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COMPARATIVE STUDY BETWEEN CONVENTIONAL AND CONSERVATION TILLAGE SYSTEM OF CORN CULTIVATION IN NGANJUK REGENCY, EAST JAVA PROVINCE OF INDONESIA

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ABSTRACT

Corn cultivation techniques can be performed using a conventional tillage system (CovTS) and conservation tillage system (CosTS), which consists of minimum tillage (MT) and no-tillage (NT) systems. These systems have been implemented by almost every corn-producing region in Indonesia. One of these areas is Patianrowo District, Nganjuk Regency of East Java Province, Indonesia. The study was conducted to analyze the comparison from the economic side, such as the use and cost of farming inputs, revenue, income, and farming feasibility of the two cultivation systems. The study applied the methods of interview, documentation, and literature study in collecting the required data. Differences in costs, income, and the R/C ratio of maize farming from the two cultivation systems were tested statistically for independent samples. The analysis results stated that the no-tillage system was economically more profitable than the conventional system. A higher R/C Ratio value indicated that the NT system was more efficient in using costs, coupled with production time, than the CovTS. However, statistically, the two cultivation systems did not differ in production and income but showed a significant difference in labor employment. The condition of an area experiencing labor difficulties and supported by soil types such as grumosol is suitable for implementing a no-tillage system. In this case, the local government, through field extension officers, can guide farmers' decision to apply either cultivation system. Providing information, knowledge, and skills will assist maize farmers and other related parties in making decisions to obtain maximum profit and increase welfare.

Keywords: *corn, conventional tillage system, farmers' income, no-tillage*

BACKGROUND

Agricultural development is an integral part of regional development. Therefore, the vision and mission of regional development help formulate the framework for achieving the principles of agricultural development. The focus of national agricultural development is to realize stable food security in terms of quality, quantity, and continuity. It is supported by independent farming with an agribusiness perspective by increasing the production of food and nutrition diversification, increasing farmers' income, and improving the quality of human resources in agriculture (Lisanty et al., 2021). In national food security, corn or maize (*Zea mays L.*) is a strategic commodity that significantly influences the socioeconomic, political, and security aspects (Aidah & Tim Penerbit KBM Indonesia, 2020). In line with the increasing population and decreasing productive agricultural land, corn farming productivity is still being developed to increase farmers' income (Aldillah, 2017).

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As the primary food commodity for people in several regions in Indonesia, corn also has excellent potential in the feed industry. Apart from being a source of carbohydrates, the seeds can be made into oil or flour, while the cob flour can be used as raw material for various industries (Gandakusumah and Marta, 2020). This causes the demand for corn to be higher. The average national corn productivity in 2020 is 5,474 tons per hectare, with the highest productivity obtained by planting in paddy fields. Unfortunately, 71.4% of national corn production is carried out on non-paddy fields, of which more than 80% apply monoculture systems (Astuti et al., 2020). Efforts to increase corn production are directed at achieving sustainable self-sufficiency. However, there are still several obstacles and problems, including the lack of adoption of appropriate cultivation technology and the lack of availability of proper production facilities.

Corn cultivation techniques can be performed using a conventional tillage system (CovTS) and conservation tillage system (CosTS), which consists of minimum tillage (MT) and no-tillage (NT) systems. Many studies have discussed the advantages and disadvantages of each cultivation system. According to Hadianto et al. (2019), the CovTS significantly affected plant height, cob weight, and corn stalk diameter. Moreover, the interaction of CovTS and hybrid maize varieties would affect maize growth and production (Pobela, 2016). Meanwhile, Azis et al. (2020) revealed that combining the MT system with compost and mulching could increase hybrid corn production (Adrinal et al., 2012).

Contrarily, Khair et al. (2017) indicated no significant difference among CosTS, namely MT and NT systems. In each cultivation system, maize production and soil physical properties, such as bulk density, total pore space, and soil hardness, are similar, but long-term nitrogen fertilization significantly affects them. This statement is also supported by Satriawan et al. (2003) and Utomo (2015). They found that the NT system supported sustainable agriculture due to its ability to improve soil physical and biological properties by reducing the intensity of soil mechanical disturbances and reducing CO_2 gas emissions. On the other hand, according to Utami (2020), intensive land cultivation was the cause of land degradation and decreased productivity.

