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The Test of Genotype Adaptation of Several Garlic Varieties on the Highland

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Abstract: This study aims to determine the growth patterns of four types of local garlic (*Allium sativum L.*) and to obtain the adaptive appearance of the agronomical characteristics with maximum tuber weight in two different altitude places. The research was conducted in the Borah garlic farmer garden, Wiyurejo village, Pujon subdistrict, Batu city with an altitude of 1200 m above sea level, daily temperature of 15-20°C and average rainfall of 21.400 millimeter/year and in the UB pilot garden of Cangar, Tulungrejo Urban village, Bumiaji Sub district, tourism city of Batu with an altitude of 1600 m above sea level, daily temperature of 17.5-22.8°C and average rainfall of 2733 millimeter/year/year. The experimental design used was a Nested completely randomized design. The parameters observed were measuring plant variables consisting of plant height, number of leaves, leaf area, tuber diameter, tuber wet weight, tuber dry weight and tuber dry weight (tons per hectare). The results showed that the best growth pattern occurred at an altitude of 1600 m above sea level with 10 weeks after planting/meters sea level (weeks after planting). On the other hand, the highest weight is found in the type of Atsabe (3.932ton ha^{-1}) but not significantly different from Saigon (3.735ton ha^{-1}) at altitude of 1600 m above sea level as well as genotype of Saigon (3.628ton ha^{-1}) and Atsabe (3.355ton ha^{-1}) at altitude of 1200 m above sea level. Besides that, the highest percentage of *allicine* is found in the varieties of Atsabe (19.18%) and the lowest is found in the varieties of Sembalun (4.87%) at an altitude of 1200 m above sea level. For the growth and productions of local garlic plants from the four varieties, it is recommended to use Saigon and Atsabe genotypes at altitudes of 1600 m above sea level and 1200 m above sea level.

Keywords: Altitude, Garlic, Genotype, Tuber Yield, Growth

Introduction

Garlic (*Allium sativum L.)* is one of the products of horticultural plants that have a high demand. High demand is based on high consumption. Indonesia is an agrarian country that has high demand for garlic products and has high consumption, but the consumption is not balanced or in accordance with production that is capable of or can be produced by the Indonesian country so it must carry out the import policy of garlic at the time of the high demand of garlic so that the supply of garlic in Indonesia increases. Garlic bulbs/tuber is widely used as cooking spices. Besides being consumed as a cooking spice, it is also consumed either as raw vegetables (fresh or dried clove leaves), or after being processed in the form of oil, extracts and even powder. Garlic is one of the most important tuber crops produced by small and commercial farmers for local use and export (Metasebia and Shimelis, 1998; Diriba-Shiferaw *et al*., 2013). The main qualities of garlic products are the different flavors, as a result of complex biochemical reactions (Randle and Lancaster, 2002; Doi *et al*., 2019; Wang *et al*., 2019; Kim *et al*., 2019; Yang *et al*., 2019). There are differences in chemical composition and, consequently, the content of bioactive compounds is observed among available garlic formulations (Lanzotti *et al*., 2014). The center of garlic in Indonesia is generally concentrated in Java Island. Based on exploration survey, about 72% of garlic planting areas are in Java (Buurma, 1991). Most of the planting of garlic in Java (66%) conducted in the highlands (> 700 m above sea level). The main garlic varieties cultivated in the highlands are Lumbu Hijau, Tawangmangu, Lumbu Kuning, Gombloh and Tes.

The need for garlic from year to year continues to increase in line with the increasing number of population, the improvement of the national economy and the increasing public knowledge of the importance of nutrition of these commodities. However, this increase has not been able to be offset by the increase in production. From the references we can identify that either the harvest area and production have increased from year to year, while yield productivity is still low even though it has increased especially since 1991 so that it has not been able to meet population consumption needs because there is a tendency for imports of garlic bulbs/tuber increasing from year to year, this is related to a less optimum growing environment and high yield loss due to inadequate tuber storage techniques at the farmer level (Hilman *et al*., 1991). Thus, it is recommended that the use of good and healthy seeds can determine the quality of crop yields. Tuber size is one of the factors that can affect the presence of vigor, yield and quality (Copeland and McDonald, 2001; Goldy, 2000; MACB, 2008). In essence the farmers use makeshift planting material regardless of the size of the bulbs/tuber which will guarantee the growth, yield and quality.

