Effect of planting and harvesting time on cassava (*Manihot esculenta* Crantz) Var. Gambyong

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**Abstract.** Cassava has become a premier commodity used as the raw material for local’s food production. Gunungkidul Regency is well known as the central production of cassava, thus, becoming the main reference for the consumers either persons, group, or firms. However, Cassava’s availability has remained a problem as its productivity cannot fulfill the demand of the market. Planting and harvest time are the main problem as it remains unclear, especially for local varieties at Gunungkidul regency. This research aimed to determine the proper time to plant and harvest cassava cv. Gambyong. Factorial treatments consisting of two factors were arranged in Randomized Complete Block Design (RCBD). This first factor was the planting time (September, October, November, and December), while the second factor was the harvesting time (four, five, six, seven, eight, and nine month). There were three replications within each treatment, so that there were 72 experimental units. The result revealed that the cassava planted in September had increasing growth rate, development, and tuber yield started from 4 to 9 month of harvest time. Meanwhile, the cassava planted in October, November, and December showed decreasing growth rate, development, and tuber yield of all harvest time.

1. **Introduction**

The demand of cassava in Indonesia is predicted to reach 30 million tons in 2025, which must be met by the increase in production by 27% [1]. The potential for great opportunities must be accompanied by efforts to increase production through intensification, extensification and diversification. Gunungkidul Regency is one of the areas that is very suitable to realize efforts to increase production since Gunungkidul is a center of cassava production with a high variability [2].

There are 34 cassava varieties (21 local varieties) planted by farmers in the Gunungkidul Regency, some of them are Ketan (15.94%), Gatot Kaca (13.76%), Mentega (7.24%), Ireng (7.24%), Kirik (5.79%), Kacibali (4.34%), Abang (4.34%), and Gambyong (3.62%). Many cassava farmers in Central Java still use local varieties (56%) rather than superior ones (44%). One of the local varieties used is variety Gambyong (3.20%). However, there is limited information about the planting time and harvest time for all the varieties [2].

In general, all varieties of Cassava in Gunungkidul is planted in November-December and harvested around August of the following year or at the harvest time of 9 or 10 months. However, information about planting time and harvesting time specifically for each variety is not available yet.

Cassava does not have a clear maturity period because the tubers continue to grow [3]. As a result, harvest periods can vary, thus cassava can be produced with different physical and chemical
properties. Physical and chemical properties such as the shape and size of granules, amylose content, and non-starch components are influenced by genetic factors, climatic conditions, and time of plants. Based on the harvest time, cassava can be divided into two, namely short-lived or early cassava (5-8 months) and long-lived cassava (9-10 months) [4]. Feliana et al. [3] stated that the criteria for cassava that could be harvested were the decreasing in lower leaf growth, high number of fall-of leaves, and the yellowing of the leaves. One of the factors that influence the quantity and quality of cassava is the climate conditions of the planting area. Rainfall is a high fluctuating element of climate.

The overall amount of rainfall is very important in determining yield. Cassava plant require 150-200 mm, 250-300 mm, and 100-150 mm of rainfall when they are 1-3 months, 4-7 months old, and before harvested, respectively [5]. In addition to rainfall, the length of photoperiod determines the formation of tuber, thus the different dark and light treatments can affect and stimulate the beginning of tuber formation [6]. It can be said that the higher the rainfall and the more the rainy days in a month, the lower the photoperiodicity, hence the formation of tubers is disturbed and the yield of tubers is low, both in quantity and quality. Miti [7] said that the larger number of varieties resulted in varied nutritional and physical properties of cassava. Based on the results of Susilawati et al. [8] research, the content of starch tested from the time of 7 months to 10 months continued to increase to 35.93%.

Based on the explained phenomena and facts, it is necessary to study the planting time and harvest time of cassava, especially variety Gambyong which is widely planted by farmers. The aim of this study was to determine the proper planting time and harvest time for Cassava cv. Gambyong.

2. Materials and Methods
The study was conducted with factorial experimental methods arranged in a Randomized Complete Block Design (RCBD). Tested treatment consisted of a combination of two factors. The first factor was planting time consisting of 4 (four) levels, namely September, October, November, and December 2018. The second factor was the harvest time consisting of 6 (six) levels, namely 4, 5, 6, 7, 8, and 9 months after planting. There were 24 combinations of treatments tested and each combination consisted of three replications, so there were 72 experimental units.

Growth parameters and yield components were observed, namely plant height, leaf number, leaf area, stem diameter, number of tubers, tubers weight per plant, tuber length, tuber diameter, and tuber yield (ton/ha). Data from the observations were analyzed by analysis of variance at 5%. Data showing significant difference between treatments were tested using the Duncan’s Multiple Range Test (DMRT) at 5%.

