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# SYNCHRONIZATION BETWEEN AVAILABLE NITROGEN AND MAIZE (Zea mays) NEED: STUDY ON DIFFERENT APPLICATION TIME AND TYPE OF GREEN FERTILIZERS

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## ABSTRACT

Utilization of legume cover crop (LCC) as insitu-green fertilizer is an alternatives for carbon (C) storage in soil and nitrogen (N) source for organic farming. However, its usages were not optimum due to lack of synchronization state (un-matching point between nutrient release and plant need). This research aim to describe model of synchronization point of Maize (Zea mays) using green feilizer from LCC. A pot experiment had conducted using factorial block randomized design (RBD) with two factors: 1) types of LCC residues (Crotolaria usaramoensis and Phaseolus lunatus); and 2) application time (10, 20 and 30 days before planting-DBP). The results showed that, there was no difference between types of LCC, mean while application time (10 DBP) was significant ($p<0.05$) difference for synchronization state of N during vegetative phase (60 days) than others.

**Keywords:** legume cover crop, green fertilizer, nitrogen synchronization, Maize

## Introduction

Conventional farrmig system by returning crop residues to soil was an alternative approach for increasing C storage that could become as source and sink of nutrients. On of the C source is annual legume cover crop (LCC), for instance: *Crotolaria usaramoensis* L., and *Phaseolus lunatus* L. This type of plants has important role for management of soil fertility regarding its functiong for covering soil surface that can reduce run off, soil erosion and evaporation; and also soil C and nutrients input to the soil (Power, 1987). The LCC could be used as green manure due to high input of N and organic matter that benefits for other soil properties (Sarrantonio, 2007; Acosta, 20109). The application of LCC as green manure had been done by many farmers at dryland farming system for soil conservation and soil fertility purposes especially during the resting time (free growing, intermediate time between planting periode) (Power, 1987; Sarrantonio, 2007; Acosta, 2009). However, there were still some challanges for the farmers when using LCC as green manure, such as: little interest for growing those plants because they are not food crops and limited information about the benefits of LCC as green manure. Common people used LCC mainly for soil conservation and rarely used as green manure. In some cases, a

Vol. 2, No. 05; 2017

ISSN: 2456-8643

successful application LCC green manure depended on the quality of organic matter itself (Tian *et al.*, 1992; Stevenson, 1994; Hairiah *et al*., 2003).

Inefficiency application of the green manure because of overdose or low application causing deficiency or surplus of nutrients then will effect to crop growth and production (Terrance *et al*., 2012). One strategy to overcome those problems is time management for returning crop residues to the soil. It is important regarding decomposition and immobilisation proses in the soil. The right time of appication will match between nutrients release and plant need with consideration on the quality of organic matter and the phase of plant growth (Hadyanto et al., 1997). This point is called synchronization which is macthing state between time of nutrients release and plant need on those nutrients (Murwira, 1994; Myers *et al*., 1997). The level of synchronization depends on decomposition and mineralisation rate of organic matter (Myers *et al*., 1997). Optimum production of plant could be reached when synchronization state happened. High crop production depends on application time, how to apply and the quality of organic input (Myers *et al*., 1997). Therefore, the increasing of synchronization through application time, quality insitu-biomass of LCC and planting time of annual crops need to be considered. Incorporation of biomass into the soil could use used freshly before planting the crops (Rupa *et al.*, 2013). Incorporation of biomass prior to planting the crops gave more time for the biomass to be decomposed then planting when mineralisation time. Therefore, this research was carried out to understand synchronization of N from LCC to Maize growth.

**Materials and Method**

**Site description**

This study was conducted at experimental field of Agriculture Polythechnic in Kupang-East Nusa Tenggara-Indonesia for 6 months. This area was located at 9º19 – 10º57 Lat. and 121º30 – 124º11 Longt, under sub tropical climate with total rainfall 1.400 mm.yr$^{-1}$ and mean annual temperature 27$^{o}$C. In addition, the soils used in this experiment was Grumusols that has characteristics: clay soil (72.74% clay), $C_{org}$ 1.56% (low) pH 7.35 (netral), $N_{tot}$ 0.16% (low) and C/N 9.75. There were two types of LCC (*Crotolaria usaramoensis* and *Phaseolus lunatus*) that have different chemical compunds (Tabel 1).

