RESEARCH ARTICLE Indian Journal of Agricultural Research, Volume 56 Issue 1: 65-69 (February 2022)

Pattern of N Mineralization and Nutrient Uptake of *Tithonia diversifolia* and *Saccharum officinarum* Leaves in Sandy Loam Soil

Yulfita Farni[1,2], Sugeng Prijono[3], Retno Suntari[3], Eko Handayanto[4]

10.18805/IJARe.A-626

Abstract

Background: This study aimed to determine the pattern of N mineralization of tithonia (*Tithonia diversifolia*) and sugarcane (*Saccharum officinarum*) leaves and assess the uptake of N nutrients in maize by giving *T. diversifolia* and *S. officinarum* leaves with different qualities on sandy loam soil.

Methods: The research used a completely randomized design (CRD) with following treatment: T1 (100% *T. diversifolia*), T2 (100% *S. officinarum*), T3 (75% *T. diversifolia*: 25% *S. officinarum*), T4 (50% *S. officinarum*: 50% *T. diversifolia*), T5 (25% *T. diversifolia* leaves: 75% *S. officinarum*), T6 (without *T. diversifolia* and *S. officinarum* or control).

Result: The results showed that the N mineralization pattern of the organic matter combination was significantly higher than the control for all observations. The amount of N mineral released in each treatment was T1 (54.58-529.7 mg/kg), T2 (41.80-381 mg/kg), T3 (47.69-473.6 mg/kg), T4 (46.70-424.0 mg/kg), T5 (70.69-378.9 mg/kg) and T6 (47.14-303.6 9 mg/kg). The sequence of cumulative N release during 12 weeks of incubation was T1 (529 mg/kg)> T3 (573.6 mg/kg)> T4 (424.0 mg/kg)> T2 (381 mg/kg)> T5 (378.9 mg/kg)> T6 (303.6 mg/kg). These results suggested that *T. diversifolia* and *S. officinarum* leaves significantly increased N nutrient uptake in maize by 125% to 144.54%.

Key words: Mineralization, Nutrient uptake, *Saccharum officinarum,* Sandy loam soil, *Tithonia diversifolia.*

Introduction

Bambang village is one of 13 villages in Wajak Subdistrict, Malang Regency, which known as a food crops area including maize (150 ha) and sugarcane (51 ha) (Central Bureau of Statistics, 2019). Bambang village is faced with the problem of decreasing agricultural productivity due to generally dominated by sandy soil texture and have a low soil organic C, water retention capacity, water and nutrients (Ro, 2016). The use of inorganic fertilizers continuously with an unbalanced dose will cause soil damage and environmental pollution especially on sandy soils.

A suitable cropping system is needed to increase the stability of crop production (Ali *et al*., 2021). The application of organic matter is a common practice in sustainable agriculture because soil organic matter is essential to maintain ecosystem productivity (Zhao *et al*., 2016). Organic matter is also one of the keys that determines soil fertility and productivity, which is the primary source of several plant nutrients, especially nitrogen (N), Phosphorus (P), sulfur (S) and most kalium (K) (Vasileva and Dinev, 2021; Dutta and Tamuly, 2021).

Tithonia (*Tithonia diversifolia*) have a fast growth cycle, high nitrogen fixation capacity and P content (Scrase *et al*., 2019). *T. diversifolia* is used as green manure because this plant contains macro and micronutrients that can improve soil fertility (Dayo-Olagbende *et al*., 2019). *T. diversifolia* can increase growth and yields of sweet corn (Hidayat *et al*., 2017). The use of green Tithonia fertilizer 10 t/ha gives the same results as NPK fertilization on radishes (Aboyeji *et al*., 2019). The use of Tithonia biomass, either alone or in combination with phosphorus fertilizers, significantly increases the efficiency of phosphorus, grain yield and maize yield components (Endris, 2019). The most widely available organic material in Bambang Village is sugarcane leaf litter, which classified as low-quality organic material, including low nutrient content, high C/N and Si ratios. Therefore, the current research aimed to analyze the pattern of N mineralization from *T. diversifolia* leaves and sugarcane leaves on sandy

