Quest Journals
Journal of Research in Agriculture and Animal Science
Volume 12 ~ Issue 6 (June 2025) pp: 08-14
ISSN(Online) : 2321-9459
www.questjournals.org

Research Paper

Education for Agricultural Extension Officers On Conservation Tillage in North Sumatra, Indonesia

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ABSTRACT: *Extension education is a crucial subsystem within the agribusiness framework, as it catalyzes other subsectors' success. Given that extension education is a prerequisite for sustainable development in transferring research results and new agricultural techniques to farmers, equipping agricultural extension officers with conceptual knowledge and practical skills is necessary. This community service activity aims to enhance agricultural extension officers' knowledge of soil health management. The activity results showed an increase in understanding of soil health management in addition to participant satisfaction. Before the presentation, more than half of the participants were unfamiliar with the term 'soil management.' After attending the presentation, participants' knowledge increased regarding various aspects of soil management, with scores ranging from 73 to 93 on a scale of 0–100.*

KEYWORDS: *Agricultural Extension, Soil health management, Soil tillage, Conservation soil tillage, Community service activity.*

Received 14 June., 2025; Revised 27 June., 2025; Accepted 29 June., 2025
*Published with open access at **www.questjournas.org***

I. INTRODUCTION

Population growth data and projections for 2015-2045 estimated that in 2045, the population of Indonesia will reach 318.96 million or grow by 24.80% (63.37 million) from 2015. The agricultural sector is required to meet the need for safe and nutritious food for the entire population of Indonesia [1]. This challenge is in line with the second goal of the SDG (Sustainable Development Goals), namely, "end hunger, achieve food security and improve nutrition and promote sustainable agriculture" [2].

As a global trend [3; 4], one of the crucial problems faced by the Indonesian agricultural sector is land conversion, which not only causes food production to decline but is also a form of investment loss, ecosystem degradation, degradation of agricultural traditions and culture, which results in increasingly narrowing of the area of farming and declining farmer welfare so that farming activities cannot guarantee a decent standard of living [1]. Therefore, increasing production is pursued by increasing land productivity, either by increasing production per land area per planting season or by increasing harvest intensity (cropping index) as an alternative to land-intensive production [5].

From the agribusiness system perspective, to increase Indonesian agricultural production, the education support subsystem (agricultural extension) plays an important role as a catalyst to make the role of other subsystems more effective [6; 7]. The extension organization in Indonesia is structured from the national/central level to the village level as regulated in Law Number 16 of 2006 regarding the Agricultural, Fisheries, and Forestry Extension System. Table 1 presents the organizational structure of Indonesian agricultural extension.

Table 1: Organization Structure of Agricultural Extension in Indonesia.

Level	Organization*	Tasks and Function
National	Agency for Agricultural Extension and Human Resources Development (BPPSDMP) Center for Agricultural Training/Extension (BBPP)	- Formulating national extension policies - Technical guidance and human resource development for extension officers - Training and capacity building for extension officers and farmers
Province	UPTD Agricultural Extension Center	- Coordination of provincial extension programmes - Sub-district supervision
District	Agricultural Division	- Implementation of local outreach programmes - Guidance for BPPs and extension officers
Sub-district	Agricultural Extension Center (BPP)	- Field extension operational center - Coordinating PPL activities and farmers
Village	Field Agricultural Extension Officer (PPL) Farmer's Group (Poktan) and Farmer's Group Association (Gapoktan)	- Direct guidance to farmers/farmer groups - Transfer of agricultural technology - Implementing partners for extension services at the village level - Application of extension results

Table 1 indicates that PPL, coordinated by BPP, is at the forefront of agricultural extension in Indonesia. PPL deals directly with farmers to guide and assist them, both individually and in groups, in the process of agricultural technology transfer.

Extension is a prerequisite for sustainable development. To transfer research findings and new agricultural techniques to farmers, someone needs to guide them in applying and adopting these new practices. Therefore, extension officers must explain new technologies to farmers and teach them how to adapt and adopt better production practices to increase production and income. Extension officers also play a vital role in ensuring researchers understand farmers' agro-economic and social environment in developing new techniques/practices [8; 9; 10].

