Asian Journal of Plant Sciences

ISSN 1682-3974

science alert

ANSInet
an open access publisher
http://ansinet.com

OPEN ACCESS

Asian Journal of Plant Sciences

ISSN 1682-3974
DOI: 10.3923/ajps.2022.460.468

Research Article
Improvement of Taro Mbothe Yield (*Xanthosoma sagittifolium* L.) Schott on Dry Land Indonesia by Potassium Application and Tuber Size Selection

Nur Edy Suminarti, Deby Alfian Chriswanto and Aninda Nur Fajrin

Department of Agricultural, Faculty of Agriculture, Brawijaya University, East Java, Indonesia

Abstract
Background and Objective: The mbothe taro tuber is a potential food source for people in dryland areas. Therefore, to increase its productivity, the application of K fertilizer and tuber size are the main keys. This study aimed to obtain the right dose of K fertilizer and tuber size for mbothe taro plants in dry land. **Materials and Methods:** Materials in the form of mbothe taro tubers with 3 sizes, namely 25-30, 35-40 and 45-50 g, as well as fertilizers N, P, K. The split-plot design was used in this study and was repeated 3 times. The size of tubers (25-30, 35-40, 45-50 g) was placed as the main plot, while the dose of K fertilization (50, 75 and 100%) was the sub-plots. The 5% F test is used to determine a significant interaction or significant effect of the treatment, while the 5% HSD test is used to determine the difference between treatments. **Results:** The combination of 75% K with tuber size of 45-50 g was able to produce the highest growth and yields variables, compared to 50 and 100% K fertilization. The optimum K fertilizer was reached at a dose of 71% or equivalent to 192.42 kg KCl ha^{-1}, with a maximum fresh tuber weight of 182.16 g/plants. **Conclusion:** The use of K fertilizer at a dose of 192.42 kg KCl ha^{-1} with a tuber size of 45-50 is a treatment that can be recommended for farmers in production areas similar to this research location.

Key words: *Xanthosoma sagittifolium* (L.) Schott, size of tuber, dryland, potassium, planting material, tuber size, K fertilizer, dryland, agronomic aspects

Citation: Suminarti, N.E., D.A. Chriswanto and A.N. Fajrin, 2022. Improvement of taro mbothe yield (*Xanthosoma sagittifolium* L.) Schott on dry land Indonesia by potassium application and tuber size selection. Asian J. Plant Sci., 21: 460-468.

Corresponding Author: Nur Edy Suminarti, Department of Agricultural, Faculty of Agriculture, Brawijaya University, East Java, Indonesia

Copyright: © 2022 Nur Edy Suminarti *et al.* This is an open access article distributed under the terms of the creative commons attribution License, which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited.

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Climate change poses challenges to agricultural production and its impacts vary depending on regional conditions and the type of production system used. Meanwhile, the agricultural production system in Indonesia is mostly rainfed. In such cases, extreme rainfall patterns (low or high) constitute a critical production risk[1]. In general, rainfed agricultural production systems are quite susceptible to seasonal variability, which in turn will affect the livelihoods of farmers and farm labourers who depend on such agricultural systems. In conditions of uncertain rainfall, the irrigated area is insurance for rainfed agriculture[2]. However, in reality, the area of wetlands is decreasing with the increasing activity of conversion of agricultural land to non-agricultural land. As a result, the development of agriculture remains focused on the use of dryland conditions that are more uncertain due to the impact of climate change. Therefore, to anticipate food insecurity events, the main strategy that can be applied in dry land is through adaptation theory by reviving local commodities that have been abandoned[3]. The excellence of local commodities other than tolerance of prevailing environmental conditions also aims to revive local commodities that until this have received less attention from both researchers and governments to become the leading commodity locally a region. Several types of local commodities that have an important role in producing alternative food sources are the mbothe taro plant (*Xanthosoma sagittifolium* L.) Schott. This is in line with the opinion of Lobell *et al.*[4], which states that, the main priority in the face of climate change is to build strong food security.

