Jurnal Pertanian Tropik ISSN NO: 2356- 4725/p- ISSN : 2655-7576
Vol.7. No.1. April 2020 (1) 1- 7 **DOI:** https://doi.org/10.32734/jpt.v7i1.April.3679

The Effect of Different Doses and Potassium Fertilizer Sources on Growth Rate and Formation Time of Garlic Bulbs (Allium sativum L.)

Pengaruh Dosis dan Sumber Pupuk Kalium yang Berbeda terhadap Laju Pertumbuhan dan Waktu Pembentukan Umbi Bawang Putih (Allium sativum L.)

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ABSTRACT

The purpose of this research was to assess the effect of different potassium doses and fertilizer sources on growth rate and time of bulb formation of garlic (Allium sativum L.). The research was conducted in April to Agustus 2019 in Sidomukti Village, Bandungan District, Semarang Regency and at Ecology and Crop Production Laboratory, Faculty of Animal and Agricultural Sciences, Diponegoro University, Semarang. The research used a factorial randomized block design with three groups. The first factor was the dose of potassium fertilizer which consisted of a dose of 60 kg K_2O/ha, 120 kg K_2O/ha, 180 kg K_2O/ha and 240 kg K_2O/ha. The second factor was the source of potassium fertilizer which consisted of KCl, ZK, and KNO_3. Parameters that collect were a time of bulb formation, growth rate, relative growth rate and potassium absorption of the bulb. The data obtained were analyzed by analysis of variance and obtained further by the Duncan test (Duncan's Multiple Range Test) at a significance level of 5%. The results showed that the application of ZK and KNO_3 fertilizers at 240 kg K_2O/ha had been able to increase the growth rate and the relative growth rate. The higher dose of fertilizer was increasing of potassium absorption of the bulb and made time of bulb formation getting slower.

Keywords: bulb, garlic, growth rate and potassium,

ABSTRAK

Penelitian ini bertujuan untuk mengkaji pengaruh dosis dan sumber pupuk kalium yang berbeda terhadap laju pertumbuhan dan waktu pembentukan bawang putih (*Allium sativum* L.). Penelitian telah dilaksanakan pada bulan April 2019 – Juli 2019 di Desa Sidomukti, Kecamatan Bandungan, Kabupaten Semarang dan di Laboratorium Ekologi dan Produksi Tanaman, Fakultas Peternakan dan Pertanian, Universitas Diponegoro. Penelitian menggunakan Rancangan Acak Kelompok faktorial dengan tiga kelompok. Faktor pertama adalah dosis pupuk kalium yaitu: A_1 = 60 kg K_2O/ha; A_2 = 120 kg K_2O/ha; A_3 = 180 kg K_2O/ha dan A_4 = 240 kg K_2O/ha. Faktor kedua adalah sumber pupuk kalium yaitu: B_1 = KCl; B_2 =ZK; dan B_3 = KNO_3. Parameter yang diamati adalah waktu pembentukan umbi, laju pertumbuhan, laju pertumbuhan relatif dan serapan kalium umbi. Data yang diperoleh dianalisis dengan analisis ragam dan diuji lanjut dengan uji Duncan (*Duncan's Multiple Range Test*) pada taraf signifikansi 5%. Hasil penelitian menunjukan bahwa pemberian pupuk ZK dan KNO_3 pada dosis 240 kg K_2O/ha sudah mampu meningkatkan laju pertumbuhan dan laju pertumbuhan relatif. Semakin tinggi dosis pupuk maka serapan kalium umbi pun semakin meningkat dan waktu pembentukan umbi semakin lambat.

Kata kunci : bawang putih, kalium, laju pertumbuhan dan umbi

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INTRODUCTION

Garlic (*Allium sativum L.*) is a vegetable crop that has high economic value. Garlic also has a secondary function, namely as medicines ranging from cholesterol to coronary heart disease (Sulichantini, 2016). Garlic is the second most cultivated plant in the onion family after shallots (*Allium cepa*) (Nainwal et al., 2015). National garlic production in 2018 has decreased from the previous year, which was 14.4%, to 6,818 tons per hectare (BPS, 2018). Total domestic demand is only able to be fulfilled by 5% by local garlic farmers (Sholihin et al., 2016). Unstable production and the inability to meet domestic demand is caused by the attacks of suboptimal cultivation techniques, less optimum growth environment and poor storage techniques.

