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Relationship between Several Biological and Chemical Soil Properties to Maize Productivity in Kecamatan Cibugel, Kabupaten Sumedang

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ABSTRACT: Maize was a crucial staple crop and played a pivotal role in the food security. However, the productivity of maize remained insufficient to saturate the market demands. Improving maize productivity can be achieved on the available land by considering the soil characteristic. One of the impediments encountered in the challenges of maize productivity was the lack of information regarding the interaction of biological and chemical soil parameters that influenced maize productivity. This study aimed to investigate the relationship between the biological and chemical characteristics of the soil to maize productivity. The method in this study was descriptive and comparative. The methods in this study were descriptive and comparative. This study was conducted at 18 points located in Cibugel, Sumedang. The land used was a land unit sampling based on slope, elevation, climate, and maize production area. The parameters carried out in this study consist of *Azotobacter* sp., fungi, soil organic C, total N, and C/N ratio. Soil samples were collected using composite sampling and analyzed in the laboratory. Statistical analysis was conducted by correlation analysis using Smartstat XL and *Microsoft Excel 2019*. The result showed that there were correlations among various soil chemical and biological properties. Specifically, there were relationships between fungal populations with soil organic C and C/N ratio, and soil pH with total N.

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KEYWORDS: *Azotobacter,* chemical, maize, production

INTRODUCTION

Maize was a staple food crop crucial in providing sustenance in Indonesia. As the population of Indonesia continued to grow, the demand for food experienced a concomitant increase. According to the data obtained from the 2020 population census, Indonesia's population reached 270.20 million individuals. Among the provinces, West Java demonstrated the highest population count, with a notable figure of 48.27 million inhabitants. The rise in population showed a direct correlation with the escalated demand for food consumption among the populace. Nevertheless, the index of food crop production in Indonesia underwent a decline. Food availability was augmented by implementing diversification of the primary food sources, thereby altering the societal reliance on rice consumption and introducing alternative commodities like maize.

The increase in maize consumption in Indonesia from 1993 to 2018 was characterized by a growth rate of 763,040 tons, corresponding to an annual rise of 5.68% (Saputra *et al*., 2022). West Java stood out as one of the regions in Indonesia with the highest maize productivity. In 2020, Sumedang, a region in West Java, demonstrated significant maize productivity, securing the fourth position with a harvested area of 15,436 hectares (Dinas Tanaman Pangan dan Hortikultura, 2021). However, it was still striving to optimize food provision and meet market demands. Achieving stability and productivity improvement of maize plants on available land can be accomplished by meticulously considering its inherent characteristics.

The balanced relationship between the biological and chemical characteristics of the soil was identified as a significant factor in increasing maize plant productivity (Pasaribu, P, 2020). Pasaribu revealed a correlation between soil chemical and biological properties, wherein plants cannot directly absorb Nitrogen from the air, as it needs to be fixed by soil microorganisms and converted into a plant-available form. Sari & Prayudyaningsih (2015) previously stated that the relatively higher nitrogen content in the soil is primarily attributed to the ability of certain microbes to fix Nitrogen. This nutrient, Nitrogen, plays a crucial role in plant height growth. The amount of Nitrogen absorbed by plants was found to influence the height and leaf area of maize

plants (Dewi *et al*., 2017). Furthermore, Sagiarti *et al*. (2020) research emphasized the importance of the carbon-to-nitrogen ratio (C/N ratio) in the soil as a crucial determinant for nutrient provision.

Soil microorganisms, including fungi, were found to impact maize productivity. For instance, Musafa *et al*. (2017) observed that the total length of maize plant roots was affected by the inoculation of mycorrhizal fungi and phosphate-solubilizing bacteria. These findings indicated that the interrelationship between soil biological and chemical characteristics could significantly influence maize plant productivity. As a result, this research aimed to understand the relationship between several soil biological and chemical characteristics in maize production area.