3. Results and Discussion
Growth and yield of plants are strongly suspected to be influenced by interactions between planting time and harvest time of cassava.

3.1. Non-interactive Factors
There was no interaction effect between planting time and harvest time on the plant height, leaf area, and number of tubers (Table 1). The results of the analysis showed no interaction effect between the planting time the harvest time on the plant height, leaf area and number of tubers. However, the planting time and the harvest time individually gave significant effects. The plant height, leaf area and number of tubers of cassava plants planted in September were significantly higher than those of cassava planted in October, November and December. When the cassava plants are planted later, the plant height is lower, the leaf area is smaller and the number of tubers is getting less. This is because the suitability of water availability needed by cassava plants is not in balance with the environmental conditions, especially the amount of rainfall. The cassava plants planted in September (the beginning of the rainy season) obtained water as needed. Cassava plant require 150-200 mm, 250-300 mm, and 100-150 mm of rainfall when they are 1-3 months, 4-7 months old, and before harvested, respectively [5]. Data on rainfall distribution during the study can be seen in appendix I. Meanwhile, rainfall which
was high in October, November and December was not suitable for the initial growth of cassava plants. Conversely, during accelerated vegetative growth which requires a sufficient amount of water, the volume of rainfall (water availability) was decreasing. It can be seen in Table 1 that cassava plants planted in December were not able to grow optimally (timed 4 - 6 months) because it had entered the dry season, so the plants experienced a lack of water. As a result, photosynthesis rates were low leading to lower plant height, smaller leaf area and lower number of tubers.

### Table 1. Plant height (cm), leaves area (cm) and number of tubers of cassava affected by difference planting time and harvesting time.

| Treatment            | Plant height (cm) | Leaves area (cm) | Number of tubers |
|----------------------|-------------------|------------------|------------------|
| **Planting time:**   |                   |                  |                  |
| September            | 233.43 a          | 473.42 a         | 13,11 a          |
| October              | 147.01 b          | 183.54 b         | 8,22 b           |
| November             | 90.16 c           | 81.13 c          | 4,25 c           |
| December             | 68.97 d           | 34.27 c          | 1,07 d           |
| **Harvesting time:** |                   |                  |                  |
| Month 4              | 92.65 b           | 105.35 c         | 8,35 a           |
| Month 5              | 109.14 b          | 160.00 bc        | 7,00 ab          |
| Month 6              | 149.79 a          | 322.71 a         | 8,25 a           |
| Month 7              | 146.40 a          | 295.10 a         | 6,20 ab          |
| Month 8              | 155.15 a          | 228.82 ab        | 7,04 ab          |
| Month 9              | 156.26 a          | 115.30 c         | 5,72 b           |

Values followed by the same letters in the same column are not significantly different based on DMRT at 5%.

The effect of harvest time on plant height showed that plant height increased from 4 and 5 months of time and reached a maximum height in 6 months. This shows that the results of photosynthesis have been concentrated for the development of tubers. Whereas, the influence of harvest time on leaf area indicated that the leaf area of cassava plants increased from 4 and 5 months of time, reaching a maximum value in 6 to 8 months and decreased at 9 months after planting, because some leaves have begun to fall indicating maximum plant development.

### 3.2. Interactive Factors

The effect of the interaction between planting time and harvest time on the number of leaves and diameter of the stem is indicated by the results of the analysis presented in Table 2 and 3. The results of the analysis showed that there was an interaction effect between the planting time and the harvest time on the number of leaves and stem diameter. The highest number of leaves and stem diameter of cassava plants were observed in cassava plants planted in September and harvested at 8 months, while cassava planted in October and November produced lower number of leaves and stem diameter, reaching maximum values at 6 months of time. Cassava planted in December produced the lowest number of leaves and stem diameter and showed no significant difference between harvest time of 4, 5, 6, 7, 8 and 9 weeks.

The results of the analysis showed that there was an interaction effect between the planting time and the harvest time on the weight of tubers per plant. The effect of planting and harvesting time on the weight of tubers per plant showed that the weight of tubers per plant of cassava planted in September increased with the increasing harvest time. The maximum weight of tubers per plant was reached at harvest time of 6 months, which was not significantly different from the weight of tubers per plant at harvest time of 7, 8, and 9 months. Meanwhile, cassava planted in October reached the maximum weight of tubers per plant at harvest time of 8 months, which was not significantly different
from the weight of tubers per plant at the harvest time of 5, 6, 7 and 9 months as well as the weight of tubers per plant planted in September at the harvest time of 4 months. The cassava planted in November and December produced the lowest weight of tubers per plant and there was no significant difference between the values at the harvest time of 4 to 9 months.