ISSN: 2456-8643

**Table 1. Chemical compounds of *Crotolaria usaramoensis* and *Phaseolus lunatus***

| | | LCC types | |
|---|---|---|---|
| | | *Crotolaria usaramoensis* | *Phaseolus lunatus* |
| a. | N- total (%) | 4,19 | 3,48 |
| b. | P- total (%) | 0,25 | 0,37 |
| c. | C -total (%) | 39,22 | 42,72 |
| d. | C/N | 9,36 | 10,73 |
| e. | C/P | 156,88 | 115,46 |
| f. | Lignin (%) | 9,64 | 11,36 |
| g. | Polifenol (%) | 3,76 | 4,01 |

***Sumber:*** *Rupa, 2014*

**Research design and statistical analysis**

The experiment was designed on pot experiment using factorial block randomized design with two factors. Factor LCC biomass *Crotolaria usaramoensis* and biomasa *Phaseolus lunatus* and application time (10, 20. 30 day before planting-DBP), three replications. Biomass of LCC was 10t.ha$^{-1}$ of fresh biomass (50g per 10kg of soil). Soils were incubated based on the treatment of application time. Indicator plant used Maize (*Zea mays*) local variety (Lamuru), two seeds per pot. After seven days of planting (DAP), one crop was cutted, so then only one crop remain per pot. The crops were maintained by regularly watering about 800 ml.pot$^{-1}$ up to 60 DAP.

Soil and plant samples were collected at 15, 30, 45 and 60 DAP using destructive method. Then, the data was analyzed based on Sulaeman *et al*. (2005) for soil: $N_{tot}$ (%) and available (total $NO_3^-$, $NH_4^+$) (%); and for plant: $N_{tot}$ ($NO_3^-$ and $NH_4^+$) of plant tissue (%), N absorpted by Maize (N plant tissue x dry mass of plant shoot) measured from 15 DAP, and drymass of plant (g) using Kejdhal method.

Data was collected to be analyzed using analysis of variance (ANOVA) for factorial BRD continued to Duncan test at 5% ($p<0.05$) (Go mez dan Gomez, 2007) using COSTAT dan MSTATC while graphs using Exel.

## Results and Discussion

### Total Nitrogen of soil

LCC biomass used as green manure has significantly effect to $N_{tot}$ of soil in terms of different time application during vegetative phase ($p<0.05$) (Tabel 2).

**Table 2. Total Nitrogen of soil under different LCC types and application time in vegetatatif phase of Maize**

| Treatments | $N_{tot}$ (%)*) | | | | |
|---|---|---|---|---|---|
| | 0 DAP | 15 DAP | 30 DAP | 45 DAP | 60 DAP |
| LCC types: | | | | | |
| *Crotolaria usaramoensis*: | 0,27-a | 0,34-a | 0,37-a | 0,36-a | 0,31-a |
| *Phaseolus lunatus* | 0,26-a | 0,34-a | 0,36-a | 0,36-a | 0,32-a |
| Application time: | | | | | |
| 10 DBP | 0.13-c | 0.31-b | 0.36-b | 0.39-a | 0.42-a |
| 20 DBP | 0.23-b | 0.33-b | 0.37-b | 0.40-a | 0.33-b |
| 30 DBP | 0.40-a | 0.38-a | 0.37-a | 0.28-b | 0.21-c |

*) The different of lower case at the same column shows significant difference ($p<0,05$)

Table 2 shows that there was no effect of LCC types to $N_{tot}$ of soil over period of growing time. On the other hand, application time at 10 DBP shown that $N_{tot}$ linearly increased as well as at 20 DBP. At 10 DBP $N_{tot}$ decreased 19% (0.16 to 0.13%) from initial soil to 0 DAP, but after that it increased almost 1.5 times at 15 DAP and later on. Meanwhile, at 20 DBP, there was increasing of $N_{tot}$ (44% at 0 DAP) from initial one as well at 15 DAP (43%) but then decreased at 60 DAP (17%). Surprisingly, only at 30 DBP shown different direction of $N_{tot}$. After 30 days of biomass addition to the soil, $N_{tot}$ increased 1.5 times from initial one but then decreased slowly started with 5% (at 0 DAP) continued to 60 DAP (loosing up to 47%). Based on those results and

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related to plant demand, although application time at 10 DBP provided $N_{tot}$ significantly lower than at 30 DBP up to 30 DAP, it has consistent performance during growing periode.