Bayer et al. (2014) broached that NT systems are possibly an effective way to lessen greenhouse gas emissions. Other researchers argued that NT systems improve soil chemical quality (Martínez et al., 2013) and enrich and diversify active soil bacteria (Pastorelli et al., 2013) compared to CovTS. Those are why NT systems have been performed in many countries worldwide for more than half a century. Apart from those, Derpsch et al. (2014) and Tieppo et al. (2019) confirmed that the widespread application of NT systems is primarily for economic reasons, specifically to reduce labor and energy consumption. Indonesian corn farmers also adopted and applied NT systems as an alternative to CovTS. One of the areas where a group of corn farmers decided to use either CovTS or CosTS is Patianrowo District, Nganjuk Regency of East Java Province. Farmers who applied NT systems claimed their income was higher and more feasible. However, they did not necessarily record their farming performance, calculating expenditures and returns. Maize farmer groups from other districts were even invited to adopt NT systems and were tempted to switch from CovTS based on reduced labor. Therefore, a study was conducted to compare the economics of both systems, such as the use and cost of farming inputs, revenue, income, and farming feasibility. The study results not only provide a comparison of CovTS and CosTS maize farming but are also expected to help maize farmers and other related parties make decisions to obtain maximum profit and increase welfare.

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RESEARCH METHODS

Determination of Study Location and Time

The study location was intentionally determined as Patianrowo District, Nganjuk Regency, East Java Province. Among the top 10 corn producers in Nganjuk Regency, Patianrowo District has a combination of alluvial and grumusol soil types, producing 15,420 tons of shelled corn in 2019 (Badan Pusat Statistik Kabupaten Nganjuk, 2020). Leading corn producers, such as Tanjunganom and Gondang District, have alluvial soil types that are easy to cultivate (Dinas Pertanian dan Ketahanan Pangan Provinsi Jawa Timur, 2013). Meanwhile, the grumusol soil type is unique yet suitable for zero tillage systems due to its structure (Coulombe et al., 1996; Habibie et al., 2021). Therefore, the study location was chosen based on considering a group of corn farmers in the area applying both CovTS and CosTS on the same area of land located in Rowomarto Village for around 10 hectares. The study was conducted started from April to May 2021.

Sampling Method

Corn farmers' respondents were members of a farmer group in the Patianrowo District. This group of farmers was formed based on their field location. From the initial survey, it was known that corn farmers in the village of Rowomarto applied two different cultivation systems. The population of corn farmers, according to the criteria and in the same land area of 10 hectares, was 30 farmers. Therefore, this study used the census method by making the entire population the sample, divided into 15 farmers who applied CovTS and 15 who applied CosTS.

Data Collection Method

The study applied the methods of interview, documentation, and literature study in collecting the required data. Interviews were conducted directly with respondents and related parties regarding the main source of information or primary data. The data included information on farming costs, production data, commodity selling prices, and obstacles faced in corn farming. In addition, data recorded at the relevant agencies in the form of documentation, such as data on the geographical and agricultural conditions of the location, were also extracted as secondary research data. Those data were eventually linked and reviewed with previous studies and other references through the literature study method.

Data Analysis Method

Collected data was then edited, tabulated, and analyzed to determine maize farming production, revenue, and income with CovTS and CosTS. Farming income is formulated as follows:

$$\pi = TR - TC$$

Information:

π : Income
TR : Total Revenue
TC : Total Cost

Furthermore, to determine farming feasibility (R/C) was calculated by using the formula:

$$R/C = TR / TC$$

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Information:
R/C : Farming feasibility
TR : Total Revenue
TC : Total Cost