The low production of local garlic one of the reasons is the low land area and productivity. In addition, the quality of the seeds of garlic used is low, the growing environment is less optimum and the high yield loss due to inadequate storage techniques is also one of the causes of the low production of garlic (Woldewahid *et al*., 2010; Tomšik *et al*., 2019). Apart from its importance (increasing the production and productivity of garlic), on the one hand, the production of garlic is low, because of genetic and environmental factors that affect the yield and nature of production (Nonnecke, 1989; Getachew and Asfaw, 2000; Widodo *et al*., 2008; Rai, 1992). Factors that affect the availability of garlic in Indonesia, the response of the availability of garlic in Indonesia as well as the projection of domestic production over the next few years so that it can find out Indonesia's ability to achieve self-sufficiency especially garlic. This study is important to note because to these two heights no research has been carried out to explore and characterize local Garlic plants by studying the morphological and agronomical aspects of plants to describe plants as well as patterns of plant growth and development. Specifically this research is aimed to obtain an adaptive response of growth patterns and has the potential for production yield and secondary metabolites (quality) from four types of local garlic at altitudes of 1200 and 1600 m above sea level.

Research Methods

This research was held in two different locations of height and was carried out in January 2018 until November 2018 and the heights of the different places referred to above are:

a. Plains with an altitude of 1200 m above sea level, in the garden of Borah garlic farmer, Wiyurejo village, Pujon subdistrict, administrative city of Batu with a daily temperature of 15-20°C and an average rainfall of 21.400 millimeter/year
b. Highland of 1600 m above sea level, in the pilot garden of UB Cangar, urban village of Tulungrejo, sub district of Bumiaji, tourism city of Batu with an altitude of 1600 m above sea level, the daily temperature of 17.5-22.8°C and an average rainfall of 2733 millimeter/year

Tools and Materials

The tools used in this study namely; oven, digital caliper, analytical scales, hands prayer, measuring cylinder, bucket, stirrer, ruler and planting aid (*garden tools*) and the planting material used in the study namely local garlic genotype from four genotypes (Layur, Saigon, Sembalun and Atsabe), chicken manure, NPK Phonska and PGPR basic fertilizers.

Research Methods

This study was designed with a nestead randomized design with Four treatments, each treatment four replications. The first factor is the altitude (T) namely; T1 = 1200 m above sea level and T2 = 1600 m above sea level the second factor is genotype (V) with four levels namely; V1 = Saigon and V2 = Layur, V3 = Atsabe, V4 = Sembalun. The combination of each altitude with the genotype has 16 combinations of unit experiments.

Research Implementation

The treatment was carried out in an experimental plot after the tillage and preparation of the planting had been completed. Planting was carried out by making 1×3 m planting plots and planted by drill method at a depth of 5 cm. The distance between plots 0.3 m and the distance between blocks 0.4 m. The spacing used is 20×20 cm with a trial plot of 7×3 m. As a basic fertilizer is 15 tonh^{-1} chicken manure, 800 kg Phonska/h^{-1} and phonska which given 2 stages; the first stage is 400 kg as basic fertilizer and the second stage is 400 kg at 30 days after planting/WAP, 350 kg ZA and two weeks after planting/meters sea level PGPR is given. To find out the differences in character between provenances that describe the genotype, then the observations were made during the period of growth from planting to production. Maintenance includes; weeding weeds, pest control, fertilization and watering.

Observation Variable

Observation variables were carried out by observing agronomical and morphological characteristics. Plant observations include; plant height (cm), number of leaves (strands), leaf area (cm), number of cloves per plant, tuber diameter(mm), tuber wet weight (kg), tuber dry weight(kg) and tuber dry weight tons per hectare (t/ha^{-1}).

Analysis of Plant Growth

Observations were made on the growth of local garlic plants "Layur, Saigon, atsabe and Sembalun" namely: Aspects of growth include: Total dry weight per plant, total leaf area per plant.

Data Analysis

Data from the observations were analyzed using SAS software version 9.3.1 (analysis of variance), if it shows a significant effect then proceed with the BNJ Test at the level of α 0,05.

Results and Discussion

From this study it can be concluded that the pattern of plant growth in the two soil characteristics at an altitude of 1600 m above sea level and 1200 m above sea level, can present plant growth from 4 local garlic genotypes, starting in plants aged 2, 3, 4, 6, 8, 9, 10,15 days after planting, As for the growth patterns of plant height, number of leaves, leaf area index, number of cloves per tuber, fresh weight of tubers and dry weight of tuber at an altitude of 1200 m above sea level and 1600 m above sea level each are presented in the following Table.