One form of problems in crop cultivation, in general, is inefficient fertilization. This often happens among farmers who are unable to adjust fertilizer needs optimally and efficiently, hence there is often a shortage and an excess of fertilizer dosages in the field (Putra, 2013). One of the essential elements that play an important role after nitrogen in plant metabolism is potassium. Potassium catalyzes the conversion of proteins into amino acids, carbohydrate compilers, regulates the accumulation and translocation of carbohydrates formed and activator enzymes in plant photosynthesis (Uke et al., 2015). Potassium in onion plants can stimulate plant growth at the initial level, strengthen the stems, reduce tuber decay, and be able to increase plant resistance to disease (Gunadi, 2009).

Potassium fertilizer which is widely used in Indonesia today is KCl (potassium chloride) fertilizer with 60% K_2O content. The advantage of KCl is the price is cheaper than other K fertilizers; the disadvantage is that highly chlorine content can cause poisoning in plants. High Cl^- concentration can cause membrane damage which then inhibits enzymes, thus negatively affecting photosynthesis (Purwaningrahayu, 2016). Besides, there are also other potassium fertilizers, such as potassium sulfate (ZK), potassium magnesium sulfate ($K_2SO_4 \cdot MgSO_4$), and potassium nitrate (KNO_3) (Gunadi, 2009). Potassium sulfate fertilizer has the characteristics of small granules, white in color; its nature is not hygroscopic and contains as much as 49-50% K_2O for the type of ZK-90 and 52% for the type of ZK-96.

The advantage of potassium sulfate is easily stored for a long time, dissolves easily in water and contains sulfate which is good for tubers. The disadvantage is the price of potassium sulfate is more expensive than potassium chloride. The application of K_2SO_4 is more effective than KCl, this is due to the effect of SO_4 ions on the formation of photosynthetic pigments and the assimilation of carbohydrates that are transferred to tuber filling hence it increases yield (Ahmed et al., 2009). Potassium nitrate is a fertilizer that dissolves easily in water. The KNO_3 fertilizer content consists of 13% nitrogen, 46% potassium and 2% chloride (Amiroh, 2017). The nitrogen element in white KNO_3 produces nucleic acids that play a role in the cell nucleus in the cell division process hence the formation of leaf layers can be formed properly which then develops into bulbs of onions (Utomo and Suprianto, 2019). The disadvantage of potassium nitrate fertilizer is that it has a higher price than other fertilizers.

This research aims to examine the effect of different potassium doses and fertilizer sources on the growth rate and formation time of the garlic bulb.

MATERIALS AND METHODS

The research was conducted in April - July 2019 in the Sidomukti Village Experimental Field, Semarang Regency which is geographically located at 7°11'53.2" South latitude and 110°22'36.7" East longitude with an altitude of 862 masl and Laboratory of Ecology and Plant Production, Faculty of Animal Husbandry and Agriculture, Diponegoro University.

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The materials used in this research were garlic seeds of Lumbu Hijau variety, soil, KCl fertilizer (60% K_2O), ZK fertilizer (50% K_2O), KNO_3 fertilizer (46% K_2O), SP 36 fertilizer (36% P_2O_5), urea (46.67% N), Trichoderma, PGPR (Plant Growth Promoting Rhizobacteria), Beauveria bassiana, Agrimeth, furadan, Voltraze 30 EC, Centa-zole 250 EC and water. The tools used in this research were hoe cultivators, mulch holes tools, sprayers, buckets, measuring cups, gauges, stationery, cameras, ovens and flame-photometer.

The research used factorial randomized block design with the first factor of potassium fertilizer (A) ie A1: 60, A2: 120, A3: 180, A4: 240 kg K_2O/ha and the second factor was the source of potassium fertilizer (B), namely B1: KCl, B2: ZK, B3: KNO_3 with 3 groups as replications hence there are 36 experimental units.

