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Research Article

Land suitability evaluation of shallot (*Allium ascalonicum* L.) at production centres in Losari District, Brebes

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Abstract: The demand for shallots is getting higher as the population grows. Indonesia targets to become a self-sufficient country of onion and the largest exporter of shallots in ASEAN by 2045. One of the shallot production centres is Losari District, Brebes, but the shallots productivity has decreased, so it is necessary to know the cause and the improvement effort to overcome it. The research was a land survey and evaluation to determine the current and the potential land suitability classes for the shallot. Data analysis using LMU (Land Map Unit) as the unit of analysis, which is the result of an overlay of soil type map, slope map and land use map using ArcGIS 10.3. The sampling method was purposive sampling and data analyzed using the matching method between the results of land characteristics data with the requirements of shallots growing. Results showed that even in production centres, the current suitability classes are marginally suitable (S3) as the heaviest limiting factors are very high rainfall. Improvement efforts to overcome this can be done by using suitable varieties, making gully drainage and using mulch/shade so that the potential land suitability class increases to be moderately suitable (S2).

***Keywords**: land suitability, land mapping unit, rainfall, shallot, water availability*

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Introduction

Shallot (*Allium ascalonicum* L.) is one of the leading vegetable commodities that farmers have been intensively cultivating in almost all parts of Indonesia (Holish et al., 2014). These commodities based on Nurhasanah et al. (2015) have high economic value and have attractive market prospects. Shallot has many benefits, as not only as flavouring spice related to the aroma but also used as a cough medicine (phlegm spray), shortness of breath, fevers, colds and appetite enhancers.

Shallot includes ten national superior horticultural commodities that are being boosted production. Along with the increasing population in Indonesia, the need for shallot increases also. The national shallot production target between 2005 and 2025 is expected to increase from 847.883 tons to 1.541.737 tons (Syukur et al., 2011). According to the Directorate General of Horticulture (2017), that Indonesia will develop shallot production and become a self-sufficient state of shallot as well as the leading exporting country of shallots in ASEAN by 2045. Indonesia targets 40.000 tons of exports. Fulfilment of these targets still requires the addition of shallot production land area of 34.307 ha or 1.183 ha/year. To increase the production of shallots can be pursued by the addition of land production and land management that already exist with as much as possible, through land improvement efforts so that the productivity of land will increase.

Losari District is an area in Brebes Regency that has been cultivating shallot as its primary commodity. Shallot production in Losari District from 2007 to 2014 decreased from 12,085 t/ha to 9,239 t/ha based on TCSA Losari District

(2015). The lowering of shallot productivity needs to know the cause so that it can be determined the improvement effort. One method that can be done to determine the causes of decreasing the land productivity of land is using land suitability evaluation methods.

Materials and Methods

This research was conducted in September 2017 until January 2018, in Losari District, Brebes Regency, Central Java. Analysis and preparation of the mapping were conducted at the Land Survey and Pedology Laboratory, Soil Science Study Program, Faculty of Agriculture, Sebelas Maret University, Surakarta. Soil analysis was carried out at the Physics and Soil Conservation Laboratory, and the Laboratory of Chemical and Soil Fertility of the Soil Science Study Program, Faculty of Agriculture, Sebelas Maret University, Surakarta. This research was carried out by a descriptive exploratory survey method, with an analysis unit of the Land Mapping Unit (LMU).

The land map unit was obtained from the results of overlaying of the soil type map, slope map, and Losari District land use map, Brebes using ArcGIS 10.3 to get 12 LMU. The determination of soil sample points using purposive sampling technique. The land suitability class was determined by the matching method between the characteristics of the land and the requirements for shallots growing according to Wahyunto et al. (2016) (Table 1).

