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Conservation agrotechnology to improve soil quality and potato productivity Kuta Rayat Village, Naman Teran District, Karo Regency, North Sumatra

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ABSTRACT

Potato production in North Sumatra is productive compared to other provinces with a yield of 124 326 tons in 2020. To continue to improve the quality and quantity of potato harvest each year, continuous innovation is needed in implementing agricultural systems and technologies that can increase productivity. This research aims to find agrotechnology that can increase productivity by focusing on developing the quality of soil as farming land in Kuta Rayat Village, Naman Teran District, Karo District, North Sumatra Province. Potato agrotechnology was studied through plot trials using the Randomized Block Design method with 7 treatments (agro-potato: mounds across the slope, quality seeds, lime dosage, manure and chemical fertilizer according to the recommendations given). Data collected included before and after treatment of soil properties and potato productivity. The results of this study showed that the dose of Dolomite lime 1.5 tons/ha, manure 20 tons/ha, 150 kg Urea, 150 kg ZA, 250 kg SP-36 and 200 kg KCl was sufficient to obtain optimal potato productivity and improve soil quality.

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Introduction

Conservation agrotechnology is an approach or method in agriculture that aims to optimize crop productivity and agricultural production in a sustainable manner, while maintaining ecosystem balance and protecting natural resources. The main goal of conservation agrotechnology is to reduce the negative impact of agriculture on the environment, prevent soil erosion, improve soil fertility, and minimize the use of harmful chemicals(La Ode & Marwah, 2014).There are several key principles in conservation agrotechnology: Sustainable soil management, Water management, Natural pest and disease control, Use of improved crop varieties, Crop diversification, and Organic waste management.

Sustainable soil management involves reducing soil erosion, improving soil quality, and avoiding soil compaction(Sutrisno & Heryani, 2013). Examples of practices that fall under sustainable soil management are cover cropping, minimum tillage, and use of organic fertilizers.Water management is done to ensure efficient use of water in agriculture through techniques such as technology-based irrigation, rainwater collection and storage, and good drainage to prevent excess water and erosion(Hasibuan, 2023).Natural pest and disease control uses environmentally friendly and sustainable pest and disease control methods, such as using natural predators, planting pest-resistant crops, and crop rotation(Budi, 2021).

Selecting and developing crop varieties resistant to local environmental conditions, minimizing pesticide use, and increasing agricultural productivity will produce superior crop varieties(Somantri, 2016). In addition, it also utilizes diverse cropping patterns to reduce the risk of crop failure and increase the sustainability of the farming system(Utami & Rangkuti, 2021).To reduce its negative impact on the environment, agricultural waste such as organic fertilizers and crop residues must be properly managed(Banu, 2020).

Conservation agrotechnology brings benefits to farmers, communities and the environment as a whole(Lagiman, 2021). Agriculture can contribute to global food security by adopting this approach while conserving critical natural resources.

Potatoes are one of the horticulture commodities that are of more concern becausethey have the second largest contribution to national vegetable production in the country(Hunde, 2017). Potatoes are able to be a good food alternative because they contain carbohydrates and other nutrients that are beneficial to the body(Mohanraj & Sivasankar, 2014). Horticultural crops, such as potatoes, are plants that are suitable for cultivation on Andisol soil, which is soil derived from the mother volcanic ash of volcanoes(Yhudistira, 2018).

Andisol soils are commonly found on plateaus with relatively high slopes. Contains minerals that have a high capacity to hold nutrients and water in the soil, so Andisol soil is a very potential and fertile soil to be used as an agricultural field. However, the content of minerals such as allofan, Fe and Al oxide hydrates inandisol soils causes low P availability because most of the P availability in the soil has been absorbed by these minerals.

Efforts that farmers can make to increase the availability of P in andisol soils are to use fertilizers in the form of organic or chemical fertilizers.However, based on the facts in the field, there are still many farmers who have a habitof using fertilizers excessively without conservation of the soil so that the soilis at risk of erosion and causing soil degradation which results indecreased land quality, especially in aspects related to water, soil, and air in the root area of the plant.This is in line with the opinionof (Anasiru et al., 2015) The occurrence of erosion has a direct effect on reducing the level of land productivity, infiltration capacity, soil moisture, and erosion of tillage layers as well as drainage of nutrients and soil fauna.