Research implementation includes; land preparation, basic fertilization, planting, subsequent fertilization, caring and harvesting. The first stage is; land preparation carried out with the land processed by cultivators until loose and then made beds with hoes. Beds are made with a size of 0.9 x 1.5 m as many as 36 beds.

The second stage is basic fertilization using SP-36 fertilizer with 1/3 dose of 180 kg P_2O_5/ha or 22.5 g/plot. The second stage is planting including seed preparation, potassium treatment and seed planting. Garlic seed preparation is done by selecting seeds that weigh about 1-2 g, then the seeds are mixed with 20 grams of Agrimeth and PGPR. The first treatment of potassium is done at planting or 0 WAP as much as 1/3 of the treatment dose for each source of fertilizer.

Fertilization is done by dissolving potassium fertilizer that has been weighed for one bed into 3 litres of water then poured as much as 50 ml/planting hole. The third stage is subsequent fertilization including urea fertilization, SP-36 and potassium treatment. Urea fertilization was carried out three times at the age of 21, 42 and 56 DAP with 1/3 dose of 200 kg N/ha or 19.26 g/plot. SP-36 subsequent fertilization was carried out twice at the age of 21 and 42 DAP as much as 22.5 g / plot.

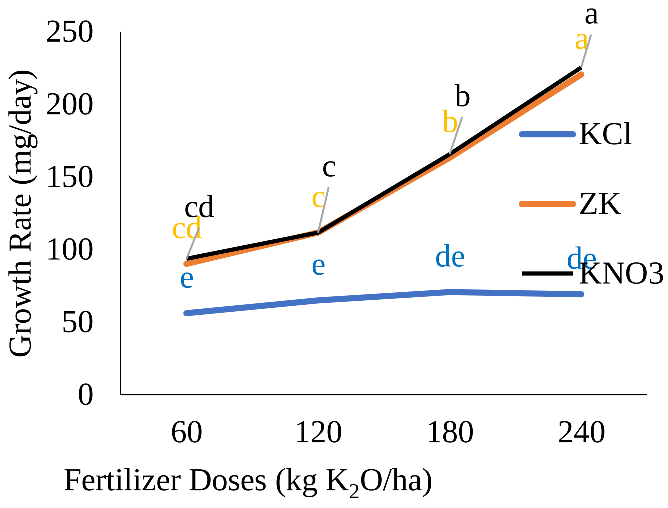

Fig 1. Growth Rate Graphic

Potassium subsequent fertilizer treatments were carried out twice at 3 and 9 WAP. The fourth stage is the plants caring, includes; watering, controlling HPT and weeding. The fifth stage is harvesting when the plants are 90 days after planting (DAP), the garlic roots are pulled out and harvesting is done simultaneously.

Observations began when the plants were 1 week after planting up to 13 weeks after planting, including the time of tuber formation, growth rate, relative growth rate and tuber uptake. The data obtained were then analyzed by variance (F test) to see the effect of treatment and continued with the DMRT test (Duncan's Multiple Range Test) at a significance level of 5%.

RESULTS AND DISCUSSION

Growth rate

Variance analysis results on the growth rate parameters showed that there is an interaction between the dose of fertilizer and the source of potassium fertilizer on the growth rate (Illustration 1).

The application of ZK and KNO_3 fertilizer has increased the growth rate along with the increase in fertilizer dosage. Whereas the application of KCl did not experience a significant increase in growth rate along with increasing doses. ZK fertilizer can provide an equivalent effect of KNO_3 fertilizer on the growth rate, this is presumably because there

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are other elements namely sulfate and nitrate which can influence the dry weight of the tubers. Gunadi (2009) stated that the sulfate content of ZK fertilizer can be used by plants to stimulate plant growth and development as well as tuber yields.

This is also supported by the opinion of Hilal et al. (1992); Mazrouh and Ragab (2000) which stated that sulfur was found to improve soil structure, facilitate water absorption and availability of nutrients for garlic plants. Ahmed et al. (2009) stated that the application of K_2SO_4 is more effective than KCl, this is due to the influence of SO_4 ions on the formation of photosynthetic pigments and the assimilation of carbohydrates that are diverted for tuber filling hence increase yield. While the effect of nitrate on KNO_3 fertilizer is thought to be able to increase biomass because nitrate functions to stimulate cell division, thus making more garlic bulb layers. This is in accordance with the opinion of Utomo and Suprianto (2019) which stated that nitrate in KNO_3 plays a role in producing nucleic acids, which stimulates cell division to form leaf layers properly and then forms layers of tubers.