[1]Postgraduate Program, Faculty of Agriculture, Brawijaya University, Malang 65145, East Java, Indonesia.
[2]Faculty of Agriculture, University of Jambi, Jambi 36122, Indonesia.
[3]Department of Soil Science, Faculty of Agriculture, Brawijaya University, Malang 65145, East Java, Indonesia.
[4]International Research Centre for the Management of Degraded and Mining Lands, Brawijaya University, Malang 65145, East Java, Indonesia.

Corresponding Author: Yulfita Farni, Postgraduate Program, Faculty of Agriculture, Brawijaya University, Malang 65145, East Java, Indonesia. Email: yulfitafarni@unja.ac.id

How to cite this article: Farni, Y., Prijono, S., Suntari, R. and Handayanto, E. (2022). Pattern of N Mineralization and Nutrient Uptake of *Tithonia diversifolia* and *Saccharum officinarum* Leaves in Sandy Loam Soil. Indian Journal of Agricultural Research. 56(1): 65-69. DOI: 10.18805/IJARe.A-626.

Submitted: 05-03-2021 **Accepted:** 05-07-2021 **Online:** 09-08-2021

loam soils and to assess the uptake of N nutrients in maize by giving *T. diversifolia* leaves and *S. officinarum* leaves with different qualities on sandy loam soil texture.

MATERIALS AND METHODS

This research was conducted at the Laboratory of Biology, Soil Chemistry and Soil Physics, Faculty of Agriculture, Universitas Brawijaya from January to May 2019 and the Greenhouse of Balitkabi Malang. *T. diversifolia* leaves, sugarcane leaves and soil samples for experiments were obtained around the land located in Bambang Village, Wajak District, East Java.

Experimental design

The incubation experiment carried out using non-leaching incubation method. Treatments was randomly divided into 6 group (n=4): 100% *T. diversifolia* leaves (T1); 100% sugarcane leaves (T2); 75% *T. diversifolia* leaves and 25% *S. officinarum* leaves (T3), 50% *T. diversifolia* leaves and 50% *S. officinarum* (T4), 25% *T. diversifolia* and 75% *S. officinarum* leaves (T5) and control (T6). Each treatment was mixed with 100 g of soil (sandy loam texture, diameter<2 mm, air dry) and added with water until 70% of the soil's water holding capacity. All bottles are covered with aluminium foil and given a small hole to reduce evaporation and keep aeration at ± 26°C. During the incubation period, the water content is maintained at 70% of the capacity of the soil to hold water by weighing the bottles periodically.

Greenhouse research

Sandy loam texture soil weighing 10 kg (top layer 0-20 cm, dry wind, passing 2 mm sieve) is mixed evenly with each treatment then put in a plastic bucket and incubated for 2 weeks while maintaining soil moisture at field capacity. After incubation, 3 pertiwi maize seeds were planted in a plastic bucket. Each pot was given a basic fertilizer of 300 kg urea/ha, 100 SP-36 kg/ha and 75 kg KCl/ha. During the experiment, water was given every day and N nutrient uptake of corn plants was observed by harvesting corn at its maximum vegetative growth.

The characteristics of soil and organic matter used in this experiment are as follows: pH H_2O=5.1, pH KCl=4.9, organic C=1.89%, N-total=0.19%, C/N=10, total P (/Bray) =5.87 mg/kg, K=0.16 me/100 g, Na=0.05 me/100 g, Ca=3.80 me/100 g, Mg=1.37 me/100 g, CEC=23.06 me/100 g, base saturation (KB)= 3%, N-NH_4=2.10 mg/kg, N-NO_3=14.31 mg/kg body weight, BI=1.07 g/cm^3, specific gravity=2.25 g/cm^3, porosity=52.4%, moisture content pF 2.5=26%, KA pF 4.2=7%, soil texture sandy loam with content sand=70%, dust=20% and clay=10%.

