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Assessment of Andisol characteristics for the development of potato crops in Pangalengan

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ABSTRACT

Pangalengan is a horticultural crop center area in Bandung Regency. The soil in this area consist of Andisol, which is developed from volcanic ash. One of the primary commodities in this area is potatoes. Intensive farming in Pangalengan is a problem that has an impact on soil and environmental conditions, thereby disrupting crop productivity. The research aimed to assess the characteristics of Andisols for the development of potato crop in Pangalengan. This research used qualitative, descriptive, and survey methods. The survey based on physiographic methods. Soil samples were taken purposively. The observations consisted of soil characteristics, erosion, soil fertility and land suitability. The research results show that the soil type is Typic Hapludans. Erosion is moderate (19.06-94.41 tons/ha/year) in SMU 1 and 2, high (311.22 tons/ha/year) in SMU 3 and very high (798.04 tons/ha/year) in SMU 4, soil fertility is low with land suitability for potato crop including marginally suitable (S3) and not suitable (N). Fertilization, especially P fertilizer and organic fertilizer as well as making bunds in the direction of the contour, are recommended for the development of potato crops in Pangalengan.

Keywords: Andisols, Evaluation, Erosion, Potato crops, Soil fertility

INTRODUCTION

Pangalengan is a part of the Cisangkuy Sub-watershed, located in Bandung Regency. Pangalengan is a very important center for horticultural crops, especially potatoes. The most favored agricultural products are from the horticulture sector. The five largest productions in 2020 are potatoes, namely 51,600 tons (Badan Pusat Statistik, 2021). Most of the soil types in the Pangalengan are Andisols, which are fertile soil that contains high organic material, so they are favorable for agriculture.

Agricultural activities carried out intensively are the root of the problems that cause the decline in soil and environmental quality. Pangalengan is a hilly to mountainous area, so agricultural management must consider sustainable agriculture principles when implementing conservation agriculture. In reality, many farmers have not implemented soil conservation in their farming activities. Therefore, it will have an impact on erosion, decreasing soil fertility and crop production. Based on the research reported by Suriadikusumah and Ganjar (2015), Pangalengan is included in the Cisangkuy sub-watershed, where erosion has increased from 45.24 tons/ha/year in 1997 to 303 tons/ha/year in 2010. The amount of erosion will affect soil fertility level. Determining soil fertility is very important to properly manage land, especially Andisol, so soil productivity increases.

The impact of soil and environmental damage will disrupt plant productivity. Currently, land assessment for potato crops is necessary, considering that land has been disturbed by intensive agricultural activities. Land suitability evaluation is a way to find out problems that occur and provide recommendations for these land problems (Ritung et al., 2011). Much research has been carried out in Pangalengan, but not much has been done regarding land evaluation. The study determines land characteristics as a basis for regional planning. This research aims to assess the characteristics of Andisols for the development of potato crops in Pangalengan.

MATERIALS AND METHODS

The research was conducted in Pangalengan District, Bandung Regency, West Java. Soil type is included as Andisols (Soil Survey Staff, 2022). The research used qualitative, descriptive, and comparative methods and field surveys. The survey uses a physiographic approach based on Soil Map Units (slope differences 0-8%, 9-15%, 16-25%, 26-40%) (Figure 1). Soil samples were taken purposively. The observations in this research were soil characteristics (pedon observation (Barham et al., 2006)), erosion (USLE method (Wischmeier & Smith, 1978)), soil fertility levels (assessment of soil chemical parameters, namely CEC, base saturation, organic carbon, P and K) and evaluation of land suitability (evaluation based on plant growth requirements of potato crops and land characteristics). Determination of soil characteristics based on the morphological properties of the soil using the minipit method (Soil Survey Staff, 2014). The number of samples collected was 24, based on physiographic data.

Data analysis

Erosion was calculated by using the Universal Soil Loss Equation (USLE) formula (Wischmeier and Smith, 1978). Determination of soil fertility levels (assessment of cation exchange capacity, base saturation, organic C, available P, and available K) was done based on technical instructions for soil fertility evaluation (Pusat Penelitian Tanah dan Agroklimat, 1995). Evaluation of land suitability was based on Technical Guidelines for Land Evaluation for Agricultural Commodities (Ritung et al., 2011).

