THE EFFECT OF ADDING LEUCITE MINERAL AND POTASSIUM SOLUBILIZING BACTERIA ON THE POTASSIUM AVAILABILITY IN SOIL, POTASSIUM UPTAKE AND PLANT GROWTH OF TOBACCO (*Nicotiana tabacum*) BESUKI NA-OOGST

Widya Irawati[1], Tri Candra Setiawati[2] and Sugeng Winarso[3]
[1]Study Program of Agrotechnology, University of Jember
[2,3] Soil Departement, Faculty of Agriculture, University of Jember
E-mail address: widyairawati08@gmail.com

Abstract

Tobacco (*Nicotiana tabacum*) is a plantation crop as a raw material for making cigarettes. The quality of cigarettes depends on tobacco leaves as raw materials and the fuel is affected by the potassium content in plant tissues. So that, potassium affects the quality of the leaves. Potassium is absorbed by plants that come from several sources of chemical fertilizers and potassium mineral that can be found in nature. In this study, besides the addition of leucite mineral as a source of potassium is also done the addition of potassium-solubilizing bacteria to increase the availability of potassium in the soil and accelerate the process of dissolving potassium in the soil. Potassium-solubilizing bacteria (PSB) can accelerate the solubilizing of potassium into K^+ ions so that more is available in soil and plants are able to uptake potassium in large quantities. This study used Factorial Randomize Complete Block Design which included 4 levels of potassium and 3 levels of PSB with three replications. The purpose of this research is to know the effect of leucite and PSB in increasing the availability of potassium in the soil, potassium concentration in plant tissue, potassium uptake and plant growth of Besuki Na-Oogst tobacco. The results showed that the interaction between the addition of potassium source and inoculation of potassium-solubilizing bacteria had a significant effect on potassium availability in soil, potassium concentration in plant tissue, potassium uptake and a height of the plant. The interaction between the leucite rocks and PSB may increase the availability of potassium in the soil and give the same results compared with the addition of KNO_3 fertilizer.

Keywords: Besuki Na-Oogst Tobacco, Potassium, Leucite, Potassium-solubilizing bacteria

1. Background

Indonesia is a country that producing tobacco in large quantities, which is included in the top ten tobacco-producing countries. Indonesia contributes as much as 2.3% of the world supply of about 15,000 tons. Total land used for tobacco cultivation in East Java area is 101,095 ha. Percentage of land used was 43.6%. East Java is the most widespread area in cultivating tobacco plants because East Java has potential in developing tobacco plants (Putri *et al*., 2015).

Tobacco plant growth can not be separated from the availability of nutrients in the soil. Nutrient elements needed are macro nutrients and micro nutrients. The macro nutrient element is needed nutrients in very large quantities such as nitrogen, phosphorus, potassium, calcium, magnesium, sulfur. Nutrient elements play an important role in the growth and development of tobacco plants, therefore their availability in the soil should be sufficient. The availability of potassium (K) in soil varies depending on the type of soil used. Potassium is a third nutrient element after nitrogen and phosphor. Potassium has an important function in the growth and development of tobacco plants. The role of potassium in the plant is to influence the metabolic process and give special effects in nutrient absorption and photosynthesis process. If the plant has a deficiency of potassium, then the plant will show symptoms such as plant leaves will look burning. Lower leaves of the plant will appear chlorosis with spots. Potassium can be an indicator of the quality of tobacco because potassium can affect the fuel of the tobacco leaf.

Potassium will be available in the soil in large quantities by adding potassium-containing ingredients such as KNO_3 fertilizer. Continuous and large amounts of KNO_3-fertilized fertilizer will have a negative impact on the environment. Therefore, a technology is needed to replace or reduce the use of KNO_3 fertilizers such as by utilizing potassium minerals available in the nature, but not available to plants so that aid is needed from microorganisms to help accelerate the process of dissolving the minerals so that potassium can be available in the soil and can be absorbed by plants. Commonly used microorganisms are potassium-solubilizing bacteria. By doing this research, it is expected to replace the use of KNO_3 fertilizer by utilizing potassium minerals such as leucite mineral and utilizing PSB to increase the availability of potassium in the soil. The purpose of this research is to know the effect of leucite and PSB in increasing the availability of potassium in the soil, potassium concentration in plant tissue, potassium uptake and plant growth of Besuki Na-Oogst tobacco.

