovar D.I. Effect of Irrigation Timing on Root Zone Soil Temperature, Root Growth and Grain Yield and Chemical Composition in Corn. *Agronomy*, 2016, Vol. 6(2), Article#34. https://doi.org/10.3390/agronomy602003

58. Della Lunga D., Brye K.R., Mulvaney M.J., Daniels M., de Oliveira T., Baker B., Bradford T.Jr., Arel C.M. Cover Crop Effects on Greenhouse Gas Emissions and Global Warming Potential in Furrow-Irrigated Corn in the Lower Mississippi River Valley. Atmosphere, 2025, Vol. 16(5), Article#498. https://doi.org/10.3390/atmos16050498

59. Jones J.W., Antle J.M., Basso B.O., Boote K.J., Conant R.T., Foster I., Godfray H.C.J., Herrero M., Howitt R.E., Janssen S., et al. Brief history of agricultural system models. *Agric. Syst.*, 2017, Vol. 155. P. 240–254.

60. Sadsad J.S., Ella V.B., Lampayan R.M., Sta. Cruz PC. A VBA-Based Field Water Balance Model for Efficient Irrigation Water Management of Corn (Z*ea mays L*.). Agronomy, 2023, Vol. 13(3), Article#751. https://doi.org/10.3390/agronomy13030751

61. Abd El Baki H.M., Fujimaki H. An Evaluation of a New Scheme for Determination of Irrigation Depths in the Egyptian Nile Delta. *Water*, 2021, Vol. 13, Article#2181.

62. Pereira L.S., Teodoro P.R., Rodrigues P.N., Teixeira J.L. Irrigation Scheduling Simulation: The Model Isareg. In Tools for Drought Mitigation in Mediterranean Regions, Springer: Dordrecht, The Netherlands, 2003. P. 161–180.

63. Cavalcante E.S., Lacerda C.F., Costa R.N.T., Gheyi H.R., Pinho L.L., Bezerra F.M.S., Oliveira A.C., Canjá J.F. Supplemental irrigation using brackish water on maize in tropical semi-arid regions of Brazil: Yield and economic analysis. *Sci. Agric.*, 2021, Vol. 78, Article#e20200151.

64. Cruz J.C., Pereira Filho I.A., Alvarenga R.C., Gontijo Neto M.M., Viana J.H.M., de Oliveira M.F., Matrangolo W.J.R., de Albuquerque Filho M.R. EMBRAPA Milho e Sorgo: Cultivo do Milho, Sistemas de Produção, v. 2 (6). 2010. Available online: https://ainfo.cnptia.embrapa.br/digital/bitstream/item/27037/1/Plantio.pdf

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