RESULTS AND DISCUSSION

Characteristics of Andisols

The results found that soil types at the research location are Typic Hapludands (Soil Survey Staff, 2022). Table 1 shows the morphological characteristics of each Soil Map Unit (SMU). In general, soil morphological characteristics are almost similar. The texture of the A horizon is dominated by loamy sand and the B horizon has silty clay loam and clay loam textures. This phenomenon shows that the soil at the research location was produced by volcanic eruptions, and the bottom layer was usually a fine texture, ranging from sandy clay loam, silty clay loam and clay loam (Arifin et al., 2022). The structure shows crumb, granular, angular blocky in all SMUs from the A horizon to the horizon below. Consistency of the soil generally shows loose to firm at each SMU, it is suspected that the soil at the research location came from old parent material. Soil with old parent material generally has a loose to firm consistency (Mahfud Arifin et al., 2022).

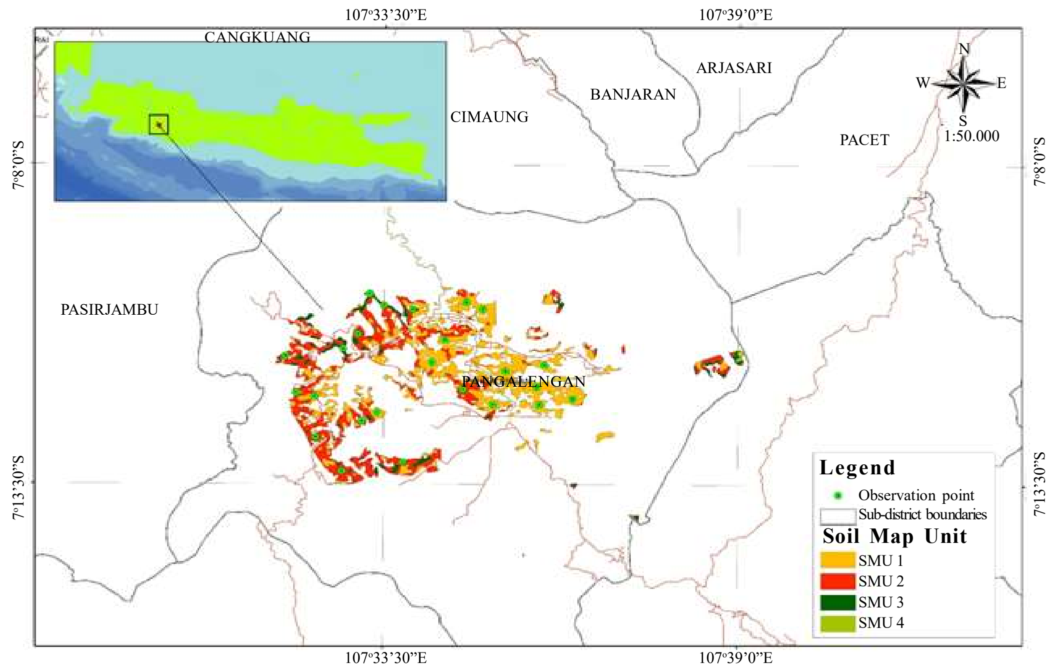

Figure 1. Soil map unit in the research area

Table 1. Morphological Properties of Andisols.

SMU	Slope (%)	Horizon	Depth (cm)	Color	Texture	Structure	Consistensy	Classification (Sub Group)
1	8	Ap	0-17	7.5YR 3/4	sl	gr	l	Typic Hapludands
		AB	17-22	7.5YR 4/4	scl	gr	fr	
		Bw1	22-60	7.5YR 4/6	scl	abk	fi	
		Bw2	60-100	10YR 4/6	sicl	abk	fi	
		Bw3	100-120	10YR 5/6	sicl	abk	fi	
2	11	Ap1	0-9	7.5YR 3/2	sl	cr	l	Typic Hapludands
		Ap2	9-24	7.5YR 3/2	sl	cr	fr	
		AB	24-30	7.5YR 3/4	scl	gr	fr	
		Bw1	30-48	7.5YR 4/4	sicl	abk	fi	
		Bw2	48-60	10 YR 4/6	sic	abk	fi	
		Bw3	60-93	10 YR 3/6	sic	abk	fi	
		Bw4	93-120	10 YR 3/6	sic	abk	fi	
3	22	Ap1	0-10	7.5YR 3/4	sl	cr	l	Typic Hapludands
		Ap2	10-19	7.5YR 3/4	sl	gr	l	
		AB	19-38	7.5YR 3/4	sl	gr	fr	
		Bw1	38-60	7.5YR 4/4	scl	gr	fi	
		Bw2	60-96	10 YR 4/6	cl	gr	fi	
		Bw3	96-133	10 YR 4/6	sicl	abk	fi	
		Bw4	133-150	10 YR 4/6	cl	abk	fi	
4	35	Ap1	0-14	7.5YR 3/2	ls	cr	l	Typic Hapludands
		Ap2	14-35	7.5YR 3/4	ls	cr	fr	
		Bw1	35-60	7.5YR 4/4	scl	abk	fi	
		Bw2	60-86	10 YR 4/6	cl	abk	fi	
		Bw3	86-120	10 YR 4/4	cl	abk	fi	