2. Methods – Pot Experiments

2.1 Flow of Research

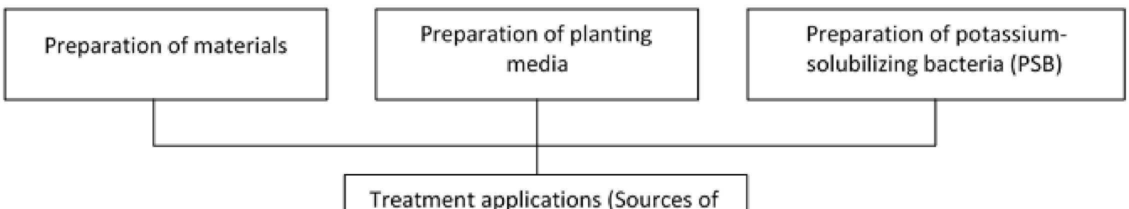

Fig. 1: Flow Diagram of Research

2.2 Materials

Materials used in this study include seeds of tobacco Na-Oogst, compost, KNO_3 fertilizers, leucite mineral, Aleksandrov agar (glucose, $MgSO_4$, $FeCl_3$, $CaCO_3$, $Ca_3(PO4)_2$, agar and distilled water). The materials used in the process of soil chemical analysis are (1) pH (distilled water); and (2) K (ammonium acetate pH 7.00 and principal solution K_2O).

The tools used in this study include Petri dishes, test tubes, tube flask, shaking machine, autoclave, incubator, Laminar Air Flow, micro pipette, a heater, a pH meter, a tool of destruction, AAS, volume pipette, rubber suction tube digest, boiling flask, automatic titar, stirrer.

2.3 Characteristics of Land Used

The land used is located in Candijati Village area, Arjasa Subdistrict, Jember

Regency. Samples were taken from four sample points randomly then compiled.

Table 1. Characteristics of Land Used

Analysis	Unit	Value	Category *)
pH H_2O	-	6,17	Slightly acid
CEC	cmol/kg	20,1	Moderately
Nitrogen (N)	%	0,13	Low
Carbon (C)	%	1,60	Low
C/N		12,31	Moderately
Potassium (K)	me/100 g	0,3	Low

* Based on the Assesment Criteria of Soil Analysis, Soil Research Institute (Eviati and Sulaeman, 2009)

2.4 Populations of Potassium Solubilizing Bacteria

The bacteria used in the study consisted of two types of bacteria, namely *Pseudomonas* sp. and *Pediococcus* sp. The bacteria cultured on Alexandrov media then counted the population before being propagated. The purpose of calculating the bacterial population is to know how much bacteria is applied to the soil. Once the population is known then the bacteria can be propagated and inoculated using a carrier. Carrier used is compost.

Table 2. Population of Potassium-Solubilizing Bacteria

Kind of Bacteria	Unit	Population
Pseudomonas sp.	CFU/ml	$4,87 \times 10^6$
Pediococcus sp.	CFU/ml	$6,23 \times 10^6$

2.5 Characteristics of Leucite

Leucite mineral is one of the sources of potassium used in the study. Leucite mineral used to come from two different places, so the potassium content in it is also different. The purpose of using leucite from different places is to compare how well the results obtained and the effects resulting from the use of both types of leucite.

Table 3. Content of K_2O in Leucite Mineral

Analysis	Unit	Leucite of Pati	Leucite of Ringgit
K_2O	%	7,25	7,47

2.6 Experimental Design

This research uses Factorial Randomize Complete Block Design with two factor and three replications. Each experiment consists of 3 subplots, parallel design so that each polybag can be used as an analysis material for each stage of analysis. The data obtained will be analyzed using variance analysis or ANOVA. Then proceed with Duncan test at 5%. The treatment consists of:

Factor I: Sources of potassium. Consist of four levels, that is 1. Kontrol or no addition of potassium sources (K0), 2. Leucite of Ringgit with dose 27,72 g/plant (K1), 3. Leusit of Pati with dose 28,53 g/plant (K2), 4. KNO_3 fertilizer with dose 4,5 g/plant (K3). And Factor II: Potassium-solubilizing bacteria. Consist of three leves, that is 1. Control or no addition of potassium solubilizing bacteria (I0), 2. *Pseudomonas* sp. bacteria (I1), 3. *Pediococcus* sp. bacteria (I2).