If the R/C value was equal to 1, corn farming was breaking even (no profit nor loss). If the R/C value was less than 1, corn farming was at a loss. Otherwise, it was profitable. Differences in costs, income, and R/C ratio of CovTS and CosTS maize farming were analyzed using independent samples t-test. The test aims to determine whether the difference between these two samples is statistically significant. The significance level ($\alpha = 0.05$). The degrees of freedom (df) are based on the sample sizes of the two groups minus two, which equals 28. The t value with $\alpha = 0.05$ and 28 degrees of freedom is 1.701. This value can also be called a t_{table}, which will then be compared to t_{count} or t-statistic. The null hypothesis is that both samples' means are the same. The null hypothesis is written as follows:

1. H_0: $\mu 1 = \mu 2$
2. H_1: $\mu 1 \neq \mu 2$

The rule of decision-making was that if the t_{count} value is more significant than the t_{table} value, the null hypothesis is rejected and concluded that there was a difference between the data being compared and otherwise.

RESULT AND DISCUSSION

Regional and Agricultural Conditions of Study Locations

Most of the sub-districts in the Nganjuk Regency are lowlands with an altitude between 46 to 95 meters above sea level. Physiography and the shape of the area significantly affect plant growth directly through soil and climate. Based on the area's topography, the study location is flat to sloping, with a sloped area of less than 3% and a height difference of less than 5 m. Land use in the site is distinguished as paddy fields, dry land, and other uses. Data from Patianrowo District indicates that paddy fields occupy a large percentage compared to other services. The most extensive monthly rainfall occurs in January, which is 5,359 mm, and the smallest in June, with a total rainfall of 217 mm. There is no rain from July to November every year. Daily air temperature ranges from 20 to 25 degrees Celsius.

The location has soil conditions and structures that are quite productive for various plants. The type of soil is grumosol soil, supported by the availability of water from the Widas River, which flows along 69,332 km. The agriculture sector experiences rapid progress due to this condition and reliable human resources. The farmers formed farmer groups consisting of around 359 farmers. Despite the lack of Village Unit Cooperative or other similar farming cooperatives, farmers as parts of certain farmer groups of Sumber Mukti received assistance for Rural Agribusiness Development worth Rp. 100,000,000 in 2020. This assistance fund was channeled to member farmers through loans from agricultural facilities, such as fertilizers. The fee charged from the loan was 1% per month, which could be paid at the end of the growing season or harvest.

The main cropping pattern carried out by most of the farmers in one year is paddy-paddy-corn (with an intercropping system). Especially for corn, farmers generally use seeds from PT Bisi, namely

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Bisi 2, C05, and Pioneer. Farmers do not sell their crops in local markets but sell them to collectors. The marketing channels for corn products consist of farmers, collectors, wholesalers, retailers, and consumers.

Characteristics of Respondent Farmers

The analysis of the respondents' characteristics in this study included age group, education level, number of dependents, area of arable land, land ownership status, and participation in agricultural extension activities. Table 1 below depicts the characteristics of the two groups of respondent farmers, namely farmers who applied CovTS and CosTS, particularly the NT system.

Table 1. Characteristics of Respondents Who Applied Conventional Tillage and No-Tillage System

No	Characteristics	Tillage System			
		CovTS		NT	
		Respondent	Percentage (%)	Respondent	Percentage (%)
1.	Age (year)				
	a. 15-25	1	6.67	2	13.33
	b. 26-35	3	20.00	4	26.67
	c. 36-45	6	40.00	5	33.33
	d. 46-55	4	26.67	3	20.00
	e. >55	1	6.67	1	6.67
2.	Education				
	a. Not graduated primary school	3	20.00	2	13.33
	b. Graduated primary school	2	13.33	4	26.67
	c. Graduated junior high school	5	33.33	5	33.33
	d. Graduated senior high school	5	33.33	4	26.67
3.	Dependent (person)				
	a. < 2	1	6.67	-	-
	b. 2 - 3	8	53.33	7	46.67
	c. 4 - 5	6	40.00	5	33.33
	d. > 5	-	-	3	20.00
4.	Land Area (ha)				
	a. < 0.2	5	33.33	6	40.00
	b. 0.2–0.3	5	33.33	6	40.00
	c. > 0.3	5	33.33	3	20.00
5.	Land Ownership				
	a. Own	5	33.33	6	40.00
	b. Rent	7	46.67	7	46.67
	c. Profit-sharing	3	20.00	2	13.33
6.	Participation in Extension Activities				
	a. Participate	12	80.00	13	86.67
	b. Never participate	3	20.00	2	13.33