Note : sl= loamy sandy; scl= sandy clay loam; sicl= silty clay loam; sic= silty clay; cl= clay loam; ls= sandy loam; cr= crumb; gr= granul; abk= angular blocky; l= loose; fr= fragile; fi= firm; SMU= Soil Map Unit.

Andisols are soils that develop from volcanic ash parent material. The clay mineral allophane dominates andisols. Andisol soil has clay minerals which are dominated by amorphous aluminum compounds such as allophane (Soil Survey Staff, 2022). Allophane minerals with a wide surface type result in Andisol's ability to adsorb, bind or fix P elements strongly (Tan, 1965). In addition, according to Yulnafatmawita et al. (2005), at a lower pH, Andisol is able to absorb organic acids, so that organic matter functions as it should; therefore, adding organic matter to the soil is very necessary.

Erosion

The results of erosion prediction show that there was moderate erosion (19.06-94.41 tons/ha/year) in SMU 1 and 2, high erosion (311.22 tons/ha/year) in SMU 3, and very high erosion (798.04 tons/ha/year) in SMU 4 (Table 2 and Figure 2). SMU 4 has the highest erosion value, this is caused by the steep slope, so the potential for soil loss is greater. Based on field observations, this erosion value is caused by inadequate soil conservation efforts. Conservation techniques used by farmers in the form of bunds along the slope and traditional terraces have not been able to overcome the danger of erosion optimally. Apart from that, high rainfall and land use also influence the erosion value. High rainfall, loose soil, steep slopes, sparse vegetation and intensive human activity play an important role in the erosion process (Nasir Ahmad et al., 2020).

Rainfall at the research location is considered high, namely 2500 mm/year. Apart from slope being a differentiating factor, rainfall is also the cause of high erosion. According to Luwih (2019) rain plays a role in soil erosion through the release force of raindrops hitting the soil surface and partly through its contribution to flow. High rainfall is a factor that cannot be managed so that proper Andisol soil management can reduce the rate of erosion, so as not to damage soil fertility and productivity. Andisol soil has a high erodibility value so it is susceptible to

Table 2. Erosion assessment at the research site.

SMU	R	K	LS	C	P	Erosion ($Mg\ ha^{-1}\ year^{-1}$)	Area (Ha)
1	1255.48	0.4	0.25	0.4	0.4	19.06	840.38
2	1255.48	0.4	1.2	0.4	0.4	94.41	612.93
3	1255.48	0,36	4.25	0.4	0.4	311.22	106.32
4	1255.48	0.42	9.5	0.4	0.4	798.04	8.45

Notes: SMU= Soil Map Units, R= rainfall erosivity, K= soil erodibility, LS= slope length and steepness, C= cover management, P= conservation practice.