Results of the research by (Henny & Mahbub, 2013) showed that planting potatoes in ridges across the slope with 0.5 tons of Dolomite lime, 10.0 tons of manure, 150.0 kg of Urea, 150.0 kg of ZA, 25.00 kg of SP-36 and 20.00 kg KCl per hectare were sufficient to obtain optimal productivity of potato (39.52-37.0 kg/plot, equivalent 32.93-30.91 t/ha) and improved soil chemical properties of Andisol Gunung Labu Village (especially pH, base saturation and exchangeable bases) in the Western Sub District of Kayu Aro, Kerinci District.

Based on the explanation above, this study aims to conduct an experimental experimentonagro-technology conservation technology on potato field soil by considering the use of manure doses,chemical fertilizers and lime doses that can improve soil quality with the main objective, namely increasing potato productivity in Kuta Rayat Village, Naman Teran District, Karo Regency, North Sumatra Province.

Method

This research was conducted in Kuta Rayat Village, Naman Teran District, Karo Regency, North Sumatra Province. The location was chosen because Kuta Rayat Village is a high area with an Andisol soil type from the eruption of Mount Sinabung.In testing the conservation agrotechnology model, various potato agricultural materials are used, namely,seedsof potato plantsof type G-4, both typesof manure and chemical fertilizers (SP-36,Urea,KCl,ZA), Dolomite lime, insecticides and the use of chemicals assupporting mediain analyzingsoil samples in the laboratory.

This research is a quantitative study. Quantitative research isa study that uses methods based on the philosophy of positivism, the purpose is to examinecertain populations or samples, sampling techniques are generally carried out randomly, data collection using quantitative / statistical data analysis research instruments with the aim of testing predetermined hypotheses (Sugiyono, 2019). The research design used in this study isan experiment research plan.Experimental research is research used to look for the influence of a certain treatment on another under controlled conditions. This experimental research is part of a quantitative method with its own characteristics, especially with a control group (Sugiyono, 2019). The experiment was carried out by testing 7 agrotechnology packages with a Randomized Design Group (RAK) on land with aslope of 3.6 and 15% with a map area of 4 m x 3 m.

This research scheme is carried out by checkingthe condition of of the andisol soil, including the mineral content, nutrients and the availability of P in the soil before conservation practices are carried outon the

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soil.Then land clearing is carried out for the manufacture ofplots of agrotechnological models as experimental samples. Afterthat, the planting groove to the potato pananen beginswith the preparation of potato seeds directly after treatment of the soil using manure, chemical fertilizers with a dose of 1/2dose on Urea, ZA and KCl, then a full dosedoseon SP-36.After30 days ofplanting seedlings (30 HST), proceed proceed with the applicationof follow-up fertilizer with a 1/2 dose of Urea, ZA and KCl. Protection of potato plants from disease andpest attacksis carried out with theuse of insecticides and pesticides (recommended doses on the packaging) with a sprayingcycle carried out periodically every 3-5 days.Finally, the harvest will be carried out after 119 days of planting.

Table 1. Agrotechnology Model Data Konservation

Code	Treatment
MAp	MGPSL, without the use of manure, without lime, farmer's dose chemical fertilizer
MA1	MGPML, 10 tons/hakandan fertilizer g +0.5 tons/ha lime +chemical fertilizer recommended by BPTP SUMUT
MA2	MGPML, 10 tons/haof fertilizer ka ndang+ 1 ton/ha lime + chemical fertilizer recommended by BPTP SUMUT
MA3	MGPML, 10 tons / hakandan fertilizer g +1.5 tons / ha lime +chemical fertilizer recommended by BPTP SUMUT
MA4	MGPML, 20 tons/hakandan fertilizerg+ 0.5 tons/ha lime + chemical fertilizer recommended by BPTP SUMUT
MA5	MGPML, 20 tons/hakandan fertilizerg+ 1.5 tons/ha lime + chemical fertilizer recommended by BPTP SUMUT
MA6	MGPML, 10 tons/hamanure + 0.5 tons/ha lime + chemical fertilizer recommended by BPTP SUMUT
MA7	MGPML, 10 tons/hamanure + 1 ton/ha lime + pupuk chemical recommended by BPTP SUMUT

