RESPONSE OF CASSAVA VARIETIES (*MANIHOT ESCULENTA* CRANTZ) TO DIFFERENT FERTILIZER DOSES IN ALFISOL DRY LAND AREA OF INDONESIA

WAHYUNINGSIH, S. – SUTRISNO – NURYATI – MEJAYA, M. J.* – HARSONO, A. – HARNOWO, D. – KUNTYASTUTI, H. – PURWANINGRAHAYU, R. D. – WIDODO, Y. – KRISDIANA, R. – ARSANA, I. G. K. D. – BUDIONO, R.

Research Center for Food Crops, Research Organization for Agriculture and Food, National Research and Innovation Agency, Bogor, West Java, Indonesia

**Corresponding author*
e-mail: mmejaya@yahoo.com; madejmejaya@gmail.com

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Abstract. The constraints to increase the productivity of cassava in Alfisol dry land area are various soil fertility levels and low production input by farmers. The objective of this research was to study the response of cassava varieties on different fertilizer doses on Alfisol dry land area of Indonesia. The research was carried out in Malang district, East Java, Indonesia in 2013. The treatments were arranged in a split plots design, repeated three times. The main plots were four varieties: Litbang UK 2, Malang 4, Adira 4, and Cecek Ijo; and the sub-plots were three levels of fertilizers: Low dose (90 kg N/ha + 76 kg P_2O_5/ha + 90 K_2O/ha), Medium dose (112.5 kg N/ha + 108 kg P_2O_5 + 120 kg P_2O_5), and High dose (225 kg N/ha + 108 kg P_2O_5/ha + 180 kg K_2O /ha + 5 t manure/ha). The results indicated that in light soils with a deep tillage layer (60-80 cm) and relatively low soil fertility, such as in the Kalipare, South Malang area, to obtain high yields of cassava, UK2 variety can be planted with a medium dose of fertilization, namely 112.5 kg N + 108 kg P_2O_5/ha + 120 kg K_2O. This technology package was able to produce 80.22 t/ha of fresh tuber, higher than with the use of other varieties such as Cecek Ijo, Malang4, and Adira4. However, the starch content of the UK2 variety (18.6%) was lower than other varieties', which reached more than 22%.
Keywords: *manure, production input, soils fertility, technology package, tuber yield*

Introduction

Cassava (*Manihot esculenta* Crantz) originates from Latin America and now is widely grown all over the world. In Indonesia, cassava is used as feed material and raw material for various food and non-food industries (Howeler, 2012). Cassava is a food substitute for rice which plays an important role in supporting the food security of a region. Apart from being a source of carbohydrate food, cassava can also be used as animal feed and industrial raw materials.

The cassava production in Indonesia in 2021 was 18.73 million tons with harvested area of 649,000 hectares and the productivity of 37.93 t/ha (Kementerian Pertanian, 2021). Cassava can adapt to various agro ecosystems and various levels of soil fertility. The important environmental factors affecting yield stability of cassava promising genotypes based on tuber yield (Sholihin et al., 2022a). In Indonesia, Cassava is mostly planted on Ultisol lands, which are distributed outside Java Island.

The government of Indonesia continues to increase cassava production, both through increasing productivity and expanding the planted area. The opportunity for cassava development is directed to outside Java regions, where extensive land is available. There is a potential dry land area of 25,955,901 hectares consisting of 10,775,051 hectares of upland, 3,839,093 hectares of land and land temporarily not

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cultivated covering an area of 11,341,757 ha (BPS, 2014). These lands are the potential available for the development of cassava cultivation / farming areas. In addition to the availability of large enough land, there is also a location-specific cassava cultivation technology package.

Until 2019 the Indonesia Ministry of Agriculture has released 15 varieties of cassava with various characters. The varieties UJ-3 and UJ-5 have grown widely in Lampung, Malang 4 with Vati 1 and Vati 2 growing a lot in North Sumatra. In Lampung, the variety Malang 4 showed the highest yield (49.83 tons/ha), which was above the 2018 national productivity of 23.39 tons/ha (Widodo et al., 2021). Cassava is tolerant to drought stress and has wide adaptability from marginal land to fertile land to grow and produce tuber yield (Misganaw and Bayou, 2020).