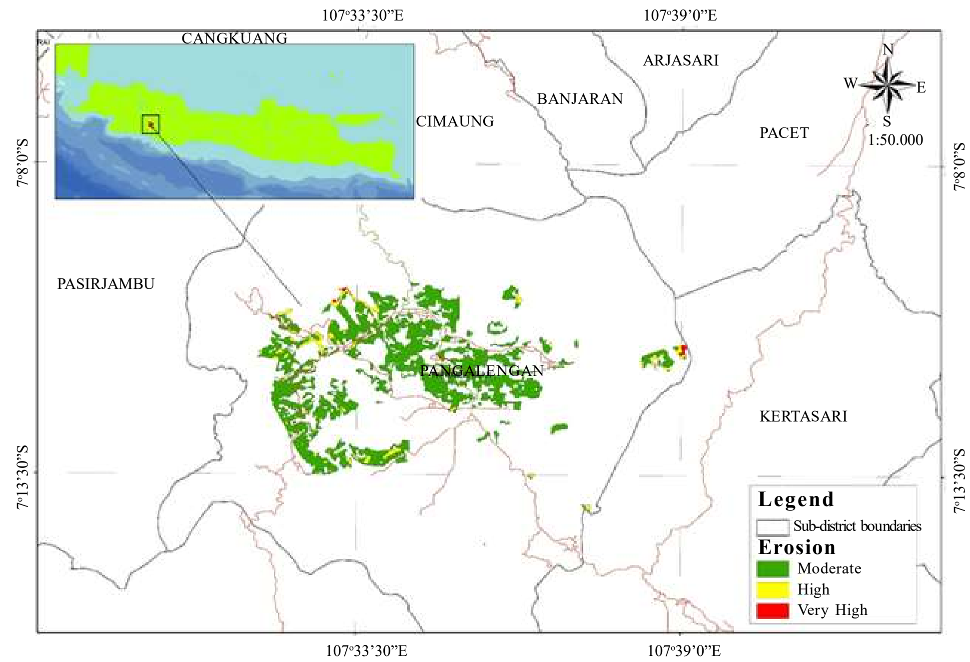

Figure 2. Map of erosion hazard level at the research location.

erosion. According to Rianto and Marwadi (2023) that the correlation test results show that there is a relationship between the amount of erosion and the soil erodibility value, so that the higher the erodibility value, the more susceptible it is to erosion. The erosion value at the research location is influenced by land use. The land use observed was fields with potato crop commodities. Potato cultivation is vulnerable to erosion so conservation efforts are needed to overcome this erosion. vegetation such as bushes, rice fields, plantations and forests have moderate to heavy erosion, because vegetation can reduce surface erosion caused by rainwater (Luwih, 2019).

Evaluation of soil fertility

The results show that the level of soil fertility at the research location is low. Table 3 shows that CEC is low to high, base saturation is low to medium, available K is low to medium and organic C content is high; however, soil fertility is considered low. Soil properties (CEC, Base Saturation, P, K and organic C) influence each other to determine soil fertility values. Low potassium content is influenced by CEC. The greater cation exchange capacity increases the soil's ability to retain K, so that the soil solution is slow to release K and reduces the potential for leaching (Prabowo and Subantoro, 2017). The K value at the research location is also caused by the fertilization process and agricultural tillage. The greatest limiting factor is low available P, which causes low soil fertility. This is related to the nature of Andisol soil which has high P retention so that available P is low. The low P content in Andisols can be caused by a strong P fixation process by hydrous oxide or silicate clay and precipitated by Fe, Al, and Mn ions (M. Arifin et al., 2019). The high P retention in Andisol is due to the dominance of the minerals Alophane and Imogolite,

Table 3. Soil properties at the research location.

SMU	CEC (me.100 g^{-1})	BS (%)	P_2O_5 (mg.100 g^{-1})	K_2O (mg.100 g^{-1}g)	Organik carbon (%)	Soil Fertility
1	31.24	37.5	12.6	0.22	4.08	Low
2	17.71	23.97	13.1	0.20	4.17	Low
3	35.72	41.98	13.3	0.21	3.99	Low
4	14.84	21.1	11.2	0.14	4.16	Low

Notes: SMU= Soil Map Units, CEC= Cation Exchange Capacity, BS= Base Saturation

which have strong P adsorption properties, these allophane minerals have a greater P adsorption capacity than gibbsite (Gusmaini and Syakir, 2020).

The high organic carbon content indicates that the research location is rich in organic material but not enough to increase soil fertility. Organic carbon is an indicator of the amount of organic material in the soil. The high level of organic carbon cannot be separated from the allophane minerals in Andisols, where the allophane minerals influence the rate of decomposition of organic material (Hifnalisa et al., 2022). Allophane minerals form complex compounds with organic materials which are able to block organic compounds from being attacked by organisms, causing relatively high C-organic levels (Kautsar, Ilyas and Sufardi, 2018).