Table 1. Land characteristics and shallot growing requirements

Land characteristic	S1	S2	S3	N
Temperature (tc)				
Maen temperature (^{o}C)	25 - 28	>28 - 31	>31 - 33	>33
		23- <25	21 - <23	<21
Water availability (wa)	1.000 – 1.400	900 - <1.000	800 - <900	<800
Mean annual rainfall		>1.400 – 1.700	>1.700 – 2.500	>2.500
(mm/year)	4 - 6	>6	-	-
Total rainfall in one season	350 - 600	600 – 800	800 – 1600	>1600
(3 months)$^{*)}$ (mm)		300 - 350	230 -500	<250
Long of the dry month (<100 mm/month)		-	2 - <4	<2
Oxygen availability (oa)				
Drainage	Well drained. Somewhat poorly drained	Somewhat excessively drained. moderately well drained	Poorly drained	Very poorly drained. excessively drained
Rooting condition (rc)				
Texture	Moderately fine	Fine	Moderately coarse – very fine	Coarse
Coarse material (%)	<15	15 - 35	35-55	>55
Soil depth (cm)	> 50	30 - 50	20 - 30	< 20
Nutrient retention (nr)	>16	5 - 16	<5	
CEC (cmol/kg)	>35	20 - 35	<20	
Base saturation (%)	6.0 – 7.5	5.5 - 6.	<5.5	
pH H_2O		7.5 – 8.0	>8.0	
	>2.0	0.8 – 2.0	<0.8	
Nutrient available (na)				
Total Nitrogen	Moderate	Low	Very low	-
P_2O_5 (mg/100g)	High	Moderate	Low – very low	-
K_2O (cmol/kg)	Moderate	Low	Very low	-
Toxicity (xc)				
Salinity (dS/m)	< 2	2 - 3	3 - 5	>5
Sodicity (xn)				
Alkalinity/ESP (%)	<20	20 - 35	35 - 50	<50
Erosion Hazard (eh)				
Slope (%)	<3	3-8	8 - 15	>15
Erosion		Very light	Light-moderate	Heavy – very heavy
Land preparation (lp)				
Surface stoniness (%)	<5	5- 15	15 - 40	>40
Surface outcrops (%)	<5	5 - 15	15 - 25	>25

Remarks: Wahyunto et al. (2016); *) Djaenudin et al. (2011)

The soil samples collected from the field were then air-dried and sieved using a soil sieve Ø 2 mm and Ø 0.5 mm, followed by analysis of soil physical and chemical characteristic. The characteristics of the land analyzed included texture, cation exchange capacity (CEC), base saturation, pH H_2O, organic C, total N, available P, available K, salinity, and alkalinity. The soil characteristics were then matched with the requirements of shallots growth according to Wahyunto et al. (2016). Matching results show the characteristics of the suitable land, suitable and not suitable for the growth of shallots which were classified into four suitability classes, highly suitable (S1), moderately suitable (S2), marginally suitable (S3) and not suitable (N).

Results and Discussion

Description of the study area

Losari District is geographically, based on UTM (Universal Transverse Mercator) coordinates, located at 252,000-264,000 m East and 9,232,000-9,252,000 m North. Based on TCSA Losari District (2017), the total area of Losari District is 8,942.56 ha comprising an area of 4,545.57 ha of rice fields, yards/buildings covering an area of 1,275.68 ha, moor/gardener/plant covering an area of 647.47 ha of wood, pond/pond area of 2010.17 ha, state forest area of 195.25 ha and another area of 268.52 ha. Losari District is located at 5-40 meters above sea level and has a slope of 0-8%. Losari District has five soil types, namely: at LMU 1, 4, 9 and 11 are Alluvial Dark Gray; at LMU 2, 6, and 8 are Ground Alluvial Dark Gray and Alluvial Chocolate Grayness; at LMU 3 and 7 are Low Humus Glei and Gray Alluvial soil; at LMU 3 is Hydromorphic Alluvial; at LMU 10 and 12 are Gray Grumusol. There are three types of land use in Losari District, namely: Gardens at LMU 1, 2, 3, 9, and 10; Paddy Fields at LMU 4, 5, 6, 7, 11 and 12; and Dry Field at LMU 8.