Preliminary lost of $N_{tot}$ during the first 10 days after biomass addition was due to N-immobilisation by soil microbes as their energy during decomposition process (Moata *et al.*, 2009; Moata *et al.* 2016). At the time, N release from the decomposition of biomass (3,9 % N) was still little. Although in this study the soils itself have low C/N (9.75) which probably has rapid decomposition and mineralisation rate, the biomass still need some period of time (about 14 days) to be decomposed. Hazelton & Murphy (2007) suggested that mineralisation might occur when C/N <25, it means decomposer need lots of energy during decomposition and mineralisation processes. Thus, the critical point for decomposition was 10 DBP where microbes were working actively.

In addition, $N_{tot}$ at 20 DBP and 30 DBP were higher than at 10 DBP. This proved that N already started to be released from mineralisation process about (43% at 20 DBP) and even double at 30 DBP compared to the initial one. The $N_{tot}$ of soil continued to be improved through out the time. The application of LCC biomass at 30DBP provided higher N release significantly ($p<0.05$) compare to others but at 45 DAP it decreased, meanwhile application at 20 DBP started to decrease at 60 DAP. In general. all application shown that $N_{tot}$ release during vegetative priode (60 DAP). However, the application time at 30 DBP provided opposite trend that tended to decrease over period of time during vegetative phase. It could be assumpted that after 30 days biomass addition, the $N_{tot}$ was the pick one then decreased slowly until 60 DAP and they were higher ($P<0.05$) than others applications times until 30 DAP. It means likely decomposition and mineralisation of biomass process happened for 60 days after biomass addition for all the treatments of application time. At the first 10 days was decomposition time, then after 10 days to 60 days was mineralisation process where soils have plenty of N, and after 60 days biomass addition, the $N_{tot}$ in the soil started to decrease. This became critical time for plant uptake regarding when the better time for addition biomass or when the right time for planting the crops.

**Available N in the soil**

Similar results as above that types of LCC were not significantly different on the available N of soil but difference on the application time and the 10 DBP provided the best one ($p<0,05$) compare to others (Table 3).

**Table 3. Mean of available N in the soil on different types of LCC and application time during vegetative phase of Maize**

| Treatments | Availble N (%) | | | | |
|---|---|---|---|---|---|
| | 0 DAP | 15 DAP | 30 DAP | 45 DAP | 60 DAP |
| LCC types: | | | | | |
| *Crotolaria usaramoensis*: | 0.016-a | 0.025-a | 0.028-a | 0.029-a | 0.026-a |
| *Phaseolus lunatus* | 0.016-a | 0.026-a | 0.031-a | 0.030-a | 0.024-a |
| Application time: | | | | | |
| 10 DBP | 0.005-c | 0.020-c | 0.029-a | 0.034-a | 0.036-a |
| 20 DBP | 0.013-b | 0.026-b | 0.030-a | 0.032-b | 0.026-b |
| 30 DBP | 0.030-a | 0.032-a | 0.029-a | 0.023-c | 0.013-c |

*) The different of lower case at the same column shows significant difference ($p<0,05$)

Table 3 shows that application time at 10 DBP had increased 6 times of available N linearly during vegetative growing phase of the Maize up to 60 DAP. Like for $N_{tot}$, available N was low at the beginning due to low amount of nutrients release from the biomass of LCC during decomposition process and N-immobilisation by soil microbes.

In addition, similar trend to $N_{tot}$ that at 20 DBP and 30 DBP, biomass addition had increased available N linearly but then decreased at 60 DAP and 45 DAP respectively. Interestingly available N increased sharply from 0 DAP to 15 DAP at 10 DBP (6 times) and double at 20 DBP but not to 30 DBP (only 6%). Only at 10 DBP provided consistency increasing of available N. Although, at 30 DBP provided significantly higher available N but at critical point of plant demand during vegetative periods which is started at 30 DAP, the available N started to decreased while at 10 DBP kept increasing to the end of vegetative periods.

### 3.3 Absorption of N by plant

Different to the N in the soils, N in plant tissue was different ($p<0.05$) in terms of LCC types and application times. As table 4 shows that absorption of N at the begining of plant growth (up to 30 DAP) was not significant difference for both types of LCC, however since 45 DAP and above the LCC of *Phaseolus lunatus* has higher N ($p<0.05$) in its tissue than *Crotolaria usaramoensis*.