Efforts to increase soil fertility are by fertilizing P. According to Arifin et al. (2019), P fertilization with a higher dose was able to reduce P retention from 90.7% to 64.8-55.8%, so that available P increased. Applying organic materials is also an effort to increase the availability of P in Andisol. Based on research Jin et al. (2023), increasing the application of organic fertilizer, the available P will also increase. Apart from P, using organic fertilizer can also increase the uptake of Nitrogen and Potassium nutrients (Sofyan et al., 2019). So, fertilizing with organic fertilizer is more effective in increasing soil fertility. According to Suntoro et al. (2020), to maintain and increase the level of soil fertility, it is necessary to apply organic materials.

Land suitability for potato crops

Land evaluation is needed to assess the performance of the land as a plant growth medium (Ritung et al., 2011). This assessment is also useful in harmonizing agricultural land use and assisting in

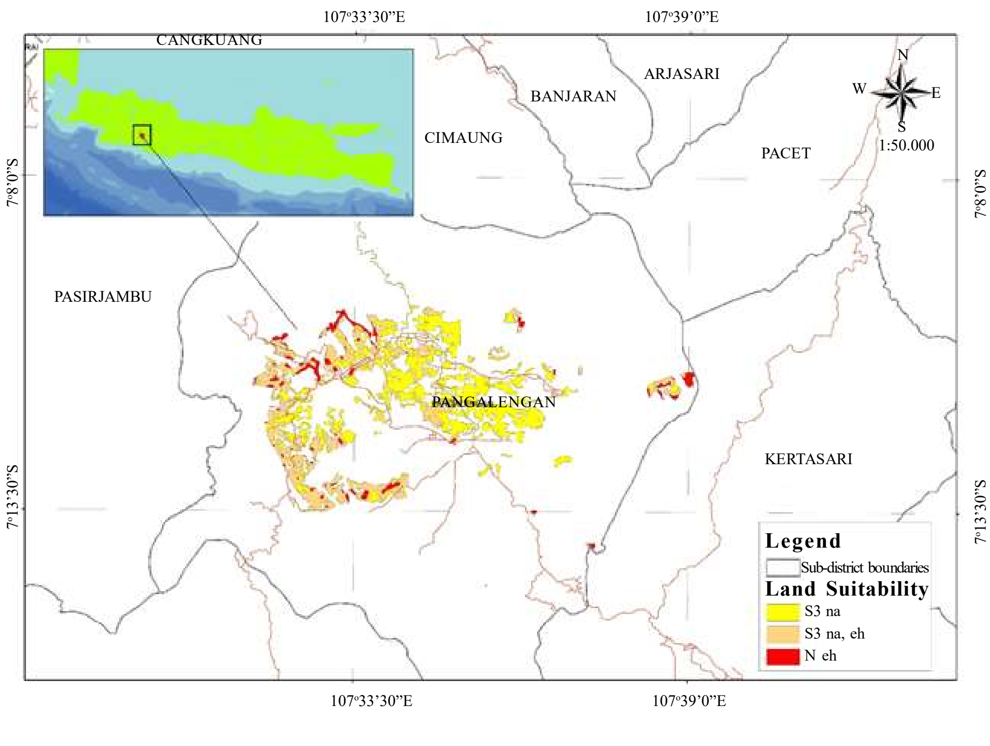

Figure 3. Map of land suitability of potato crops.

making agricultural land use planning decisions to overcome competition between various possible land uses so that land can be used efficiently (Sappe et al., 2022). Based on the evaluation results, it shows that the research location is classified as marginally suitable (S3) and not suitable (N) for potato plants (Figure 3). Limiting factors are nutrient availability (na) and slope (eh) (Table 4).

Table 4. Evaluation of land suitability for potato crops.