Information:
MA = Agrotechnology Model
MAp = Model Agroteknologi petani.
M GPSL = Model Guludan Unidirectional PlotL ereng.
MGPML = Modelof Guludan Plot Cutting Lereng.
Recommended dose of BPTP SUMUT: 150 kg of Urea fertilizer, 150 kg of ZAfertilizer,350 kg of SP-36, 200 kg of KCl per hectare.

The data collected includes: 1) Soil chemistry data at the timeof the beginning and post-application of conservation agrotechnology experiments include the amount of C-organic, N-totalvalue, pH value, KTKvalue,KB, P and K available aswell as bases (Ca, Mg, K, Na); 2) Data onplants infectedwithdiseases caused by Fusarium and thepathogen P. infestans; 3) Data on the number of rotten potatotubers; 4) P yield of potato conductivity.

Observations ofdiseases that attack potato plants are carried out regularly in themorningand the countingof plants infected with thedisease isindicated based on the condition of damagedpotato plants according tothe symptoms of Fusarium sp wilt attacksand stem and leaf rotby P. infestans (Duriat et al., 2006).

Results and Discussions

Application of Conservation Agrotechnology Modelin Improving Soil Quality

To find out the pH of the soil suitable for potato farming, the author refers to the statement of (Sunaryono, 2007) Potato Plants ideally grow well on soils with a pHvalue of 5.0-5.5. Therefore, experiments with the application of 10 tons / ha to 20 tons/ ha of manure along with Dolomite lime both at doses of 0.5 tons, 1ton and 1.5 tons per hectare followed by chemical fertilizers recommended doses of BPTPSumut (150 kg Urea, 150 kg ZA, 350 kg SP-36, 200 kg KCl per hectare) resulted in a higher soil pH value compared to without manure,chemical aswell as limeless fertilizer based on Model Agrotechnologyfarmers (MAp) (Table 2).

Table 2. Data on the Effect of The Useof Manure, Chemical Phosphorusand Lime on the values of pH, KTK, KB and bases

Treatment	pH	KTK (me/100g)	KB (%)	Interchangeable bases (me/100 g)			
				Ca-dd	Mg-dd	K-dd	Nadd
MAp	5.23 d	25,47 a	69,35 c	11,73 b	3,78 b	0,74 b	0,63 a
MA1	5,88 abc	25,10 a	92,21 abc	16,14 from	6.07 from	0.94 from	0,71 a
MA2	6.01 from	26,51 a	88,72 abc	16,79 a	6.08 from	0,90 from	0,75 a
MA3	6.08 from	27,23 a	91,40 abc	17,28 a	6,70 a	0.96 from	0,76 a
MA4	6,20 a	27,83 a	94.37 from	17,89 a	7,23 a	0,95 from	0,74 a
MA5	6,28 a	26,70 a	97,43 a	18,30 a	7,20 a	1,07 a	0,83 a
MA6	6.06 from	27,86 a	89,53 abc	17,63 a	6,82 a	0.81 from	0,70 a
MA7	6,10 a	25,87 a	96,00 a	17.16 a	6.27 from	0.84 ab	0,71 a
SP	5.70	25.41	100	17.84	5.70	1.07	0.70

