I. INTRODUCTION

A. Background

Sustainable agricultural development is one of the main goals of the agricultural sector, and has been gradually implemented in several countries. Nevertheless, the main challenge for sustainable agriculture is feeding a growing global population while reducing the environmental impact and conserving natural resources for future generations. These challenges can negatively impact pollution and the degradation of land, water, and air because of the rapid degradation of natural resources and biodiversity, while rapidly increasing goods and services from agriculture. In addition, intensive agricultural activities are the main drivers of global climate change that accelerate soil erosion and environmental pollution owing to improper carbon sequestration, fossil fuel emissions, and land and water use approaches. According to the FAO (2023), the current agricultural production growth trajectory is generally unsustainable because of its negative impact on natural resources and the environment. One-third of agricultural land is degraded, and up to 75% of crop genetic diversity has been lost. Over the past decade, more than half of fish stocks have been fully exploited, and approximately 13 million hectares of forest each year have been converted to other land uses.

Therefore, contributing to the global transformation of sustainable agriculture requires significant improvement in resource efficiency, environmental protection, and system resilience. Agricultural land can be lost daily owing to industrial and residential developments. Therefore, remaining land must be used more efficiently. To be sustainable, agriculture must meet the needs of the present and future generations for its products and services. Nurturing healthy ecosystems and supporting the sustainable management of land, water, and natural resources while ensuring global food security is part of sustainable agricultural practices. Supporting sustainable soil management includes the use and management of nutrients, energy, and water; less rational use of these inputs per unit of soil, especially when using pesticides and herbicides.

In Indonesia's agricultural development strategy, efforts to achieve food self-sufficiency are made by applying intensive agricultural technology in the form of the use of quality seeds, fertilizers, pesticides to control pests and plant diseases, and herbicides to control weeds. In the agricultural development strategy in Indonesia, efforts to achieve food self-sufficiency are carried out by applying intensive agricultural technology in the form of the use of quality seeds, fertilizers, pesticides in controlling pests and plant diseases, and herbicides in controlling weeds. In contrast, herbicides are commonly used in the cultivation of food crops, particularly corn and rice.In contrast, herbicides are commonly used in the cultivation of food crops, especially corn and rice.

Herbicides, used in large quantities in agriculture to control undesirable plant species, optimize labor, and achieve high efficiency. The increased application of herbicides increases the residue concentration in soil, changes the soil response, and adversely affects soil flora. Repeated application of herbicides may be associated with the risk of reducing or changing soil microorganisms' activity and increasing herbicide species' resistance. Herbicides are biologically active compounds, and an unintended consequence of their effects can lead to significant changes in the microbial population and activity, thereby affecting soil fertility (Baboo *et al.*, 2013). They are accompanied by the decomposition of organic matter in the soil by soil organisms, which greatly influences soil fertility, plant growth, soil structure, and carbon cycles.

Herbicides are widely used in Indonesia, including those containing glyphosate and 73% of the total circulating herbicides (Brookes, 2020). Glyphosate is a non-selective herbicide with a broad spectrum of control. Glyphosate controls annual broadleaf weeds and is used during the pre-emergence stage. The dose varies depending on the type of weed being controlled, and is usually in the range of 6–11 liters ha^{-1} (Anwar *et al.*, 2019). These compounds are absorbed by the leaves and transported to all plant tissues. It also affects nucleic acid and protein synthesis (Mertens, 2017). Glyphosate is traded under Roundup and Polaris (Harrington *et al.*, 2014).

Herbicide molecules in soil solutions can also be absorbed or metabolized by microorganisms. High persistence of the active ingredients of herbicides affects the population of microorganisms in the soil. This suggests that the increasing content of toxic elements in the soil owing to the application of herbicides that are relatively resistant to biodegradation will significantly inhibit the biodegradation function of microorganisms and can even kill microorganisms in the soil itself (Zobiole *et al.*, 2010 and 2011).

Glyphosate is an herbicide that has long been widely used in agricultural cultivation. The effects of glyphosate on the soil are controversial (adverse results). Many studies have shown that the use of glyphosate reduces the activity of the enzyme catalase or using Glyphosate at a dose that can stimulate the activity of catalase, in contrast to high doses that inhibit this enzyme (Ratcliff *et al.*, 2006). Furthermore, high doses of Glyphosate contaminate the soil and affect the number, activity, and biodiversity of biotic soil communities. It is crucial to maintain soil quality using biological parameters. One biochemical parameter is the activity level of enzymes (urease, dehydrogenase, cellulase, phosphatase, and other hydrolases) secreted by microorganisms in the soil (Cherni *et al.*, 2015). Soil hydrolases are a group of enzymes responsible for catalyzing the hydrolysis of soil substances. Regarding soil hydrolases, they are a group of enzymes responsible for catalyzing the hydrolysis of soil substances. Hydrolase enzyme activities are essential because they show the potential of the soil to conduct reactions in the nutrient cycle. The hydrolase enzyme activities are essential because these activities show the potential of the soil to conduct reactions in the nutrient cycle. It is central to the primary metabolism and acquires C, N, and P. For example, urease, phosphatase, and arylsulphatase catalyze the hydrolysis of soil amide N, organic P, and organic S, respectively, which are significant in the uptake of N, P, and S by plants. Specifically, enzymes, such as amidohydrolases, are involved in the hydrolysis of organic N compounds (Ekenler and Tabatabai, 2004). Extracellular phosphatases mineralize organic P compounds. Adaptive enzymes are produced by plant roots and soil microorganisms to meet plant's P requirements (Schneider *et al.*, 2001). Adaptive enzymes are produced by plant roots and soil microorganisms to meet the plant's P needs (Schneider *et al*, 2001). Moreover, different crops can have different effects on different soil types. Further biochemical changes in each soil type were performed using glyphosate and other crop plantings.

In developing countries, the biggest challenge is to improve and maintain sustainable agricultural productivity to meet the domestic and export needs for economic development. Therefore, for a long time, farmlands have been used with agrochemicals to increase productivity. So for a long time, farmland has been used with agrochemicals to increase productivity. Currently, agroecosystems are characterized by low biodiversity and the strong development of farming systems, which has led to the large-scale adoption of pesticides, particularly pesticides, fungicides, and herbicides. These chemicals include herbicides, which can pollute the soil environment, unbalance the biota in the soil, and change agricultural ecosystems. Furthermore, currently, there are few studies on the effect of pesticides on soil biochemical properties, and very few reports on their effects on Ultisols. Determining the effect of glyphosate herbicides on the soil biochemical properties of Ultisols should be studied as the basis for assessing the damage caused by herbicides on sweet corn growth. For this reason, the research on the "Effect of herbicide application on the change in biochemical properties on Ultisols" was intended to be executed at the experimental station of Universitas Andalas, Indonesia.

B. Problem Formulation

The problem of this study were:

There is a lack of information about changes in the biochemical properties of Ultisols due to the effects of the Glyphosate herbicide.

Lack of information on the effects of Glyphosate herbicides on beneficial soil microorganisms.

Lack of information about the effectiveness level of Glyphosate herbicide on Ultisols.

C. Objective of Research

The research objectives were:

to study the effect of Glyphosate herbicide on the biochemical properties of Ultisols.

To determine the dose level that causes the most significant changes in the biochemical properties of Ultisols in limed and non-limed soil.

D. The benefits of Research

The benefit of this research were:

to identify biochemical changes in the Ultisol caused by Glyphosate herbicide application and its effect on the condition and function of soil.

To assist further research should be conducted on the management of herbicide use in cultivation and promoting the development of sustainable agriculture.