The characteristics of the organic material used were as follows: C-organic *T. diversifolia* leaves=28.08%, N-total =4.17%, C/N ratio=7.02, P=0.41%, K=3.62%, polyphenols =7.82%, lignin=8.89%, Ash=1,8%, Cellulose= 15.92%, L/N=2.14, L+P/N=4,03. The characteristics of *S. officinarum* leaves are C-organic=35.01%, N-total= 1%, C/N ratio=39.35, P=0.15%, K=1.23%, polyphenols=6.69%, lignin=24.26%, cellulose=34.14%, L/N=27.18, L+P/N=34.69%.

Data collection

Data were collected at 1, 2, 4, 6, 8, 10 and 12 weeks destructively on 168 sample bottles. Soil samples for $NH4^+$ and NO_3^- analysis were immediately analyzed under humid conditions, chemical analysis of soil was carried out by freeze drying and weighing. Determination of NH_4^+ and NO_3^- levels was carried out by extracting the soil with the distillation method using KCl 1N+HCl 0.1N; then the extract was analyzed by the Distillation method. Soil pH consisting of pH H_2O and pH KCl (1:1) was analyzed using a pH meter, organic C, total N used the Kjeldahl method. Total P was measured using a spectrophotometer, K was measured using atomic absorption spectrophotometry, cation exchange capacity (NH_4OAC pH 7.0) (Indonesian Soil Research Institute, 2012).

Statistical analysis

Observation data were analyzed for variance at the confidence level of 95% (α=5%) and if there was a significant effect, Duncan's continued test was carried out at the 5% level. All analyzes were performed with the Genstat program.

RESULTS AND DISCUSSION

Mineral N-cumulative released

The combination of tithonia and sugarcane leaves had a significant effect on the cumulative N release in sandy loam soils. In general, T1 treatment released the highest cumulative N at each observation time. The cumulative N-release from the T3 and T4 treatments showed the same pattern until the 4th week (Fig 1). The amount of Mineral N released in each treatment was 54.58-529.7 mg/kg (T1), 41.80-381 mg/kg (T2), 47.69-473.6 mg/kg (T3), 46.70-424.0 mg/kg (T4), 70.69-378.9 mg/kg (T5) and 47.14-303.6 9 mg/kg (T6). The amount of N released into the soil increased after treatment with large amounts of tithonia. This indicates that mixing organic matter derived from tithonia with a low C/N ratio with organic matter from sugarcane leaves which has a high C/N ratio can increase the rate of soil mineralization compared to organic matter from sugarcane leaves alone, due to the reduced C/N ratio.

The decomposition and release of N from organic matter were partly related to the biochemical composition of the material, in addition to the residual N concentration, the C/N ratio and the lignin content of the material (Sholihah *et al.* 2012). The N content of tithonia (4.17%) higher than sugarcane leaves (1 %) was one of the factors that cause the fast release of N from tithonia and the amount was more than with sugar cane leaves alone. Vahdat *et al.* (2011) states that the level of N mineralization is positively correlated with the residual concentration of N. N mineralization was influenced by the C/N ratio, organic matter that has a low C/N ratio results in a higher mineralization rate compared to organic matter with a high C/N ratio (Abera *et al*., 2012). Organic matter which had a high C/N ratio will inhibit N mineralization due to a large amount of carbon and higher levels of N decomposition, causing nitrogen to be suppressed in the amended soil.

N mineralization rate

The constant rate of N mineralization at all observation times indicated that the application of tithonia and sugarcane leaves had a significant effect on the rate of mineralization. The highest mineralization speed at all observation times was found in T1 and the lowest in control. Tithonia undergoes mineralization faster than sugarcane leaves (T2) and the higher the amount of tithonia in the mixture, the faster the mineralization occurs compared to only sugarcane leaves (Fig 2).

