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Research Article

Regulating mineralization rates of *Tithonia diversifolia* and *Lantana camara* prunings to improve phosphorus availability in calcareous soils

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Abstract: The effect of mixing of *Tithonia diversifolia* and *Lantana camara* prunings to improve synchronization between P released from the prunings with crop demand for P was studied in a laboratory and in a glasshouse. *Tithonia diversifolia* prunings (Td), *Lantana camara* prunings (Lc), and farmyard manure (Pk) were thoroughly mixed with the proportion (% of dry weight) of; 25Td +75 Lc ; 50Td +50 Lc ; 75Td +25 Lc ; 90Lc +10 Pk ; 45Td +45 +10 Lc Pk ; 100Td and 100Lc, and then mixed with 100 g of air-dried soil with a rate equivalent to 100 kg P / ha. Results of the study showed that the pruning mixtures decomposed and mineralized faster than that of *Lantana camara* pruning only, but slower than that of *Tithonia diversifolia* pruning only. The amount of P released from the pruning mixtures increased with increasing proportion of *Tithonia diversifolia* pruning in the mixtures. Increasing proportion of *Tithonia diversifolia* pruning in the mixture applied to the soil increased the amount of P taken up by maize.

***Keywords**: Lantana camara, P mineralization, synchronization, Tithonia diversifolia*

Introduction

Critical land area covering 162 819 ha of Brantas watershed is dominated by calcareous soil The soil is characterized by low soil productivity, mainly due to the availability of nutrients is very low due to P fixation by calcium. Soil productivity can be improved by the use of inorganic fertilizers. However, the limitations of socio-economic conditions of local communities make them difficult to provide fertilizers. In addition, the low soil organic matter content leads to low soil buffering capacity so that the efficiency of fertilizer use is low.

Another alternative for soil fertility improvement is the addition of organic matters, such as crop residues. However, due to the low productivity of the land, the crop residues produced in the process of crop production is also low. In addition, socio-economic conditions of farmers are very limited also be limiting the use of commercial organic fertilizer. The final alternative to achieve a healthy agriculture in the Upper Brantas watershed is to utilize biomass of dominant plant species in the Upper Brantas river basin as a source of organic matter and soil cover. Results of previous study conducted by Handayanto and Arisoesilaningsih (2004) showed that in the Brantas River Basin there were least 260 local plant species consisting of ground cover plants, plantation crops / farm and roadside plants or trees.

Results of a study conducted by Pratikno et al. (2002) about the use of *Gliricidia sepium, Tithonia diversifolia, Cromolaena odorata, Lantana camara* and *Agerathum conyzoides* prunings as sources of organic matter to improve soil fertility in the Upper Brantas watershed showed that the addition of *Tithonia diversifolia* prunings increased the availability of P in the soil by 77.13%. Pratikno (2001) reported that Tithonia diversifolia prunings have high quality materials with organic-C content of 45.90%, 5.31% total-N, C / N ratio 8.64, P - 0.47% total, Lignin 5, 32% and a 2.08% Polyphenols. *Tithonia diversifolia* increased decomposition and P mineralization rates compared to control (no organic matter). This suggests that *Tithonia diversifolia* pruning is potential to improve availability of soil P. However, the rapid decomposition and mineralization rates of *Tithona diversifolia* prunings resulted in the release of P faster than the time needed by maize plant. As a result, not all P released from *Tithonia diversifolia* prunings can be taken up by plants. Conversely the addition of *Lantana camara* increased the immobilization of P in the soil.

Pratikno (2001) reported that *Lantana camara* prunings has low quality with organic-C content of 46.92%, 3.19% total-N, C / N ratio 14.71, P - total of 0.31%, Lignin Polyphenols 19.96% and 0.78%. *Lantana camara pruning was* very slowly to decompose so the supply of the P from the prunings could not meet the needs of P by maize plants. In order to optimize the use of *Tithonia diversifolia* prunings and *Lantana camara* to provide benefits for soil productivity and crop growth improvement, it is necessary to improve the synchronization. One of methods that can be apply to improve the synchronization is to modify or manipulate the quality of the prunings by mixing prunings of high quality (low lignin and polyphenols) with low-quality prunings materials (high lignin and polyphenols) (Handayanto et al., 1997).

