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Supporting Plants to Thrive in Drought Conditions: Review of Sustainable Solutions

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ABSTRACT: Even in Europe, the intensity of droughts is increasing while the experts anticipate continuous gradual rise of temperature in the future. The problem of water shortage is not to be taken lightly. Agricultural production suffers from short–or long–term drought periods. The purpose of the study is to identify effective sustainable drought mitigation strategies, using a descriptive–analytical framework. Sustainable agriculture delivers greater water holding capacity compared to industrial agriculture and contributes to drought tolerance through different measures like appropriate sowing time, plant density, adaptation to hydrological conditions, composting, crop rotation, sowing legumes, and intermediate crops, mulching, establishing agroforestry systems, conservation of the diversity of agricultural species, livestock incorporation into the agricultural production, etc. The invention of foliar drought concentrate is added to the list of sustainable solutions. The foliar drought concentrate allows the plants to take the water from the air up to 10 meters above the surface. The plants can develop due to having enough water during the vegetative season. Those favourable conditions allow achieving rather promising results. The study offers insights into meaningful integration of sustainable solutions in an agronomic framework while strengthening the awareness about the need to find environmentally friendly solutions.

KEYWORDS: drought conditions, sustainable agricultural solutions, innovative foliar drought concentrate.

I. INTRODUCTION

Even in Europe, the intensity of droughts is increasing while the experts anticipate the continuous gradual rise of temperature in the future. Water shortage that is a result of climate change seems to be the most severe problem. Agricultural production suffers from short–or long–term drought periods. Drought stress is a serious concern threatening food production. The problem occurs in form of groundwater shortage and also soil water deficit in the dry season (Bodner, Nakhforoosh, & Kaul, 2015). The experts expect an increase in evapotranspiration which is correlated to higher demand for water for agriculture (Iglesias & Garrote, 2015). By 2050, the experts expect water demand higher than water supply (Damerau, Patt, & van Vliet, 2016). The global water crisis is known to be the greatest problem of the 21st century (UNESCO, 2012). Alternative solutions need to be established even in agriculture.

Drought stress in plants is a serious threat to food production (Bodner, Nakhforoosh, & Kaul, 2015). However, food security remains a top priority. Agenda 2030 (United Nations, 2015) foresees pursuing 17 goals of which the second and the sixth seem to be the most important within the realm of agriculture. The second goal aims to eradicate hunger, achieve food security, accomplish improved nutrition and promote sustainable agriculture while the sixth goal aims to ensure water availability and establish sustainable water management, and also to deliver basic sanitation for all.

Undeniably there is a need to finding ways to produce sufficient foodstuffs that satisfy the needs of the global population even in an arid period while respecting sustainable principles. In this line, the purpose of this study is to identify the most effective sustainable drought mitigation strategies, using the descriptive–analytical framework.

The paper encompasses five sections. After the introduction, the methodology is presented. The third section offers insights into different sustainable agricultural solutions for overcoming drought difficulties. The central, fourth section of the paper presents the results of the crops treated with innovative sustainable foliar drought concentrate in 2020. The final section offers concluding thoughts.

II. METHODOLOGY

Within the descriptive–analytical framework, the study presents different strategies for overcoming the difficulties in crop production that emerge due to drought conditions. The central section of the paper introduces the results – factual data values and rates gained within different studies on treating crops with innovative sustainable foliar drought concentrate in 2020.

III. SUSTAINABLE AGRICULTURAL SOLUTIONS FOR COMBATING DROUGHT DIFFICULTIES

Due to climate change, water demand in agriculture recently increased. Simultaneously, there is a need to establish a sustainable agroecosystem. Inappropriate ecosystem management causes several problems like loss of natural habitats, nutrient loss, greenhouse gas emissions, and pesticide poisoning (Pham, & Stack, 2018). There are several sustainable agricultural practices presented of which some of them overlap.

[1]. **Organic farming.** Organic agricultural products are certified to be free from pesticides, fertilizers, and GMOs (Hunter et al. 2011). Even when it comes to difficulties due to climate changes Gilbert (2012) emphasises the need to focus on cultivating climate–hardy crops and establishment of agriculture practices that help ensure food security.