3. Results

The addition of leucite mineral of Ringgit and Pati did to increase potassium in the soil so that the availability of potassium can be increased and absorbed by the higher the plant. Other potassium source factors are without providing additional potassium and KNO_3 synthetic fertilizer. Potassium source factor combined with inoculation of potassium-solubilizing bacteria, that are *Pseudomonas* sp. and *Pediococcus* sp. The use of two factors is done to determine whether there is an interaction between potassium source with potassium solubilizing bacteria. Effect of potassium addition in the soil and potassium content in the plant is done periodically ie at the age of 15, 30 and 45 days after transplanting.

Table 4. Summary F-Count Results of End Analysis Variable Observations

Variable Observations	Potassium Sources	Inoculation of PSB	Potassium Sources × Inoculation of PSB	CV (%)
Available potassium	21,86**	3,54*	3,36*	11,48
K-concentrations in plant tissue	16,50**	4,56*	$0,86^{ns}$	6,48
Potassium uptake	17,89**	5,41*	5,15**	12,59
A Height of the plant	$2,28^{ns}$	$0,48^{ns}$	4,39**	9,27
Number of leaves	$1,19^{ns}$	$0,39^{ns}$	$1,57^{ns}$	4,4

Soil potassium availability, potassium concentrations in plant tissues and potassium uptake have a very real correlation relationship (Table 5.). So if the availability of potassium in the soil is not sufficient, it will affect the potassium concentration in the tissues and potassium uptake that will have a low value. On the contrary, if the soil content is sufficient or even excessive the potassium concentrations in the tissue and potassium uptake will increase.

Table 5. Correlations of Variables

Variabel	Potassium Available	Potassium Concentrations	Potassium Uptake	Height of Plant
Potassium Concentrations	,556**			
Potassium Uptake	,427**	,684**		
Height of Plant	-0,107	-0,155	-0,252	
Number of Leaves	-,378*	-0,259	-0,061	,370*

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

3.1 Available Potassium

Potassium is one of the macro nutrients needed by plants to survive. Potassium can be derived from several sources that exist in nature. There are four different sources of potassium in the soil: (1) feldspar and mica; (2) non-exchangeable potassium in association with Klei 2: 1 minerals; (3) potassium may be exchanged or potassium available; (4) potassium derived from organic matter (Prajapati and Modi, 2012). Potassium in tobacco plants plays a role in making plants resistant to disease, producing hard and strong stems, improving starch performance and transfer of starch. Sufficient potassium levels in the plant will cause resistance to temporary drought, enzyme active regulation, increase photosynthetic intensity, accelerate the transfer of materials made during the photosynthesis process and have a positive role in the transfer of nitrogen and protein synthesis (Gholizadeh et.al., 2012).

