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Mini Review

A Comparative Analysis of Agriculture in Tropical and Temperate Climates

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Abstract

The largest agricultural areas in the world are in North America, Euro-Asia, and Central South America. However, agriculture in tropical and temperate climates is very different, mainly because of the environmental conditions. Unlike in temperate climates, there are not four seasons in the tropics. The tropics have only two seasons, rainy and dry, with plants flowering all year round because air temperatures are not too low in the winter, and crops can grow during this season; thus, some crops may have three cycles per year in the tropics. In most temperate climates, there is only one crop cycle per year due to low winter temperatures, but the yield can be the highest. The low temperatures of a temperate climate, below 0°C, allow soils to be shallow, with high organic matter content and fertility because soil microbial activity and lixiviation are arrested at such temperatures, and organic matter is less degraded than in tropical soils where soil microorganisms and lixiviation continue throughout the year. As a result, yields of major crops in temperate climates are the highest in the world, confirming the efficiency of temperate agriculture, even with only one crop cycle per year. On the other hand, in tropical climates, yields are lower, but crops can be grown several times a year, thus increasing the annual production.

Introduction

The tropics, located between 23.5 degrees north (Tropic of Cancer) and south (Tropic of Capricorn) of the Equator, receive more solar radiation for photosynthesis than temperate regions due to the more perpendicular angle of the sun during the year [1]. The seasons in the tropics are defined by rainfall, in rainy and dry seasons, not by temperature, hot and cold, as in a temperate climate. The Aw climate, especially when combined with low humidity at the dry season, can lead to environmental stresses that significantly reduce the yield of tropical crops [1]. According to the Köppen-Geiger climate system, the most common climate type in tropical climates in terms of land area is hot desert (BWh) with 14.2% of the land area, but where major crops fail, followed by tropical savanna (Aw) with 11.5% [2]. The Aw climate has a drier winter season, where the driest month has precipitation of less than 60 mm, which is less than 4% of the total annual rainfall.

Nevertheless, the air temperature in winter is above 20°C in the tropical Aw climate. Therefore, much of the cultivated land in tropical climate is located in tropical savannas (Aw), such as the Brazilian "Cerrado," which is more frequently exposed to environmental stresses during the year that can reduce yield [1]. However, temperature does not limit plant growth throughout the year in tropical climates, allowing multiple growing cycles to improve annual production [1]. For example, a common bean can have three cycles per year, and melons and grapes can have five harvests in two years. In temperate climates, the highest crop yields are obtained in a humid continental summer with a hot summer (Daf) or a humid continental summer with a cool summer (Dfb), which is associated with some of the best soils in the world [1]. In the Daf climate, the average of the coldest month is below 0°C or -3°C, the average temperature of at least one month is above 22°C, and at least four months have an average above 10°C. There is no significant difference in precipitation between the seasons [2]. For the Dfb climate, the coldest month averages below 0°C or -3°C, every month has an average temperature below 22°C, and at least four months have an average above 10°C. In Daf and Dfb climates, only one crop cycle is possible due to low winter temperatures but with a high yield because soil fertility [1].

Tropical Climate

The tropical climate occurs in the planet's intertropical zone. In these regions, the predominant climate type by land area is tropical (A). Tropical climates are characteristic of the following locations: Central America and central and northern parts of South America; regions of central, western, and eastern Africa, including the islands and territories bathed by the Indian Ocean; South and Southeast Asia; northern Australia and other islands of Oceania and the South Pacific, mainly [2]. It has a high average temperature throughout the year, above 18°C, with a low annual temperature range, meaning there is little temperature difference between the hottest and coldest periods because the area's tropical climate receives significant heat from the sun throughout the year. The tropical wet climate (Aw) or savanna climate has two seasons: rainy and dry. The Aw climate has a pronounced dry season characterized by precipitation of less than 60 mm in the driest month. Sometimes, As is used instead of Aw when the dry season occurs during the higher sun and longer days (during summer); this is the case in the northeastern coast of Brazil [2].

The largest tropical agricultural area in the world is the savanna of central Brazil, called the "Cerrado." With an Aw climate, total precipitation is about 1500 mm, and minimum temperatures are above 20°C. Thus, food production is very high throughout the year [2]. Other important tropical areas for agriculture include Central Africa and North Australia.