Current land suitability

Current land suitability is a land characteristic generated by ongoing land conditions assessment, without improvement input (Ritung et al., 2011). Based on the matching results between the characteristics of the land and the terms of shallot growing requirements according to Wahyunto et al. (2016), the current land suitability classes at 12 LMU in Losari District, Brebes are marginally suitable (S3) as in Figure 1, with the highest limiting factor is high rainfall (Table 2). The marginally suitable class requires a high level of improvement so that it needs support from the government and the private parties to overcome these limiting factor.

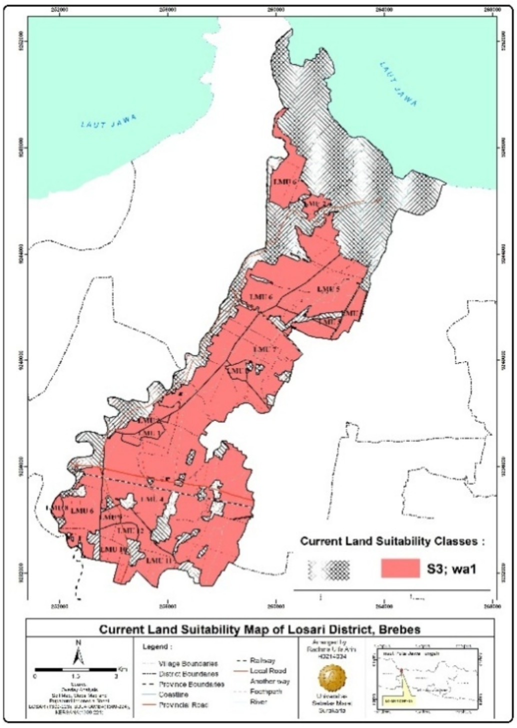

Figure 1. Current Land Suitability Map of Losari District, Brebes

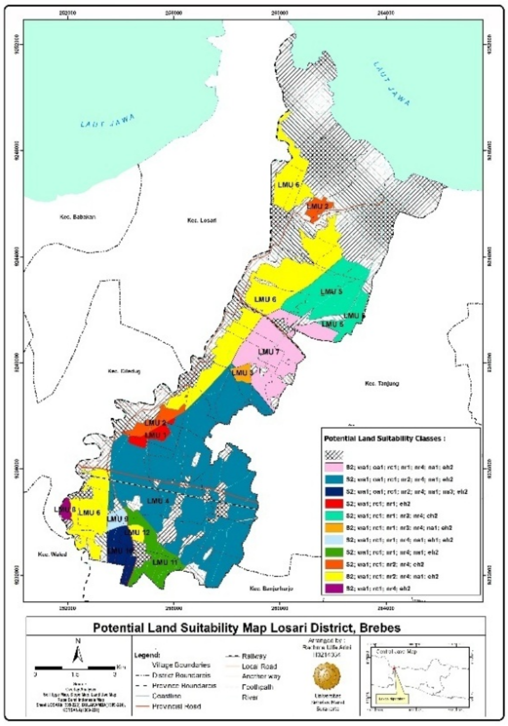

Figure 2. Potential Land Suitability Map of Losari District, Brebes

Table 2. Land characteristic data from the observed land mapping unit

Land Characteristic	LMU 1	LMU 2	LMU 3	LMU 4	LMU 5	LMU 6	LMU 7	LMU 8	LMU 9	LMU 10	LMU 11	LMU 12
Temperature (tc)												
Mean Termperature (^oC)	26.14 (S1)	26.18 (S1)	26.15 (S1)	26.15 (S1)	26.21 (S1)	26.20 (S1)	26.17 (S1)	26.13 (S1)	26.11 (S1)	26.16 (S1)	26.10 (S1)	26.12 (S1)
Water Availability (wa)												
Mean annual rainfall (mm/year)	**1,827.00 (S3)**	**1,827.00 (S3)**	**1,827.00 (S3)**	**1,827.00 (S3)**	**1,827.00 (S3)**	**1,827.00 (S3)**	**1,827.00 (S3)**	**1,827.00 (S3)**	**1,827.00 (S3)**	**1.827,00 (S3)**	**1,827.00 (S3)**	**1,827.00 (S3)**
Number of dry moon (<100 mm/month)	5 (S1)	5 (S1)	5 (S1)	5 (S1)	5 (S1)	5 (S1)	5 (S1)	5 (S1)	5(S1)	5 (S1)	5 (S1)	5 (S1)