Climate changes are disrupting weather patterns, leading to soil water deficit and water stress. In severe agricultural conditions, organic yields might be even higher than industrial yields (Kovacevic, & Lazic 2012). Organic farming generates more organic matter that correlates with greater water holding capacity compared to industrial agriculture while it also contributes to drought tolerance (Singh, 2013).

Several empirical studies present results on the loss of efficiency between water arrival by rainfall or irrigation on one hand and uptake by the plant on the other. Evaporation, runoff, and unused water after harvest limit potential yield. In this context, plant root is closely involved. However, the root system cannot be understood without its interaction with the soil. The root–soil interaction is relevant for crop production: soil conditioning by roots, and root conditioning by soil. There is a need to understand site hydrology interactions to decide about a suitable management strategy (Bodner, Nakhforoosh, & Kaul, 2015).

Farmers need to practice crop rotation, composting, planting cover crops to re-establish nutrients and reduce soil erosion (Singh, 2013). The key elements of the natural cycle of resources on the farms are also measures like composting, growing intermediate crops, and legumes (Podmenik, 2012). Extremely efficient is soil coverage that reduces runoff losses of rainfall and evaporation from bare soil surfaces. Indeed, cropping and organic fertilization add to the improvement of soil hydrology (Bodner, Nakhforoosh, & Kaul, 2015).

[2]. **Permaculture** is one of the organic farming practices. Bill Mollison and David Holmgren founded permaculture as alternative agriculture which "Consciously designs landscapes which mimic the patterns and relationships found in nature while yielding an abundance of food, fiber, and energy for provision of local needs" (Holmgren, 2004). Its unique alternative agricultural model integrates management practices in a way to optimise ecosystem services (Holmgren, 2004). It incorporates agroecological principles of avoiding negative ecological impacts of input–intensive agricultural production but still delivers the agriculturally productive ecosystem with its diversity, stability, and resilience. Despite multiple contributions, the permaculture potential is not fully explored due to the lack of clear definitions and lack of systematic research of permaculture's impacts (Ferguson & Lovell, 2014).

[3]. **Agroforestry systems.** Thirty years ago, agroforestry became interesting to developing countries. Recently, agroforestry is recognized as a system that ensures food security within environmental integrity in rich countries alike (Nair, 2008). Agroforestry is an integration of trees and crops in a system which is (besides several benefits like buffering wind and soil erosion, reestablishing nutrients in the soil, providing shelter for livestock and wildlife) a great tool of agricultural water management. The trees capture raindrops and assist in process of condensation of water droplets from fog and dew. The deeper root systems that are offered by the trees draw water from deeper soil horizons while interacting and delivering water to other plants with shallower roots (Eichhorn et al, 2006).

[4]. **Agroecology** is a sustainable agricultural practice that emerged in the 1980s as a response to the negative environmental, social, and economic concerns and was acknowledged by ecologists, agronomists, and ethnobotanists. The scientists overlooked reasonable agricultural production that is self–sufficient and sustainable. Sustainable strategies demand a deeper understanding of natural habitats and the principles

they rely on. Recent scientific evidence acknowledges agroecology as a scientific discipline that focuses on productive ecosystem services which allow maintenance of natural resources. Agroecology builds on the potential of biodiversity shaping strategies that support environmental stability. There is a need for the appropriate establishment of agricultural species that suit the soil characteristics, sunlight intensity, humidity, and coexistence with other organisms. It provides a productive and healthy ecosystem where the plants are resistant to environmental stress, even in severe conditions (Altieri, 2018). Introducing higher biodiversity into the ecosystem increases ecosystem services and strengthens the resilience of the cropping system which consequently results in improved soil fertility, limits nutrient losses, and reduces negative impacts of pests and diseases (Altieri, Nicholls & Montalba, 2017). Greater biodiversity offers beneficial species as natural enemies of crop pests and ecosystem engineers (Médiène et al., 2011)

An ecosystem with a diversified assemblage of crops and livestock delivers synergies providing mechanisms for creating benefits in terms of enhanced soil productivity, nutrient cycling, crop protection, water storage, and other ecosystem services (Altieri, Nicholls, & Montalba, 2017). Rosset and Altieri (2007) argue that greater biodiversity correlates with lower vulnerability to weather variability.