Cassava can adapt to various agro ecosystems and various levels of soil fertility. The right combination of fertilizer rates, the site-specific conditions of soil fertility, and soil nutrient status were needed to achieve high tuber yield of cassava (Subekti et al., 2021). The combination of N, P, K and manure improved nutrient use efficiency and cassava productivity (Biratu et al., 2018).

Cassava plants grow optimally in the pH range of 5.5-6.5. On acid soils, cassava plants often show symptoms of Zn deficiency, resulting in yellow and stunted plants (Widodo et al., 2018, 2019). In acidic wet climates, the soil needs to be added 300 kg of lime/ha in addition to 50 kg of Urea, 100 kg of SP36 and 50 kg of KCl (Widodo et al., 2018). Research on Ultisol soil in Lampung province had identified that four cassava varieties Litbang UK-2, Malang-6, Adira-4, and Kaspro were adapted to Ultisol (Radjit et al., 2014). However, on Alfisol soil with marginal soil fertility there is no study has been reported.

High yielding cassava varieties with big tuber roots, tolerant to poor soil, and have more edible root per area are the characters that farmers want to grow (Bentley et al., 2017). To increase the productivity of cassava is possible through improved cultivation, that is, providing the right variety and inputs. Therefore, the objective of this research was to study the response of cassava varieties on different fertilizer doses in Alfisol dry land area of Indonesia.

Materials and Methods

Research Site

The field research was carried out on Alfisol dry land in Sukowilangun village, Kalipare sub-district, Malang district, East Java province, Indonesia in 2013. The location of the sampling experimental site was 8°11'29.2" S and 112°26'38.8" E. The location map of the sampling experimental site is presented in *Figure 1*.

The Kalipare sub-district is a center for cassava production in Malang district. This experiment was carried out on dry land owned by farmers, which was always planted with cassava every year. Farmers in this village often use high doses of fertilizer for one crop. The land conditions are flat, and the drainage is good enough that there is never a puddle when it rains. The results of soil analysis before the experiment showed that the soil reacted slightly acidic (6.06), the levels of C-organic, N, K and Ca were in the low category, namely 0.79%; 0.08%; 0.32 me/100g and Ca 3.82 me/100 g, respectively. Meanwhile, the high P_2O_5 level was 17.96 ppm (*Table 1*). Although the organic matter content is low, the soil is loose and the layers of cultivation are deep, about 60 - 80 cm.

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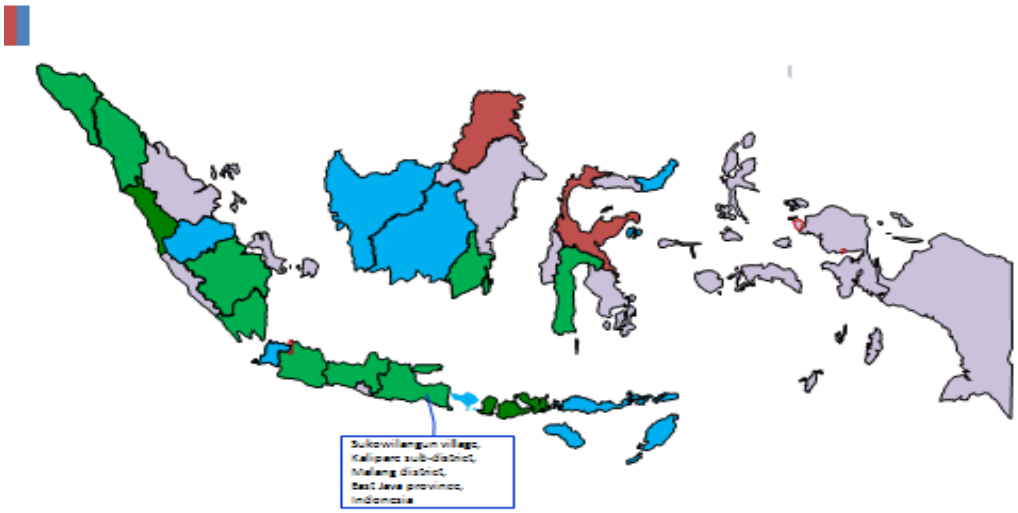

Figure 1. *Sukowilangun village, Kalipare sub-district, Malang district, East Java province, Indonesia*

