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Optimum Doses of N, P, And K Fertilizers for Samosir Shallot Varieties in the Plains of the Lake Toba Region

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ABSTRACT

This study aims to obtain the optimum dose of N, P and K fertilizers in the cultivation of shallot varieties of Samosir planted in the rainy season in the plains around Lake Toba. This study consisted of 3 parallel experiments to determine the optimum N, P, K fertilization with a non-factorial randomized group design (RAK). P_2O_5 and K_2O fertilizers were applied 100% in the N rate experiment, N and K_2O fertilizers were applied 100% in the P rate experiment, and N and P_2O_5 fertilizers were applied 100% in the K rate experiment. Each experiment consisted of 5 levels, namely 0, 50, 100, 150, and 200% of the reference dose and each treatment was repeated 3 times so that there were 45 experimental plots. Parameters were: fresh weight of tubers and crowns at the late of the vegetative period, crown weight and wind-dried harvest tubers. Determination of the optimum dose is based on the maximum value of the quadratic equation of relative yield. The results obtained for the optimum dose of N and P fertilizer recommendations are 154.22 kg N ha^{-1} and 126.62 kg P_2O_5 ha^{-1}. For K fertilization does not give a quadratic response pattern so there is no optimum dose.

Keyword: shallots, Samosir variety, fertilizer, optimum dosage

ABSTRAK

Penelitian ini bertujuan untuk memperoleh dosis optimum pupuk N, P dan K pada budidaya bawang merah varetas Samosir yang ditanam pada musim hujan di dataran sekitar Danau Toba. Penelitian ini terdiri atas 3 percobaan paralel untuk menentukan pemupukan N, P, K optimum dengan rancangan acak kelompok (RAK) non faktorial. Pupuk P_2O_5 dan K_2O diberikan 100% pada percobaan N bertaraf, pupuk N dan K_2O diberikan 100% pada percobaan P bertaraf, pupuk N dan P_2O_5 diberikan 100% pada percobaan K bertaraf. Setiap percobaan terdiri atas 5 taraf yaitu 0, 50, 100, 150, dan 200% dari dosis acuan dan setiap perlakuan diulang 3 kali sehingga terdapat 45 petak percobaan. Data diolah dengan SPSS v.27. Jika hasil analisis ragam menunjukkan pengaruh yang nyata/ sangat nyata, maka dilanjutkan dengan uji regresi polinomial. Apabila hasil dari uji tersebut menunjukkan respon kuadratik maka dilanjutkan mencari titik optimum dari perlakuan. Hasil penelitian menunjukkan Dosis pupuk N berpengaruh sangat nyata terhadap parameter bobot umbi pada akhir vegetatif dan panen. Dosis pupuk P berpengaruh sangat nyata terhadap parameter bobot tajuk dan umbi saat panen. Dosis pupuk K tidak berpengaruh terhadap semua parameter. Rekomendasi pupuk N dan P dosis optimum adalah 154,22 kg N ha^{-1} dan 126,62 kg P_2O_5 ha^{-1}. Untuk pemupukan K tidak memberikan pola respon kuadratik sehingga tidak ada dosis optimumnya.

Kata kunci: bawang merah, varetas Samosir, pupuk, dosis optimum.

1. Introduction

Shallots have been cultivated in almost all regions in Indonesia (Yamhuri et.al, 2022). Until now, shallot production in North Sumatra Province is still lacking so that it must be imported from other provinces or imported. special attention is given by the North Sumatra Provincial government to shallot commodities because it is one of the sources of inflation and in order to achieve shallot self-sufficiency (Novita et. al., 2019). One of the factors that support plants in growing and producing optimally is the availability of nutrients in sufficient quantities in the soil. If the soil cannot provide enough nutrients for plants, then fertilizer needs to be applied to meet the shortage. Each type of plant requires different amounts of nutrients. Inaccuracy in the application of nutrients/fertilizers will not only cause plants not to grow and produce optimally, but also a waste of energy and costs (Tando, 2018). Fertilization is one of the important factors in shallot cultivation. Fertilizer application ensures the availability of nutrients during growth and determines the success of shallot farming (Basundari and Krisdianto, 2020). To be able to grow and produce optimally, shallot plants need sufficient and balanced amounts of Nitrogen (N), phosphorus (P) and Potassium (K) (Sumarni et. al., 2012b). The plain area around Lake Toba is still the mainstay location of the North Sumatra Provincial government to increase shallot production in North Sumatra. This plain is located at an altitude of 900-1000 m above sea level and is part of the highlands of the Bukit Barisan Mountain range. Generally, local farmers cultivate shallots in the dry season. There is still an opportunity to increase production if cultivation is carried out in the rainy season although according to Muliana et.al., (2018) shallot production is higher in the dry season than the rainy season. The shallot cultivation land in this location has the same soil texture. Razali et.al., (2023), shallot cultivation areas in the plains around Lake Toba have a sandy loam soil texture.