IV. TEST RESULTS: TREATMENT WITH SUSTAINABLE FOLIAR DROUGHT CONCENTRATE

Even in Europe, climate changes correlate with water shortage which translates into poorer irrigation water stock (European Environment Agency, 2012). The irrigation system needs to follow the water management guidelines. When irrigation run time is too short, water cannot infiltrate deep enough into the soil which results in water loss due to evaporation (Doll & Shackel, 2015). Irrigation is known to be an extremely efficient mechanism in overcoming drought difficulties. However, even when using data to make appropriate decisions within precision agriculture, the agri-food industry remains a substantial water consumer. Long–term forecast predicts water shortage. Therefore, any contributory strategy that can be integrated into sustainable water management is essential.

In the domain of finding solutions outside the box (not focusing on water in the soil that is available for the plants), the scientists from the fields of chemistry and biochemistry developed foliar drought concentrate. It can be applied on all green crops, in the forests, on low vegetation, and on grass (Sertifikat, 2020). The concentrate is beneficial in a semi–arid period and extremely effective in droughts. Exceptional results are possible because the foliar drought concentrate allows the plants to take the water from the air up to 10 meters above the surface. In this way, there are 5 litres of water available for the plants per day per m^2. The foliar drought concentrate allows the plants to take the water through the leaves and afterward the water travels down the stem to the root system. In this way, the plants can develop due to having enough water through the vegetative season when the plants easily absorb nutrients from the soil even when the soil is dry and air humidity under 50 %, while temperature above 30°C. There is a sufficient amount of water available for the plants to the end of the vegetation period (Eco Patents New: Fiprot-F Drought concentrate, 2021) without watering them or conducting irrigation. The result of the foliar drought concentrate is creating conditions within which the plants can take air moist water through the leaves.

Foliar drought concentrate is an environmentally friendly product that is not harmful to fauna or flora (Ministarstvo poljoprivrede, šumarstva i vodoprivrede, 2020). According to the certificate data (Sertifikat, 2020), foliar drought concentrate contains sustainable substances and elements which emerge during a special technological procedure (which is being patented) that is taken place in inox–vessels. The procedure takes place in reactors that feature specific pressure, temperature, vacuum, electromagnetic fields, high voltage with low current. Seawater runs over the tubes while elements, solutions, and compounds are gradually added. In the next step, nitrogen is used for cooling. After the extraction process is over, magnetized water is being added that had flowed through the magnetic field with bipolar and unipolar magnets. Then all the elements and compounds in solution (N, MgO, SiO_2, ZnO, FeO), all the required components are put in a mixer with the required speed and temperature. Finally, the micro-elements in the chelate form are added (Fe, Zn, Cu).

The results of the testing the application of foliar drought concentrate are available for 2020. Agronomic Advisory Service Samobor tested foliar drought concentrate on sunflower hybrid Sumico in 2020 in Gakovo, Serbia. The test group yield of sunflower oil was 1,920 kg/ha compared to the control group yield that was 1,620 kg/ha as evident from Table 1 (Poljoprivredna stručna služba »Somobor« doo, 2020).

Table 1: Results of testing foliar drought concentrate on sunflower hybrid Sumico in 2020 in Gakovo, Serbia

	The yield in kg/ha, 9% moist	The yield of sunflower oil in kg/ha
Test group	3,742	1,920
Control group	3,171	1,620

Source: Poljoprivredna stručna služba »Somobor« doo, 2020

Results on treating soy with foliar drought concentrate in 2020 are presented in Table 2. Agricultural company Salix inger Lokve reports a 24.6 % higher yield of the test group, namely 3,339 kg/ha of soybean yield compared to 2,620 kg/ha of soybean yield of the control group (Salix inger Lokve, 2020). Further, agricultural company Sava Kovačević Vrbas treating soybean variety Galina reports 8.5 % higher soybean yield, namely the test group yield was 3,488 kg/ha compared to test group soybean yield of 3.214 kg/ha (Sava Kovačević Vrbas, 2020). Promising are also the test results of Agronomic Advisory Service Vrbas in Zmajevo, municipality Vrbas. They report 33.3 % higher yields of the test group, treating soybean hybrid Rubin. The test group yield was 3,666 kg/ha compared to the 2,750 kg/ha yield of the control group (Poljoprivredna Stručna Služba Vrbas, 2020).