Land characteristics	SMU 1		SMU 2		SMU 3		SMU 4	
	Value	Suitability class	Value	Suitability class	Value	Suitability class	Value	Suitability class
Temperature (tc)								
Average temperature (°C)	20	S2	20	S2	20	S2	20	S2
Water avaibility (wa)								
Rainfall (mm.month^{-1})	174	S1	174	S1	174	S1	174	S1
Oxygen avaibility (oa)								
Drainage	Well drained	S1	Well drained	S1	Well drained	S1	Well drained	S1
Rooting condition (rc)								
Texture	moderately fine	S1	moderately fine	S1	moderately fine	S1	moderately fine	S1
Rough material (%)	< 15	S1	< 15	S1	< 15	S1	< 15	S1
Soil depth (cm)	150	S1	150	S1	150	S1	120	S1
Nutrient retention (nr) ;								
CEC (cmol kg^{-1})	31.24	S1	17.71	S1	35.72	S1	14.84	S2
Base saturation (%)	37.5	S1	23.97	S2	41.98	S1	21.1	S2
pH H_2O	5.7	S1	5.6	S1	5.8	S1	5.6	S1
organic carbon (%)	4.08	S1	4.17	S1	3.99	S1	4.16	S1
Nutrient avaibility (na)								
Total N (%)	medium	S1	medium	S1	medium	S1	medium	S1
P_2O_5 (mg 100g^{-1})	low	S3	low	S3	low	S3	low	S3
K_2O (mg 100g^{-1})	medium	S1	medium	S1	medium	S1	low	S2
Soil toxicities (xc)								
Salinity (dS/m)	-	S1	-	S1	-	S1	-	S1
Sodicity (xn)								
Alkalinity/ESP (%)	-	S1	-	S1	-	S1	-	S1
Erosion hazard (eh)								
Slope (%)	8	S2	11	S3	22	N	35	N
Observed erosion	low	S2	medium	S3	very high	N	very high	N
Flood hazard (fh)								
flood frequency (day)	-	S1	-	S1	-	S1	-	S1
Land preparation (lp)								
Surface rock (%)	< 5	S1	< 5	S1	< 5	S1	< 5	S1
Rock outcrop (%)	< 5	S1	< 5	S1	< 5	S1	< 5	S1
Land Suitability		S3 na		S3 na, eh		N eh		N eh
Limiting factors		Nutrient avaibility		Nutrient avaibility, Erosion hazard		Erosion hazard		Erosion hazard

The limitation of nutrient availability is dominated by low available P; this has a direct effect on soil fertility. High P retention is one of the problems that causes low available P. Another limiting factor is the slope. The results found slopes on SPT 1-SPT 4 are in the range of 8-35%. Based on the growing conditions for potato plants, it shows that potato plants will grow optimally on slopes of 0-8%. On slopes >8%, this is a factor that will inhibit the growth of potato plants. Therefore, efforts are needed to minimize the influence of these slope factors.

Improvement efforts needed to overcome the limiting factors for potato crop growth are the application of P fertilizer and organic fertilizer. Utilizing P fertilizer is recommended to increase available P and reduce P retention, providing the right type of P fertilizer, the right dose, the right time, and the right method so that fertilization can be useful effectively and efficiently. Using organic materials is a good step to increase the P element. Research of Yulnafatmawita et al. (2005) showed that the application of organic material to Andisol soil increased available P (94.58 ppm), the increase was caused by organic acids produced during the decomposition process. Other researchers have shown that the application of organic fertilizer from chicken manure can increase P availability and potato crop production (Ritonga and Sembiring, 2015). Land management that is limited by slopes can be carried out by managing land in accordance with soil and water conservation principles to reduce the rate of erosion and landslides. Farmers can make terraces and bunds in the direction of the contour to overcome these limiting factors. The erosion calculations result show that steeper slopes (35%) produce very high erosion (798.4 tons/ha/year), this can result in soil degradation and a decrease in potato production if not addressed as early as possible. The high erosion cannot be separated from the farmers' habit of cultivating potatoes, namely by making bunds in the direction of the slope. This habit is carried out because potato plants are susceptible to disease if drainage conditions are poor. However, making beds in the direction of the slope must be accompanied by making bunds in the direction of the contour so that erosion can be controlled. The government's role is very necessary to overcome this problem, namely the Agricultural Research and Development Agency has developed various technologies for managing highland vegetable land that are environmentally friendly, including balanced fertilization and specific conservation technology for vegetable land (Sukarman and Dariah, 2015).

CONCLUSIONS

Soil types in the research area are Andisols with the Typic Hapludans subgroup. Erosion assessments are moderate (19.06-94.41 tons/ha/year) in SPT 1 and 2, high (311.22 tons/ha/year) in SPT 3, and very high (798.04 tons/ha/year) on SPT 4. The of soil fertility Andisols are low with land suitability for potato plants including marginally suitable (S3) and not suitable (N). Fertilization, especially P fertilizer and organic fertilizer, as well as making bunds in the direction of the contour, are recommended for the development of potato plants in Pangalengan.

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