The Samosir variety has long been known as the mainstay variety of onion farmers in this area. According to Napitupulu et al, (2021), the Samosir variety has distinctive characteristics that are different from other varieties and also a stable selling price. According to Hutapea et.al, (2015), the Samosir variety of shallots is location specific, which if planted in other areas, the aroma will be different.
Until now, the optimum doses of nitrogen (N), phosphorus (P), and potassium (K) fertilizers for Samosir variety shallots cultivated in the best agroclimate, namely in the plains around Lake Toba, especially in the rainy season, are unknown. Therefore, it is necessary to make recommendations for optimal fertilizer doses to increase the productivity of Samosir variety shallots and also prevent the use of excess fertilizers so as not to pollute the environment and reduce the production costs of agricultural businesses.

2. Methods

The research location is in Palipi District, Samosir Regency, North Sumatra Province. Located 910 meters above sea level. Conducted in October - December 2023 (rainy season). Materials used: shallot seedlings of Samosir variety, N fertilizer (source of 50% Urea and 50% ZA), P fertilizer (source of SP-36) and K fertilizer (source of KCl).

This study consisted of 3 parallel experiments to determine the optimum N, P, K fertilization with a non-factorial randomized group design. P_2O_5 and K_2O fertilizers were applied 100% in the N rate experiment, N and K_2O fertilizers were applied 100% in the P rate experiment, and N and P_2O_5 fertilizers were applied 100% in the K rate experiment. Each experiment consisted of 5 levels, namely 0, 50, 100, 150, and 200% of the reference dose and each treatment was repeated 3 times so that there were 45 experimental plots. The standard N, P, K fertilizer reference dose for upland shallots is N 190 kg/ha, P_2O_5 92 kg/ha, and K_2O 120 kg/ha (Sumarni et.al., 2012b) (Table 1).

The experiment started with initial soil analysis, then tillage was conducted twice (2 weeks before planting and 1 week before planting). The size of the experimental unit plot was 110 cm x 110 cm, the spacing was 15 cm x15 cm so there were 49 planting holes/plot (one tuber/planting hole). The distance between plots and between replications was 50 cm. Black plastic mulch was used to cover the entire surface of the experimental plots (except planting holes) to eliminate the adverse effects of high rainfall during the planting period. Before planting, the tubers were first cut at the ends of approximately ¼ of the tuber. This aims to ensure even growth of the bulbs, stimulate shoot growth, accelerate plant growth, and encourage the formation of tillers. P fertilizer is applied one week before planting while N and K fertilizers are applied 3 times: 1/3 at 15 days after planting (DAP), 1/3 at 30 DAP and 1/3 at 45 DAP. Maintenance includes replanting, watering, weeding and pest control.

Table 1. Fertilizer dosages for N, P, and K were compared to reference doses Sumarni et al. (2012) in order to determine the ideal dosages for Samosir shallot variety

fertilizers	% of reference dose				
	0	50	100	150	200
	N Experiment (kg ha^{-1})				
Urea + ZA	0,0 + 0,0	103,2 + 226,2	206,5 + 452,4	309,7 + 678,6	413,0 + 904,8
SP-36	255,6	255,6	255,6	255,6	255,6
KCl	120,0	120,0	120,0	120,0	120,0
	P Experiment (kg ha^{-1})				
Urea + ZA	206,5 + 452,4	206,5 + 452,4	206,5 + 452,4	206,5 + 452,4	206,5 + 452,4
SP-36	0,0	127,8	255,6	383,4	511,2
KCl	120,0	120,0	120,0	120,0	120,0
	K Experiment (kg ha^{-1})				
Urea + ZA	206,5 + 452,4	206,5 + 452,4	206,5 + 452,4	206,5 + 452,4	206,5 + 452,4
SP-36	255,6	255,6	255,6	255,6	255,6
KCl	0,0	60,0	120,0	180,0	240,0