The amount and rate of N mineralized depend on environmental factors, particularly humidity and temperature. This temperature and humidity affect the growth of soil microorganisms which are responsible for the breakdown of organic matter. The decomposition of organic matter will be faster at high temperatures (Yuan *et al*., 2016). Optimal mineralization occurs at higher temperatures (24-30°C) and water content of 100% field capacity. The incubation was set at the same temperature and humidity; it was assumed that the mineralization rate constant (k) was more influenced by the chemical composition of the added organic matter. The highest k value was found in the treatment of 100% tithonia/T1 (0.02623) and the lowest in control/T6 (0.02162) in each week. In general, the control treatment for mineralization constants was lower than that with the addition of organic matter. This was due to the absence of the addition of organic matter which performed as an energy source for soil microorganisms. The number of microbes in the soil with a low, low organic matter content would inhibit the rate of N mineralization (Abera *et al*., 2012).

In general, the pattern of NH_4^+ and NO_3^- released in the combination treatment of tithonia and sugarcane leaves fluctuated every week (Fig 3). The amount of NH_4^+ in each treatment is: T1 = 18.32 -118.0 mg/kg, T2 = 16-155.4 mg/kg, T3 = 14.25-124.9 mg/kg, T4 = 16.42-126.0 mg/kg, T5 = 25.49-143.7 mg/kg and T6 = 12.48- 104.1 mg/kg. The administration of tithonia and sugarcane leaves could increase NH_4^+ compared to the control for 12 weeks. The largest increases in NH_4^+ was found in T2 group. The combination of tithonia leaves and sugarcane leaves with

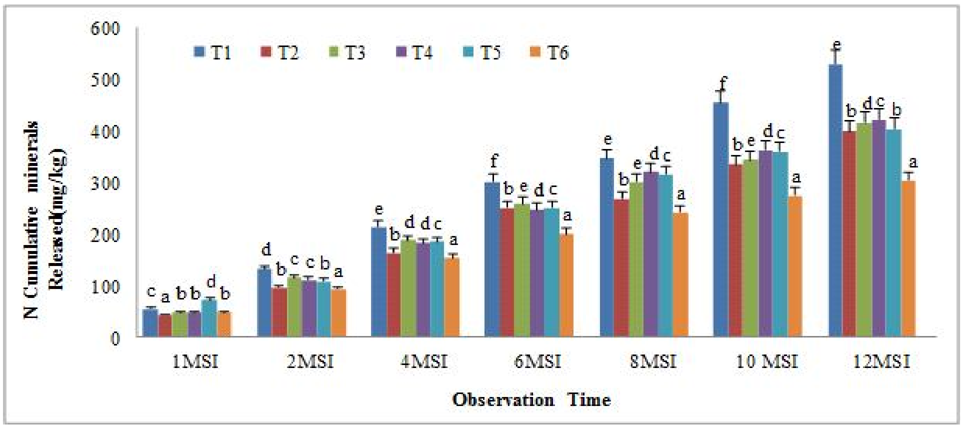


Fig 1: N mineralization pattern from the combination of tithonia (*T. diversifolia*) and sugarcane (*S. officinarum*) leaves at various observation times (incubation).

