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Effects of Soil Erosion on Sunflower Crop Productivity and Measures to Combat it

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Abstract

This study analyzes the influence of soil erosion on the morphometric characteristics and productive potential of sunflower crop in Corni commune, Galați county. Data obtained in the non-eroded area (control) reveal an average plant height of 111.8 cm and an average calathidium size of 7.3 cm. In contrast, in the heavily eroded area, these parameters are significantly affected, with the height reduced to 76.2 cm (-31.9%) and the calathidium size decreased to 5.4 cm (-26.1%). The reduction of these essential parameters reflects a negative systemic impact on aerial biomass and inflorescence development, which directly influences seed production capacity and agricultural yield. From a physiological perspective, the reduction in plant height indicates a decrease in the active photosynthetic area and the accumulation of dry biomass, essential for supporting reproductive processes. Also, the reduction in the size of the calatidium is associated with a lower number of fertile flowers and, implicitly, seeds produced, which negatively affects the volume of production. These findings highlight the fundamental role of erosion as a limiting factor in the productivity of the sunflower crop. The study highlights the need to implement effective soil conservation measures, including conservation tillage, the use of cover crops and the correct management of land slopes, to prevent soil degradation and ensure the sustainability of sunflower agricultural production.

***Key words*: Erosion, Sunflower, Productivity, Calathidium, Conservation**

Soil erosion is a natural process aggravated by intensive agricultural activities, through which the upper fertile layer, which plays an essential role in supporting plant production, is removed by the action of water or wind, leading to the degradation of arable soils and a significant decrease in the yield of agricultural crops [1]. In the case of sunflower (*Helianthus annuus* L.), erosion not only reduces soil fertility through significant losses of essential nutrients such as nitrogen, phosphorus and potassium, but also affects the morphological development of the plant, reflected in the reduction of the height and size of the calathea, critical parameters for the productive potential of the crop [2].

Soil erosion is a major constraint to sunflower (*Helianthus annuus* L.) productivity as it directly removes the fertile topsoil rich in organic matter and essential nutrients, thereby limiting plant growth, seed filling, and oil accumulation. The reduction in effective soil depth restricts root penetration, diminishing the crop's capacity to extract water and nutrients, particularly under rainfed conditions where sunflower is often cultivated. Erosion also reduces soil porosity and moisture retention; while crusting and compaction of the exposed soil surface adversely affect seed germination and uniform crop establishment [3]. Consequently, yield levels decline not only in terms of seed quantity but also in oil quality, posing long-term threats to the sustainability of sunflower-based farming systems. To combat these challenges, integrated soil conservation practices are vital, such as conservation tillage, mulching, contour farming, strip cropping with legumes, and the use of cover crops, all of which reduce runoff, enhance organic matter, and stabilize the soil [4]. Likewise, structural measures like bunding, terracing, and shelterbelts mitigate erosion in sloping or wind-prone areas, while organic amendments and judicious water management further improve soil structure and resilience. Therefore, adopting such holistic erosion control strategies not only safeguards soil fertility and water availability but also ensures stable sunflower yields and long-term agro-ecosystem sustainability [5].

Soil erosion can markedly compromise sunflower productivity by stripping away the nutrient-rich topsoil essential for root development, water retention, and nutrient uptake. A global meta-analysis consolidating 290 topsoil-removal experiments found that when erosion depth exceeds approximately 25 cm, crop yields including for grain-type crops experience significant declines, whereas yield remains relatively stable if the remaining A-horizon stays above this threshold [6]. Though sunflowers were not singled out, this highlights a critical tipping point beyond which restoration of soil productivity becomes far more challenging. In tropical smallholder contexts like Tanzania, land degradation including erosion and nutrient mining is a leading barrier to sunflower yields and is closely linked to declining soil fertility [7]. Moreover, conservation tillage practices have demonstrated substantial erosion control benefits reducing surface runoff by up to 75% and soil loss by as much as 95%, which in turn

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supports yield stability [8]. Crop residues, when retained, shield the soil from both wind and water erosion, enhancing moisture infiltration and preserving organic matter [9]. Together, these data underscore that, while moderate erosion (e.g., losing under 5 cm of topsoil) may have limited impact, deeper soil losses severely impair sunflower yield potential, particularly in degraded agro-ecosystems. Erosion control through conservation tillage and residue management is thus vital to sustaining productivity.

The reduction of plant height and size of the calathea is closely linked to the nutritional and water stress caused by soil erosion, which limits the development of the root system and the plant's ability to absorb water and nutrients necessary for optimal growth [10]. Thus, erosion affects the phenotypic development of sunflower, which causes a reduction in the number of seeds and their size, directly influencing agricultural production [11]. To counteract the negative effects of erosion, effective soil conservation measures are necessary, such as conservative agricultural practices, anti-erosion crop rotations, grassing of land and the use of nutrient amendments, which reduce soil losses and increase its fertility [12]. The implementation of these measures is essential for protecting the agricultural environment and for maximizing the economic and ecological benefits associated with sunflower cultivation, in a context in which climate change and unsustainable practices amplify the risks of soil degradation [13].

MATERIALS AND METHODS

The study was conducted in Corni Commune, Galați County, located in the hilly area of Covurlui, on the banks of the Suhurlui River, with altitudes of approximately 95 m (in the Suhurlui area) and 230 m (in the Smulți Hill). The area is part of the Siret River watershed and is characterized by a temperate continental climate, with an average annual air temperature of around 9.9°C. The rainfall regime is variable, with an average annual rainfall of approximately 467 mm. In the autumn of 2024, in September, an extreme rainfall event was reported, with a rainfall amount of approximately 300 l/m² in a single night, which had a significant impact on the processes of water and soil dynamic erosion.