Sampling when the plants entered the final vegetative phase (50 DAP) was done by taking 3 clumps of plants in the center of the plant plot. Harvesting was done when the plants were old enough with signs of 60% soft stem neck, lodging, and yellowing leaves (65 DAP).
Parameters are:

a. Average fresh weight of tubers and crowns per clump of 3 samples at the late of vegetative time.
b. average weight of tubers and crowns / clumps at harvest which has been air-dried for 5 days, obtained by means of data on the weight of tubers / crowns of each plot divided by the number of clumps in each plot.

Data were processed with SPSS v.27. If the results of the analysis of variance showed a significant/very significant effect, then continue with the polynomial regression test to determine the response pattern of the observed variables. If the results of the test showed a significant/very significant effect in quadratic response ($y = ax^2 + bx + c$; y = relative yield, x= fertilizer dosage, and a, b, c are constant values), determination of the maximum fertilizer dosage was calculated by using the derivative formula of the regression equation $dy'/dx = 2ax + b$ (Suminar et.al., 2017).

3. Results and Discussion

3.1 Preliminary soil analysis results

The results of soil analysis on the land before planting and its criteria can be seen in Table 2.

Table 2. Preliminary Soil Analysis Results.

Parameter	units	value	Criteria *
- Sand fraction	%	68	-
- Silt fraction	%	13	-
- Clay fraction	%	19	-
Texture	USDA	sandy loam	-
- pH (H_2O)	-	5,61	low (slightly acid)
- C-organik	%	1,16	low
- N-total	%	0,20	low
- C/N	-	5,80	low
- P-av (Bray_1)	ppm	15,28	low
- K-dd (AAS)	me/100g	0,52	moderate

* According to the Soil Research Center (1983)

Table 2 shows that:

a. From the physical properties of the soil that the soil in the research location has a sandy loam texture. This is in line with the research of Razali et.al. (2023) that shallot cultivation areas in the plains around

Lake Toba have a sandy loam texture. The soil texture in the research location has a percentage of sand fraction reaching 68%. Soils that have a higher sand fraction will lose water more easily (lower water storage capacity). One side of this is not good for the availability of water for plants, but the other side will be good for onion plants to avoid bulb rot.

b. From the soil chemical properties, C, N, C/N and P nutrients are low; only K nutrients are medium. This illustrates that to cultivate shallots in order to get good production, fertilization is very necessary.

3.1. Yield of samosir variety shallots at various doses of fertilizer.

The effect of N, P, and K fertilizer doses on the weight of the crown and bulbs at the late of vegetative growth and harvest of shallots of Samosir variety cultivated in the plains around Lake Toba can be seen in Table 3.

Table 3 shows that the dose of N fertilizer had a very significant effect on the parameters of tuber weight at the late vegetative and harvest stages. The N fertilizer dose of urea and ZA mixture ((103.2 + 226.2) kg ha-1), which is 50% of the reference N fertilizer dose, gave the highest yield. The application of higher N fertilizer doses caused the tuber weight obtained to be lower. Table 1 shows that the N content of the soil is low, so it requires sufficient N fertilization so that onion plants can grow and produce well. Widiana et.al. (2020), the application of N fertilizer in high doses does not guarantee an increase in yield and will actually reduce yields.