Plant Height

Based on the results of variance analysis showed that the treatment of genotypes at various heights was significantly different on the height of the garlic plants aged of 2, 4, 6, 8 and 10 weeks after planting/meters above sea level the plant height increased from 2 weeks after planting/meters above sea level until 10 weeks after planting/meters above sea level. The response of plant height was started on plants aged two weeks after planting/meters above sea level where the Sembalun genotype at 1600 m above sea level with an average plant height higher (9.53 cm) but not significantly different from the Atsabe genotype treatment (8.51 cm) at an altitude of 1600 m above sea level and Sembalun genotype (7.81 cm) at an altitude of 1200 m above sea level. In the plant aged four weeks after planting/meters above sea level, the Sembalun genotype at an altitude of 1600 m above sea level has the highest average plant height (16.74 cm) compared to genotypes at various other heights but not significantly different from the Atsabe genotype (15.37 cm) at an altitude of 1600 m above sea level. In plants aged 6, 8 and 10 weeks after planting, the Sembalun genotype at an altitude of 1600 m above sea level shows the highest plant height (23.00, 27.99 and 41.80 cm) compared to genotypes at other heights. As for the treatment effect on the height of garlic plants in the age of 2, 4, 6, 8 and 10 weeks after planting/meters above sea level can be seen in Table 1.

Leaves Area Index

Garlic leaves area index on plant aged 2, 4, 6, 8 and 10 weeks after planting. Growth response of leaf area index increased starting from 2 weeks after planting to 10 weeks after planting. Growth of leaf area index in the observation of 2 weeks after planting where the Sembalun genotype (0.61 cm^2.tan^{-1}) at an altitude of 1200 m above sea level shows the leaf area index was higher but not significantly different from the sembalun treatment at the altitude of 1600 m above sea level and saigon genotype (0.57 cm^2.tan^{-1}) at an altitude of 1200 m above sea level.

Table 1: Average of plant height at various ages of local garlic growth towards the place height/altitude

		Plant height (cm) at the age of weeks after planting (WAP)				
Altitude (mASL)	Genotype	2	4	6	8	10
1200 (T1)	Saigon (V1)	4.56a	9.24A	14.65a	17.85a	21.76b
	Layur (V2)	5.74abc	9.62Ab	14.46a	16.44a	19.01a
	Atsabe (V3)	7.00bcd	13.17cd	17.82b	21.70bc	26.79c
	Sembalun (V4)	7.81de	13.90de	20.52c	23.76cd	32.51d
1600 (T2)	Saigon (V1)	5.30ab	11.10ab	17.75b	20.75b	27.82c
	Layur (V2)	7.15cd	11.64bc	14.39a	18.39a	20.80ab
	Atsabe (V3)	8.51de	15.37ef	20.36c	25.12d	31.21d
	Sembalun (V4)	9.53e	16.74f	23.00d	27.99e	41.80e
	LSD	1.73	2.02	2.47	2.18	2.37
	CV (%)	17.1	11.00	9.48	6.95	5.83

Information: Numbers accompanied by the same letter on the same row and column are not significantly different at the 5% LSD test, WAP = Weeks After Planting, CV = Coefficient of Variation. mASL = meters above sea level

Table 2: Average of Leaves Area Index at various ages of local garlic plants towards the place heights/altitude

Altitude (mASL)	Genotype	Leaf Area Index (cm^2 tan^{-1}) at the age of Weeks After Planting (WAP) 2	4	6	8	10
1200 (T1)	Saigon (V1)	0.57de	0.56f	0.93b	0.93b	0.82C
	Layur (V2)	0.23b	0.29b	0.37a	0.37a	0.29A
	Atsabe (V3)	0.28bc	0.35c	0.94b	0.94b	0.85B
	Sembalun (V4)	0.61e	0.62g	1.02b	1.02b	0.99D
1600 (T2)	Saigon (V1)	0.32c	0.35c	0.66bc	0.94b	0.83C
	Layur (V2)	0.06a	0.25a	0.27a	0.36a	0.52B
	Atsabe (V3)	0.33c	0.36d	0.76cd	0.96b	0.86C
	Sembalun (V4)	0.52d	0.55e	0.88e	1.15c	1.05D
	LSD 5%	0.069	0.026	0.108	0.115	0.093
	CV (%)	12.95	0.42	12.04	9.46	8.24