Table 2: Results of testing foliar drought concentrate on soybean in 2020, Serbia

	Yield in kg/ha, town Lokve	% higher yield	Yield in kg/ha, town Vrbas	% higher yield	Yield in kg/ha, town Zmajevo	% higher yield
Test group	3,339	24.6 %	3,488	8.5 %	3,666	33.3 %
Control group	2,680		3,214		2,750	

Source: Salix inger Lokve, 2020; Sava Kovačević Vrbas, 2020; Poljoprivredna stručna služba Vrbas, 2020.

V. CONCLUSION

The article opens by addressing the crucial problem that climate change brings even in Europe – water shortages that need to be addressed in agriculture water management. The study offers the analysis of the effective sustainable adaptive measures for overcoming drought stress that farmers of different sustainable agriculture systems rely on.

Sustainable agricultural strategies deliver greater water holding capacity compared to industrial agriculture and contribute to drought tolerance. Generating much organic matter in the soil delivers improvements of soil that increase yield stability. Climate change conveys damages caused by warmer and drier weather. During conditions of water deficit in soil, the plants experience greater water stress. In the context of severe conditions in times when the plants undertake problem of water shortage, the scientists even argue that organic yields (featuring appropriate sowing time, plant density, adaptation to hydrological conditions, composting, crop rotation, legumes, sowing intermediate crops, mulching, establishing agroforestry systems, conservation of the diversity of agricultural species, livestock incorporation into the agricultural production, etc.) are greater than industrial yields. A new, innovative solution emerged in a form of a foliar drought concentrate as the result of years of dedication Serbian scientists who developed a solution outside of the box - finding a way for the plants to take water not from the soil as usual, but elsewhere. The foliar drought concentrate that can be used on all green crops is not harmful to the environment nor living organisms. It allows the plants to take the water from the air up to 10 meters above the surface. In this way, 5 litres of water are available for the plants per day per m^2. The foliar drought concentrate allows the plants to take the water through the leaves and afterward the water travels down the stem to the root system. In this way, they easily absorb nutrients from the soil even when the soil is dry and air humidity under 50 %, while temperature above 30°C. When applying the foliar drought concentrate, farmers need not be concerned about drought and need not be worried about finding sources of water for irrigation.

The holistic review of solutions in crop production during the drought period offers insights into meaningful integration of sustainable solutions within the agricultural framework through awareness about the need to find environmentally friendly solutions that are not harmful to fauna or flora.

REFERENCES

[1]. Altieri, M–A., Nicholls, C–I., and Montalba, R., 2017, "Technological approaches to sustainable agriculture at a crossroads: an agroecological perspective," Sustainability, 9(3): 349–352.

[2]. Altieri, M–A., 2018, "Agroecology: The Science of Sustainable Agriculture," New York: CRC Press Taylor & Francis Group.

[3]. Bodner, G; Nakhforoosh, A: and Kaul, H–P., 2015, "Management of crop water under drought: a review," Agronomy for Sustainable Development, 35(2): 401–442.

[4]. Damerau, K., Patt, A–G., and van Vliet, O-P., 2016, "Water saving potentials and possible trade-offs for future food and energy supply," Global Environmental Change, 39: 15–25

[5]. Doll, D., and Shackel, K., 2015, "Drought tip: Drought management for California almonds – Impacts of Stress on Almond Growth and Yield," ANR Publication 8515.

[6]. Eco Patents New: Fiprot–F Drought concentrate, 2021, https://eco-patents.com/en/products/fiprot-f-en/

[7]. Eichhorn, M-P., Paris, P., Herzog, F., Incoll, L-D., Liagre, F., Mantzanas, K., Mayus, M., Moreno, G., Papanastasis, V-P., Pilbeam, D. J., Pisanelli, A., and Dupraz, C., 2006, "Silvoarable systems in Europe–past, present and future prospects," Agroforestry systems, 67(1): 29–50.

[8]. European Environment Agency, 2012, Water "Resources in Europe in the Context of Vulnerability: EEA 2012 State of Water Assessment," Report No. 11/2012, Luxembourg: Office for Official Publications of the European Union.

[9]. Ferguson, R–S., and Lovell, S–T, 2014, "Permaculture for agroecology: design, movement, practice, and worldview. A review," Agronomy for Sustainable Development, 34(2): 251–274.