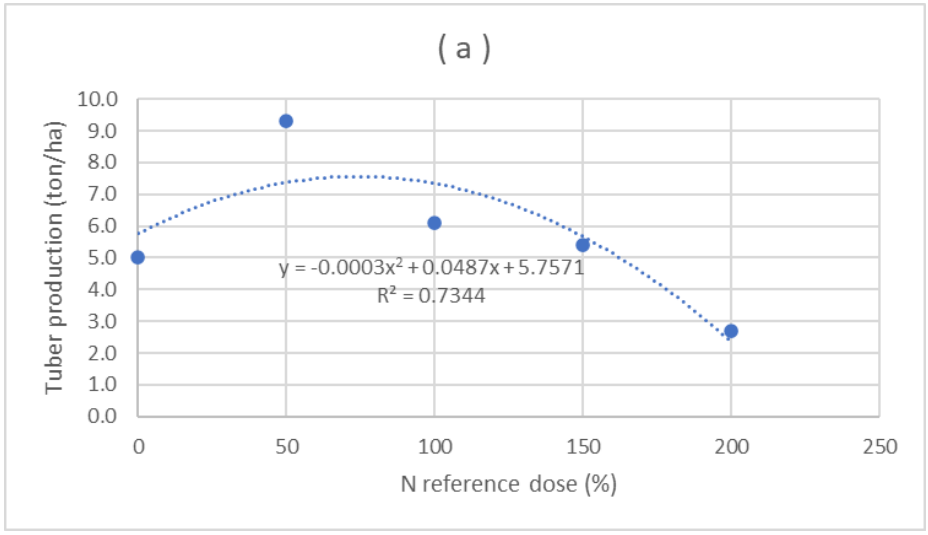
The treatment of various doses of N fertilizer gave a quadratic response pattern to harvest tuber weight with the regression equation $y = -0.0003x^2 + 0.0487x + 5.7571$ with the determination coefficient (R^2) = 0.7344 (Figure 1a). This figure indicates that approximately 73.44% of the variation in tuber production can be explained by the dose of N fertilizer. Meanwhile, the remaining 26.56% is variation explained by other factors not included in the model being studied. The optimum N dose in the equation was 81.17% of the reference dose (equivalent to 154.22 kg N ha^{-1} or ((167 kg urea + 367 kg ZA) ha^{-1})).

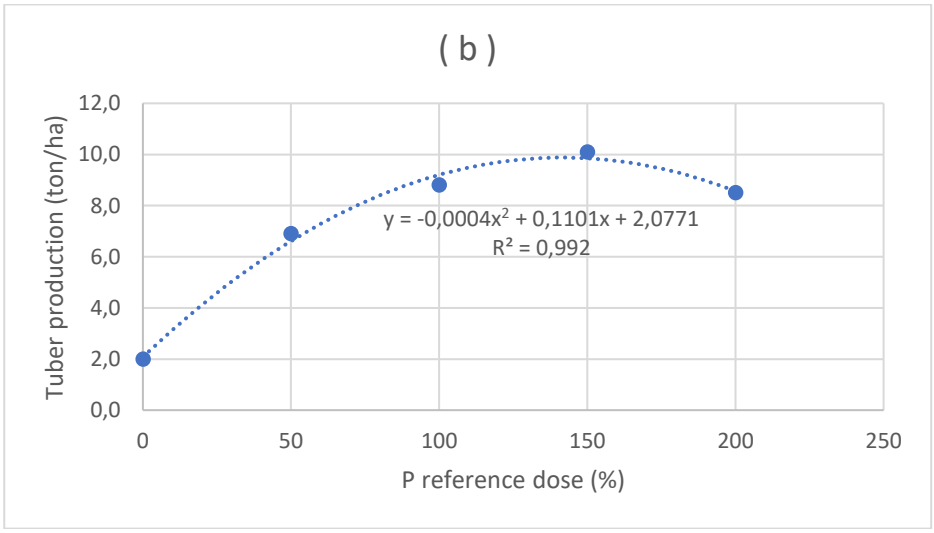
Tabel 3. Effect of N, P, and K doses on crown and tuber weights at late vegetative and harvest.

Fertilizer dose (kg ha^{-1})	late vegetative		harvest		
	weight/clump (g)		weight/clump (g)		Tuber weight# (ton ha^{-1})
	crown	tuber	crown	tuber	
N (Urea + ZA)					
0.0 + 0.0	8.1	13.3	4.6	22.8	5.0
103.2 + 226.2	10.3	24.4	6.6	42.8	9.3
206.5 + 452.4	8.3	10.6	8.7	28.1	6.1
309.7 + 678.6	6.3	9.6	5.9	25.0	5.4
413.0 + 904.8	6.7	3.5	1.8	12.6	2.7
Response pattern t	ns	Q*	ns	Q**	Q**
P (SP-36)					
0.0	6.4	6.7	1.1	9.1	2.0
127.8	6.9	17.6	9.1	31.9	6.9
255.6	6.6	20.4	15.7	40.3	8.8
383.4	6.2	15.2	16.4	46.4	10.1
511.2	7.2	18.4	10.7	39.2	8.5
Response pattern t	ns	ns	Q**	Q**	Q**
K (KCl)					
0.0	7.7	12.4	15.9	29.3	6.4
60.0	9.4	14.9	16.0	31.0	6.8
120.0	11.2	18.7	17.1	30.1	6.5
180.0	12.0	19.0	12.4	26.9	5.9
240.0	9.7	18.3	12.8	34.0	7.4
Response pattern t	ns	ns	ns	ns	ns

Notes: t = orthogonal polynomial test on fertilizer dose; Q = quadratic;
ns = not significantly; * significant at 5% level; ** significant at 1% level
# conversion of tuber weight ha^{-1} with a population size of 311111 (15 cm x15 cm spacing) and a correction factor of only 70% of the effective land area for planting (Simatupang, 2019).