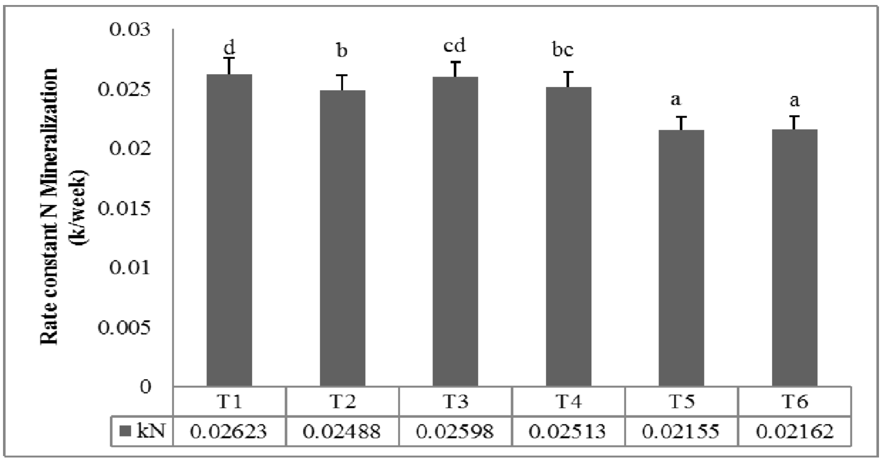


Fig 2: Average N mineralization rate constants (mg/kg/week) from a mixture of tithonia (*T. diversifolia*) and sugarcane (*S. officinarum*) leaves.

the same proportion (T4) gave the same effect a combination of 75% tithonia leaves; 25% sugarcane leaves (T3).

Based on Fig 3, the highest NO_3- release was found in 100% tithonia (T1) treatment and the lowest was in 100% sugarcane leaf treatment and control treatment. The amount of NO_3- released in each treatment was T1=36.26-411.7 mg/kg, T2=25.81-226.4 mg/kg, T3=33.44-348.7 mg/kg, T4=30.28-298.1 mg/kg, T5=39.42-234.8 mg/kg and T6=34.46-199.5 mg/kg. Treatment with a higher amount of tithonia releases N faster than the other combinations. The amount of N released to plants depends on the organic chemical composition such as N content, C/N ratio, cellulose and hemicellulose content, polyphenols (Mohanty *et al*., 2011) and also depends on pH, moisture and soil temperature (Biswas *et al*., 2016).

The application of *T. diversifolia* leaves and its combination with sugarcane leaves significantly affected N nutrient uptake in corn (Fig 4). T1 group significantly increased N uptake compared to T2, T6 and control group (T7). The increase in N uptake due to giving 100% tithonia leaves was 81.51%, 83.12% and 144.54% compared to T2, T6 and control. T4 group significantly increased the N uptake by 78.29%, 76.86% and 140.18% compared to T2, T6 and control. 75% combination of tithonia leaves; sugarcane leaves 25% significantly increased N nutrient uptake by 67.74%, 69.22% and 125.98% compared to T2, T6 and T7 group, while the combination of tithonia leaves 25%; sugarcane leaves 75% significantly increased N uptake by 73.74%, 75.27% and 134.06% compared to T2, T6 and T7. T2, T6 and T7 groups gave the same effect on N nutrient uptake in corn plants.

The increase in N nutrient uptake due to administration of 100% tithonia leaves and a combination of tithonia leaves and sugarcane leaves compared to controls was 125% to 144.54%. Based on the N content in the organic material used, it shows that tithonia has the highest N compared to sugarcane leaves and the combination of tithonia leaves and sugarcane leaves, the N content in tithonia is (4.17%), sugarcane leaves (1.00%), T3 (3.37%), T4 (2.53% and T5 (1.42%). This may be one of the causes of the high N uptake in the 100% tithonia leaf treatment compared to other treatments. The application of tithonia leaves and sugarcane leaves had a significant effect on the cumulative N release compared to the control, as well as the N uptake in plants