Table 2. Number of leaves and stem diameter (cm) of cassava affected by difference planting time and harvesting time.

| Planting Time | Harvesting Time | Number of Leaves | Stem Diameter (cm) |
|---------------|----------------|-----------------|-------------------|
|               | Month 4 | Month 5 | Month 6 | Month 7 | Month 8 | Month 9 | Month 4 | Month 5 | Month 6 | Month 7 | Month 8 | Month 9 |
| Sep           | 128.67  | 227.00  | 496.22  | 523.89  | 619.44  | 501.44  | 1.83    | 1.79    | 2.20    | 2.14    | 2.64    | 2.23    |
| Oct           | 66.56   | 91.11   | 156.67  | 186.00  | 172.22  | 211.78  | 1.39    | 1.30    | 1.46    | 1.45    | 1.56    | 1.71    |
| Nov           | 58.22   | 72.33   | 107.00  | 99.34   | 101.17  | 94.00   | 1.00    | 0.96    | 1.36    | 1.13    | 1.10    | 1.06    |
| Dec           | 42.78   | 55.17   | 55.11   | 48.44   | 49.89   | 56.00   | 0.72    | 0.67    | 0.71    | 0.78    | 0.73    | 0.82    |

Values followed by the same letters are not significantly different based on DMRT at 5%

The analysis results showed that there was an interaction between the planting time and the harvest time on the weight per tuber. The effect of planting time and harvest time on weight per tuber showed that the weight per tuber planted in September increased with the increasing harvest time, reaching the maximum value in 9 months. Whereas, the cassava planted in October and November reached the maximum weight per tuber at the harvest time of 9 months but not significantly different from the values at the harvest time of 6, 7 and 8, and significantly lower than the values of the cassava planted in September at the harvest time of 6 to 9 months.

The analysis results showed that there was an interaction between the planting time and the harvest time on the tuber diameter. The effect of planting time and harvest time on tuber diameter showed that there was an increase in tuber diameter from harvest time of 4 months to a maximum value at the harvest time of 9 months obtained in cassava planted in September, October and November, but not significantly different from the tuber diameter at harvest time of 6, 7 and 8 months. Meanwhile, cassava planted in December reached the maximum diameter of tuber at the harvest time of 8 months.

The effect of planting time and harvest time on the length of tuber showed that tuber length of cassava planted in September tended to increase with the increasing harvest time and reached a maximum value at the harvest time of 9 months. Meanwhile, the tuber length of cassava planted in October, November and December did not increase with the increasing harvest time.

Based on the results of the analysis of tuber yield data, there was an interaction effect between the planting time and harvest time. Tuber yield of cassava planted in September tended to increase with the increasing harvest time, reaching maximum value at the harvest time of 6 months and remaining the same at the harvest time of 7, 8, and 8 months. Cassava planted in October produced lower tuber yield compared to that planted in September and reached maximum yield at the harvest time of 8 which was not significantly different from the values at the harvest time of 5, 6, 7 and 9 months. Whereas, the tuber yield of cassava planted in November and December did not show any increase
from the harvest time of 4 -9 months. Cassava planted in November and December produced significantly lower yield than cassava planted in September and October.

Table 3. Average of weight of tubers per plant (kg), weight of tuber (kg), tuber diameter (cm), tuber length (cm), and tuber yield (ton/ha) of cassava affected by difference planting time and harvesting time.