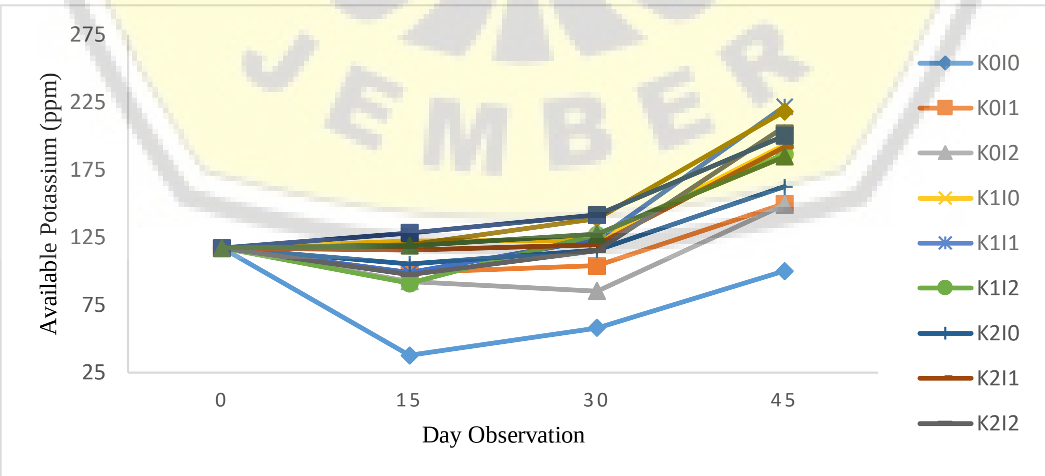

Fig. 2: Potassium content in the soil

The results showed that the treatment showed the highest increase of potassium content was a K1I1 treatment (Fig. 2) with potassium content of 221,83 ppm. Increased potassium content occurs during periodic analysis. The 45th-day analysis showed an increase in potassium content in the soil except for K0I0 treatment ie the control treatment without the addition of potassium source and bacteria inoculation.

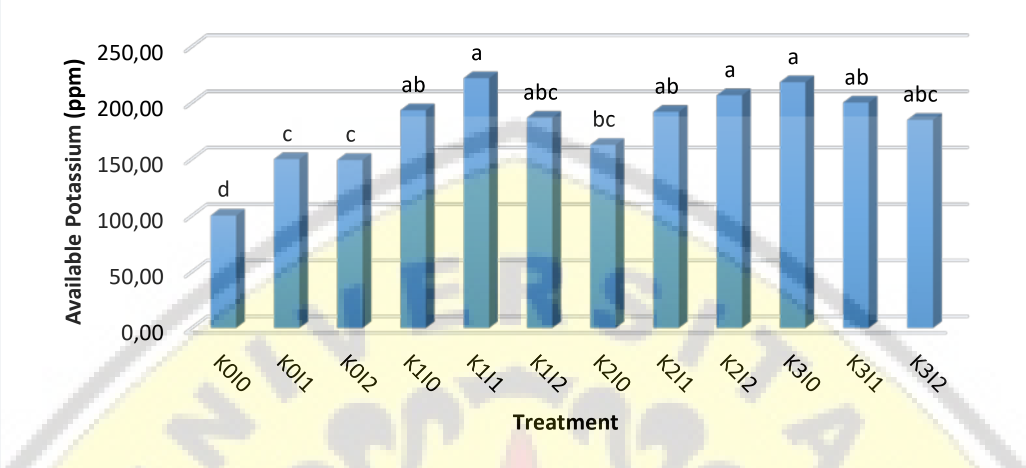

Fig. 3: Interaction effect of potassium sources and bacteria inoculation on available potassium

There is an interaction between the potassium sources and inoculation of potassium-solubilizing bacteria for the effect on the availability of potassium in the soil. The best potassium source in influencing the response of potassium content in the soil is the application of KNO_3 fertilizer. KNO_3 fertilizer clearly produces a high potassium content increase because it is easily biodegradable so it is readily available in the soil but adding leucite mineral of ringgit can gave same result with KNO_3 fertilizers.. The best treatment of inoculation potassium solubilizing bacteria influencing the response of potassium content in the soil is the inoculation of bacteria *Pseudomonas* sp. and *Pediococcus* sp., but the addition of these two types of bacteria did not differ significantly in responding to increased potassium content in the soil.

Parmar and Sindhu (2013), explained in his research that the use of potassium-solubilizing bacteria became one of the alternative technologies to make potassium available in the soil and capable of being absorbed by plants. The potassium-solubilizing bacteria may convert insoluble K-bearing minerals such as mica, illite, and orthoclases by removing organic acids or products from the polysaccharide capsule which can directly dissolve the potassium mineral and carry the K + ion into the solution (Mursyida et al., 2015). Shanware et.al. (2014) in his research explains that the ability of bacteria to decompose potassium minerals involves the production of protons, organic acids, siderophores and organic ligands. Setiawati and Mutmainnah (2016) in their research explained that potassium-solubilizing microorganisms can be solubilizing potassium from mineral with produce acid like organic acid citric, ferulic and coumaric, malic and syringic acid.