Relative Growth Rate

Variance analysis results on growth rate parameters showed that there was an interaction between fertilizer dosage and potassium fertilizer source on the relative growth rate of garlic (Illustration 2).

The application of ZK and KNO_3 fertilizers increased relative growth rates along with increasing fertilizer doses. KCl application at a dose of 60-180 kg K_2O/ha increased relative growth rates but at a dose of 240 kg K_2O/ha it decreased. The application of KCl fertilizer with a high dose gives the same response to the lowest dose, this is suspected because the potassium content can inhibit plant growth, as well as the Cl- ion which can be toxic to garlic. This is in accordance with the opinion of Aslamiah and Sularno (2017) which stated that the application of fertilizers in accordance with the needs of plants will provide a positive response, but with the addition of high doses can inhibit plant growth.

The application of ZK and KNO_3 at a dose of 180 kg K_2O/ha has been able to increase the relative growth rate. ZK or K_2SO_4 fertilizer has an equivalent effect with KNO_3 fertilizer, it is suspected that there are other elements, namely sulfate and nitrate, which can influence the increase of garlic biomass.

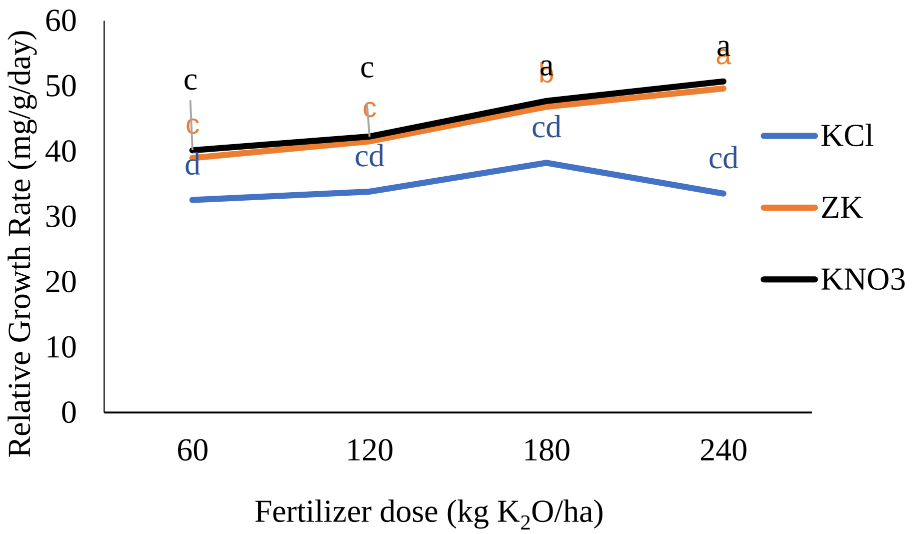

Fig 2. Relative Growth Rate Graph

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This is consistent with the opinion of Ahmed et al. (2009), who stated that the application of K2SO4 is more effective than KCl, due to the influence of SO4 ions on the formation of photosynthetic pigments and the assimilation of carbohydrates that are diverted for tuber filling hence increase yield. The effect of nitrate on KNO3 fertilizer is thought to be able to increase biomass because nitrate functions to stimulate cell division thus forming a lot of tuber layers. This is in accordance with the opinion of Utomo and Suprianto (2019), who stated that nitrate in KNO3 plays a role in producing nucleic acids, which stimulate cell division to form the leaf layer properly and then form a layer of tubers.

Bulbs/Tubers Formation Time

Variance analysis results in the time parameters of tuber formation showed that there was a significant effect of fertilizer dosage on the time of tuber formation (Table 1).