The mbothe taro plant is one of the plants that are not only rich in carbohydrates and crude fibre content but also excels in its ability to adapt to a less favourable environment. Therefore, this plant is widely planted in sub-optimal land such as dry land. However, to obtain high yields per unit area and time, soil and plant management in the form of potassium fertilization and the selection of appropriate planting materials need to be done. This is reasonable because the element K is needed in higher quantities in the tuber plant group, while the results of soil analysis show that it is in the moderate category (0.54 Cmol kg^{-1}). Dzida *et al.*[5] stated that, the role of potassium in root crops is to stimulate the translocation of photosynthate from the source (leaves) to the storage organ (tubers). The presence of K^+ ions stimulates the opening of the stomata due to an increase in the concentration of solutes which causes a decrease in the osmotic potential. The decrease in the osmotic potential triggers the guard cells to absorb water which causes the stomata to open. This mechanism becomes important in water management efforts in the drylands[6]. The availability of potassium causes plants not to collapse easily, because K is involved in the formation of cell walls, especially in stems. Xylem and phloem are tissues, shaped like tubes and play a role in the transport system. Therefore, when the cell wall is not able to support the performance of the xylem and phloem tissues, it can have an impact on the disruption of the mineral and water transport system, as well as food substances that will be distributed to the plant body parts[6]. Considering the important role of the K element, especially in the dry land, K fertilization needs to be done.

Apart from the element of potassium, the success of plant cultivation is also greatly influenced by the size of the planting material, namely the weight of the tubers. Tuber's different weights will give a different effect on the rate of speed of growth, as well as seedling vigour. The growth rate process that must be passed for small planting materials requires a longer time than for larger planting materials. This is in line with the opinion of Ebrahim *et al.*[7] which stated that tuber size affects the emergence of seedlings. The results showed that potato planting material from seeds with a size of 46-55 mm, the emergence of seeds takes a relatively shorter time of about 11.6 days after planting. Meanwhile, planting material from smaller seeds, i.e., 35-45 and 25-34 mm, took longer, 13.5 and 14.6 days, respectively, to germinate. The speed of growth is closely related to the number of food reserves (carbohydrates) stored in the tubers, which will then act as growth energy. Therefore, the purpose of this study was to obtain information about tuber size and proper K fertilization to increase taro crop production in the dry land.

MATERIALS AND METHODS

Study area: A field study was conducted in UB's experimental garden, in the village of Jatikerto, Malang, Indonesia, from November, 2018 until May, 2019. The location is at an altitude of 330 m above sea level, in the form of dry land. Chemically, the N-soil status is low (0.13%), the K-soil is moderate (0.54°C mol kg^{-1}) and the soil-P status is in the medium category (13.46 ppm P). Climatologically, the average annual rainfall is around 1200 mm, with average daily temperatures ranging from 24-31°C.

Research material: Planting material in the form of mbothe taro tubers with 3 sizes weights, namely: 25-30 g/tuber, 35-40 g/tuber and 45-50 g/tuber.

Table 1: Initial status of soil nutrient content and range of N, P, K doses of mbothe taro

		Soil nutrient content		
Soil samples	pH H_2O	N (%)	P_2O_5 olsen (ppm)	K NH_4OAC1N pH 7 (me 100 g^{-1})
Dry land (Jatikero)	6.3	0.13	13.46	0.54
Criteria				
Very low	<4.0	<0.10	<5	<0.1
Low	4.1-5.5	0.11-0.20	5-10	0.1-0.2
Medium	5.6-7.5	0.21-0.50	11-15	0.3-0.5
High	7.6-8.0	0.51-0.75	16-20	0.6-1.0
Very high	>8.0	>0.75	>20	>1.0
The range of N, P, K doses of mbothe taro plant				
Source of fertilizer				
N				35-125 kg ha^{-1}
K				60-135 kg ha^{-1}
P_2O_5				30-60 kg ha^{-1}

Source: Physical-Chemical Laboratory of Soil, Faculty of Agriculture, Brawijaya University (2018)

Table 2: Dosage of N, P, K fertilizers applied

	Dosage of fertilizer applied		
Source of fertilizer	t ha^{-1}	kg/plot	g/plant
N (urea)	98 kg N ha^{-1} (213.04 kg urea ha^{-1})	0.137 kg N/plot (0.3 kg urea/plot)	5.36 g urea/plant
P_2O_5 (SP_{36})	79.8 kg P_2O_5 ha^{-1} (221.67 kg SP_{36} ha^{-1})	0.112 kg P_2O_5/plot (0.31 kg SP_{36}/plot)	5.53 g SP_{36}/plant
K (KCl)			
100% K_2O (KCl)	162.6 kg K_2O ha^{-1} (271 kg KCl ha^{-1})	0.228 kg K_2O/plot (0.38 kg KCl/plot)	6.79 g KCl/plant
75% K_2O (KCl)	121.95 kg K_2O ha^{-1} (203.3 KCl ha^{-1})	0.17 kg K_2O/plot (0.29 kg KCl/plot)	5.09 g KCl/plant
50% K_2O (KCl)	81.3 kg K_2O ha^{-1} (135.5 kg KCl ha^{-1})	0.114 kg K_2O/plot (0.19 kg KCl/plot)	3.4 g KCl/plant