Table 1. *Results of soil analysis of experimental site in South Malang*

Soil analysis	Sample number						Mean	Category
	1	2	3	4	5	6		
pH	6.28	6.15	5.83	6.00	6.12	6.00	6.06	Slightly acid
C-org (%)	0.62	0.73	0.77	0.91	0.86	0.89	0.79	Low
N (%)	0.16	0.03	0.06	0.07	0.09	0.09	0.08	Low
P_2O_5 (ppm)	11.30	20.40	11.70	7.69	24.10	32.60	1.96	High
K (me/100g)	0.24	0.24	0.31	0.37	0.37	0.38	0.32	Low
Ca (me/100g)	3.88	3.99	3.58	3.53	3.93	4.02	3.82	Low
CCC (cmol+/kg) *	6.29	6.39	8.76	8.97	10.34	9.69	8.41	Low

*CCC = cation change cavacity

Plant Materials

The plant materials used were five cassava varieties (Litbang UK 2, Malang 4, Adira 4, and Cecek Ijo), in-organic fertilizers (N, P_2O_5, and K_2O), and organic fertilizer. The clones of cassava varieties were obtained from the Indonesian Legume and Tuber Crops Research Institute (ILETRI), Jl. Raya Kendalpayak km 8, PO Box 66 Malang 65101, East Java, Indonesia. Cecek Ijo was a local variety planted by farmers in Malang district. Stem cuttings were planted on the soil mounds with a base width of 125 cm, height 80 cm and a distance between mounds of 20 cm. Cassava stem cuttings were planted 100 cm apart on the mounds. Weeding and soils hilling up were done 2 times, namely at the age of 2 and 4 months. At age of one month, 2 stems per tree were left to grow. The plant protection was based on pest incidence, and fortunately, there was no major pest occurred during study.

Field Design

The research used a split plot design and repeated three times. The sub-plot size was 12.5 m x 10 m. The main plots were cassava varieties, namely: Litbang UK 2, Malang 4, Adira 4, and Cecek Ijo, and as sub-plots were 3 levels of fertilizer input, namely:

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Low dose (90 kg N + 76 kg P_2O_5 + 90 K_2O), Medium dose (112.5 kg N + 108 kg P_2O_5 + 120 kg K_2O), and High dose (225 kg N + 108 kg P_2O_5 + 180 kg K_2O + 5 t/ha of organic (manure) fertilizer). All fertilizers were given when the plants were 2 weeks old, except for N fertilizer was given 2 times, namely 2/3 of the dose given at the age of 2 months. A "high dose" fertilization means that a fertilizer dose of 225 kg N + 108 kg P_2O_5 + 120 kg K_2O + 5 t of manure was applied by several farmers in the location of study. This dose was higher than the recommended dose of 112.5 kg N + 108 kg P_2O_5 + 120 kg K_2O. The levels of fertilizer input were based on results of several studies reported by Taufiq et al. (2016); Wahyuni and Sundari (2014); Noerwijati (2014); and Wahyuni and Sholihin (2018).

Data Analysis

As a comparison, harvest samples were also taken from non-cooperator farmers who used traditional methods. To compare the two treatments, a t-test was used and the harvest plots were taken randomly. Plant harvest was done after ten months of age (planted at early rainy season January 2013 and harvested at late dry season of October 2013).

The data collected from agronomic observations include plant height, number of tuber per plant, tuber length, tuber diameter, tuber weight per plot, and starch concentration of cassava varieties. Plant height at harvest was conducted by measuring 5 plant samples from the soil surface to the upper plant canopy. Yield components which include the number of tubers, tuber length, and tuber diameter per plant conducted by measuring 5 plant samples representing plant diversity). Productivity (ton/ha) was observed by weighing the weight of fresh tubers per plot after harvest converted to ton per hectare. Quality of tubers was done by analysing of tuber starch content at harvest.

The data collected were analized using MSTATC by indicating mean separation by Least Significant Difference (LSD 5%).

Results

Tuber Yield and Yield Components of Cassava

Plant growth for all varieties was very good and significantly different, which was reflected in the plant height which reached more than 250 cm. The highest average plant growth rate was obtained in Malang 4 variety which reached 505 cm, followed by Cecek Ijo, Litbang UK2 and Adira 4 varieties, each reaching 315 cm, 275 cm and 258 cm. While the treatment of differences in input had no effect on plant height (*Table 2*).