MATERIAL AND METHODS

Location

This study was conducted at 18 points located in Cibugel, Sumedang. The land used was a land unit sampling based on slope, elevation, climate, and maize production area. The soil sampling was performed at elevations ranging from 682 to 929 meters above sea level (m dpl), with slope gradients between 10 to 30%. The air temperature ranged from 22.4 to 23.7°C, air humidity between 78.5 to 80.2%, and monthly rainfall between 314.5 to 379.5 mm. The soil types at the research site were Andisol, Entisol, and Inceptisol. The soil texture at the research site was generally dominated by clay and fine fractions. The pH at the research site was categorized as acidic, ranging between 5.05 to 5.58.

Method

The research method employed in this study was descriptive and comparative. The soil sampling points were selected in homogenous fields, considering the similarity of land physiography and plant varieties. Soil samples were collected using the composite sampling method, and subsequent analyses were conducted in the laboratory.

Stage of Study

The research was conducted in four stages. Firstly, in the preparation stage, a literature review was carried out from various relevant books and journals. Land Utilization Type (LUT) based on FAO 1976 was identified, and a map of land unit sampling locations was created based on similarities in slope, elevation, and crop production areas. Secondly, during the field survey stage, interviews were conducted, and soil samples were collected. Thirdly, soil analysis was performed in the laboratory. Lastly, the data were processed and analyzed.

Parameters and Statistical Analysis

The variables to be tested are divided into two categories: dependent variables, which included the population of Azotobacter sp (Total Plate Count), fungi (Total Plate Count), C-organic (Walkey *and* Black), N-total (Kjeldahl), C/N ratio, and the independent variable was maize productivity. Statistical analysis will be performed using correlation analysis with SmartstatXL in Microsoft Office Excel 2019.

RESULT

Maize Productivity

Table 1. Regional Scale Maize Productivity Data

Scale	Productivity ($ku.ha^{-1}$)						Average
	2016	2017	2018	2019	2020	2021	
Cibugel	75,75	67,45	75,28	72,19	73,39	69,01	72,18
Sumedang	65,30	61,85	63,47	69,39	62,43	60,51	63,83
Jawa Barat	81,7	80,4	73,8	75,1	76,3	74,4	76,95
Indonesia	52,2	52,3	53,3	55,2	55,8	55,5	45,73

Source: Central Statistics Agency (BSA 2020, 2021), Sumedang District Agriculture Office 2021, Center for Agricultural Data and Information Systems 2020

Based on the data presented in Table 1, the average maize productivity at the regional scale exhibited annual fluctuations. Maize productivity at the district level experienced a decline from 75.28 in 2018 to 69.01 in 2021. However, from 2019 to 2020, maize productivity increased at the provincial and national scales. The national average maize productivity from 2016 to 2021 was reported to be 45.73.

Table 2. Results of maize Crop Productivity Trials at the Research Location.

No	District	Productivity ($ku.ha^{-1}$)
1	Cipasang 1	99,03
2	Cipasang 2	76,05
3	Cipasang 3	96,28
4	Sukaraja 1	100,32
5	Sukaraja 2	87,38
6	Sukaraja 3	90,62
7	Cibugel 1	92,23
8	Cibugel 2	87,38
9	Cibugel 3	96,28
10	Jayamekar 1	61,49
11	Jayamekar 2	63,11
12	Jayamekar 3	65,53
13	Buanamekar 1	69,58
14	Buanamekar 2	63,11
15	Buanamekar 3	72,01
16	Jayamandiri 1	98,71
17	Jayamandiri 2	101,94
18	Jayamandiri 3	104,86

Source: Hasil Data Ubinan UPTD Cibugel, Februari 2023

The maize plant productivity at the research location displayed significant variation. Plant productivity was calculated after harvesting through yield calculations. The highest maize productivity was observed in Jayamandiri 3 Village, reaching 104.86, whereas the lowest productivity was recorded in Jayamekar 1 Village, with a value of 61.49.

Soil Characteristics and Maize Productivity

Based on the Pearson correlation analysis, significant relationships were found between the biological and chemical characteristics of the soil. Table 3 shows that there was a strong correlation between soil fungi and soil organic C (r = 0.64) and a moderate correlation with the C/N ratio (r = 0.50). The soil pH characteristic had a moderate correlation with the percentage of N (r = 0.53). Besides being correlated with fungi, soil organic C also had a strong correlation with the C/N ratio (r = 0.67).