Tropical Soils

Oxisols are the most common soils in tropical Africa and South America [3]. They are the oldest soils in the world, formed from decomposed savanna grasses about five million years ago or even earlier. However, most soils are more recent, such as the Drummer and Chernozem soils, which are less than 1.5 million years old [4]. Oxisols are well developed, with great depth (sometimes more than five meters) and porosity. Oxisols are mature soils formed under tropical conditions. Therefore, they are considered soils with the most decomposed materials. Due to intense weathering and leaching, they are deep and lack easily weathered minerals [3]. Consequently, soils of tropical climates have low fertility, low pH, and high Al+3

content, needing liming and high fertilization application, which are deep, reaching more than 5 m, due to high erosion and lixiviation, as well as microbiological activity during the rainy season, except for new volcanic soils [3] (Table 1).

Table 1: Tropical Oxisol soil analysis.

Na	Ca	Mg	H+Al	Al	S	T	V	pH	Corg	P	K
0.5	0.7	0.5	7.8	1.8	1.9	9.7	20	4.4	1.4	3.0	22.0
---------- cmolc/dm³----------						-------- % --------		1:2,5	%	--mg/kg--	

Temperate Climate

In North America and Northern Europe-Asia, where crop yields are highest, cold (D) is the dominant climate type by land area, specifically the humid continental summer of a hot, humid continental climate (Dfa) or the humid continental summer of a fresh summer (Dfb) [2]. Dfa is characterized by the coldest month with an average temperature below 2°C, at least one month with an average temperature above 22°C, at least four months with an average temperature above 10°C, and no significant differences in precipitation between the seasons. In comparison, Dfb has the coldest month averaging below 0°C, with average temperatures below 22°C, at least four months averaging above 10°C, and no significant precipitation differences between seasons. In these climates, crops are sown from April to October [1] (Table 2).

Table 2: Temperate climate Drummer soil analysis.

Na	Ca	Mg	H+Al	Al	S	T	V	pH	Corg	P	K
0.1	21.0	7	8.3	0.0	28.5	42.1	80	6.2	4.1	178	156
---------- cmolc/dm³----------						-------- % --------		1:2,5	%	--mg/kg--	

Data modified from Suleymanov et al. [4].

Temperate Climate Soils

It may be observed that soils in temperate climates tend to be the world's richest organic matter (OM). It is not uncommon for the OM content of soils to reach levels around 10%, as observed in the Drummer soils of central USA or Chernozem soils of Russia or Ukraine in northern Europe [4,5]. The organic matter in the soil may have been decomposed slowly from steppe grasses [5], as tropical soils are thought to originate from savanna grasses with more rapid decomposition due to climate [3]. It would seem that the Chernozem and Drummer soils might have originated from steppe rather than forest or peat, contrary to the assumptions of many scientists [5]. A connection was made between the origins of Chernozem and Drummer soils and herbaceous, or grassy, plants [4].

In temperate climates, where soils are typically shallow, at one to two meters deep, lixiviation and soil microorganism activity is generally stopped during the winter months, from October/November to March/April of the following year. In the temperate region, the annual solar radiation averages approximately half of that in the tropics but reaches relatively high levels during summer due to the longer days. Black lowland soils (such as Chernozem in Eurasia and Drummer in Central North America), similar to prairie soils, are found in the central regions of Eurasia and North America. They are well-structured soils rich in organic matter, giving them dark colors, with relatively recent formation, around 2.5 to 4 thousand years [4] (Table 3).

Table 3: Temperate climate Chernozem soil analysis.

Na	Ca	Mg	H+Al	Al	S	T	V	pH	Corg	P	K
0.1	21.2	3.2	-	0.5	24.7	26.8	92	7.5	5.6	196	448
---------- cmolc/dm³----------						-------- % --------		1:2,5	%	--mg/kg--	

Data modified from Fernández et al. [5].

Conclusion

Therefore, in these soils of temperate climate, Chernozem and Drummer soils, there is no need for fertilization to have a high yield because of the natural fertility of these soils [4,5]. Fertilization is made to replace the nutrients absorbed by the crop. Also, the pH and Al^{+3} content are adequate, with no necessity for limestone application, as in tropical oxisols, where the nutrients were lixiviated, and pH and Al^{+3} content need to be corrected by the incorporation of limestone one to two months before the fertilization and cultivation [3]. Thus, for these soils, the cost of cultivation is lower, with a higher yield than in degraded tropical soils. In temperate climates, the government and seed-producing multinationals subsidize agriculture, while in the tropics, the farmer is in charge of all the costs of the cultivation of crops [1,6]. Despite the higher productivity in Drummer and Chernozem soils, it is only possible to have one crop cycle under the environmental limitations of a temperate climate, primarily due to low winter temperatures. In contrast, low temperatures do not limit crop growth in the tropical environment. Farmers can cultivate several crops throughout the year, with lower yields per crop but an annual production equivalent to temperate climate cultivation [1,6].

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