Doses of fertilizer at 180 and 240 kg K_2O/ha have the same effect and significantly different compared to fertilizer dosages at 60 and 120 kg K_2O/ha on the time of bulb formation, the higher the dose of potassium fertilizer, the slower the formation time of the tubers. Vice versa, with a low dose of fertilizer, tuber formation accelerates. This is presumably due to the higher availability of nutrients for garlic and with low-temperature conditions on the 68th day which is 22^{o}C causing deceleration in the tuber formation where the plant will focus on the vegetative phase. A low dose of fertilizer causes low nutrient availability and with high-temperature conditions on the 60th day (25.1^{o}C) is making garlic plants accelerate the formation of tubers. Wu et al. (2016) stated that the time to form tubers in garlic varies based on the condition of the ambient temperature, at temperatures of 15^{o}C, 20^{o}C and 25^{o}C respectively, the average time of tuber formation is 101.56 days, 69.06 days and 56.83 days hence the higher the temperature the acceleration of tuber formation occurs. High environmental temperature conditions can stimulate the formation of tubers more quickly because garlic experiences temperature stress. This is consistent with the opinion of Hickey (2012), who stated that the acceleration of tuber formation time occurs when the ambient temperature and the exposure time are increasing.

Table 1. Time of garlic bulbs/Tubers Formation affected by different fertilizer doses and sources of potassium fertilizer

Fertilizer Dose (kg K_2O/ha)	Fertilizer Sources			Averages
	KCl	ZK	KNO_3	
		----(hst)----		
60	63,15	59,65	58,48	60,42^{b}
120	58,19	60,52	61,98	60,23^{b}
180	67,52	69,27	69,27	68,69^{a}
240	66,94	65,63	69,42	67,33^{a}
Averages	63,95	63,77	64,79	

*Different superscripts in the average column showed significant differences ($p < 0.05$)

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Table 2. Potassium uptake of garlic tubers affected by different fertilizer doses and sources of potassium fertilizer

Fertilizer Doses (kg K_2O/ha)	Fertilizer Sources			Averages
	KCl	ZK	KNO_3	
	-----(mg/umbi)-----			
60	38,69	40,76	46,72	42,06[b]
120	48,67	53,74	49,89	50,77[b]
180	66,85	82,06	75,51	74,81[a]
240	63,35	97,48	65,10	75,31[a]
Averages	54,39	68,51	59,30	

* Different superscripts in the average column showed significant differences ($p < 0.05$)

Tuber Potassium Uptake

Variance analysis results in the parameters of tuber potassium uptake showed that there was an effect of the dose of potassium fertilizer on garlic's tuber potassium uptake (Table 2).

Doses of fertilizer at 180 and 240 kg K_2O/ha have the same effect on potassium absorption and are significantly different compared to doses of 60 and 120 kg K_2O/ha. These results are in accordance with the research of Arisha et al. (2017), which stated that the application of potassium fertilizer at doses of 180 and 240 kg K_2O/ha provides the highest potassium uptake in roots, tubers and garlic leaves compared with the application of potassium at doses of 0,60 and 120 kg K_2O/ha. The higher the dose of potassium fertilizer applied, the higher the potassium absorbed by garlic. This is according to the opinion of Shafeek et al. (2013), who stated that the value of N, P and K in the tuber network increases with the increasing levels of potassium fertilizer from 0 to 350 kg K_2O/ha.

Potassium fertilizer is absorbed by plants in the form of K+ ions, the opening of plant stomata is caused by the large number of K+ ions contained in guard cells hence it can result in decreased osmotic potential and is followed by increased turgor cell pressure. Marschner (2012) stated that potassium plays a role in stimulating water absorption as a result of the presence of K+ ions, hence it will spur turgor cell pressure which results in the process of opening and closing the stomata.

CONCLUSION

Based on the research conducted it can be concluded that the application of ZK and KNO3 fertilizers increased the growth rate along with the increase in fertilizer dosage. Doses of fertilizer at 180 and 240 kg K2O/ha have the same effect on potassium absorption and are significantly different compared to doses of 60 and 120 kg K2O/ha, the higher the dose of potassium fertilizer, the slower the time formation of the tubers.

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ACKNOWLEDGEMENT

Thank you PT Indofood Sukses Makmur Tbk for sponsoring this research in the context of the 2019/2020 Nugraha Research Indofood Program.

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DOI: https://doi.org/10.32734/jpt.v7i1.April.3679

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