3.2 Potassium Concentrations in Plant Tissue

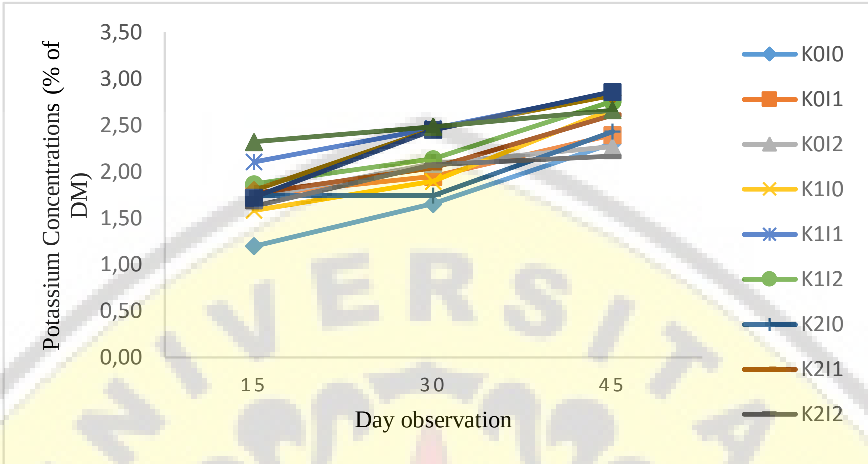

Fig. 4: Potassium Concentrations in Plant Tissue

Based on the results of the analysis, concentrations of potassium has increased (Fig. 4). The interaction between the addition of potassium sources and bacterial inoculation is not significant. This shows that there is no influence of the addition of potassium source and bacterial inoculation to potassium concentration in plant tissue. No interaction occurred, but there was an effect that occurred from a single factor that is very different in the factor of potassium source distribution and significantly different in bacterial inoculation factor (Fig. 5).

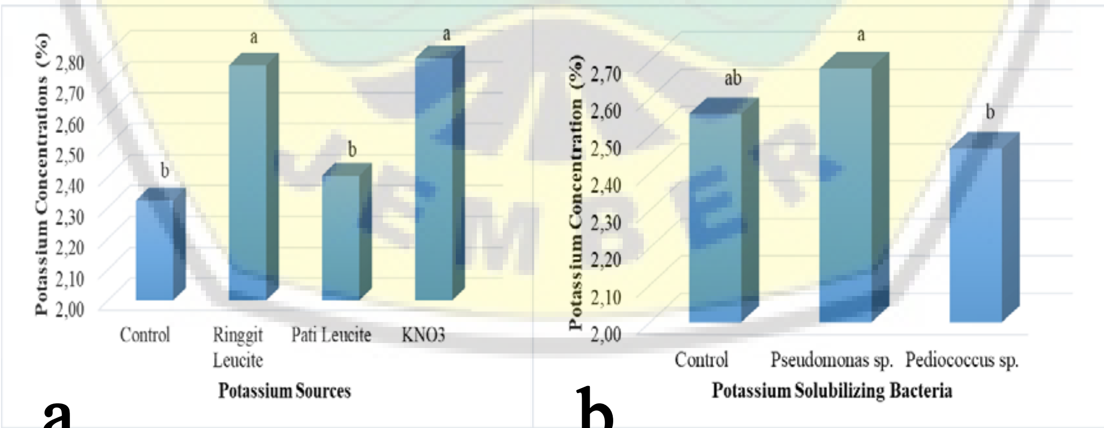

Fig. 5: The influence of single factor; a) Sources of Potassium and b) Potassium Solubilizing Bacteria on Potassium Concentrations in Plant Tissue

The results showed that the best treatment that can increase potassium concentration in plant tissue was treatment of K3I1 with potassium concentration value of 2.86%. Potassium concentration in tobacco plants should range from 2-2.5% to produce tobacco leaves of good quality (Marchand, 2010). Analysis of potassium concentration on the 15th-day, showed potassium concentrations in leaf tissue is not sufficient for potassium needs in tissues because potassium value is still below the range of adequacy. Analysis of potassium concentration on the 30th-day tissue showed an increase and its concentration was almost all sufficient treatment. Analysis of potassium concentration on the 45th day showed an increase and value of potassium concentration in some treatments over the range of adequacy. This shows that the quality of tobacco leaves produced is higher when compared with the control treatment. The higher the potassium concentrations in the leaf tissue the better the quality of the tobacco leaf.