Djaenuddin in (Jawang, 2018) Categorization of landsuitabilityclasses based on soil pH values for potato cultivation, namely "very appropriate" (pH value from 5.6 - 7.0) then with the category "moderately appropriate" (pH value from 5.2 - 5.6).Based on Djaenuddin's in (Jawang, 2018)statement as a reference basis and theresults obtained in tabel 2, it is known that the pH valueof the soil between treatments (other than PA0) is not real and it is known that (calculated) the soil pH has increased which is directly proportional to theincrease in the amount oflime use that di apply toeach Model of Agrotechnology plots (generally the pHvalueof the soil is in the range of 5.7 2, 5.8 7 and6.01) each plot is given a doseof lime starting from 0.5 tons / ha , 1 ton / ha and1.5tons / ha. Then the soil pH in all Agrotechnology Models that use manure and lime(pH value 5.7-6.17) has apH value that is "very suitable' withthe landstandard for potato planting, while Model Agrotechnology is not given limeas well aspupuk cage (MAp) produces a pH value of 5. 23 includes "quite appropriate".From these results, it can be concluded that the use oflime dolomite doses of0.5 tons / ha as in the Agrotechnology Model MA1, MA4 and MA6is sufficient to improve the pH value of the soil to matchthe land suitable for growth and is able toincreaseproductivityoptimally.In addition, the use ofDolomite lime in the soilcanalso increase the content of bases (KB) classified as high (Criteriain the Assessment of ChemicalPropertiesinthe Soil by Bogor PPT Staff, Hardjowigeno, 2013).

Table 3. Data on the Effect of chemical fertilizers, manureandlime on C-organic, N and P total, P and K

Treatment	C-organic (%)	N-total (%)	P-total (ppm)	P-available (ppm)	K-available (ppm)
MAp	3,67 b	0,23 a	75,23 a	7,23 a	209,76 a
MA1	4,68 from	0,26 a	85,88 a	7,26 a	218,97 a
MA2	4.61 from	0,23 a	86,01 a	8,23 a	258,85 a
MA3	4.18 ab	0,21 a	76,08 a	7,21 a	263,65 a
MA4	3,90 ab	0,21 a	82,20 a	7,21 a	276,00 a
MA5	4,51 ab	0,23 a	72,28 a	8,23 a	297,15 a
MA6	4.22 from	0,22 a	75,06 a	7,22 a	286,07 a
MA7	3,90 ab	0,21 a	73,10 a	8,21 a	298,08 a
SP	3,67	0,17	65,25	6,97	275,63

Based on the results in Model A of agrotechnology with the use ofmanure with a dose of 10 tonsor 20 tons andthe use of Dolomite lime starting froma dose of 0.5 tonsand then 1 tonto 1.5tons on farmland shows organic carbon content(C-organic) that differs unreal. The result (Tabel 3) namely the percentage oforganic carbon (C-organic) ofreal soil is higher in the application of manure witha dose of 20 tons/haand Dolomite limeas much as 1.5 tons / ha with chemical fertilizers in the agrotechnology model (MA7) compared to theAgrotechnology Model (MAp) without the use of manure, dolomite lime serta chemical fertilizer.

The treatment between organic fertilizer and lime on farmland showed that N-total differences were not real.Itis well known that the main source of N itrogen (N) in the soil is the weathering of organic matter in the soilandm the use oforganic fertilizers. However, Nitrogen (N) in the soil isa mobile nutrient, so its presenceis easily lost from the root area (Hardjowigeno, 2013). Therefore, it can be concluded thatthe use of manure inmanifestly increasestheamount of Nitrogen-total (N-total) of thesoil ineach agrotechnological treatment.

Based on the results on (Tabel 3) it is also known that P-total and P-available differ insignificantly betweena treatments using manure or with chemical up. However, this P-totalresult isgreater than theP-total value beforethe treatment of the model.In addition, K-available also does not differ markedly betweena treatments using chemical fertilizers, pupk cages and lime. This occurs because the nature of the element Kin the soil is luxurious, which does not significantly have a beneficial effect onthe soil or plants if its availability in the soil has met the needs of the plant.