Information: Numbers accompanied by the same letter on the same row and column are not significantly different at the 5% LSD test, WAP = Weeks After Planting, CV = Coefficient of Variation., mASL = meters above sea level

In plants aged 4 weeks after planting/meters above sea level, the sembalun genotype at an altitude of 1600 m above sea level showed the highest leaf area index (0.74 cm^2.tan^{-1}) compared to genotypes at other heights but not significantly different from the treatment of the Sembalun genotype (0.78 cm^2.tan^{-1}) at an altitude of 1200 m above sea level. In plants aged 6 weeks after planting/mst, Sembalun genotype at an altitude of 1600 m above sea level shows the highest leaf area index (0.88 cm^2.tan^{-1}) compared to other treatments. In plants aged 8 weeks after planting/mst, Sembalun treatment at an ltitude of 1600 m above sea level shows the highest leaf area index (1.15 cm^2.tan^{-1}) significantly different from other genotypes.

In plants aged 10 weeks after planting/meters above sea level, Sembalun treatment at an altitude of 1600 m above sea level shows the highest leaf area index (1.05 cm^2.tan^{-1}) but not significantly different from the Sembalun genotype (0.99 cm^2.tan^{-1}) at an altitude of 1200 m above sea level and the Atsabe genotype (0.85 cm^2.tan^{-1}) at an altitude of 1200 m above sea level.

Number of Leaves

Based on the results of variance analysis, it was shown that the treatment was significantly different towards the number of leaves on the plant aged 2, 4, 6, 8 and 10 weeks after planting/meters above sea level. The number of leaves increased starting from 2 weeks after planting to 10 weeks after planting. The response of the number of leaves began in plants aged 2 weeks after planting where the sembalun genotype at an altitude of 1600 m above sea level showed a higher number of leaves (0.52 cm^2 tan^{-1}) and significantly different from the Atsabe genotype (0.33 cm^2 tan^{-1}) at an altitude of 1600 m above sea level.

In plants aged 4 weeks after planting/meters above sea level, the Sembalun genotype at an altitude of 1600 m above sea level shows the highest number of leaves (0.55 cm^2 tan^{-1}) but not significantly different from the genotype of Atsabe (0.36 cm^2 tan^{-1}) and saigon (0.35 cm^2 tan^{-1}) at an altitude of 1600 m above sea level and the genotype of sembalun (0.62 cm^2 tan^{-1}) and Saigon (0.56 cm^2 tan^{-1}) at an altitude of 1200 m above sea level. In plants aged 6 weeks after planting/meters above sea level, the Sembalun genotype at an altitude of 1200 m above sea level shows the highest number of leaves (1.02 cm^2 tan^{-1}) but not significantly different from the genotype of Atsabe (0.94 cm^2 tan^{-1}) and Saigon (0.93 cm^{2}tan^{-1}) at an altitude of 1600 m above sea level and genotype of Sembalun (0.88 cm^2.tan^{-1}) and not significantly different from Atsabe (0.94 cm^2.tan^{-1}) and Saigon (0.93 cm^{2}tan^{-1}) at an altitude of 1200 m above sea level.

In plants aged 8 weeks after planting/mst, the Sembalun genotype shows the highest number of leaves (1.02 cm^2 tan^{-1} and 1.15 cm^2 tan^{-1}) compared to other genotypes at an altitude of 1200 and 1600 m above sea level. In plants aged 10 weeks after planting/mst, the Sembalun genotype at an altitude of 1200 m above sea level shows the highest number of leaves (1.05 cm^2 tan^{-1}) and but not significantly different from the Atsabe genotype (0.86 cm^2 tan^{-1}) at an altitude of 1600 m above sea level. As for the effect of treatment towards the number of leaves of garlic plants on the age of 2, 4, 6, 8 and 10 weeks after planting/meters above sea level can be seen in Table 3.

Plant yield Components from Four Local Garlic Genotypes at an Altitude of 1600 and 1200 m Above Sea Level

The results of the variance analysis showed that the altitude and genotype had a significant influence on the

local garlic plant yield component among Sembalun, Saigon, Atsabe and Layur including tuber diameter, number of cloves, tuber wet weight, tuber dry weight and tuber dry weight per hectare (t ha^{-1}).