The number of large and small tubers were significantly different between the varieties tried. Malang 4 variety gave the highest number of tubers (6.61) although it was not different from Cecek Ijo and Litbang UK2 varieties. Meanwhile, the lowest average number of large tubers was found in Adira4 variety, namely 5.17. Likewise, the highest number of small tubers was obtained in Malang 4 variety. All varieties have a larger number of tubers than small ones. The average variety reaches a large tubers length between 40 - 50 cm and 17 - 20 cm for small casava tubers. The range of mean length of cassava for all varieties was 40 - 50 cm (*Table 2*). While the diameter of large tubers reached 76 - 78 mm and small tubers between 45 - 47 mm, and this is a size that is quite large compared to other places which only reaches 50 mm (*Table 3*). This

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suggests that plant growth and development of tubers are very good because they are supported by very suitable land conditions accompanied by proper management. Meanwhile, the input difference treatment did not affect all observed parameters.

Table 2. *Plant height, number of tuber, and length of tuber of several varieties of cassava and fertilizer inputs*

Treatments	Plant height (cm)	Number of big tuber/plant	Number of small tuber/plant	Length of big tuber (cm)	Length small tuber (cm)
Varieties:					
Cecek Ijo	315.88 b	6.28 ab	2.81 b	53.56	20.58
Malang 4	505.89 a	6.61 a	7.58 a	35.11	17.83
Litbang UK 2	275.67 c	6.33 ab	2.76 b	53.11	19.02
Adira 4	258.33 c	5.17 b	2.67 b	39.41	18.67
LSD 0.05	18.2	1.2	2.8	ns	ns
Fertilizer dose*:					
Low	316.92	6.58	4.24	44.70	18.31
Medium	358.50	6.60	4.00	45.47	19.43
High	363.00	5.54	3.62	45.73	19.32
LSD 0.05	ns	ns	ns	ns	ns

*Low dose: 90 kg N + 76 kg P2O5 + 90 K20; Medium dose: 112.5 kg N + 108 kg P2O5 + 120 kg K20; *High dose: 225 kg N + 108 kg P2O5 + 180 kg K20 + 5 t manure. The value for the same observation in the same treatment followed by the same letter is not significantly different according to the 5% LSD test

Table 3. *Tuber diameter, tuber yield, and starch concentration of cassava varieties and fertilizer input*

Treatments	Big tuber diameter (mm)	Small tuber diameter (mm)	Tuber yield (t/ha)	Starch concentration (%)
Varieties:				
Cecek Ijo	77.97	47.56	67.66 b	22.14
Malang 4	77.89	47.28	61.67 b	22.68
Litbang UK 2	76.22	47.87	80.22 a	18.60
Adira 4	76.67	45.15	52.33 c	22.20
LSD 0.05	ns	ns	8.12	
Fertilizer dose*:				
Low	79.46	50.03	66.08 b	22.35
Medium	75.49	45.08	89.22 a	22.26
High	76.62	45.78	83.33 a	22.14
LSD 0.05	ns	ns	12.31	ns

*Low dose: 90 kg N + 76 kg P2O5 + 90 K20; Medium dose: 112.5 kg N + 108 kg P2O5 + 120 kg K20; *High dose: 225 kg N + 108 kg P2O5 + 180 kg K20 + 5 t manure. The value for the same observation in the same treatment followed by the same letter is not significantly different according to the 5% LSD test

Tuber yield per ha among varieties was significantly different (*Table 3*). The highest tuber yields (80.22 t / ha) were obtained by Litbang UK 2 variety which was 19% higher than Cecek Ijo local variety (67.66 t/ha). Malang4 and Adira4 varieties yielded of 61.67, and 52.33. t / ha, respectively which was lower than Cecek Ijo local variety.

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Litbang UK 2 as a new high yielding variety, showed high response to a very good growing environment such as in Kalipare. However, the Litbang UK 2 variety had the lowest starch content (18.60%), compared to other varieties, which was above 20%. The Litbang UK2 variety was moderately resistant to mite based on the field experiment and the greenhouse experiment (Sholihin et al., 2022b).

In the present study, the high fertilizer dose of 225 kg N + 108 kg P_2O_5 + 180 kg K_2O + 5 t of manure yielded 83.33 t/ha which was 7% lower than the medium dose of 112.5 kg N + 108 kg P_2O_5 + 120 kg K_2O which yielded 89.22 t/ha (*Table 3*). The performance of cassava plants and fresh tubers is presented in *Figure 2*.