Using the regression equation $y = -0.0004x^2 + 0.1101x + 2.0771$ and the determination coefficient (R^2) = 0.992, the weight of harvested tubers showed a quadratic response pattern to the application of different dosages of P fertilizer (Figure 1b). According to this statistic, the P fertilizer dosage accounts for almost 99.2% of the difference in tuber yield. Other factors that are not part of the model under study account for the remaining 0.8% of the variation. The equation's optimal P dose was 137.63% of the reference dose, which is equivalent to 351.72 kg SP-36 ha^{-1} or 126.62 kg P_2O_5 ha^{-1}.





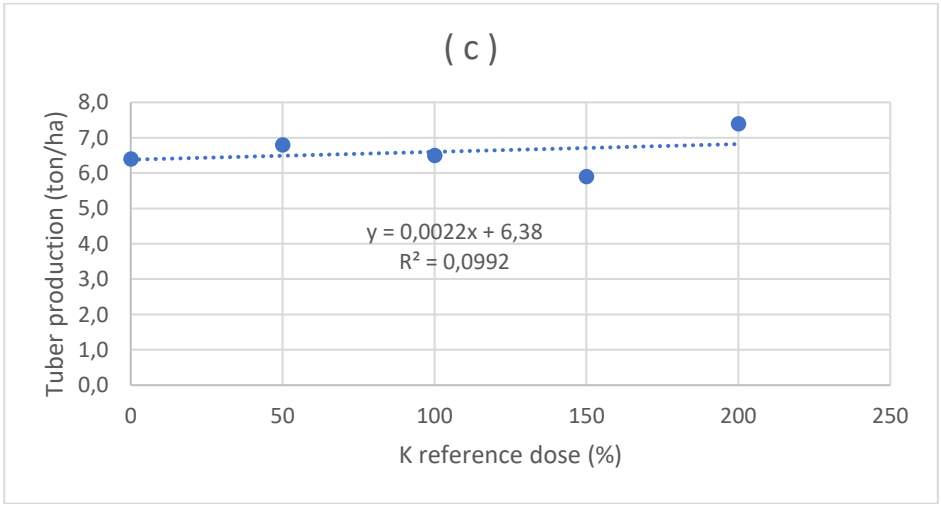


Figure 1 : Weight of harvested tubers per clump due to N fertilizer dose (a), P fertilizer dose (b) and K fertilizer dose (c).

According to Table 1, the soil's pH is categorized as mildly acidic, and its accessible P concentration is low. Because of these two factors, plants can access P in comparatively small amounts, making them highly responsive to fertilization. Shallots require a lot more P fertilizer than is advised in order to grow well. According to Sumarni et al. (2012a), the ideal amount of P fertilizer needed for shallots varies based on the variety and the P-soil condition.

The dose of K fertilizer had no effect on all parameters. Martinus et.al. (2017), conducted experiments in different locations in the plains around Lake Toba also obtained the results that the application of various doses of inorganic K fertilizer also had no effect on soil K nutrient content, growth and production of shallots. This is thought to be because the K content in the soil is sufficient for the growth and production of onions so there is no need for additional K fertilizer. Table 1 shows that the available K content of the soil is categorized as moderate. Sitompul et al. (2017) the availability of K elements in high amounts in the soil and exceeding plant needs will cause these nutrients to no longer have an effect on increasing plant growth.

CONCLUSIONS

This study obtained the optimum doses of N and P fertilization for the cultivation of shallot varieties Samosir in the plains around Lake Toba in the rainy season. For K fertilization does not give a quadratic response pattern so there is no optimum dose. N and P fertilizer recommendations based on the optimum dose are 154.22 kg N ha^{-1} and 126.62 kg P_2O_5 ha^{-1}.

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