In the 1980s, the World Bank introduced a method of agricultural extension management called the training and visit system (T&V). T&V emphasizes simplicity in organization, objectives, and operations. This system has a clear organizational structure with well-defined operational methods, provides continuous feedback from farmers to extension officers and researchers, and allows for ongoing adjustments based on farmers' needs. This system spread rapidly due to its appeal as a means to increase agricultural production and farmers' income and a flexible management tool tailored to the needs of agricultural departments/divisions in developing countries [11].

Agricultural extension officers receive regular training on farming practices appropriate to specific times during the growing season. They usually visit once every two weeks, and each group of farmers knows exactly when the extension officers will visit. The training also follows a fixed schedule, with specialists as resource persons who provide training and diagnose problems faced by field agricultural extension workers [12; 11].

Soil is fundamental in agricultural development and food security as the foundation for plant growth, water retention, and nutrient cycling. Maintaining soil health is critical for global food security, and long-term agricultural sustainability strategies like crop rotation, organic farming, and environmentally friendly soil tillage help protect and restore soil integrity. Bagnal et al. [13] explore the relationship between soil health and food security, emphasizing climate change and farmer profitability as follows: (i) soil health impacts food security through crop yield, resilience, and farmer profitability, (ii) climate change plays a significant role in soil degradation, affecting food production, (iii) agricultural production influences global food prices, linking soil health to food security, (iv) over half of increased crops yields due to soil health management, (v) farmers using soil health system saw an increase in net farm income, and (vi) scaling adoption of soil health practices is crucial for sustainable food production.

Environmentally friendly soil tillage minimizes soil disturbance, preserves soil health, and reduces erosion while promoting sustainable agriculture. The following are types of environmentally friendly soil tillage [14; 15]: (i) No-till farming, avoiding traditional plowing helps maintain soil structure, improve water retention and reduce erosion, (ii) Strip-till, tilling only narrow strips where seeds are planted, leaving the rest of the soil undisturbed, (iii) Cover crops, growing plants like clover and rye during the off-season to prevent soil erosion, improve fertility, and enhance biodiversity, (iv) Contour plowing, plowing along the natural contours of the land to reduce the water run-off and prevent soil erosion, (v) Mulching, using organic or in-organic materials to cover the soil, which reduces evaporation, suppresses weeds, and enriches soil nutrients, and (vi) Reduce tillage (conservation tillage), minimizing the depth and extent of tillage to retain organic matter and improve soil health.

This community service activity aims to broaden the knowledge of agricultural extension workers in soil health management, specifically regarding conservation tillage, as part of training in T&V extension management.

II. METHOD

The Community Service Activity was held on July 31, 2024, at the Beringin Agricultural Extension Centre (BPP-Beringin), Deli Serdang Regency, North Sumatra Province, Indonesia. The event was attended by 19 extension officers serving an area of 54.32 square kilometers, administratively comprising 11 villages. Education on conservation tillage was conducted using lectures and interactive discussion methods. The atmosphere of the lecture and discussion is illustrated in Fig 1.

Figure 1. Lecturing and Interactive Discussion on Conservation Tillage Education

III. RESULTS AND DISCUSSION

3.1. Presentation of Subject Matter

In the form of lectures and interactive discussions, participants were presented with the following material:

Soil is a dynamic three-dimensional substance that covers part of the world's land surface. Soil varies from place to place in response to five factors that shape it: climate, topography, organisms, parent rock beneath the surface, and time.

To understand soil conditions as a growing plant medium, it is necessary to know some basic things. Optimal agricultural soil for plant growth must be able to meet all the needs of plants, such as water, air, nutrients, and others (Fig. 2). Therefore, the soil must be managed to meet all the needs of the plants being cultivated.

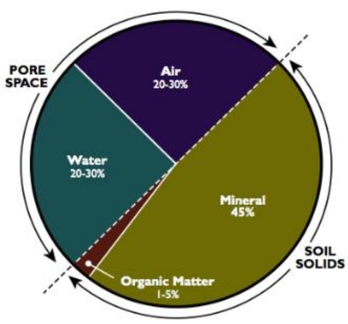

Figure 2: Soil as A Three-Phase System

In addition to the above conditions, it is also important to note that in order to create optimal conditions for soil as a medium for plant growth, it must be understood that soil is a system that contains living components, such as macro- and microorganisms, that are highly interdependent. When these variables are in harmony, will soil conditions be optimal for plants? Theoretically, the soil is often likened to a life system known as the pedosphere, which can be understood as the soil itself, encompassing the concept that soil serves as a habitat where there is integration between rock (lithosphere), air (atmosphere), water (hydrosphere), and living organisms (biosphere) (Fig. 3).