Figure 2. *The performance of cassava plants and fresh tubers in Sukowilangun village, Kalipare sub-district, Malang district, East Java province, Indonesia, 2013*

Discussion

The Role of Varieties

The performance of Litbang UK 2 improve variety was the best among four varieties tested as well as Cecek Ijo local variety. Litbang UK 2 could replace Cecek Ijo local variety which was the existing variety grown by farmers. This result agreed with the result reported by Radjit et al. (2014) that Litbang UK2 was also the variety of choice in Lampung province. Cassava genotype interacts with the environment for the characters of fresh tuber yield, starch content, and starch yield (Noerwijati, 2014).

The Role of Fertilizer Dose

Fertilizer application is one of the key factors in achieving high yields. From the results of the current soil analysis (*Table 1*), the content of C-organic, N and K was very low, therefore the addition of these elements was needed. To achieve optimal results, cassava requires relatively high organic matter, namely 2 - 4% and K fertilizer is absolutely necessary for growing tubers **(**Howeler, 2012**)**. The present study showed the addition of 5 t of manure as organic matter yielded did not increase tuber yield compared to medium dose (*Table 3*).

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In Alfisol soil in Nigeria, fertilizing cassava with high doses (2.5 t of manure + 450 kg NPK / ha) can increase tuber yield by 39.5% and NPK levels in leaves (Ojeniyi et al., 2012). Cassava planted in good land preparation, suitable time period for plantation, and other important inputs may improve the technical efficiency of cassava farming (Soukkhamthat and Wong, 2016). The 300 kg ha^{-1} of NPK did achieve a significant output on both growth and yield parameters compare to the other rates. The number of tuber per plant and fresh tuber yield increased by 49% and 133%, respectively in the plot which received 300 kg ha^{-1} of NPK compared to the controls. There was a significant correlation (r=0.6533 at P =0.0005) between the NPK fertilizer rates and fresh tuber yield in Loulouni. The results will form a basis for NPK use on cassava in the study area and policy briefs in the country (Macalou et al., 2018).

The use of organic fertilizers is proven to be effective in increasing yields. Organic fertilization reduces soil bulk, increases porosity and root growth, and root growth correlates with tuber yield. Fertilization of 135 kg N/ha accompanied by 5 t/ha organic fertilizer increased the yield by 20% compared to only N fertilizer, and the yield obtained was equivalent to fertilizing 135 kg N/ha, 54 kg P_2O_5/ha, 60 kg K_2O/ha (Prasetyo et al., 2014). Cassava tuber yields of 20 - 50 t/ha were obtained in 4 locations in Java (South Malang, Wonogiri, Tulunggagung, and Karanganyar) with 135 kg N/ha, 36 kg P_2O_5/ha and 60-90 kg K_2O/ha (Taufiq et al., 2016). At fertilization dose of 135 kg N/ha, 36 kg P_2O_5/ha, 60-90 kg K_2O/ha, cassava yields reached 43-91 t/ha (Wahyuni and Sundari, 2014; Noerwijati, 2014; Wahyuni and Sholihin, 2018). Cassava yields were positively correlated with plant growth, indicated that an increase in nutrient supply will improve growth and will further increase yields (Sutrisno and Sundari, 2013). Fertilizer N, P and especially K is really recommended to be applied in some countries due to farmers are mostly still less utilized this kind of input (Abula and Mohammed, 2013; Patino et al., 2013; Biscaye et al., 2015). The highest fresh and dry weight of cassava storage roots was achieved in the application of 138 kg N + 36 kg P_2O_5 + 60 kg K_2O + 37 kg Ca + 13 kg Mg + 41 kg S/ha (Subekti et al., 2021).

Conclusions

On the light soils with a deep tillage layer (60-80 cm), and relatively low soil fertility, such as in the Kalipare - South Malang area, to obtain high yields of cassava, UK2 variety can be planted with a moderate dose of fertilization, namely 112.5 kg N + 108 kg P_2O_5/ha. The technology package was able to produce 80.22 t/ha tuber production, higher than the use of other varieties such as Cecek Ijo, Malang4, and Adira4. However, starch content UK 2 variety (18.6%) was lower than other varieties, which reached more than 22%.

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