Table 3. Correlation Between Soil Biological and Chemical Characteristics .

	Azotobacter sp.	Fungi	pH	Soil Organic C	Total N	CN Ratio
Azotobacter sp.	1,00	0,12	0,34	0,26	0,02	0,22
Fungi	0,12	1,00	0,42	0,64 *	0,17	0,50 *
pH	0,34	0,42	1,00	0,18	0,53 *	-0,22
Soil Organic C	0,26	0,64 *	0,18	1,00	0,38	0,67 *
Total N	0,02	0,17	0,53 *	0,38	1,00	-0,41
CN Ratio	0,22	0,50 *	-0,22	0,67 *	-0,41	1,00

*significant at the real level of 0.05

DISCUSSION

The relationship between soil biological and chemical characteristics significantly influenced the growth of maize plants, subsequently affecting the plant's productivity. Soil biological characteristics played a vital role in plant organic matter decomposition and nutrient supply. The activity of Azotobacter sp required carbon as an energy source to convert nitrogen into plant-available forms. Kusumawati & Prayogo (2019) previously found a significant correlation between soil organic C and the total bacterial population (r = 0.62). The content of soil organic C, total N, total Mn, available P, and soil moisture was observed to influence the abundance of Azotobacter sp in the soil (Czaban & Wróblewska, 2017).

Apart from bacteria, fungi also played a crucial role. The Pearson correlation analysis indicated a strong relationship between fungi and soil organic C (r = 0.64). Total soil organic C and total N in the soil were found to have affected the distribution of fungi in the soil (Li *et al*., 2009). Earthworms served as indicators of soil fertility, and fertile soil facilitated the successful growth of maize plants due to the availability of nutrients. This was consistent with Zhang *et al*. (2016), which revealed that fungi and earthworms significantly increased shoot and root biomass, enhancing nutrient uptake for maize plants. The presence of earthworms was influenced by various factors, such as pH, soil organic C, total N, and C/N ratio, leading to different earthworm populations in different locations (Mariappan *et al*., 2013).

The analysis correlated soil pH and total N (r = 0.53). The effect of soil pH on N availability was indirect and affected the activities of microorganisms involved in N availability (Hartati *et al*., 2023). Mieke *et al*. (2017) previously stated that high rainfall could lead to N loss through leaching. Nitrogen-fixing bacteria were generally sensitive to pH, and acidic soil conditions could inhibit microbial activity, including organic matter mineralization and nitrification (Munawar, 2011). Microorganisms thrived when the organic matter content, as a food source, was available in their environment (Purwoko, 2007). Changes in the percentage of soil organic C influenced soil microbial biomass (Blanco-Canqui *et al*., 2013). Temperature and rainfall were among the factors that affected the presence of soil organic C and total N in the soil (Bi *et al*., 2018).

According to the Pearson correlation analysis, soil organic C strongly correlated with the C/N ratio (r = 0.67). The relationship between soil organic C and total N could be determined through the soil's C/N ratio, an important indicator of soil quality (Zhang *et al*., 2011). Mahmood *et al*. (2017) previously found that significant changes in organic matter could increase soil organic C, thereby influencing microbial activity, nutrient availability, and nutrient uptake, consequently altering the C/N ratio. Based on the Pearson correlation analysis, the C/N ratio had a significant relationship with the population of soil fungi (r = 0.50). The abundance of soil microorganisms varied greatly with changes in the C/N ratio (Sun *et al*., 2020).

CONCLUSION

Based on the results and discussion, there were significant relationships between soil biological and chemical properties that influenced the growth of maize plants then subsequently affecting the plant's productivity. Correlations were observed between fungal population with soil organic C (r = 0.64) and C/N ratio (r = 0.50), C/N ratio with soil organic C (r = 0,67), as well as soil pH with total N (r = 0.53)

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