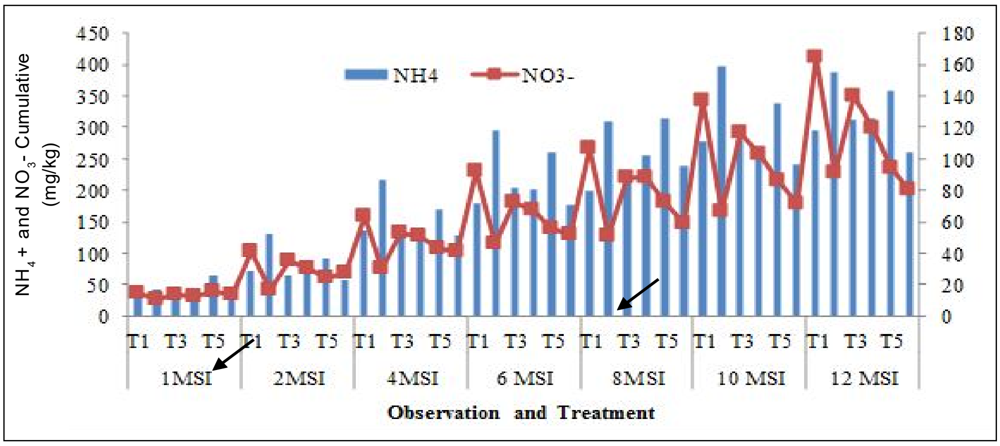
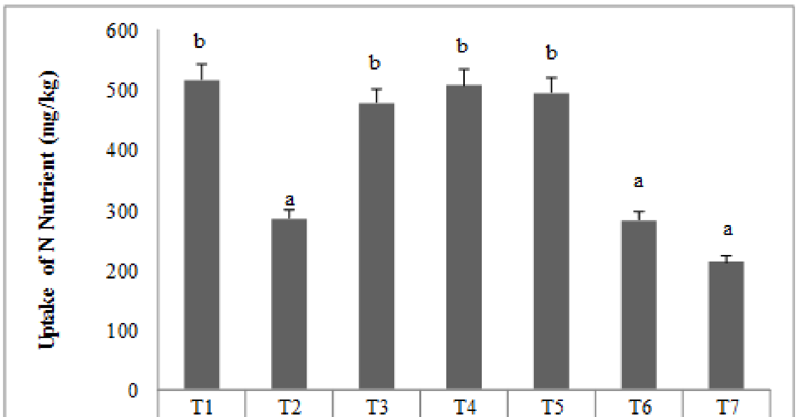


Fig 3: Cumulative release pattern of NH_4+ and NO_3- from the combination of tithonia (*T. diversifolia*) and sugarcane (*S. officinarum*) leaves at various times.



	T1	T2	T3	T4	T5	T6	T7
N Uptake	517.15	284.9	477.91	507.95	495	282.41	211.48

Fig 4: Nutrient N uptake of corn plants due to the application of tithonia (*T. diversifolia*) and sugarcane (*S. officinarum*) leaves on sandy loam soils.

maize, which showed that the highest N uptake was found in T1 treatment which also released the highest N nutrient.

CONCLUSION

The cumulative N mineral release pattern was significantly influenced by the organic matter of tithonia (*T. diversifolia*) and sugarcane (*S. officinarum*) leaves and the combination of both. Application of tithonia leaves and sugarcane leaves on sandy loam soil texture significantly affected N nutrient uptake in maize. N uptake in maize increased by 125.98% to 144.54% compared to control.

ACKNOWLEDGEMENT

This study financially supported by BUDI-DN LPDP Indonesia. The gratitude is also addressed to the technicians from the Laboratory of Soil Chemistry, Laboratory of Soil Physics, Faculty of Agriculture, Universitas Brawijaya. Highest appreciation to the Promoter Team for their guidance in writing this article.

REFERENCES

Abera, G., Wolde-meskel, E. and Bakken, L.R. (2012). Carbon and nitrogen mineralization dynamics in different soils of the tropics amended with legume residues and contrasting soil moisture contents. Biology and Fertility of Soils. 48: 51-66.

Aboyeji, C.M., Adekiya, A.O., Dunsin, O., Agbaje, G.O., Olugbemi, O., Okoh, H.O. and Olofintoye, T.A.J. (2019). Growth, yield and vitamin C content of radish (*Raphanus sativus* L.) as affected by green biomass of *Parkia biglobosa* and *Tithonia diversifolia*. Agroforestry Systems. 93: 803-812.