[10]. Gilbert, N., 2012, "One-third of our greenhouse gas emissions come from agriculture. Nature," October 2012.

[11]. Holmgren, D., 2004, "Permaculture: principles and pathways beyond sustainability," Hepburn: Holmgren Design Services.

[12]. Hunter, D., Foster, M., McArthur, J–O., Ojha, R., Petrocz, P., and Samman, S., 2011, "Evaluation of the Micronutrient Composition of Plant Foods Produced by Organic and Conventional Agricultural Methods," Critical Reviews in Food Science and Nutrition, 51(6): 571–582.

[13]. Iglesias, A., and Garrote, L., 2015, "Adaptation strategies for agricultural water management under climate change in Europe," Agricultural water management, 155: 113–124.

[14]. Kovacevic, D., and Lazic, B., 2012, "Modern trends in the development of agriculture and demands on plant breeding and soil management," Genetika, 44(1): 201–216.

[15]. Médiène, S., Valantin-Morison, M., Sarthou, J–P., de Tourdonnet, S., Gosme, M., Bertrand, M., Roger-Estrade, J., Aubertot, J–N., Rusch, A., Motisi, N., Pelosi, C., and Doré, T., 2011, "Agroecosystem management and biotic interactions: a review," Agronomy for sustainable development, 31(3): 491–514.

[16]. Ministarstvo poljoprivrede, šumarstva i vodoprivrede, Uprava za zaštitu bilja (2020). Rešenje za sredstvo za ishranu bilja u Registar sredstava za ishranu bilja i oplemenjivača zemljišta pod rednim brojem upisa 3478. / *Ministry of Agriculture, Forestry and Water Management. Plant Protection Administration, 2020, Announcement of Plant Nutrition Product into Register of Plant Nutrition Products and Soil Enhancers, registered under the regular number 3478.*

[17]. Nair, P–R., 2008, "Agroecosystem management in the 21st century: It is time for e for a paradigm shift," Journal of Tropical Agriculture, 46: 1–12.

[18]. Pham, X., and Stack, M., 2018, "How data analytics is transforming agriculture," Business Horizons, 61(1): 125–133.

[19]. Podmenik, D., 2012, "Trendi in perspektive ekološkega kmetijstva s poudarkom na Sloveniji in Slovenski Istri," Ljubljana: Založba Vega. / Podmenik, D., 2012, "Trends and perspectives of organic farming focusing on Slovenia and Slovenian Istra," Ljubljana: Založba Vega.

[20]. *Poljoprivredna stručna služba "Somobor" doo, 2020,* Rezultati ogleda sa primenom folijarnog djubriva kompanije "Eco Patent New" u suncokretu u 2020. godini / *Agronomic Advisory Service "Somobor" doo, 2020,* Results of treatments of foliar

concentrate developed by company “Eco Patent New” on sunflower in 2020.

[21]. Poljoprivredna stručna služba Vrbas, 2020, Soja demo ogled u 2020. godini / Agronomic Advisory Service Vrbas, 2020, Results of treatments on soy in 2020.

[22]. Rosset, P–M., and Altieri M–A., 2017, “Agroecology: Science and politics,” Nova Scotia: Fernwood Publishing.

[23]. Salix inger Lokve. (2020). Soja demo ogled u 2020. g. setva / (Agricultural company) Salix inger Lokve, 2020, Results of testing the foliar drought concentrate on soy in 2020.

[24]. Sava Kovačević Vrbas. (2020). Ogled sa preparatom protiv suše Fiprot–F / (Agricultural company) Sava Kovačević Vrbas, 2020, Test results using the foliar drought concentrate Fiprot–F.

[25]. Sertifikat, 2020, Eco Patents New Novi Sad, Srbija / Certificate, 2020, Eco Patents New Novi Sad, Serbia.

[26]. Singh, K–M., 2013, “Sustainable Agriculture: Potential and Strategies for Development,” Munich Personal RePEc Archive, Paper No. 47418: 116.

[27]. UNESCO. (2012). *Managing water under uncertainty and risk. UN World Water Development Report 4*. Paris: UNESCO.

[28]. United Nations. (2015). *Transforming our world: The 2030 Agenda for Sustainable Development, A/RES/70/1*. New York: United Nations.