Effects of nitrogen rate and harvesting age on herbage and essential oil of *Cymbopogon citratus*

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**Abstract.** This research is about herbage and essential oil yield (EOY) of *Cymbopogon citratus* subjected to multiple harvesting period and nitrogen rate. This study was carried out in Ladang 1, MARDI Kluang between June 2018 to February 2019. The experimental design used for this study was Randomized Complete Block Design with Factorial under 3 replications. The aims of this study are to evaluate effect of nitrogen rate, harvesting age and the interaction between nitrogen rate and harvesting age on *C. citratus* herbage yield and EOY. Some of the parameters evaluated in this study include herbage yield, EOY, height and girth. The study discovered that, girth and height show a significant positive linear response towards harvesting age while EOY shows significant negative linear response. Herbage yield was significantly affected by both nitrogen rate and harvesting age but with no significant interaction between the two. Present finding may give rise to improvement on *C. citratus* production SOP.

1. **Introduction**

Lemongrass was scientifically known as *Cymbopogon citratus* under the family of Gramineae and the locals called it as ‘serai makan’. It is a perennial narrow leaf crop that has wide variety of usage than ranges from essential oil, cosmetic and pharmaceutical [1]. Department of Agriculture (DOA) indicates that there was increase demand for *C. citratus* between 2005 and 2008 [2]. Minister of Food and Agriculture Industries (MAFI) estimated that national spice herbs production should exceed 117,000 metric tonnes by year 2020 [3]. In other words, an approximate of 11.2% increment per year. An approach to achieve this target is by increasing productivity through research and development [2].

Use of herbs can be grouped into several approach including cultivation, harvest period, plant parts, transportation, and post-harvest processing [4]. One element of cultivation is fertilizer management and harvesting period.
2. Materials and methods
A total of 60 plots were laid out in Randomized Compete Block Design (RCBD). Each plot has 32 planting points with 1 slip per point. The planting distance used in this study was 1 m x 0.5 m [6]. There were 5 intervals of harvesting period which are 150, 180, 210, 240 and 270 days after transplant (DAT). 4 intervals of nitrogen rate were employed for this study which comprise of 0, 100, 200 and 300 kg/ha. Crop Cutting Test (CCT) used for this study was 3 m x 1.5 m [7]. Height was measured by selecting longest leaf blade from 4 random hills per plot [8]. Girth was measured using veneer caliper with 5 cm above ground from slip with longest leaf blade from the exact hills measured for height. Means were subjected to Duncan Multiple Range Test if significant.

3. Results and discussion
Mean square ANOVA analysis suggest that height, girth and EOY were significantly affected by harvesting age (Table 1). Furthermore, herbage yield was significantly by both nitrogen rate and harvesting age but no significant interaction between them.

**Table 1. Mean Square ANOVA on effect of nitrogen rate and harvesting age on Yield component of Cymbopogon citratus**

| Source of variance   | Parameter          | Height          | Girth     | Herbage yield | Essential Oil Yield (EOY) |
|----------------------|--------------------|-----------------|-----------|---------------|--------------------------|
| Rep                  |                    | 477.19          | 0.095     | 10084.11      | 0.26                     |
| Nitrogen (N)         |                    | 295.17          | 0.669     | 275073.34**   | 0.098                    |
| Harvesting age (Hvp) |                    | 2318.19**       | 5.731*    | 350113.63**   | 1.46**                   |
| N x Hvp              |                    | 275.60          | 2.295     | 28234.82      | 0.028                    |
| Grand mean           |                    | 111.5           | 12.5      | 1128.8        | 1.95                     |
| C.V. (%)             |                    | 20.09           | 9.74      | 20.72         | 15.07                    |

Note: mean followed by * is significant at 0.05
      Mean followed by ** is significant at 0.01

3.1 Height
Plant height shows significant positive linear response with harvesting period. Harvesting period between 150 to 210 DAT contribute to significantly lower reading compared to those harvested at 240 and 270 DAT (Figure 1). Heights between 150 to 210 are at par with each other. The difference between 240 and 150 DAT was 23.84%. Use of height as an indicator age has been studied and discovered that height of 1.5 m contributes to highest herbage yield (t/ha) and total essential oil yield (t/ha) [9]. Another study discovered that C. citratus height was significantly affected by interaction between location and year of harvest [10]. Location designated as Awassa contributed to the highest plant height while second year harvest scored the highest significant height reading and in the same tome both plant height and fresh yield are positively correlated.
3.2 Girth
Similar significant positive linear response was observed for girth towards harvesting age (Figure 2). Harvesting age of 180 DAT increases girth reading by 0.85% compared to 150 DAT. However, this increment was at par. Further delay in harvesting period to 210 DAT increases girth reading by 4.24% compared to 180 DAT and still at par. Subsequent delay to 240 DAT increases girth reading by 8.94% and it was significantly higher compared to those harvested at 150, 180 and 210 DAT. Final delay of 270 DAT contributes highest reading however it exhibits statistical parity with 240 DAT. The increment at between 240 and 270 DAT was not significant. Slip with diameter of more than 12 mm is considered as marketable and it was significantly affected by harvesting age [11]. The study discovered that C. citratus harvested at 225 DAT contributed to the highest marketable herbage yield compared to those harvested at 165 and 195 DAT. In other words, harvesting age can influenced girth size of C. citratus.