The fertilizers used are nitrogen fertilizers (in the form of urea: 46% N), phosphorus fertilizers (in the form of SP_{36}: 36% P_2O_5) and potassium fertilizers (in the form of KCl: 60% K_2O). Phosphorus fertilizer was applied at the beginning of planting all doses, while N and K fertilizers were applied gradually. Phase I is done when the plant was 15 days after planting as much as 1/3 dose and the rest (2/3) was applied when the plant was one month after planting. The dose was applied, respectively of 221.67 kg SP_{36} ha^{-1}, 213.04 kg $urea^{-1}$ and 271 kg KCl ha^{-1} (for the treatment of 100% potassium), 203.3 kg KCl ha^{-1} (for treatment 75% potassium) and as much as 135.5 kg KCl ha^{-1} (for treatment of 50% potassium). Fertilizer is sown in each fertilizer hole which is about 5 cm from the plant, with a depth of about 7-10 cm.

Calculation of fertilizer requirements is based on the initial soil analysis and the level of N, P, K fertilizer requirements of the mbothe taro plant given in Table 1. While the calculation method refers to the Suminarti *et al.*[8] as follows:

$$N = \frac{A_2\text{-}B}{A_1\text{-}A_2} = \frac{N\text{-}X_A}{X_A\text{-}X_B}$$

Where:

N = Nutrient dose that must be added according to soil criteria (kg ha^{-1})
A_1 = Top content of the total soil N range (%)
A_2 = Lowest level of the range of total soil N (%)
B = Total N content of the soil (%)
X_A = Highest value of the required dose of N plants (kg ha^{-1})
X_B = Lowest value of the required dose of N plants (kg ha^{-1})

Based on the above formula and the experimental plot size is 14 m^2, the amount of fertilizer dose should be given as presented in Table 2.

Experimental design: The split-plot design was used in this study and was repeated 3 times. Tuber size consisting of three weights, namely: 25-30, 35-40 and 45-50 g is placed on the main plot. Meanwhile, the K fertilizer dosage, namely, 50, 75 and 100% of the recommended dosage was placed in sub-plots. F test at the 5% level is used to determine the interaction or effect of the treatment. While Honestly Significant Difference (HSD) test at 5% was used to determine differences among treatments. Regression analysis was used to explore the relationship between two or more variables observed.

Research implementation: The initial soil analysis was carried out before planting, aiming to determine the N, P, K content of the soil and then it would be used to determine the fertilizer requirements for plants. The next step is the selection of planting material (tubers), both for size (tuber weight) and health (not infected by pests and diseases) and freshness of the tubers (not wrinkled and keep it fresh). The tillage is carried out twice with a hoe, which aims to provide a loose planting medium for plants. Plotting was done after tillage activities were completed by dividing the land into three replications and each replication consisted of 9 plots in treatment and each treatment plot size of 14 m^2. Seedlings are carried out on a plot of land with an area of 3 m with a shade of about 30-40%. The seeding medium was a mixture of soil and compost with a ratio of 1: 1. Watering was done every day to stimulate the germination process. The beds were divided into three parts according to the size of the tuber treatment, namely 25-30, 35-40 and 45-50 g. This is done to avoid errors during transplanting.

Data collection: Agronomic observations including plant growth, namely leaf surface area, total fresh weight of plants and total dry weight of plants, were carried out when the plants entered the maximum vegetative phase, which was 85 days after planting. While the observation of yield components, namely the tuber weight/plants and the root shoot ratio were carried out when the plants were 110 days after planting. Soil analysis was done 3 times, i.e., at the beginning (before planting), 1 month after the entire fertilizer application and 1 week after harvest.

Leaf surface area: Leaf surface area was measured using a Leaf area meter type LI-3100 C for leaves that were fully opened, excluding young leaves and leaves that had experienced senescence. Leaf samples were placed on a glass lens in a position not overlapping or folded. There cording was carried out for all leaf samples from three sample plants per treatment, then averaged. The value of the leaf surface area is determined by multiplying the average value of the recording results by a correction factor. The correction factor can be found by dividing the actual paper area (e.g.,100 cm^2) by the paper area that has been measured using a leaf area meter (e.g., 75 cm^2), so the correction factor is 0.75.

Total fresh weight of plants: The total fresh weight of the plant was observed by weighing all parts of the plant using an analytical balance of the Scout-pro type.