| Planting Time | Harvesting times | Weight of Tubers per Plant (Kg) | Weight of Tuber (Kg) | Tuber Diameter (cm) | Tuber Length (cm) | Tuber Yield (ton/Ha) |
|---------------|------------------|---------------------------------|----------------------|---------------------|-------------------|---------------------|
|               | Month 4          | Month 5                          | Month 6              | Month 7             | Month 8           | Month 9             |
|               |                  |                                 |                      |                     |                   |                     |
| Sep           | 0.95 c           | 1.51 b                          | 2.46 a               | 2.38 a              | 2.58 a            | 2.68                |
| Oct           | 0.40 e-g         | 0.61 c-f                         | 0.83 cd              | 0.77 c-e            | 0.89 c            | 0.95 c              |
| Nov           | 0.15 g           | 0.15 g                           | 0.44 d-g             | 0.26 fg             | 0.29 fg           | 0.34 e-g            |
| Dec           | 0.04 g           | 0.05 g                           | 0.04 g               | 0.04 g              | 0.07 g            | 0.08 g              |
|               |                  |                                 |                      |                     |                   |                     |
| Sep           | 0.07 f-k         | 0.11 c-g                         | 0.16 bc              | 0.19 b              | 0.19 b            | 0.32 a              |
| Oct           | 0.05 i-k         | 0.07 f-k                         | 0.11 d-h             | 0.10 d-h            | 0.12 c-f          | 0.13 c-e            |
| Nov           | 0.04 i-k         | 0.04 i-k                         | 0.07 f-j             | 0.07 g-k            | 0.08 i            | 0.10 d-h            |
| Dec           | 0.03 jk          | 0.05 i-k                         | 0.02 k               | 0.06 h-k            | 0.14 b-d          | 0.05 i-k            |
|               |                  |                                 |                      |                     |                   |                     |
| Sep           | 1.77 f-h         | 2.14 d-h                         | 2.44 b-g             | 2.90 a-d            | 3.01 a-c          | 3.28 a-c            |
| Oct           | 1.50 h           | 1.97 e-h                         | 2.35 c-h             | 2.71 b-e            | 2.57 b-f          | 3.00 a-c            |
| Nov           | 1.74 f-h         | 2.03 e-h                         | 2.58 b-f             | 2.30 c-h            | 2.90 a-d          | 2.89 a-d            |
| Dec           | 1.79 f-h         | 1.71 gh                          | 1.81 f-h             | 2.00 e-h            | 3.61 a            | 2.68 b-e            |
|               |                  |                                 |                      |                     |                   |                     |
| Sep           | 24.30 c-g        | 31.17 bc                         | 34.09 b              | 29.10 b-d           | 27.08 b-f         | 41.12 a             |
| Oct           | 22.64 d-h        | 26.75 b-f                        | 27.60 b-e            | 21.50 d-h           | 22.77 d-h         | 21.02 e-h           |
| Nov           | 17.93 g-i        | 15.49 h-j                        | 19.66 f-h            | 17.20 g-j           | 16.73 g-j         | 16.05 h-j           |
| Dec           | 11.17 i-k        | 8.00 k                           | 9.81 jk              | 18.33 g-i           | 16.50 g-j         | 11.38 ik            |
|               |                  |                                 |                      |                     |                   |                     |
| Sep           | 9.48 c           | 15.07 b                          | 24.58 a              | 23.73 a             | 25.75 a           | 26.82 a             |
| Oct           | 4.00 e-f         | 6.10 c-f                         | 8.25 cd              | 7.67 c-e            | 8.85 c            | 9.50 c              |
| Nov           | 1.45 g           | 1.48 g                           | 4.33 d-g             | 2.55 fg             | 2.93 fg           | 3.62 e-g            |
| Dec           | 0.40 g           | 0.45 g                           | 0.35 g               | 0.38 g              | 0.70 g            | 0.75 g              |

Values followed by the same letters are not significantly different based on DMRT at 5%

This result is in accordance with analysis of plant height, leaf area and number of tubers per plant, that cassava planted in September (the beginning of the rainy season) obtained water as needed. At the initial growth of root, leaf and stem growth (1-3 months old), cassava required 150-200 mm and the rainfall from October to December was 83 -259 mm. Meanwhile, when plants entered active growth (time 4-5 months), the needs were 250-300 mm and the rainfall ranged from 468 - 278 mm. At the carbohydrate translocation phase and before harvest (times 6-9 months), cassava required 100-150 mm of rainfall and the rainfall ranged from 284 - 18 mm [5]. Data on rainfall distribution during the
research can be seen in appendix 1. The availability of sufficient water will allow plants to absorb the
nutrients needed in photosynthesis, such as N, P, K. The increase in photosynthesis rate provides good
growth rate and high tuber yield. The cassava planting time in October, November and December is
not suitable because it leads to high water availability during initial growth and low water availability
during active growth phase. High rainfall is not good for the beginning of the plant growth phase. Cassava planted in December experienced slow growth rate at the plant time of 4 – 5 months since it
had entered the dry season, and the plants experienced a lack of water, thus the photosynthesis rate
was low, resulting in slow plant growth rate and low tuber yield.

4. Conclusion

Planting time of cassava (Manihot esculenta Crantz.) Var. Gambyong could be optimal on September
based on the result of growth rate, development, and tuber yield harvested on 4th to 9th months after
planting. Meanwhile, the plants were cultivated on October, November, and December revealed
decreasing growth rate, development, and tuber yield of all harvesting time.

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