Vol. 2, No. 05; 2017

ISSN: 2456-8643

It shows that every crop even at the same type LCC has different ability to absorp N under similar soil and condition.

Table 4. Mean of N in plant tissue on different types of LCC and application time during vegetative phase of Maize.

| Treatments | Absorption of N by plant (%.dry weight of the plant$^{-1}$) | | | |
|---|---|---|---|---|
| | 0 DAP | 15 DAP | 30 DAP | 45 DAP |
| LCC types: | | | | |
| *Crotolaria usaramoensis* | 0.126-a | 0.758-a | 2.757-b | 3.688-b |
| *Phaseolus lunatus* | 0.124-a | 0.744-a | 2.783-a | 3.779-a |
| Application time: | | | | |
| 10 DBP | None | 0.887-c | 3.911-a | 4.086-a |
| 20 DBP | None | 0.766-b | 3.762-b | 3.912-b |
| 30 DBP | None | 0.601-a | 3.357-c | 3.024-c |

*) The different of lower case at the same column shows significant difference ($p<0,05$).

**) No measurement because of no plant biomass

In terms of application time, all treatments showed similar trend of N absorption which is tended to increase over time during vegetative phase. However, application time at 10 DBP provided significantly higher ($p<0.05$) N in plant tissue over time than others. The absorption of N increased dramatically more than 3 times from 15 DAP to 30 DAP but little increase (4.5%) from 30 DAP to 45 DAP.

Interestingly, when N absorption increased for both 10 and 20 DBP linearly, Ntot and available N in the soils also increased. It seemed likely at those application time, N in the soils were plenty from mineralisation process, even though N was taken up by the crops, still remaind enough N in the soil. On the other hand, at application time 30 DBP, Ntot and available N tended to decrease due to plant uptake and might be not enough N left after mineralisation. Less N was due to the type of plants in which *Crotolaria usaramoensis* is a type of woody plant, fibrous root

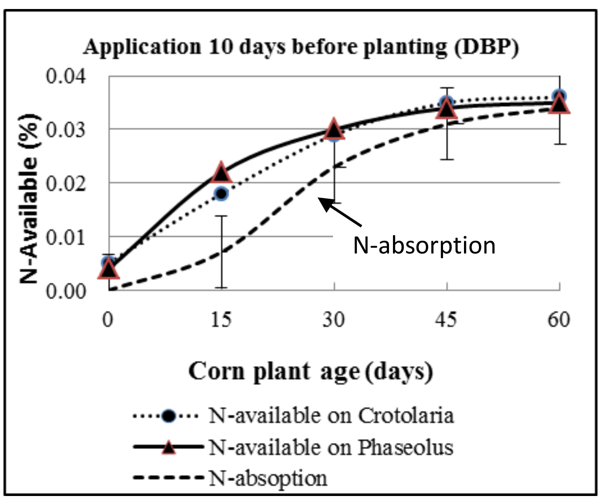
Vol. 2, No. 05; 2017

ISSN: 2456-8643

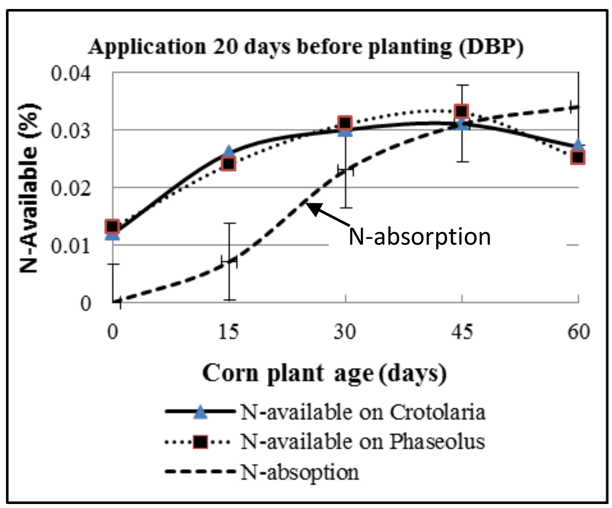
system, while *Phaseolus lunatus* is a type of herbaceous plant (vines type) with similar fibrous root system. Therefore, *P. lunatus* has high soil surface covering than *C. Usaramoensis*. This condition affected to lower evapotranspiration and soil moisturer for *P. Lunatus*. Its soils has soil moisture up to 86.5% but *C. Usaramoensis* 48.80%. Soil moisture plays important role on nutrients availability (soil solution), so that the nutrients would be easily to be up taken by plant. Thus, this study resulted higher N in plant tissue of Maize under *P. Lunatus* application.