Total dry weight of plants: The total dry weight of the plants was measured using an oven-type OVL 12, with a temperature of 81 °C. Before drying, the plant parts are separated, such as roots, leaves, stems and economic parts, because to achieve a constant dry weight it takes a different time for each part of the plant. Meanwhile, to get uniform drying, plant parts need to be chopped. The plant parts that have been separated and chopped are then put into a cement envelope that has been given a treatment code, then put into the oven. The weighing was carried out on each plant part that had reached a constant weight using an analytical balance of the Scout-pro type, then added together.

Tuber fresh weight/plant: Measurement tuber fresh weight/plant-based on all the tubers are formed/plant using an analytical balance Scout-pro-type.

Root shoot ratio: Root shoot ratio is the ratio between the economic weight (tubers) and the total dry weight of the plant.

RESULTS

Leaf surface area observation: There was a significant interaction between tuber size and potassium fertilization on leaf surface area in Table 3.

Table 3 shows that with the use of bulb sizes of 25-30 and 35-40 g, the leaf surface area produced was not significantly different for three doses of K fertilization. However, for tubers size 45-50 g, the widest leaf surface was obtained at a dose of 203.3 Kg KCl ha^{-1}, which is 8163.9 cm^2, compared to 135.5 and 271 kg KCl ha^{-1} which only reached 3532.0 and 3588.6 cm^2. Leaf surface area showed no significant difference at 135.5 and 271 kg KCl ha^{-1} fertilization levels. Judging from

Table 3: Average leaf surface area (cm^2) due to the interaction between tuber size and potassium fertilizer at the age of 85 daps

Treatments	K fertilizer dose (recommendation (%)) kg^{-1} (KCl ha^{-1})		
Tuber size range (g)	50% (135.5 kg KCl ha^{-1})	75% (203.3 kg KCl ha^{-1})	100% (271 kg KCl ha^{-1})
25-30	3154.7^{aA}	4317.1^{aA}	3569.5^{aA}
35-40	4463.6^{aA}	3747.7^{aA}	3259.3^{aA}
45-50	3532.0^{aA}	8163.9^{bB}	3588.6^{aA}
HSD 5%			2959.96

Numbers that are accompanied by the same letters in the same row, or the same capital letters in the same column are not significantly different based on the HSD test at a 5% level and daps: Days after planting

Table 4: Average of total fresh weight/plant (g) due to the interaction between tuber size and potassium fertilizer at the age of 85 daps

Treatments	K fertilizer dose (recommendation (%)) kg^{-1} (KCl ha^{-1})		
Tuber size range (g)	50% (135.5 kg KCl ha^{-1})	75% (203.3 kg KCl ha^{-1})	100% (271 kg KCl ha^{-1})
25-30	849.4^{aA}	1073.3^{aA}	1009.6^{aA}
35-40	1020.80^{aA}	914.70^{aA}	822.20^{aA}
45-50	806.70^{aA}	1518.9^{bB}	831.8^{aA}
HSD 5%			419.79

Numbers that are accompanied by the same letters in the same row, or the same capital letters in the same column are not significantly different based on the HSD test at a 5% level and daps: Days after planting

Table 5: Average total dry weight/plant at various sizes of tubers and the dose of K fertilization at the age of 85 dap

Treatments	Average total dry weight/plant (g)
Tuber size range (g)	
25-30	442.83
35 -40	407.88
45-50	455.80
HSD 5%	ns
K fertilizer dose (% recommendation)	
50% (135.5 kg KCl ha^{-1})	417.23^{a}
75% (203.3 kg KCl ha^{-1})	484.63^{b}
100% (271 kg KCl ha^{-1})	404.65^{a}
HSD 5%	34.72

Numbers are accompanied by the same letters in the same column are not significantly different by HSD 5%, dap: Days after planting and ns: No significant effect

the effect of K fertilizer on various sizes of tubers, the use of 135.5 and 271 kg KCl ha^{-1}, leaf surface area showed no significant difference in various sizes of tubers. However, for a dose of 203.3 kg KCl ha^{-1}, the widest leaf surface (i.e., 8163.9 cm^2) was found at the largest tuber size (i.e., 45-50 g) and showed no significant difference in tuber size 25-30 and 35-40 g.

Total fresh weight/plant: There was a significant interaction between tuber size and K fertilization on total fresh weight/plant in Table 4.