Oxygen Availability (oa)												
Drainage	Well-drained, somewhat poorly drained (S1)	Well-drained, somewhat poorly drained (S1)	Well-drained, somewhat poorly drained (S1)	Somewhat excessively drained, moderately well drained (S2)	Well-drained, somewhat poorly drained (S1)	Well-drained, somewhat poorly drained (S1)	Somewhat excessively drained, moderately well drained (S2))	Well-drained, somewhat poorly drained (S1)	Well-drained, somewhat poorly drained (S1)	Somewhat excessively drained, moderately well drained (S2)	Well-drained, somewhat poorly drained (S1)	Well-drained, somewhat poorly drained (S1)
Rooting condition (rc)												
Texture	Clay (S2)	Clay (S2)	Clay (S2)	Clay (S2)	Clay (S2)	Clay (S2)	Clay (S2)	Clay (S2)	Clay (S2)	Clay (S2)	Clay (S2)	Clay (S2)
Coarse material (%)	<15 (S1)	<15 (S1)	<15 (S1)	<15 (S1)	<15 (S1)	<15 (S1)	<15 (S1)	<15 (S1)	<15 (S1)	<15 (S1)	<15 (S1)	<15 (S1)
Soil depth (cm)	>50 (S1)	>50 (S1)	>50 (S1)	>50 (S1)	>50 (S1)	>50 (S1)	>50 (S1)	>50 (S1)	>50 (S1)	>50 (S1)	>50 (S1)	>50 (S1)
Nutrition retention (nr)												
CEC (cmo/kgl)	15.92 (S2)	38.85 (S1)	13.96 (S2)	32.70 (S1)	12.61 (S2)	24.96 (S1)	13.19 (S2)	22.99 (S1)	15.36 (S2)	22.92 (S1)	15.71 (S2)	29.15 (S1)
Base saturation (%)	45.63 (S1)	25.44 (S2)	49.25 (S1)	25.30 (S2)	43.78 (S1)	28.93 (S2)	48.45 (S1)	36.31 (S1)	40.76 (S1)	20.64 (S2)	50.38 (S1)	22.51 (S2)
pH H_2O	6.29 (S1)	6.77 (S1)	7.56 (S2)	7.46 (S1)	7.59 (S2)	7.04 (S1)	7.36 (S1)	7.11 (S1)	7.07 (S1)	6.70 (S1)	6.88 (S1)	7.14 (S1)
C-organic (%)	3.41 (S1)	1.67 (S2)	1.28 (S2)	1.10 (S2)	1.37 (S2)	0.98 (S2)	1.61 (S2	1.03 (S2)	1.74 (S2)	1.03 (S2)	1.17 (S2)	0.92 (S2)