Ali, S., Patel, A.M. and Sharma, S. (2021). Impact of cropping systems and resource conservation techniques on productivity and profitability of systems. Indian Journal of Agricultural Research. 55: 175-180.

Biswas, T., Paul, S.K., Sarkar, M.A.R. and Sarkar, S.K. (2016). Integrated use of poultry manure with prilled urea and urea super granules for improving yield and protein content of aromatic rice (cv. BRRI dhan 50). Progressive Agriculture. 27: 86-93.

Central Bureau of Statistics. (2019). BPS Jawa Timur. Available at https://jatim.bps.go.id/ (accessed on 6 Jan 2019).

Dayo-Olagbende, G.O., Akingbola, O.O., Afolabi, G.S. and Ewulo, B.S. (2019). Influence of *Tithonia diversifolia* on maize (*Zea mays* L) yield, fertility and infiltration status of two clay varied soils. International Annals of Science. 8: 114-119.

Dutta, A.K. and Tamuly, D. (2021). Effect of soil nutrient management on P transformation under protected cultivation. Indian Journal of Agricultural Research. 55: 257-264.

Endris, S. (2019). Combined application of phosphorus fertilizer with tithonia biomass improves grain yield and agronomic phosphorus use efficiency of hybrid maize. International Journal of Agronomy. 1-9. https://doi.org/10.1155/2019/6167384.

Hidayat, H.K., Sumarni, T. and Sudiarso, S. (2018). Pengaruh pupuk paitan (*Tithonia diversifolia*) dan NPK anorganik pada tanaman jagung manis (*Zea mays* saccharata sturt). Jurnal Produksi Tanaman. 6: 775-782.

Indonesian Soil Research Institute (ISRI). (2012). Nutrient Test Kit for Sugarcane Leaves. Indonesian Agency for Agricultural Research and Development, Jakarta, Indonesia.

Mohanty, M., Reddy, S.K., Probert, M.E., Dalal, R.C., Rao, S.A., Menzies N.W. (2011). Modelling N mineralization from green manure and farmyard manure from a laboratory incubation study. Ecological Modelling. 222: 719-726.

Ro, S. (2016). Potential of organic manure in rainfed lowland rice-based production system on sandy soils of Cambodia. PhD. Dissertation. Rheinischen Friedrich Wilhelms Universitätzu Bonn, Phnompenh, Cambodia.

Scrase, F.M, Sinclair, F.L., Farrar, J.F., Pavinato, P.S. and Jones, D.L. (2019). Mycorrhizas improve the absorption of non available phosphorus by the green maure *Tithonia diversifolia* in poor soils. Rhizosphere. 9: 27-33.

Sholihah, A., Prijono, S., Utami, S.R. and Handayanto, E. (2012). N mineralization from residues of crops grown with varying supply of 15N concentrations. Journal of Agricultural Science. 4: 117-123.

Vahdat, E., Nourbakhsh, F. and Basiri, M. (2011). Lignin content of range plant residues controls N mineralization in soil. European Journal of Soil Biology. 47: 243-246.

Vasileva, V.H. and Dinev, N.S. (2021). Mineral content and quality parameters of tomato fruits as affected by different potassium fertilization treatments and cultivar specifics. Indian Journal of Agricultural Research. 55: 169-174.

Yuan, L., Nianpeng, H., Xuefa, W., Guirui, Y., Yang, G., Yanlong, J. (2016). Patterns and regulating mechanisms of soil nitrogen mineralization and temperature sensitivity in Chinese terrestrial ecosystems. Agriculture, Ecosystems and Environment. 215: 40-46.

Zhao, S.C., Li, K.J., Zhou, W., Qiu, S.J., Huang, S.W. and He, P. (2016). Changes in soil microbial community, enzyme activites and organic matter fractions under long term straw return in north-central China. Agriculture, Ecosystems and Environment. 216: 82-88.