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Table 3: Average number of leaves at various ages of plants

		Number of Leaves (strands) at the age of weeks after planting (WAP)				
Altitude (mASL)	Genotype	2	4	6	8	10
1200 (T1)	Saigon (V1)	2.03ab	2.33a	3.20ab	4.00bc	4.83c
	Layur (V2)	2.20bc	2.75b	2.85a	3.25a	3.28a
	Atsabe (V3)	2.70c	3.23c	4.05c	5.43d	6.63e
	Sembalun (V4)	2.55bc	3.35c	4.40cd	5.43d	7.50f
1600 (T2)	Saigon (V1)	1.53a	2.60ab	3.35b	4.20c	5.63d
	Layur (V2)	2.20bc	2.70ab	3.03ab	3.55ab	3.98b
	Atsabe (V3)	2.40bc	3.43c	4.23cd	5.60d	6.58e
	Sembalun (V4)	2.35bc	3.53c	4.60d	6.33e	7.25f
LSD	0.62	0.41	0.45	0.62	0.47	
CV (%)	19.00	9.39	8.31	9.01	5.70	

Information: Numbers accompanied by the same letter on the same row and column are not significantly different at the 5% LSD test; WAP = Weeks after planting, mASL: Meters above sea level

Tuber Diameter

The average of plant yield component of local garlic at harvest due to altitude and type of genotype. The results of the variance analysis showed that the highest average tuber diameter in the Saigon genotype (4.34 mm) at an altitude of 1200 m above sea level and significantly different from the genotype at other heights while the smallest average tuber diameter was found in the Layur genotype (1.91 mm) at an altitude of 1200 m above sea level.

Number of Cloves Per Tuber

The genotypes at various heights have significantly different towards the number of cloves per tuber. The results of the variance analysis showed that the highest average number of cloves per tuber in the Saigon genotype (8.2) at an altitude of 1200 m above sea level and was significantly different from other genotypes while the least average number of cloves per tuber in the Layur genotype (4.2) at an altitude of 1200 m above sea level.

The Weight of Tubers Per Plot

Based on the results of variance analysis showed genotypes at various heights were significantly different towards tuber weight per plant. The highest average tuber weight per plant is in the Saigon genotype (4.982 kg) at an altitude of 1200 mASL and significantly different from other genotypes. While the smallest average tuber weight per plant was found in the Layur genotype (1.526 kg) at an altitude of 1200 m above sea level.

Tuber Dry Weight Ton Per Hectare

Based on the results of the variance analysis, showed the highest average weight of dry tubers ton/ha (t ha^{-1}) was found in the Atsabe genotype (3.932) at an altitude of 1600 mASL but not significantly different from the Saigon genotype (3.735) at an altitude of 1600 mASL and the genotype Saigon (3.628) and Atsabe (3.355) at an altitude of 1200 m above sea level.

The Content of Allicin Compounds

Based on the qualitative analysis result of the content of bioactive compounds contained from the 4 local garlic genotypes at an altitude of 1200 m above sea level showed that the Atsabe genotype had a highest Allicin content but was significantly different from the genotype of Saigon and Layur while the lowest quality of allicin is found in the Sembalun genotype.

The results of the variance analysis showed that the highest percentage of allicine levels was found in the Atsabe (19.18%) at an altitude of 1200 m above sea level but not significantly different from the Saigon (15.75%) at an altitude of 1600 m above sea level, while the smallest percentage of allicine was found in the Sembalun genotype (4.87%) at an altitude of 1200 m above sea level. And also that the qualitative analysis result of allicine with LC-MS/MS for the percentage of 4 local Garlic varietas at altitude 1200 m above sea level was the highest in the Atsabe which had the highest level of allicine compounds and not different from the Saigon genotype but significantly different from other varieties. Whereas for the genotype in Cangar, the highest percentage of allicine compounds from the 4 local Garlic genotypes found in the Saigon genotype was not different from the Layur but was significantly different from the Sembalun varieties. (Khar *et al.*, 2011) also observed the presence of variations in sulfoxide content among 93 garlic ecotypes and stated that breeding status, morphological features (tuber color) and place of origin had a significantly lower influence on chemical composition than the genetic background of the cultivar concerned. According to (Beato *et al.*, 2011), the selection of cultivars can be a useful way to increase the total phenolic and ferulic acid content, regardless of growth conditions. (Chen *et al*., 2013). Allicine is unstable (Amagase, 2006), so prone to further reactions, depending on processing conditions or other external factors such as storage, temperature, etc.