Land Characteristic	LMU 1	LMU 2	LMU 3	LMU 4	LMU 5	LMU 6	LMU 7	LMU 8	LMU 9	LMU 10	LMU 11	LMU 12
Nutrition Availability (na)												
Total N (%)	0.23 (S1)	0.26 (S1)	0.20 (S2)	0.16 (S2)	0.21 (S1)	0.17 (S2)	0.16 (S2	0.36 (S1)	0.18 (S2)	0.16 (S2)	0.19 (S2)	0.20 (S2)
P_2O_5 (mg/100g)	37.23 (S1)	51.62 (S1)	37.02 (S1)	36.20 (S1)	47.32 (S1)	50.19 (S1)	37.36 (S1)	38.57 (S1)	34.75 (S1)	36.49 (S1)	35.70 (S1)	35.33 (S1)
K_2O (cmol/kg)	0.73 (S1)	0.54 (S1)	0.45 (S1)	0.64 (S1)	0.62 (S1)	1.10 (S1)	1.05 (S1)	0.58 (S1)	0.52 (S1)	0.37 (S2)	0.42 (S1)	0.75 (S1))
Toxicities (xc)												
Salinity (dS/m)	0.11 (S1)	0.10 (S1)	0.10 (S1)	0.10 (S1)	0.45 (S1)	0.28 (S1)	0.16 (S1)	0.08 (S1)	0.03 (S1)	0.06 (S1)	0.11 (S1)	0.10 (S1)
Sodicity (xn)												
Alkalinity/ESP (%)	6.06 (S1)	2.60 (S1)	7.29 (S1)	2.93 (S1)	8.61 (S1)	4.08 (S1)	7.29 (S1)	4.44 (S1)	6.29 (S1)	3.37 (S1)	6.15 (S1)	6.43 (S1)
Erosion hazard (eh)												
Slope (%)	1 (S1)	1 (S1)	1 (S1)	1 (S1)	1 (S1)	1 (S1)	1 (S1)	1 (S1)	3 (S2)	1 (S1)	1 (S1)	1 (S1)
Erosion hazard	Very light (S2)	Very light (S2)	Very light (S2)	Very light (S2)	Very light (S2)	Very light (S2)	Very light (S2)	Very light (S2)	Very light (S2)	Very light (S2)	Very light (S2)	Very light (S2)
Surface stoniness (%)	1 (S1)	1 (S1)	1 (S1)	1 (S1)	1 (S1)	1 (S1)	1 (S1)	1 (S1)	1 (S1)	1 (S1)	1 (S1)	1 (S1)
Surface outcrop (%)	1 (S1)	1 (S1)	1 (S1)	1 (S1)	1 (S1)	1 (S1)	1 (S1)	1 (S1)	1 (S1)	1 (S1)	1 (S1)	1 (S1)
Land suitability classes	**S3 ; wa1**	**S3 ; wa1**	**S3 ; wa1**	**S3 ; wa1**	**S3 ; wa1**	**S3 ; wa1**	**S3 ; wa1**	**S3 ; wa1**	**S3 ; wa1**	**S3 ; wa1**	**S3 ; wa1**	**S3 ; wa1**
Limiting factor	**Water available**	**Water available**	**Water available**	**Water available**	**Water available**	**Water available**	**Water available**	**Water available**	**Water available**	**Water available**	**Water available**	**Water available**

Remark : Results of field and laboratory analysis (2017); Information : S1 = highly suitable; S2 = moderately suitable; S3 = marginally suitable; N = not suitable

Potential land suitability

The potential land suitability is land suitability class where the field conditions have undergone changes or improvement efforts. Improvement efforts were undertaken to overcome high rainfall require a moderate level of management, namely management that needs relatively large additional costs for purchasing season-suitable varieties, making mounds, using mulch/ shade. This improvement usually can be done by middle-level farmers (Ritung et al., 2011). Potential land suitability (Figure 3) can increase to S2 (moderately suitability) by improvement efforts.

The limiting factors and the improvement effort

The limiting factor that affects the productivity of shallots is the very high rainfall of 1,827 mm/ year, based on the calculation of the average rainfall in 2006-2016 according to Oldeman (1975). There are four wet months and five dry months so that it has a D3 climate type, which is suitable for one-time rice growth or one crop planting, depending on water availability. The Rainfall on wet months is very high for the shallot growth because it will be too moist and increase the attack of pests, diseases and fungi which cause decay (Limbongan and Maskar, 2003; Rosilani et al., 2005). High rainfall can cause erosion (erositvity of rainfall) and loss of nutrient in the soil (Basuki et al., 2018). Rainfall in the dry season is very low, so that there is the potential for drought, causing shallots to be lack water to grow. Planting throughout the year is an effort to increase needs of shallots. Shallot security can be carried out in the rainy and dry seasons by minimizing the risk of crop failure through improvement efforts, which are adjusted to the shallot planting period.