Table 4 shows that at 25-30 and 45-40 g tuber sizes, the total fresh weight/plant produced was not significantly different at the three levels of K fertilization, namely 135.5, 203.3 and 271 kg KCl ha^{-1}. However, at a tuber size of 45-50 g, the highest total fresh weight of per plant was produced at a dose of 203.3 kg KCl ha^{-1}, which was 1518.9 g/plant. While lower yields were obtained at a dose of 135.5 and 271 kg KCl ha^{-1}, respectively 806.70 and 831.8 g/plant. Judging from the dose of K fertilizer on the three tuber sizes, it was found that with the application of 135.5 kg KCl ha^{-1} and 271 kg KCl ha^{-1}, the total fresh weight of per plant produced was not significantly different for the three sizes of tubers (25-30, 35-40 and 45-50 g). However, in the application of 203.3 kg KCl ha^{-1}, the highest total fresh weight/plant was found in tuber size 45-50 g, which was 1518.9 g/plant compared to tubers size 25-30 and 35-40 g, which only reached 914.70 and 1073.3 g/plant.

Total dry weight/plant: There was no significant interaction between tuber size and Potassium fertilization on the total dry weight/plant. The average total dry weight/plant (g) at the age of 85 days after planting is presented in Table 5.

Table 5 shows that there was no significant effect of tuber size on the total dry weight of per plant. The total dry weight of per plant was only affected by K fertilization. Application of 135.5 and 271 kg KCl ha^{-1} resulted in total dry weight of per plant not significantly different, respectively 417.23 and 404.65 g/plant and this yield is lower than the use of 203.3 kg KCl ha^{-1} which has reached a weight of 484.63 g/plant.

Tuber fresh weight/plant: There was a significant interaction between tuber size and K fertilization on tuber fresh weight/plant in Table 6.

Table 6 shows that the use of three sizes of tubers (25-30, 35-40 and 45-50 g) resulted in fresh tuber weight of per plant which was not significantly different at the three doses of K, namely 135.5, 203.3 and 271 kg KCl ha^{-1}. Meanwhile, if viewed from the effect of K on the 3 tuber sizes, it was found that in the application of K as much as 135.5 and 271 kg KCl ha^{-1}, the fresh tubers weight/plant produced was not significantly different for the three sizes of tubers, each of 125 9, 134.4 and 164.9 g/plant for K fertilization at a dose of 135.5 kg KCl ha^{-1} and 139.3, 124.8 and 150.2 g/plant for a dose of 271 kg KCl ha^{-1}. However, when the dose used was 203.3 kg KCl ha^{-1} and followed by a tuber size of 45-50 g, the fresh weight of tuber/plant produced was higher, which was 181.6 g/plant when compared to the use of bulb size 25-30 g which only reaches the weight of 127.8 g/plant. The fresh weight of tuber/plant at tuber size 45-50 g showed no significant difference with tuber size of 35-45 g.

Root Shoot ratio (R/S): There was a significant interaction between tuber size and K fertilization on root shoot ratio in Table 7.

Table 6: Average of tuber fresh weight/plant (g) due to the interaction between tuber size and potassium fertilizer at the age of 110 daps

Treatments	K fertilizer dose (recommendation (%)) kg^{-1} (KCl ha^{-1})		
Tuber size range (g)	50% (135.5 kg KCl ha^{-1})	75% (203.3 kg KCl ha^{-1})	100% (271 kg KCl ha^{-1})
25-30	125.9^{aA}	127.8^{aA}	139.3^{aA}
35-40	134.4^{aA}	139.8^{aAB}	124.8^{aA}
45-50	164.9^{aA}	181.6^{aB}	150.2^{aA}
HSD 5%			48.04

Numbers that are accompanied by the same letters in the same row, or the same capital letters in the same column are not significantly different based on the HSD test at a 5% level and daps: Days after planting

Table 7: Average of root shoot ratio due to the interaction between tuber size and potassium fertilizer at the age of 110 daps

Treatments	K fertilizer dose (recommendation (%)) kg^{-1} (KCl ha^{-1})		
Tuber size range (g)	50% (135.5 kg KCl ha^{-1})	75% (203.3 kg KCl ha^{-1})	100% (271 kg KCl ha^{-1})
25-30	0.35^{aA}	0.29^{aA}	0.35^{aA}
35-40	0.27^{aA}	0.27^{aA}	0.40^{bA}
45-50	0.35^{aA}	0.42^{aB}	0.33^{aA}
HSD 5%			0.10

Numbers that are accompanied by the same letters in the same row, or the same capital letters in the same column are not significantly different based on the HSD test at a 5% level and daps: days after planting

Table 8: Results of the first, second, third soil analysis and estimated availability