3.3 Herbage yield
Herbage yield shows a significant positive linear response to both nitrogen rate and harvesting age. Absence of nitrogen significantly dropped herbage yield reading (Figure 3). Nitrogen rate addition of 100 kg/ha increases reading by 1.59% but it was not significant. Further addition of N rate to 200 kg/ha an increase reading by 9.94% and it was significantly higher compared to 0 and 100 kg/ha. Final addition of N rate to 300 kg/ha further increases reading by 12.08% and it was significantly highest reading compared to the rest of the intervals. Apart from nitrogen rate, organic compost also provides significant effect on C. citratus herbage yield [12]. The study found out that application of organic...
compost shows positive increment in biomass yield however it stopped shows any increment after reaching 40 t/ha and postulate a quadratic response.

![Figure 3. Relationship between nitrogen rate and herbage yield](image)

Harvesting *C. citratus* as early as 150 DAT significantly contributes lower reading compared to 180 DAT. The difference was 9.9% (Figure 4). Subsequent delay to 210 DAT increases herbage yield reading by 0.56%. The increment between these 2 periods is at par. Further delay up to 240 DAT increases herbage yield reading by 18.11% and it was significant compared to those harvested at 210 DAT. Final delay to 270 DAT increases reading by 5.43%. Nevertheless, the increment between 240 and 270 DAT was insignificant. A study suggests that *C. citratus* herbage yield was significantly affected by interaction between harvesting age and variety [13]. The study concluded that variety Lomisar Java is superior compared to variety Lomisar UA and a steady significant herbage yield increment between 40 to 105 DAT of harvesting age was established.

![Figure 4. Relationship between harvesting period and herbage yield](image)

3.4 Essential oil yield (EOY)

EOY shows a significant negative linear response towards harvesting age (Figure 5). Completely opposite compared to previous parameters. Harvesting period as early as 150 DAT contributes to highest reading but at par with 180 DAT. The difference was 9.84%. Further delay to 210 DAT reduces EOY reading by 24.29% and it was significantly lower compared to those harvested at 150 and 180 DAT. Subsequent delay to 240 DAT reduces EOY reading by 4.52% but it is at par with 210. Final delay to 270 DAT further reduces EOY reading by 1.81%. In other words, harvesting period of 210 to 270 DAT significantly reduce EOY compared to those harvested at 150 and 180 DAT. A study concluded that essential oil yield in *C. citratus* was not significantly affected by harvesting age but
significantly affects its chemical constituents [14]. Chemical composition such as Myrcene, Nera, Geranial and Citral in *C. citratus* was significantly in lower concentration when harvested at 90 DAT but shows significant increment when harvested at 180 DAT and shows no significant difference compared those harvested at subseptent 270 and 360 DAT. Another study discovered that EOY shows significant quadratic response towards harvesting age [15]. The study discovered that *C. citratus* was still undergoes division into slip after 165 DAT in which each containing 2-3 tiller with subsequent 4-5 leaves. Beyond 210 DAT, the division halted, and the old leaves dried off which in return reduced essential oil.

![Graph showing the relationship between harvesting period and EOY](image)

**Figure 5.** Relationship between harvesting period and EOY

### 3.5 Correlation analysis

Correlation analysis suggests that herbage yield has significant positive association with girth (Table 2). In other words, obtaining higher girth reading could potentially contributes higher herbage yield since both are significantly affected by treatments and significantly correlated with each other. Height somehow has no significant positive association with herbage yield. Height may not be reliable indicator of good herbage yield. Nevertheless, EOY has significant negative association with the rest of the parameters. Obtaining higher height, girth and herbage yield could potentially reduce EOY.

| Height | Girth | Herbage yield | Essential Oil Yield (EOY) |
|--------|-------|---------------|---------------------------|
| Height | 1     | 0.36          | -0.52                     |
| Girth  | 1     | 0.48          | -0.62                     |
| Herbage yield | 1 | -0.45         |                           |
| Essential Oil Yield (EOY) | 1 |               |                           |

Table 2. Correlation analysis among parameters.

Note: mean followed by * is significant at 0.05  
Mean followed by ** is significant at 0.01

### 4. Conclusions

Both herbage yield and EOY behave in opposite manner when subjected to different harvesting age. Present findings may suggest that the SOP for *C. citratus* should be split into two categories which is either for herbage yield or EOY. This is because EOY significantly dropped with harvesting age and it
was vice versa for herbage yield. Current recommendation by DOA is 6 – 8 months for herbage yield and it may need to be improved.

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