Source: Primary Data, 2021

From the table above, it is known that the respondent farmers are in the productive age group, which ranges from 15 to 55 years. The formal education of respondent farmers is varied. Some

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farmers generally have low formal education. Andajani and Rahardjo (2020) stated that farmers' education level significantly affects their mindset in developing their farming, especially in absorbing information and applying innovation. Another fact that might encourage knowledge and skills increase in farmers is their participation in agricultural extension activities. The involvement of most respondent farmers in extension is expected to contribute positively to income increase and their welfare (Bayu Aji et al., 2020).

Although labor is the main asset in farming activities, the large number of family members of farmers does not necessarily increase the number of workers in farming (Kune et al., 2016). It is not uncommon for many family members to add to the burden of costs that must be borne in the farmer's household (Purba & Lisanty, 2021). Respondent farmers belonged to small and medium families with a specific number of dependents in Indonesia. Meanwhile, the area of land cultivated by farmers was influential on the activities of farmers and their farming production. More than half of the respondent farmers acquired relatively small arable land areas of 0.1 to 0.3 hectares. More than half of them were not landowners but were tenants or users of a profit-sharing system.

All respondents were members of the maize farmer group in the area. The good thing about the respondents, as members of farmer groups, was that they were willing to play an active role and participate in group activities. It was possible due to trust between group members (Anisa et al., 2020). Farmer's decision to adopt either CovTS or CosTS is based on an agreement between the members of the corn farmer group in the area. Farmers with adjacent fields decided jointly whether their land required tillage or not. In this case, farmers were coordinating and consolidating their land. As stated by Ekowati et al. (2020), this is the main support in increasing farmers' production, productivity, and income. Farmer's collective agreement allowed them to commonly use labor, machinery, and land processing equipment. Farmers adopting CosTS were generally due to several constraints, such as labor availability, time for planting and harvesting, and the availability of business capital.

Comparison of Farming Costs, Income, and Feasibility of CovTS and NT System

Based on interviews and data analysis results, details of farming costs, production, revenue, income, and efficiency or feasibility of maize farming of Conventional Tillage System (CovTS) and No-Tillage (NT) system were presented in Table 2. Respondent farmers incurred corn farming costs for three months, from the beginning of the planting period until the harvest. These costs included land rent, taxes, depreciation of equipment, seeds, fertilizers, pesticides, labor, irrigation, and the purchase of sacks. All of them were calculated based on the average per hectare of cultivated area. There was only a slight difference in the fixed costs of CovTS and NT maize farming systems, while a significant difference was seen in the variable costs. Both groups of farmers applied hybrid seeds, which they believed to be more profitable in terms of production. Wahyuningsih et al. (2018) also stated that maize farmers' income and feasibility were higher for farmers who applied hybrid seeds than those who applied local seeds. The CovTS used chemical fertilizers of the ZA type at the beginning of the cultivation period and mainly at the time of tillage. In addition, farmers who applied this cultivation system also used more pesticides or herbicides. It is in line with Setyawati (2017), who revealed that weeds grew more in CovTS than in the NT system. According to Hafsah et al. (2019), the NT system combined with the herbicides glyphosate and paraquat treatment could suppress weed growth and even stimulate the growth of corn plants. Moreover, farmers applying NT

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systems used paddy straw as mulch on their corn fields. The use of organic mulch is one of the most common methods of weed control (Marble, 2015). Benefit-cost analysis by Jalota et al. (2007) indicated that this practice has economic viability for several crop production, including rainfed and irrigated maize.

Respondents said that the NT system could save on the use and cost of labor and the time needed in corn farming for approximately 20 days less than CovTS. The production of these two cultivation systems had a difference of 1,146 kg, resulting in revenues of Rp. 18,522,463 for CovTS and Rp. 15,658,654 for the NT system. Although there was a significant difference in revenue and costs, there was only a slight difference in income between the two cultivation systems. CovTS gave farmers a gain of Rp. 7,565,964, while farmers who applied the NT system earned an income of Rp. 7,259,891 per hectare. Moreover, the NT system displayed a higher R/C Ratio value than the CovTS, even though both are at a profitable level. A higher R/C Ratio value indicated that the NT system was more efficient in using costs and production time.