Description	K-soil content (me 100 g^{-1})	Estimated K availability for plant (%)	Estimated K availability for plants based on the dose of fertilizer applied (%)
First soil analysis	0.54		
Second soil analysis			
50% K (135.5 kg KCl ha^{-1})	2.22		
75% K (203.3 kg KCl ha^{-1})	2.61		
100% K (271 kg KCl ha^{-1})	2.94		
Third soil analysis (combination treatments)			
25-30 g+135.5 kg KCl ha^{-1}	1.63	26.4	
25-30 g+203.3 kg KCl ha^{-1}	1.63	37.5	
25-30 g+271 kg KCl ha^{-1}	2.00	31.9	
35-40 g+135.5 kg KCl ha^{-1}	1.51	32.1	
35-40 g+203.3 kg KCl ha^{-1}	1.52	41.6	
35-40 g+271 kg KCl ha^{-1}	1.84	37.5	
45-50 g+135.5 kg KCl ha^{-1}	1.59	28.6	
45-50 g+203.3 kg KCl ha^{-1}	1.54	41.1	
45-50 g+271 kg KCl ha^{-1}	1.87	36.2	
135.5 kg KCl ha^{-1}			29.0
203.3 kg KCl ha^{-1}			40.07
271 kg KCl ha^{-1}			35.2

Table 7 shows that the use of tuber sizes of 25-30 and 45-50 g resulted in R/S values that were not significantly different at the three K fertilization levels. However, with the use of 35-40 g tubers, the highest R/S value (0.40) was obtained at a dose of 271 kg KCl ha^{-1} and the lower was obtained at a dose of 135.5 kg KCl ha^{-1} (0.27) and a dose of 203.3 kg KCl ha^{-1} (0.27). Judging from the effect of K fertilization on three tuber sizes (25-30, 35-40 and 45-50 g) it was seen that with the application of K fertilizer at a dose of 135.5 and 271 kg KCl ha^{-1}, the R/S value showed not significantly different in the three tuber sizes. However, at the application of K at a dose of 203.3 kg KCl ha^{-1}, the highest R/S value (0.42) was found in tuber sizes of 45-50 g and the lower ones were found in bulb sizes of 25-30 and 35-40 g, are 0.29 and 0.27, respectively.

Soil analysis: The results of the first soil analysis (before planting), the second soil analysis (1 month after the entire fertilizer application) and the third soil analysis (1 week after harvest), as well as the estimated availability, are presented in Table 8.

Table 8 shows that the initial K-soil content is 0.54 me 100 g^{-1} and shows a change in the K-soil content after K fertilization in the form of KCl. This second soil analysis was carried out 1 month after the application of all K fertilizers. The results showed that there was a change in the value of K-soil content from the initial soil analysis, which were 2.22, 2.61 and 2.94 me 100 g^{-1} for fertilization 135.5, 203.3 and 271 kg KCl ha^{-1}. While the third soil analysis was carried out 7 days after harvest on 9 treatment combinations (1 replication). The highest value was obtained at

271 kg KCl ha^{-1} fertilization on the three tuber sizes, each of 2, 1.84 and 1.87 me100 g^{-1} for tuber sizes 25-30, 35-40 and 45- 50 g. The highest value of estimated K availability to plants was achieved at a dose of 203.3 kg KCl ha^{-1} for the three sizes of tubers, respectively 37.5, 41.6 and 41.1%.

DISCUSSION

In general, there was a significant interaction between tuber size treatment and K fertilization on the observed variables, which included leaf surface area, total fresh weight of plants, fresh weight of tubers/plants, root shoot ratio, except for the total dry weight of plants.

The widest leaf surface was found in a combination of tuber sizes of 45-50 g with a K dose of 203.3 kg KCl ha^{-1}, which was 8163.9 cm^2. This is because the larger the tuber size, the more food reserves (carbohydrates) are available in the tubers. The food reserves will act as energy, which is energy that will be used for the germination process. Larger tuber sizes can emerge from greater planting depths and show the ability to penetrate the ground cover and survive burial by litter. Generally, the larger tuber size germinates quicker and would take lesser duration when compared to that of smaller ones. This is in line with the results of research by Ambika *et al.*[9], who found that for large seeds (3.0 mm), the germination percentage and field emergence were higher, at 93.95 and 83.0%, respectively, compared to smaller seeds (2.5 mm), only 87.16 and 77.83%, respectively. Thus, tuber size was positively correlated with tuber vigour, larger bulbs tend to produce stronger seedlings. The wider leaf surface area is closely related to the sufficient level of K availability for plants. The results of soil analysis proved that with the application of 203.3 kg KCl ha^{-1}, the estimated level of K availability was the highest, namely 40%, when compared to doses of 271 and 133.3 kg KCl ha^{-1} which only reached 35.2 and 29%, respectively (Table 8). It is known that potassium for plants, especially taro plants functions to maintain plant turgidity, cell elongation and opens pores in leaves for gas exchange that causes photosynthesis to take place[10,11]. Therefore, when this potassium is not sufficiently available for plants, it causes reduced assimilate production and this will have an impact on inhibiting the process of leaf expansion, especially leaf surface area (Table 3).