Discussion

Apparently, based on the Table presented above, starting from age of plant roots appears, the number of roots, root length, plant height, number of leaves, leaves area index, stem diameter, tuber diameter per plant, number of cloves per tuber, tuber wet weight, tuber dry weight, both types of land are both increasing but there are big differences. At an altitude of 1600 m above sea level, observations of all the variables that have been produced are much higher than those on the ground at an altitude of 1200 m above sea level, where this occurs because of the variety of soil characteristics. Differences in soil quality as plant media influence plant growth and development. Plant growth and development are life processes and propagation where it depends on the results of assimilation, hormones and growth of substances and environments that support and produce growth patterns (Gardner *et al*., 1991).

The pattern of plant growth from four types of garlic at different heights showed that the Sembalun genotype with the response of the number of leaves, leaf length, leaf width, leaves area index, plant height and garlic biomass is the highest compared to other genotypes planted in two different places. Growth in the number of leaves on local garlic plants planted at an altitude of 1200 m above sea level is less than the garlic plants planted at an altitude of 1600 m above sea level and show stunted growth. This is related to the characteristics of the soil in Pujon which has a high acidity level, namely; pH 5.3 (H_2O), 4.6 (KCl) with C-organic 1.12%, N total 0.13%, C/N 9, P. Bray 36.57 mg kg^{-1}, CEC 26.97 me/100g, Wet saturation 51%, containing 41% sand, 33% dust, 26% clay with loam texture (Analysis of the Laboratory of Soil Chemistry at Universitas Brawijaya, 2018). The low pH content causes a high level of soil acidity which will cause low soil fertility and become an obstacle in its utilization (McCormack, 2012). High soil acidity also results in delays in the availability of nutrients both macro and micro nutrients and poor drainage as well as hydrolysis of organic acids (Goronski *et al*., 2010). Limin *et al*. (2000) added that the high Cation Exchange Capacity (CEC) and low wet saturation will also be obstacles so that the plants are unable to grow and develop better. This can be seen from plants that grow languish and the number of leaves is relatively small. Conversely, the pattern of growth in the number of leaves at an altitude of 1600 m above sea level tends to be more than the height of 1200 m above sea level. At that height, it has a fairly good aeration, drainage and organic matter content. Soil characteristics in Cangar have a pH content of 5.7 (H_2O), 4.9 (KCl) with C-organic 4.00%, N total 0.47%, C/N 8, P. Bray 21.45 mg kg^{-1}, CEC 33.90 me/100g, Wet saturation 50%, containing 41% sand, 46% dust, 13% clay with loam texture (*sandy loam*).

This type of soil is predominantly sandy so it has porous soil with sufficient C-organic (4.00%), C/N 8 and CEC 33.90 me/100g make the land able to withstand the availability of water in the soil and provide a better growing environment to support the growth and development of local garlic plants. Soils with high organic matter content will be preferred because they have higher moisturey and nutrient-retaining capacity and are less susceptible to cracking and compaction. (Bodnar *et al*., 1998). The use of organic fertilizers helps in structuring loam soils to open and enter water penetration to root and drainage, both of which are needed for satisfying plant growth (Eimhoit *et al*., 2005). Although garlic is a plant that is bred asexually and reproduces only in a vegetative manner, a large number of different ecotypes diversity have evolved over time in various areas of cultivation (Bradley *et al*. 1996; Avato *et al*., 1998; Baghalian *et al*., 2005). Different ecotypes show large morphological diversity in tuber and leaf size, color and shape, presence of scales and height, as well as flower color, fertility and development of tubers (topset) during inflorescence (Pooler and Simon, 1993). Thus, evaluation on the genetic resources of garlic through morphological properties and molecular markers will enable us to better understand variations between accessions and choose accessions that are in accordance with the desired character for breeding programs. The difference in soil quality as a growing medium will affect plant growth and development.