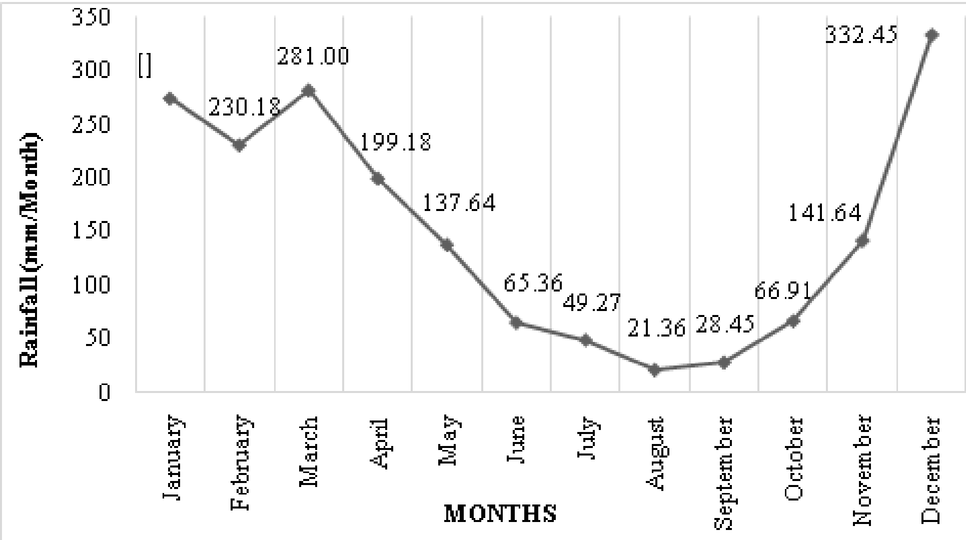

Figure 1. Average of Annual Rainfall Losari District, Brebes in 2006 – 2016

High rainfall in the rainy season (January-March) has a total rainfall of 784.73 mm. Based on Djaenudin et al. (2011) the amount of excessive rainfall needs to be overcome, such as the selection of season-suitable varieties, making mounds and using mulch/shade. Varieties that are resistant to moist conditions according to the Agricultural Research and Development Agency (2014) are Sembrani, Maja, Pancasona, and Trisula. The making mound serves to reduce the occurrence of stagnant water at the planting site, enlarge the soil pore, make it easier for the roots penetrate to the soil so that the movement of water and air becomes smooth Holish et al. (2014). The use of mulch/shade serves to maintain soil temperature and humidity, reduce erosivity of rainfall rate, reduce the occurrence of nutrient leaching and prevent the occurrence of soil-borne diseases according to Wakhid et al. (2012).

In the dry season (July-September) the amount of rainfall in one planting season is very less for shallots growing, which is 99.09 mm. Improvement efforts to overcome the water deficit are by selecting varieties that are resistant to drought and rainwater harvesting. Varieties that are resistant to drought are Bima Curut, Sembrai, Maja and Katumi according to the Agricultural Research and Development Agency (2014). Rainwater harvesting is carried out during the rainy season, where the water is collected in a drainage ditch in the middle of land / micro ponds / rainfed wells that are close to the shallot planting area. At the bottom of the trench/pond / well can be added a layer of tarpaulin/plastic lining/geomembrane to maximize water storage according to Hadinata et al. (2015). In April - June, and October - December is the most suitable planting season for shallot because it has a rainfall amount between 300-600 mm (Djaenudin et al., 2011) which meets the needs of shallot water.

Based on the potential suitability class, land characteristics such as soil drainage, soil texture, CEC, alkalinity, pH, C-organic, total N, available K, slope, and erosion hazard have a potential suitability class S2 (moderately suitable). In this suitability, the class does not significantly affect the growth of shallot because it is still following the requirements for growing shallots. However, improvements can do such as adding organic matter, fertilizing, liming, making mounds, making drainage ditch and using mulch to overcome those limiting factors according to Wibowo (2009).

Conclusion

Losari Subdistrict has an actual marginal land suitability class (S3) for shallot growth, with a limiting factor is water availability. The availability of water is excessive in the rainy season but has the potential to experience a shortage of water during the dry season. Efforts that can be made to overcome the limiting factors and increase the potential land suitability class are by using varieties that are suitable for the season, making mounds, using mulch/shade, which is supplemented by the addition of organic matter, fertilization, and liming the soil.

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