Information about soil texture and other soil properties is essential to creating the harmonious soil conditions described above. This information can be used to determine the appropriate soil management practices for the specific soil conditions.

Another important consideration in soil management patterns often involves using herbicides for weed control. To avoid disrupting the conditions for the growth of microorganisms and macroorganisms in the soil, it is crucial to select the type and dosage of the herbicide very carefully. This ensures that the growth conditions for microorganisms and macroorganisms remain optimal while supporting optimal plant growth.

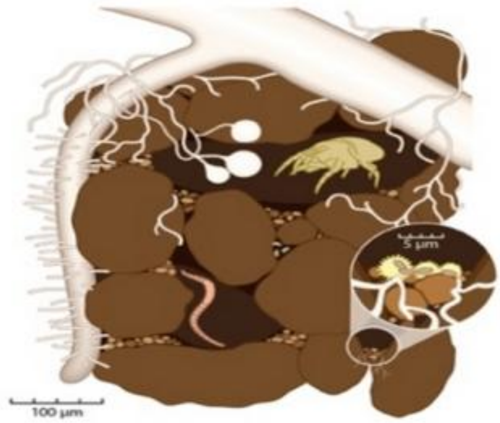

Figure 3: Soil as Pedosphere.

Soil is a medium (a place for plants to anchor/grow) because it contains nutrients, water, and air that plants need. As a brief overview of the importance of understanding the condition of cultivated soil compared to uncultivated soil, the following points should be noted:

Cultivated soil will create the following conditions:

- Improved aeration
- Burial of plant residues
- Easier root penetration
- Suppression of weed growth

Meanwhile, uncultivated soil will create the following conditions:

- Maintains soil structure
- Maintains the stability of organic matter content in the soil
- Supports soil organism conditions
- Prevents soil erosion

Fig. 4 shows non-compacted soil (conservation tillage) and compacted soil (conventional soil tillage). Conservation tillage improves soil structure by increasing organic matter, which improves infiltration rates and reduces sedimentation and nutrient runoff. Traditional tillage leaves the soil vulnerable to compaction, which leads to sedimentation and increased nutrient runoff.

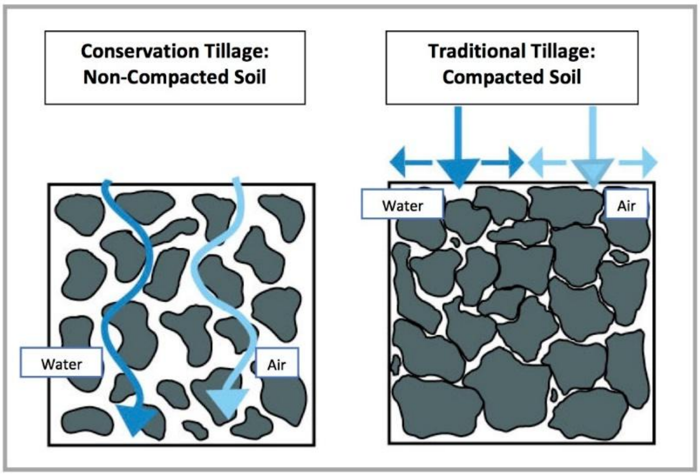

Figure 4: Schematic comparison of conservation tillage soil (uncompacted) with conventional tillage soil (compacted)

Let us consider the two differences in benefits, each of which has advantages and disadvantages regarding the purpose of soil for plant growth. It is necessary to consider which method provides the best conditions for plant growth by considering soil texture. As shown in the figure above, the differences in plant growth or root penetration are also determined by the soil conditions in which the plants grow. Given the conditions outlined above, it is crucial to consider the following soil properties:

Texture. Soil comprises minerals (derived from rocks underground or carried by wind or water) and organic matter (from decaying plants and animals). The mineral component of soil is identified based on its texture. Texture refers to the soil's relative amount of sand, silt, and clay. These three terms refer only to particle size, not the type of minerals that compose them. Sand is familiar to most of us and is the largest soil texture size. Sand grains can be seen with the naked eye or with a hand lens. Sand provides excellent aeration and drainage. Sand has a low capacity to hold water and nutrients. Clay particles, often equated with loam, are so small that they can only be seen through an electron microscope. Clay soil contains little air, and water flows slowly through it. This soil is difficult to work with; clay soil tends to erode more slowly than sand and can retain water and nutrients. Silt is sized between sand and clay. Silt particles can be seen through a low-power microscope. Silt has intermediate characteristics compared to sand and clay.

Structure. Sand is often found as individual particles in soil, but clay and loam almost always clump together into larger units called aggregates. The way these aggregates are formed determines the structure of the soil. Soil structure is described using blocky, flat, prismatic, and angular terms. Productive topsoil often has a granular soil structure. The size and shape of aggregates are influenced by mineral type, particle size, wetting and drying, freeze/thaw cycles, and root and animal activity. Decomposed organic matter, plant sugars released from roots, microbial soil waste products, and added soil conditioners all act to cement particles into aggregates. However, aggregates can break apart due to soil tillage, compaction, and the loss of organic matter within the soil. Soil structure is a highly dynamic process. Good soil structure increases pore space (see below), which supports root penetration, water availability, and aeration.

Pore space. Soil particles are rarely and rarely tightly packed together; they are separated by spaces called pores. Pores are filled with water and/or air. Immediately after heavy rain or irrigation, pore space is almost 100% filled with water. Over time, water descends through the root zone of the soil due to gravity, evaporates into the air, or is used by plant roots, and more pore space is filled with air. Clay soil particles stick together tightly and have little pore space to hold air and water.

On the other hand, beach sand has so many large pores that it dries out too quickly to support most plants. Pore space typically occupies 30–60% of the total soil volume. Well-structured soil has large pores (macropores often filled with soil air) and small pores (micropores often known as water-filled pores); this provides the balance of air and water plants need. Macropores provide good drainage, and micropores hold water that plants can access. This helps explain how you can achieve 'well-drained but moist soil.' A comparison and illustration of both types of pores in soil is shown in the image below.

Organic matter (OM). OM was previously living material. There is usually undecomposed OM on the soil surface, known as litter or mulch (or mulch in landscapes). This surface layer reduces the impact of raindrops on soil structure, prevents erosion, and eventually decomposes to supply nutrients that seep into the soil through rainfall or irrigation. OM decomposes further into humus, a stable and highly decomposed residue in the soil. Humus is an important source of plant nutrients that help to bond soil particles together. Organic matter is always in the process of decomposition, eventually becoming humus. OM levels decrease through cultivation and can be replenished by adding compost or manure, plant residues, or green manure (plants like buckwheat, clover, or wheatgrass grown as cover crops and then incorporated into the soil). Soil OM can be preserved through reduced-tillage practices, such as no-till farming. Organic matter improves water retention, making it a good addition to sandy soils. Organic matter is also added to clay or loam soils to improve aggregation and thus enhance drainage. Organic matter provides nutrients as it decomposes, buffers soil solution pH against rapid chemical changes, and increases soil cation exchange capacity.

Living organisms in the soil. Many organisms inhabit the soil: bacteria, fungi, algae, invertebrates (insects, nematodes, snails, earthworms), and vertebrates (mice, voles, moles). These organisms play many physical and chemical roles that affect plants. For example, their secretions help dissolve minerals, making them available to plants; some organisms convert inorganic substances into other forms that are more or less available to plants; organisms add organic matter (OM) to the soil; organisms help break down organic matter; many organisms aerate the soil. Some organisms living in the soil cause diseases, some feed on plant tissues, and many compete with plants for nutrients and water.