3.3 Potassium Uptake by Tobacco Plant

This study was conducted to find out how much potassium uptake is affected by a combination of treatments. Treatment of potassium source and inoculation of potassium-solubilizing bacteria gave very distinctly different results and influenced potassium uptake by plants. The results showed that the best potassium-absorbing treatment was a K1I1 treatment of 2.57 g/kg DM. The K1I1 treatment is a combination of leucite mineral from Ringgit, Situbondo with inoculation of *Pseudomonas* sp. bacteria. The uptake of potassium nutrients is affected by the potassium content in the soil and the dry weight of the plant mass.

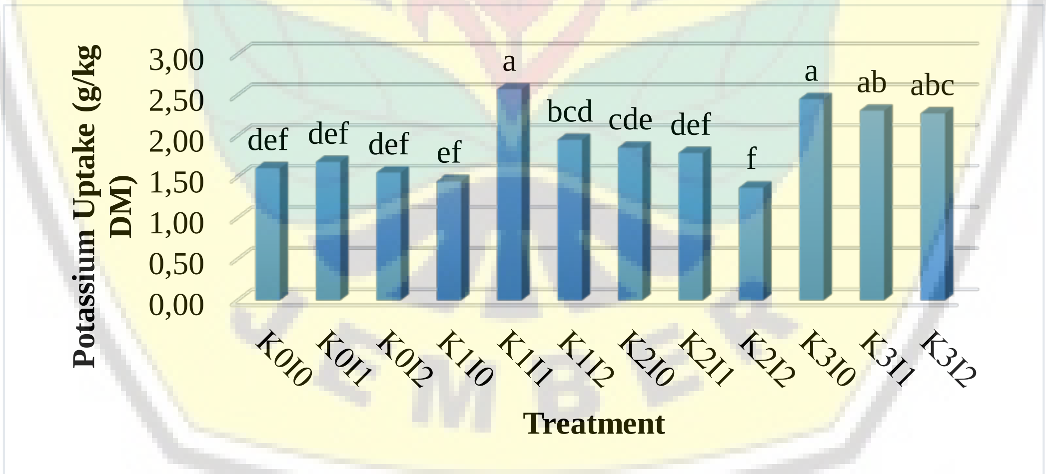

Fig. 6: Potassium uptake by tobacco day 45th

The interaction between the potassium source and bacterial inoculation differed significantly from the uptake of potassium. Sources of potassium had a very significant effect on each treatment and bacterial inoculation had a significant effect too on each treatment. The best potassium source treatment in influencing nutrient uptake response is the addition of KNO_3 fertilizer. The best bacterial inoculation in responding to potassium content in the soil is the *Pseudomonas* sp. bacteria.

3.4 Plant Growth of Tobacco Besuki Na-Oogst

3.4.1 A Height of the Plant

The best treatment that produces the highest crop is a K2I1 treatment that is the combination treatment between the supply of potassium source of Pati leucite mineral with bacterial inoculation of *Pseudomonas* sp. (Fig. 7). The optimal height generated from the K2I1 treatment is 156.67 cm. The lowest plant height is produced from the K3I0 treatment of 118.57 cm.