Leaves are one of the plant organs that play an important role in photosynthesis. Therefore, with the increase in leaf surface area, especially in taro plants whose leaf arrangement spreads horizontally, it becomes the main capital in assimilate production. Assimilate is energy, so the increase in assimilating produced will be followed by an increase in the rate of plant growth which causes an increase in the total fresh weight of the plant. This is in line with the results of the study which showed that the highest total fresh weight of plant (1518.9 g/plant) was found in tuber size of 45-50 g with fertilization at a dose of 203.3 kg KCl ha^{-1} (Table 4). The high yield was also supported by the best performance of the plants produced by this treatment compared to other treatments[12].

There was no significant interaction between tuber size and K fertilization on the total dry weight of plants. However, there was a significant effect of K fertilization on this variable (Table 5). The highest total dry weight of plants was found at a dose of 203.3 kg KCl ha^{-1}, which was 484.63 g/plant compared to a dose of 133.3 kg KCl ha^{-1} and a dose of 271 kg KCl ha^{-1} which was only 417.23 and 404.65 g/plant. This is because of the antagonistic nature between K and Mg. At high K conditions, the Mg element is chelated. The research results of Putra *et al.*[13] explained that the application of Potassium as much as 225 kg KCl ha^{-1} resulted in lower availability of Mg by around 14.29% compared to a dose of 196 kg KCl ha^{-1}. Mg is the core of chlorophyll, so with the lower Mg content, the total dry weight of the plants produced is also low due to the low chlorophyll content of plant leaves. Regression analysis proves that there is a quadratic relationship between K fertilization (X) and total plant dry weight (Y) which is given through an equation:

$$Y = -0.12\ X^2+17.43\ X-159.71,\ (R^2 = 0.99)$$

Based on the regression equation, it can be determined that the optimum K requirement is 72.63% or equivalent to 196.83 kg KCl ha^{-1} to produce a total dry weight of the plant was 473.22 g/plant.

The tuber is a storage organ and is a manifestation of the economic yield of the plant. There was a significant interaction between tuber size and K fertilization on the fresh weight of tubers/plants. At a dose of 203.3 kg KCl ha^{-1}, higher fresh tuber weight was found in tuber sizes of 45-40 g, which was 181.6 g/plant (Table 6). This is inseparable from the role of the element K, which not only functions to stimulate the translocation of assimilating from the source (leaves) to the sink. However, plants will also be able to adapt to extreme environmental pressures such as in the dry land where this research was conducted. Enzyme activation also increases with the presence of K^+ ions in plants which causes an increase in carbohydrate synthesis, as well as protein[14]. In addition, the high fresh weight of the tubers is also strongly influenced by the size of the tubers used, which is 45-50 g. The use of tubers that are smaller or larger than 45-50 g results in lower germination and takes a long time for seedlings to emerge, in addition to poor seedling vigour. The results of Gebre *et al.*[15] research suggest that the most economical size of taro tubers is 51-100 g compared to tubers smaller or larger than 51-100 g, with a yield of 44.07 t ha^{-1}.

The R/S is the ratio between the economic dry weight and the total dry weight of the plant and describes the amount of assimilating that is distributed to the tuber portion of the total assimilate produced[16]. The results showed that the highest R/S value was found in the combination of tuber size 45-50 g with 203,3 kg KCl ha^{-1}, which was 0.42 (Table 7). This means that of the total assimilate formed, about 42% is allocated to the tuber portion with a tuber yield of 181.6 g/plant. To obtain accurate information about the need for K fertilizer for taro plants in the dry land, the results of the regression analysis showed that the optimum K fertilizer requirement was 192.42 kg KCl ha^{-1}, with a maximum fresh tuber weight of 182.16 g/plant. This value is obtained from the equation[16]:

$$Y = -384.8 X^2+547.8 X-12.8 (R^2 = 0.997)$$

CONCLUSION

Based on the results of the study, it can be concluded that the use of tubers with a size of 45-50 g followed by K fertilization at a dose of 203.3 kg KCl ha^{-1} was able to provide the highest growth and yield on all observed variables. Optimum K fertilization was achieved at a dose of 192.42 kg KCl ha^{-1}, with a maximum fresh tuber weight of 182.16 g/plant.