Soil Tillage. Mechanical manipulation of soil loosens it and improves aeration, porosity, and water-holding capacity. This allows for incorporating soil amendments such as organic matter (OM) and lime. On the other hand, soil tillage tends to reduce aggregation, leading to compaction (small pores dominate compacted soil). Managing OM levels: In natural areas, dead plants and animals decompose and replenish OM in the soil. Each year, plant leaves shed and decompose (compost) in place, and their nutrients and OM are added to the soil through rainfall and freeze/thaw cycles that create cracks in the soil. Leaves from deciduous trees can be left to decompose; plant residues can be composted and returned to the garden as OM; and plant residues, green manure, and animal manure can be incorporated directly into the soil. Some soil preparation is generally required to incorporate these materials into the soil. Adding large amounts of OM at once can cause nutrient problems, especially if the material is not fully composted. Regularly adding small amounts of organic matter can contribute to long-term soil fertility, support soil microflora, good soil structure, and the soil's ability to retain water and air. All these soil properties greatly influence and determine the area's most appropriate soil management practices.

3.2. Evaluation of Community Service Activity

To evaluate the implementation of educational activities, interviews were conducted with 15 participants, comprising 67% women and 33% men. If the participants' educational level is homogeneous (bachelor's degree = 16 years), then the characteristics of age and work experience vary considerably: the age range of participants is 27–60 years (average 46 years), and work experience is 1–40 years (average 16 years). The participants' educational backgrounds in agriculture included food crops, agronomy, horticulture, general agriculture, and general extension.

Through a pre-test, it was found that all participants understood the importance of soil as a medium for plant growth and a source of nutrients for plants. More than half of the participants (53%) were unfamiliar with the term 'soil tillage' (in English), while the rest were familiar with the term through previous training. However, those who had attended training and were familiar with the term 'soil tillage' understood it differently, including no-till farming, perfect soil preparation, and traditional/simple/manual vs. mechanized soil preparation.

After hearing explanations about the physical properties of soil and the relationship between soil tillage techniques and agronomic aspects (plant growth), all participants demonstrated an increase in knowledge, as evidenced by post-test scores ranging from 73 to 93 on a scale of 0–100. The highest increase in knowledge was observed in the relationship between soil tillage and root penetration, and the choice of soil tillage techniques depends on the type of plant and soil conditions. The participants' post-test scores are presented in Fig. 5.

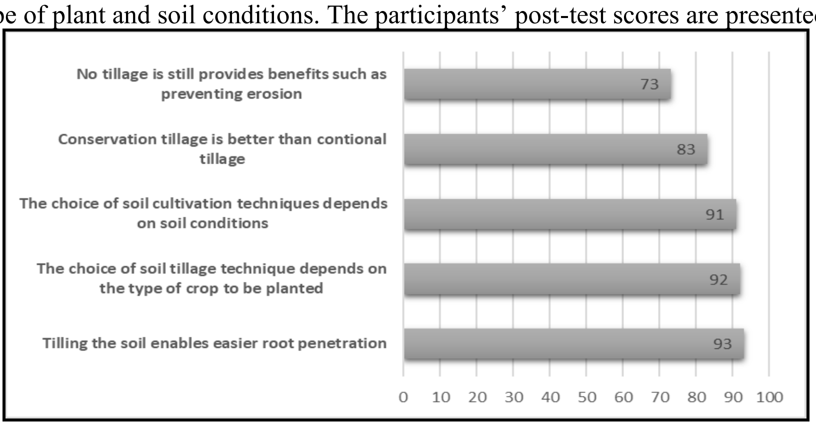

Figure 5: Participants' comprehension scores after attending education/lectures

All participants were delighted with the community service activities, which were interactive lectures/discussions. However, they hoped that similar activities in the future could include topics on the physical and chemical properties of soil, SRI (system rice intensification), and breeding. Additionally, participants suggested that future activities combine interactive lectures/discussions with practical/demonstration sessions held outdoors (not in a classroom setting).

IV. CONCLUSION

The community service activity was satisfying for the participants. Participants felt that their understanding of soil health management had been enriched. Before the lecture, more than half of the participants were unfamiliar with the term ‘soil tillage.’ In contrast, those who had heard the term only understood it in terms of simple/manual vs. modern/mechanical soil cultivation. After attending the lecture, participants’ knowledge improved regarding various aspects of soil tillage, with scores ranging from 73 to 93 on a scale of 0–100.

Participants expressed hope that similar activities could be conducted in the future on other topics, such as the physical and chemical properties of soil, the System of Rice Intensification (SRI), and breeding. They also hoped for outdoor practical demonstrations in addition to lecture-based methods.

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