Table 2. Analysis of Cost and Income of CovTS and NT Corn Farming System

No	Description	Tillage System	
		CovTS	**NT**
1	Costs (Rp.)		
	1. Fixed Cost	1,583,472	1,584,263
	a. Land Rent	1,500,000	1,500,000
	b. Taxes (4%)	60,000	60,000
	c. Equipment depreciation	23,472	24,363
	2. Variable Cost	9,373,000	6,814,500
	a. Seed	1,600,000	1,600,000
	b. Chemical Fertilizer	1,555,000	481,500
	c. Organic Fertilizer	250,000	250,000
	d. Liq. Complimentary Fertilizer	180,000	180,000
	e. Pesticide or Herbicide	770,000	540,000
	f. Labor	4,520,000	3,320,000
	g. Irrigation	300,000	300,000
	h. Sack	198,000	143,000
2	Revenue (Rp.)	18,522,436	15,658,654
	1. Production (kg)	7,409	6,263
	2. Price (Rp./kg)	2,500	2,500
3	Income (2-1) (Rp)	7,565,964	7,259,891
4	Feasibility (R/C Ratio)	1.691	1.864
5	Independent samples t-test		
	1. Income	t_{count} 0.222 < t_{table} 1.701	
	2. Production	t_{count} 0.956 < t_{table} 1.701	
	3. Labor Cost	t_{count} 1.755 > t_{table} 1.701	

Source: Primary Data, 2021

The results of the statistical difference test for income and production of the two cultivation systems showed that the value of t_{count} was smaller than t_{table}, which meant that the two cultivation systems were not different and equally profitable. Meanwhile, the statistical difference test results for

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labor costs showed a value of t_{table}, which was more significant than t_{count}, indicating that the use of labor from the two cultivation systems was significantly different.

The results of this study indicate that the decision to apply CovTS or NT systems is returned to the respective farmers. As stated by Dang et al. (2015), economic considerations are likely to be a primary factor dictating the adoption or application of specific technology or innovation. However, impacts on soil health and the environment will also influence their choice. Unfortunately, local farmers have not obtained information about soil types, knowledge of agricultural input management, and skills in good agricultural practices. Because of their limitations, farmers in the study sites generally apply a system based on imitation of the activities carried out by other farmers or the habits of local farmers. Through field extension officers, the local government can provide guidance to corn farmers regarding the decision to apply CovTS or NT systems. The local government may establish cooperation with agronomists and researchers to be involved in these efforts. The existence of field extension workers should be able to provide information, knowledge, and even skills regarding the condition of the farmer's land. For instance, the condition of an area experiencing labor difficulties and supported by soil types such as grumosol is suitable for implementing NT systems. Providing subsidies and disseminating the matters mentioned above will assist corn farmers in earning their maximum profit in farming.

The study also recommends further study on the economic efficiency of both conventional and conservation systems in maize farming. As proposed by Rustamova (2016), conservation agriculture practices give a chance to increase labor productivity, use the resource effectively, and improve soil quality and crop diversification. A qualified economic analysis regarding corn farming in the location and neighboring areas should be used more extensively to guide research and extension, particularly concerning the targeting of effort and adaptation of the system to suit local conditions (Pannell et al., 2014).

CONCLUSION AND SUGGESTION

This study compares two types of maize cultivation systems: conventional and conservation cultivation systems, especially no-tillage systems. The data analysis and statistical difference tests for income and production of the two cultivation systems showed no difference. Both cultivation systems are at a profitable level for farmers to do. However, the study found that using less labor in maize farming with a no-tillage system proved to be more beneficial. The condition of an area experiencing labor difficulties and supported by soil types such as grumosol is suitable for implementing a no-tillage system. In this case, the local government, through field extension officers, can provide guidance to corn farmers regarding the decision to apply conventional or conservation systems. Providing information, knowledge, and skills will assist corn farmers in earning their maximum profit in farming.

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