**Synchronization of available N and plant needs**

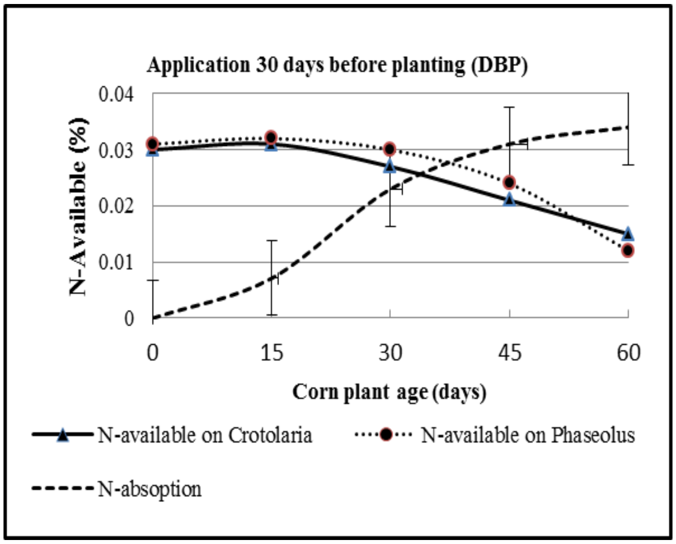
As nutrient essential, N was needed by all plants during vegetative phase to build their root, shoot parts. The application of LCC as green manure will be benefits for plant growth if applied at the right time (Palm *et al*., 1997). The increasing of the absorption of nutrients can be achieved by maintain the synchronization point (Myers et al., 1994). Synchronization depends on decomposition and mineralisation rate of organic matter that is influenced by soil moisture, soil temperature and the quality of organic matter (Handayanto *et al*., 1997; Mayers *et al*., 1997; Terrance *et al*., 2012). The quality of biomass included ratio C/N, lignin and polyphenol compounds. As table 1 shows that both LCC have comparable chemical compounds and C/N but the difference were at the types of plant (woody and herbaceous plants) that affected to microclimate of the soils that created by the plants.




Graphic 1.a. Synchronises models for application 10 DBP




Graphic 1.b. Syncronisasi models for application 20 DBP




Graphic 1.c. Syncronisasi models for application 30 DBP

Graphic 1. Synchronization of N between application time and plant uptake during vegetative phase of Maize (Zea mays); a) at application time 10 N-absorption ation time 20 DBP; and c) at application time 30 DBP. Error bars based on standard error among mean

of N absorption eas application time

Additionally, according to previous study resulted that both LCC performed similar decomposition rate where at 10 DBP (biomass incorporated into the soil) were able to release N 20,5% into the soils (Rupa *et al*. 2013). From Graphic 1 indicates that application time at 10 DBP, available N in the soils tended to increased over time but at 20 and 30 DBP tended to decreased. Meanwhile, the highest increasing point of N uptake by plant occurred between 15 DAP to 30 DAP then kept increasing over time until 60 DAP. At critical point of vegetative growth of the Mize which is between 30 DAP to 60 DAP, the application time at 20 and 30 DBP could not able to provide enough N to the plants. This condition will be risk because will effect to generative phase (flowering and fuits) productions.

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All the application times shows similar performance that before 15 days after incorporation of biomass into the soils, the biomass was in decomposition process and microbes are using the nutrients as N-immobilization, therefore this time was not really good for growing or transplanting the crops. After 15 DBP was assumed to be a good time for growing or transplanting the crops as suggested by Moata *et al*, 2016 that soil microbe was working actively during the 15 days of incubation.

## Conclusion

Based on above results, this study concluded that LCC *Phaseolus lunatus* provided apporiate condition for releasing N to the soils, therefore tha crops could easly up take the N from the soil. This is due to the type of plant which is herbaceous plant. Related to application time, 15 days after corporation of biomass to the soils was assumed to provide better time for soil to release nutrients (N) in mineralization process. Thus, synchronization point for the Maize with application green manure from LCC residues was within 15-30 DAP when the highest needs of N from the crops and the highest point of nutrient (N) release from mineralization.

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