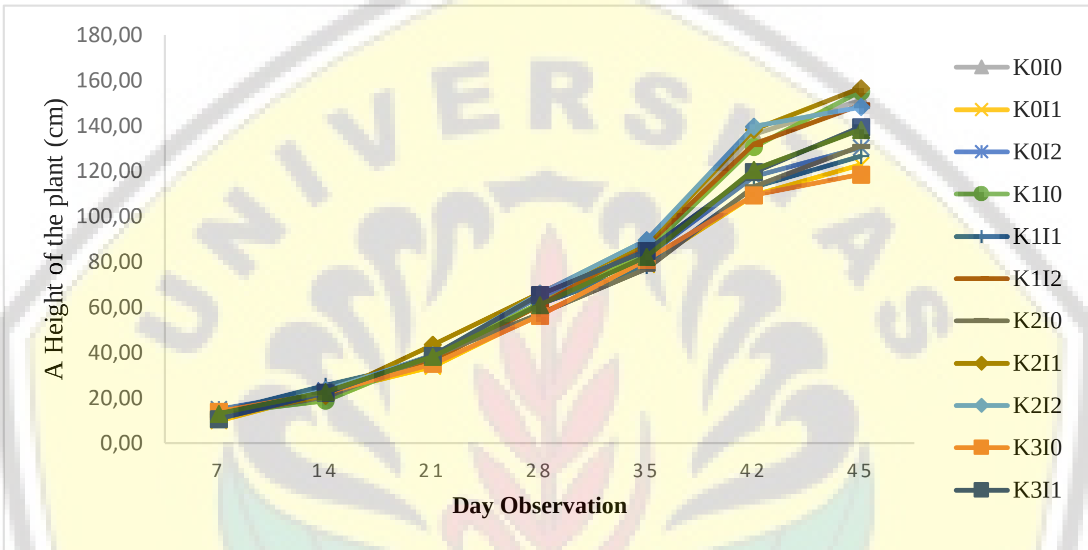

Fig. 7: Height of Tobacco Plant

The effect of interaction between the addition of potassium source and inoculation of potassium solubilizing bacteria gave very distinctly different results. However, the single factor of potassium source supply and inoculation of potassium solubilizing bacteria give different results is not real. The best source of potassium that produces the optimum plant height is the provision of leucite mineral from Mount Ringgit. The inoculation of the best potassium-solubilizing bacteria that produces the optimum plant height is without bacteria. This suggests that without the administration of potassium-solubilizing bacteria can produce optimal plant height.

Fig. 8: A Height of the tobacco plant (*Nicotiana tabacum*) Besuki Na-Oogst in the treatment: K0I0 (a); K1I0 (b); K2I0 (c); K3I0 (d)

3.4.2 Number of Leaves

The number of plant leaves is one of the observed plant growth variables. The interaction between the addition of potassium source and inoculation of potassium solubilizing bacteria was not significant, and the single factor of potassium source and inoculation of potassium solubilizing bacteria were not significant. Treatment combinations do not give a noticeable difference.

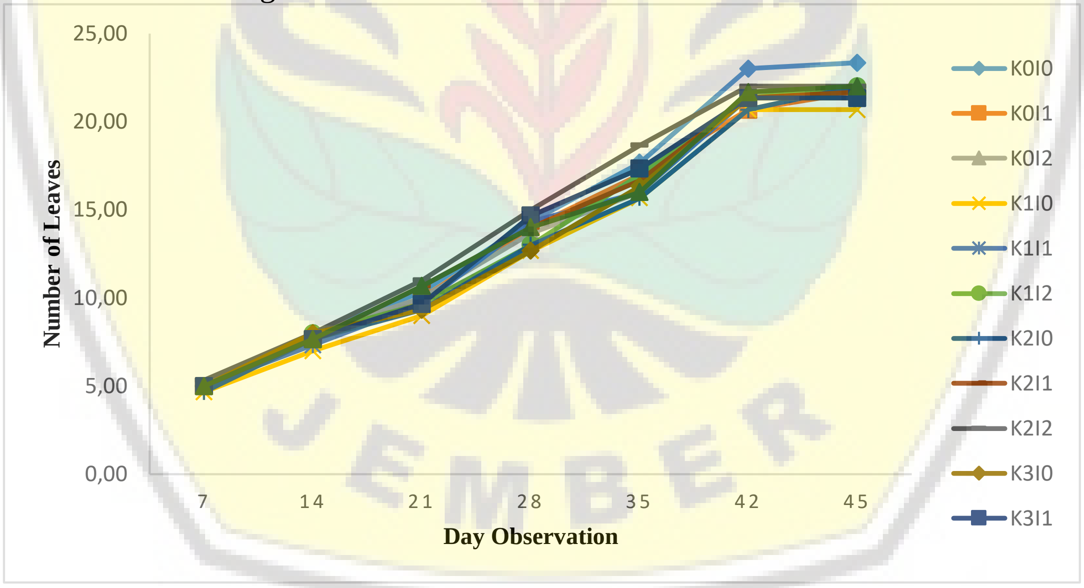

Fig. 9: Number of Leaves of Tobacco Plants

From the discussion, it can be concluded that the best potassium source treatment is the provision of KNO_3 fertilizer. However, the addition of ringgit leucite also give results comparable to the addition of KNO_3 fertilizers. While the best bacterial inoculation treatment is by bacterial inoculation of *Pseudomonas sp*. The best treatment combination was a K1I1, which was a combination of leucite ringgit addition and bacterial inoculation of *Pseudomonas* sp.

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