Table 2, showing the results of plant growth from the 4 types of garlic at different heights shows the result that the Sembalun genotype with the highest garlic leaf area index response compared to other genotypes treatment at the two different places. Leaf area index in local garlic plants which planted at an altitude of 1200 meters above sea level is less than the garlic plants that planted at an altitude of 1600 meters above sea level and shows stunted growth. This is related to the characteristics of the soil in Pujon which has a high acidity and clay texture, A low pH content causes a high level of soil acidity which will cause soil fertility to be low and become an obstacle in plant utilization (McCormack, 2012; Goronski *et al*., 2010). On the other hand, the growth pattern of number and leaf area index at an altitude of 1600 meters above sea level tends to be more than the height of 1200 meters above sea level. Because at this height has good aeration, drainage and organic material contents. Soil characteristics in Cangar have the content of pH 5.7 (H_2O), 4.9 (KCl) with C-organic 4.00%, N total 0.47%, C/N 8, P.Bray 21.45 mg kg^{-1}, KTK 33.90 me/100g, Wet saturation 50%, containing 41% sand, 46% dust, 13% clay with loam texture (*sandy loam*). The difference in soil quality as a growth medium will affect plant growth and development. Plant growth and development is a process of life and propagation in which it depends on the results of assimilation, hormones, and the growth of substances and the environment that support and produce growth patterns (Gardner *et al*., 1991).

The growth and development of the plant is a process in life and propagation which depends on the results of assimilation, hormones and substances of environmental growth that support and produce a pattern of growth (Gardner *et al*., 1991; Saleem *et al*., 2019; Mok, 2019; Gamez *et al*., 2019; Suresh *et al*., 2019). The availability of nitrogen is very important for plant growth because these compounds are the main proetin constituents and the main and irreplaceable amino acid molecules. This compound is also an integral part of the chlorophyll molecule, which is responsible for photosynthesis. Adequate nitrogen supply will be associated with strong vegetative growth and more efficient use of inputs available which leads to higher productivity.The findings of this study are close to the results found by Naruka and Dhaka (2001), Yadav (2003), Banafar and Gupta (2005), Sharma and Aggarwal (2008) and Naruka *et al*. (2005). The diversity of the morphological properties of plant germplasm resources plays a significant role for breeding programs. Variations found in qualitative properties are very useful in identifying germplasm and in developing new varieties and quantitative properties direct the results of production (Panthee *et al*., 2006).

Table 4, the yield components of 4 varieties, namely among others seen from the variable of tuber diameter, number of cloves, wet and dry weight of 10 days after harvest, Saigon and Atsabe varieties at an altitude of 1200 mpl showed the best results compared to the treatment of other varieties and Sembalun varieties at an altitude of 1600 meters above sea level has a good tuber diameter and number of cloves but there is a decrease in dry weight. This depends on the qualitative and quantitative nature of garlic accessions showing wide variations, especially in a number of quantitative properties involved in plant growth and tuber development. In addition, a number of properties which connected to the number of cloves, tuber diameter, tuber weight and yield. Because tubers are the most frequently consumed garlic organs. The tuber yield is the most important properties for garlic and has been widely evaluated by a number of researchers in previous studies (Baghalian *et al*., 2006; Jabbes *et al*., 2012), found that the yields were strongly influenced by the following characteristics: number of cloves, weight of cloves, tuber diameter and yield of dry weights. According to Baghalian *et al*. (2005) found a significant positive correlation between the average weight of the number of cloves, weight of cloves and tubers, negative correlation between the average weight of the clove and the number of cloves. Raju *et al.* (2013) get similar results based on the garlic genotype. Along with the opinions of Mishra *et al*. (2013) found that garlic genotypes also had significant differences in morphological character.

Table 5, shows that allisin compounds from the 4 local garlic genotypes, the highest found in the Atsabe varieties and not different from the Saigon genotypes but were significantly different from the Sembalun genotypes. Khar *et al*. (2011) also observes variations in sulfoxide content among 93 garlic ecotypes and stated that breeding status, morphological features (tuber color) and place of origin had a significantly lower effect on chemical composition than the genetic background of the relevant cultivar. According to Beato *et al.* (2011), selection of cultivars can be a useful way to increase the total phenolic and ferulic acid content, regardless of growing conditions. Chen *et al.* (2013). Allisin is unstable (Amagase, 2006), so that easy to experience further reactions, depending on processing conditions or other external factors such as genotype and environment (altitude, temperature, soil type, aeration and drainage), storage, temperature, etc.