SIGNIFICANCE STATEMENT

This study discovers the effect of tuber size and potassium fertilization on the agronomic aspects of taro (*Xanthosoma sagittifolium* (L.) Schott) in the dry land, Indonesia, so that it can be used as a guideline in the management of taro plants in a dry land. This study will help researchers to reveal the size of tubers and the right dose of K fertilization on taro plants in dry land. Thus, the discovery of the tuber size and dose of K fertilization will be able to assist and facilitate the management of taro plants in dry land to increase the quantity and quality of taro tubers in the dry land.

ACKNOWLEDGMENT

The author would like to thank the field workers, laboratory managers in the Faculty of Agriculture who have provided facilities where the authors carry out analysis, measurements and borrow equipment to support research activities.

REFERENCES

1. Vermeulen, S.J., P.K. Aggarwal, A. Ainslie, C. Angelone and B.M. Campbell *et al.*, 2012. Options for support to agriculture and food security under climate change. Environ. Sci. Policy, 15: 136-144.
2. Park, S.E., N.A. Marshall, E. Jakku, A.M. Dowd, S.M. Howden, E. Mendham and A. Fleming 2012. Informing adaptation responses to climate change through theories of transformation. Global Environ. Change, 22: 115-126.
3. Liang, Z., T. Gu, Z. Tian, H. Zhong and Y. Liang, 2015. Agro-climatic adaptation of cropping systems under climate change in Shanghai. Front. Earth Sci., 9: 487-496.
4. Lobell, D.B., M.B. Burke, C. Tebaldi, M.D. Mastrandrea, W.P. Falcon and R.L. Naylor, 2008. Prioritizing climate change adaptation needs for food security in 2030. Science, 319: 607-610.
5. Dzida, K., Z. Michałojć, Z. Jarosz, K. Pitura and N. Skubij, 2018. Effect of potassium fertilization on yield, growth and chemical composition of basil herb. Acta Sci. Polonorum Hortorum Cultus, 17: 135-145.
6. Zelelew, D.Z., S. Lal, T.T. Kidane and B.M. Ghebreslassie, 2016. Effect of potassium levels on growth and productivity of potato varieties. Am. J. Plant Sci., 7: 1629-1638.
7. Ebrahim, S., H. Mohammed and T. Ayalew, 2018. Effects of seed tuber size on growth and yield performance of potato (*Solanum tuberosum* L.) varieties under field conditions. Afri. J. Agricult. Res., 13: 2077-2086.
8. Suminarti, N.E., N.D. Su and A.N. Fajrin, 2021. Effect of organic compost source and application time on growth and yield of beetroot (*Beta vulgaris* L.) in dry land of Jatikerto, Indonesia. Asian J. Plant Sci., 20: 560-570.
9. Ambika, S., V. Manonmani and G. Somasundaram, 2014. Review on effect of seed size on seedling vigour and seed yield. Res. J. Seed Sci., 7: 31-38.
10. Tariq, M., M.N. Afzal, D. Muhammad, S. Ahmad, A.N. Shahzad, A. Kiran and A. Wakeel, 2018. Relationship of tissue potassium content with yield and fiber quality components of *Bt* cotton as influenced by potassium application methods. Field Crops Res., 229: 37-43.
11. Song, X.D., F. Liu, H.Y. Wu, Q. Cao and C. Zhong *et al.*, 2020. Effects of long-term k fertilization on soil available potassium in east China. CATENA, Vol. 188. 10.1016/j.catena.2019.104412.
12. Hasanah, Y., J. Ginting and A.S. Syahputra, 2022. Role of potassium source from eco enzyme on growth and production of shallot (*Allium ascalonicum* L.) varieties. Asian J. Plant Sci., 21: 32-38.

13. Putra, G.M., Sudiarso and N.E. Suminarti, 2018. Effect of potassium application on growth and yield of sweet potato varieties (*Ipomoea batatas* L.). Russ. J. Agric. Socio-Econ. Sci., 11: 346-352.
14. Kubar, G.M., K.H. Talpur, M.N. Kandhro, S. Khashkhali and M.M. Nizamani *et al*., 2019. Effect of potassium (K^+) on growth, yield components and macronutrient accumulation in wheat crop. Pure Appl. Biol., 8: 248-255.
15. Gebre, A., B. Tesfaye, B.M. Kassahun, 2015. Effect of corm size and plant population density on corm yield of taro (*Colocasia esculenta* L.). Int. J. Adv. Bio. Biomed. Res., 3: 405-412.
16. Suminarti, N.E., B.P.A.R. Pamungkas, S. Fajriani and A.N. Fajrin, 2021. Effect of size and thickness of mulch on soil temperature, soil humidity, growth and yield of red beetroot (*Beta vulgaris* L.) in Jatikerto dry land, Indonesia. Asian J. Plant Sci., 20: 33-43.