Application of Agrotechnology in Increasing Potato Productivity

Table 4. Data on the Effect of The Use of manure, chemical fertilizers and lime onthe number of plants infected with the disease, rotted tubers and productivity results

Treatment	Disease Infected Plants(%)	Rotten tubers (kg/compartment)	Potato productivity (kg/plot)				Products-vitas (ton/ha)
			L (> 60 g)	M (60-20 g)	S (< 20 g)	Sum	
MAp	20,83 a	8,77 a	21,73 b	3,78 b	1,74 b	0,63 a	25,70
MA1	12,27 from	2,50 b	36.14 from	6,07 a	1.94 from	0,71 a	33,82
MA2	8,01 b	2,51 b	26,79 ab	6.08 from	2.10 from	0,75 a	32,54
MA3	11,49 from	3,23 b	37,28 a	6,70 ab	1.36 ab	0,76 a	31,42
MA4	8,45 b	1,83b	37,89 a	7,23 ab	2,75 a	0,74 a	34,50
MA5	8,45 b	3,70 b	34,30 a	7,20 ab	2,07 ab	0,83 a	32,49
MA6	8,45 ab	1,86 b	37,63 a	6,82 b	1,61 b	0,70 a	30,65
MA7	12,70 from	3,87 b	25.16 ab	6,27 ab	1,04 b	0,71 a	26,00

Potato productivity among each Agrotechnology Model with treatment using manure, chemical fertilizers and lime gives relatively no noticeable difference (Table 4). The averagepotato productivity at the use of limedose 0.5 tons / ha produced potato pananen with an amountof 38.84 kg / plot model (34.28 tons / ha), then using a doseofDolmit lime 1 ton/ ha produced a harvestof 39.79 kg / plot model(36.27tons / ha) and withlime dose of1.5 tons per hectare found a yield of 36.9 6 kg/plot model (32. 75 tons/ha).

The average productivity of potato tubers with the application of 10 tons and 20 tons ofcage puk doses resulted in a harvest of 38.39 kg/plotmodel (31.83 tons/ha) and 36.32 kg/plot model(30.02 tons/ha), respectively. Furthermore, theaverage yield ofpotato tubers with chemical fertilizer recommended by BPTP Sumut is 39. 89 kg/plot model (34.93 tons/ha).The yieldof thesepotatoes is categorized asmarkedly higher thanwithout the useof manure aswell aswithout lime as in Model Aof farmer technology (MAp).Such results are influenced bytheincreasing quality of chemical properties in thesoil which includethe valueof pH, KB, organic carbon (C-organic) as well as the availability of nutrients needed by plants, namelyP-available and alkaline-bases including Ca, Mg, K, Na.

Potato yields in the farmer agrotechnology model (MAp) found potato tubers that were damaged due to the pathogen P. Infestans which is the cause of stem and leaf blight on plants, organism is one of the pest pests that is generally known to attack potato tuber plants in the highlands often(Kilmanun et al., 2020).This plantis one of the crucial (most serious) mainproblemsamongthe various diseases that often plague potato plants in Indonesia.Even today, there is still no fungicide that can effectively protect against Patogen P. Infestans. There are no potato plant varietiesthat are immunetothe disease, this disease can be fatal to the point of being ableto reduce potato activity products by up to 90% (Purwantisari et al., 2008).

Based on the results inTable 4, Jumlah potatoes that fail to harvest due to rotting or damage caused by pathogens P. infestans and F.oxysphorum theresults do not differ markedly from treatment, except in samples withthe Modelagrotechnology of farmers (MAp).Conditions like this indicate that the doseof manure, chemical fertilizers andlime does not affect the attack rate of P. infestans and F.oxysphorum pathogens.However, disease attacks were found to be more prevalentin theModel A treatment of farmer agrotechnology (MAp). This is caused not by the use of fertilizer or kapu but is caused by the use oflow-quality plant seeds.

This research not in line with research by (Henny & Mahbub, 2013)that showed that planting potatoes in ridges across the slope with 0.5 tons of Dolomite lime, 10.0 tons of manure, 150.0 kg of Urea, 150.0 kg of ZA, 25.00 kg of SP-36 and 20.00 kg KCl per hectare were sufficient to obtain optimal productivity of potato (39.52-37.0 kg/plot, equivalent 32.93-30.91 t/ha) and improved soil chemical properties of Andisol Gunung Labu Village (especially pH, base saturation and exchangeable bases) in the Western Sub District of Kayu Aro, Kerinci District.