The qualitative and quantitative nature of garlic accession shows wide variation, especially in a number of quantitative properties involved in plant growth and development of tubers. In addition, a number of properties which connected to the bolt, bolt length, basal bolt diameter, tuber diameter, tuber weight, spathe length and spathe width, because the tuber is the most commonly consumed garlic organ.Tuber yield is the most important properties for garlic and has been evaluated by a number of researchers in previous studies (Baghalian *et al*., 2006; Jabbes *et al*., 2012) found that the yield was strongly influenced by the following properties: Clove weight, tuber weight and diameter, number of leaves per plant and stem length. According to (Baghalian *et al*., 2005) found a significant positive correlation between the average weights of cloves and tubers, the negative correlation between the average weights of cloves and number of cloves. Raju *et al*. (2013) get similar results based on the garlic genotype. Along with the opinions of Mishra *et al*. (2013) who found that the garlic genotype also had a significant difference in terms of its morphological character.

Table 4: Average yields component of 4 local garlic genotypes at harvest at an altitude of 1200 m above sea level and 1600 meters above sea level

Altitude (mASL)	Genotype	Tuber diameter (mm)	No of cloves/tuber	Wet weight (kg)	Dry weight (t ha^{-1})
1200 (T1)	Saigon (V1)	4.34d	8.2G	4982c	3.628d
	Layur (V2)	1.91a	4.2A	1526a	1.373a
	Atsabe (V3)	3.17bc	6.9D	4383bc	3.355d
	Sembalun (V4)	3.11bc	7.8F	4133b	2.239c
1600 (T2)	Saigon (V1)	2.87b	5.3B	4903c	3.735d
	Layur (V2)	1.95a	5.8C	1626a	1.477ab
	Atsabe (V3)	3.14bc	7.3E	3922b	3.932d
	Sembalun (V4)	3.48c	5.8C	4072b	2.208bc
LSD 5%	4.49	0.37	746.77	759.2	
CV (%)	10.27	3.95	13.85	18.98	

Information: Numbers accompanied by the same letter on the same row and column are not significantly different at the 5% LSD test; mm: Millimeter, CV = coefficient of variation, mASL= meters above sea level

Table 5: Average analysis results of the compounds content of Allicin Level with LC-MS/MS from 4 local Garlic genotypes at altitude of 1200 and 1600 m above sea level

Altitude (mASL)	Genotype	Allicin level (%)
1200 (T1)	Saigon (V1)	15.59f
	Layur (V2)	11.35d
	Atsabe (V3)	19.18h
	Sembalun (V4)	4.87
1600 (T2)	Saigon (V1)	15.75g
	Layur (V2)	10.74c
	Atsabe (V3)	15.16e
	Sembalun (V4)	7.57b
LSD		0.042
CV (%)		4.76

Information: Numbers accompanied by the same letter on the same row and column are not significantly different at the 5% LSD test, CV = coefficient of variation, mASL = meters above sea level

Conclusion

Both of these heights have diverse soil characteristics and different fertility levels but both tend could be used as a growing medium of garlic plants. At an altitude of 1600 m above sea level and 1200 m above sea level both have a texture of sandy loam soil (sandy *loam*) but at an altitude of 1600 m above sea level has organic material that is high enough to provide the high plant growth patterns, number of leaves, tuber wet weight, tuber dry weight and bioactive compounds that are better than the altitude of 1200 m above sea level.

From the research results showed that the best growth pattern occurs at an altitude of 1600 m above sea level with 10 WAP (Weeks After Planting). Besides that, the highest weight is found in the Atsabe (3.932 kg ha^{-1}) at an altitude of 1600 m above sea level as well the Saigon (3.628 kg ha^{-1}) and Atsabe (3.355 kg ha^{-1}) genotype at an altitude of 1200 m above sea level, also the highest percentage of allicine was found in the Saigon (19.18%) and the lowest was found in Sembalun (4.87%) at an altitude of 1200 m above sea level. For the growth of local garlic plants from the 4 varieties, it is recommended to use Saigon and Atsabe varieties at altitudes of 1600 mASL and 1200 m above sea level.

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Author’s Contributions

All authors contributed in collecting and analyzing data. All authors participated in writing every part of this study. All authors read and approved the final version.

Ethics

This manuscript has not been published or presented elsewhere in part or in entirely and is not under consideration by another journal. All the authors have approved the manuscript and agree with submission to the esteemed journal. There are no conflicts of interest to be declared.

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