The research was carried out on a 20 ha soil plot characterized by severe water erosion and previously subjected to a prolonged period of drought of approximately five years, a context that accentuated the degradation of the physicochemical properties of the soil and its vulnerability to severe weather events.

To investigate the effects of soil erosion on the phenotypic development of the sunflower crop, precise measurements of two essential morpho-agronomic characteristics were carried out:

- Plant height, evaluated by determining the average height of the stems, an indicative parameter of vegetative vigor and phytosanitary status;
- Calathea size, determined by measuring the diameter, representing a direct indicator of the productive potential of the plant and the efficiency of using the resources provided by the soil.

The phenotypic data obtained were correlated with local pedoclimatic characteristics and the degree of erosion identified in the field, in order to quantify the impact of soil degradation on sunflower crop productivity and to substantiate soil conservation and improvement strategies.

Fig 1 Localization of the study area

RESULTS AND DISCUSSION

The influence of erosion on the height of sunflower plants

The degree of soil erosion has a major impact on the development of sunflower plants, measured by their average height in different areas of the same experimental plot (Table 1). In zone 1, equivalent to the control, the plants reach an average height of 111.8 cm, representing optimal conditions for growth. In Zone 2, where the soil is poorly eroded, a significant decrease in height is observed to 95.1 cm, as a result of the partial loss of the fertile layer and nutrients. In Zone 3, characterized by strong erosion, the impact on the soil is severe: the fertile layer rich in nutrients is lost, the water retention capacity is reduced, the soil structure is compromised, the activity of beneficial microorganisms decreases, and the instability of the soil affects the fixation of roots [14-15]. These conditions lead to a major reduction in the average height, up to 76.2 cm, i.e. 68.1% of the control value, highlighting a clear delimitation of the complex nutritional, water and mechanical stress on the plants. Contrary to these negative effects, Zone 4, which is the area of accumulation of organic matter and fertile material eroded from the other areas, shows an increase in plant height above the control value, reaching 128.3 cm (114.7%). It highlights that the redistribution of nutrients in a single point can compensate for losses from eroded areas and create a very favorable environment for growth [16].

Table 1 Influence of soil erosion rate on average height of sunflower plants

Experimental variant	Plant height		Difference (cm)
	cm	%	
Zone 1- Uneroded	111,8	100	MARTOR
Zone 2- Slightly eroded	95,1	85	-15
Zone 3- Heavily eroded	76,2	68,1	-31,9
Zone 4- Uneroded	128,3	114,7	14,7

Table 2 Influence of erosion degree on the average size of sunflower calathidium

Experimental variant	Plant calathidium		Difference (cm)
	cm	%	
Zone 1- Uneroded	7,3	100	MARTOR
Zone 2- Slightly eroded	7	95,8	-4,2
Zone 3- Heavily eroded	5,4	73,9	-26,1
Zone 4- Uneroded	8,6	117,8	17,8

The influence of erosion on the size of the calathidium of sunflower plants

The physiological and structural consequences of soil erosion limit the optimal development of the foliar and vegetative apparatus, affecting the biogenesis and expansion of Calathidium, an aspect that can be observed in (Table 2).

In the non-eroded area (control), the average size of Calathidium is 7.3cm (100%), guaranteed by the unaltered fertility, stable structure and water retention capacity at the maximum level specific to the experimental area. Continuing with the area where a weak to moderate degree of erosion occurs, Calathidium reaches 7cm (95.8%), with a negative difference of -4.2cm compared to the control, attributable to the partial loss of the organic matter horizon and the reduction of soil breathability [17-19]. This aspect induces moderate physiological stress, limiting the optimization of photosynthesis processes and the assimilation of plastic substances necessary for the development of Calathidium. In Zone 3, a strong degree of erosion can be observed the diameter of Calathidium drops to 5.4cm (73.9%), with a difference of -26.1cm, signaling a critical deficit of easily accessible nutrients, microelements and water [20]. From an agronomic point of view, soils with a high degree of erosion show compaction, unstable aggregates, creation of crust on the surface and limitation of the development of the root system, leading to a low supply of resources for Calathidium. The decrease in the total mass of plant material is a direct cause of the reduction of the seed filling potential, and therefore of the biomass that can be generated per hectare [21]. In comparison, a positive response of 8.6cm (117.8%) is observed in Zone 4, highlighting the benefits of organic matter accumulation, optimal mineralization and a macrostructure favorable to water infiltration. The effect is synergistic, reflected in the maximization of the transfer of assimilates to the Calathidium and, thus, in the increase in the number and mass of seeds [22].

CONCLUSION

The study conducted in Corni commune, Galați county, evaluated the impact of different degrees of erosion on the morphological characteristics and productive potential of sunflower crop through the prism of calathidium size and plant waist. The direct correlation between waste reduction and calathidium size suggests that erosion involves a systemic effect on the entire plant, affecting both aerial biomass and inflorescence development, which reflects a significant reduction in the number and mass of seeds, therefore a clear decrease in agricultural yield. The data underline the urgency of implementing agronomic practices for soil conservation to prevent permanent degradation, such as conservative agriculture, crop rotation with improving plants, application of organic amendments and specific anti-erosion measures (terracing, hay strips).

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