The most effective waythat is markedly able to reduce the attack rate ofpathogenic organisms is by applying IPM (integrated pest control) (Duriat et al., 2006; Purwantisari et al., 2008; Sunarjono, 2007). Agrotechnologyof proper conservationof potato farmlandand in accordance with the chemical propertiesof soil conditions and the use ofquality superiorpotatoplant seeds, land and crop managementmust be based onverifiedrecommendations to be able to control P attacks. infestans.

Although the model Aof farmer technology (MAp) uses far more chemical fertilizers than other agrotechnology models, in fact theyield obtained by potatoes is relatively noticeably lower. This isinfluenced bythe non-useoflime followed by the non-use ofmanure which results in the quality ofsoil chemical propertiesnot improving in terms of quality.It can be concluded that an increase in the doseof chemical fertilizer used alone cannot significantly increasethe productivity ofpotatoes if itsuse is notfollowed by the use oflime and followed by theuse of manure to improve the quality of soil chemical properties.

Based on data (Table 4) potato tuber yields supported alsoby soil chemical properties data on (Table 2 and Table 3) alime dose of 1.5 tons accompanied by the use of manure dosesof 20 tons / ha and chemical fertilizers of 150 kg, 250 kg SP-36 and 200 kg KCl per hectare respectively are sufficient for optimal potato productivity.In linewithSuwandi's research (2009) the dose of fertilizer use in highland vegetable cropswith aplanting period of > 2 months is100-200 kg N, 90-180 kg P2O5 and 60-150 kg K2O per hectare. In N fertilization,vegetable crops generally use a combination of chemicalfertilizers Urea and ZA (as a source of Nitrogen in the soil) proportionally (according tocultivated vegetable crops).

Improving soil quality and potato productivity can be done in several ways. These include soil testing, proper fertilization, organic management, crop rotation, weed control, efficient irrigation, cover cropping, organic matter use, pest and disease control, and selection of superior varieties.

Start by testing the soil on the farm. A soil analysis will provide information on soil fertility conditions, pH levels, acidity levels, and nutrient content such as nitrogen, phosphorus and potassium(Trisnawati, 2022). Based on the analysis results, then adjust the fertilization to the needs of the potato plants.Based on the soil test results, apply the appropriate fertilizer for the potato plants(Lestari et al., 2016). Make sure to use organic and inorganic fertilizers in the right proportions to meet the nutritional needs of the plants.Use organic fertilizers such as compost, green manure, or manure to increase the organic matter content in the soil(Roidah, 2013). Organic fertilizers can improve soil structure, water retention, and provide long-term plant nutrients.

Practice crop rotation with different crop varieties to prevent the buildup of certain potato-specific diseases and pests.Control weeds regularly to reduce competition with potato plants for water and nutrients. Weed control can be done mechanically, physically, or by using organic mulches(UMMAH, 2022).Then ensure good irrigation arrangements so that the potato plants get the right amount of water at the right time.Also consider planting ground cover or buffer crops before or after the potato growing season. Cover crops help prevent erosion, improve soil structure, and provide a source of organic matter.

Apply manure, compost, or other organic matter to the soil before the growing season. This will increase soil fertility and nutrient content.Apply pest and disease control methods, such as certain pest-resistant potato varieties or environmentally friendly biological methods(Barzman et al., 2015).Choose potato varieties that are suitable for the local environment and climate conditions for better yields(Ficiciyan et al., 2018). Implementing these practices can sustainably improve soil quality and productivity of potato crops and lead to better yields. However, keep in mind that each farming location has unique characteristics and challenges, so certain adjustments may be needed based on local conditions.

Conclusions

Based on the experimental results and the exposure that has been described, conclusions can be drawn, namely the treatment of Model Agrotechnologywith the highest potato productivity occurred in Model AgrotechnologyMA3 and MA5 with the use oflimedose 1.5 tons/ha.Model Treatment with 20 tons/ha of cage production provides high potato productivityand improves soil quality compared to 10 tons/ha of manure.Thus, it can be stated that the dose of Dolomite lime 1.5 tons / ha, kanda ng fertilizer 2 0 tons/ha, 150 kg Urea, 150 kg ZA, 250 kg SP-36 and 200 kg KCl is the most optimal dose in increasing potato productivity and soil quality.

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