The purpose of the study was to elucidate the effect of mixing *Tithonia diversifolia* and *Lantana camara* prunings on the rate of decomposition and mineralization of the prunings in order to improve the synchronization between the supplies of P from organic material with plant growth.

Materials and Methods

Pruning materials

The study was conducted in a laboratory and in a glasshouse of the Department of Soil Science, Faculty of Agriculture, Brawijaya University from March to June 2012. Prunings (young twigs and leaves) of *Tithonia diversifolia* and *Lantana camara* were obtained from the Village of Pagak, Malang that is located at the Upper Brantas watershed. Results of analysis for chemical compositions of the prunings showed that *Tithonia diversifolia* prunings contained 45.9% C, 5:31% N,% P 0:47, 5:32% 2.08% lignin and polyphenols, while prunings *Lantana camara* contained 46.92% C, 3:19% N, 0:31% P, 19.96% lignin, and 7.80% polyphenols.

Experiment 1

Decomposition and mineralization of the pruning mixtures were studied in the laboratory by incubation under non-leaching conditions. Prunings of *Tithonia diversifolia* (Td), *Lantana camara prunings* (Lc) were mixed with organic manure (Pk) with proportion of 75 + 25Td Lc ; 50Td +50 Lc ; 75Td +25 Lc ; 90Lc +10 Pk ; 45Td + 45Lc +10 Pk ; 100Td and 100Lc (% dry weight). The organic manure used for this study contained 20% N, 0.62% P, 4.8% C, 10% lignin, and 2.96% polyphenols. Chemical compositions of *Tithonia diversifolia* and *Lantana camara* pruning mixtures were determined by analyses of C, N, P, lignin and polyphenols.

Each of the pruning mixtures was mixed with 100 g air-dry soil (diameter of < 2 mm) with a rate equivalent to 100 kg P / ha and then placed into a 240 ml plastic cups. The cup was sealed with aluminum foil and then stored in a dark room at 27^{o}C for 8 weeks. During incubation, the content of water in the plastic cup was maintained at conditions of 70% water holding capacity. The eight treatments (Table 1) were arranged in a completely randomized design with four replicates. Evolution of CO_2 and the amount of available P were observed at 1, 2, 4, 6 and 8 weeks with the method used by TSBF (Anderson and Ingram, 1993). Decomposition rate constant (kD) and P mineralization rate constant (kP) were calculated with a single exponential model (Wagner and Wolf, 1998).

Table 1. Proportion of pruning mixtures added to the soil for experiments 1

Treatment *)	Description	Rate of P added
25Td+75Lc	25% *Tithonia diversifolia* + 75% *Lantana camara* prunings	100 kg P/ha
50Td+50Lc	50% *Tithonia diversifolia* + 50% *Lantana camara* prunings	100 kg P/ha
75Td+25Lc	75% *Tithonia diversifolia* + 25% *Lantana camara* prunings	100 kg P/ha
90Lc+10Pk	90% *Lantana camara* prunings + 10% organic manure	100 kg P/ha
45Td+45Lc+10Pk	45% *Tithonia diversifolia* + 45% *Lantana camara* prunings + 10% organic manure	100 kg P/ha
100Td	100% *Tithonia diversifolia* prunings	100 kg P/ha
100Lc	100% *Lantana camara* prunings	100 kg P/ha
SP36	Super Phosphate 36 (commercial inorganic fertilizer)	100 kg P/ha

Experiment 2

Each of the organic material mixtures (prunings and manure) was mixed with 5 kg of soil in a plastic pot with a rate equivalent to 100 kg P / ha. After two weeks, two seeds of maize (Surya variety) were planted and grown for 8 weeks. Eight treatments (Table 2) were arranged in a completely randomized design with four replicates. During the experiment, water was regularly added to maintain field capacity conditions. Plant height was measured at 2, 4, 6 and 8 weeks after planting. At harvest (8 weeks), P uptake by maize shoots and roots were determined using the method of Anderson and Ingram (1993). Data of decomposition and mineralization of P were subjected to analysis of variance followed by Duncan at 5% significant level to. A regression analysis was also performed for quality of organic matter and P mineralization.

Tabel 2. Initial amounts of organic materials, P and C added to the soil for experiment 2I

Treatment *)	Organic materal (g/kg)	P (mg/kg)	C (mg/kg)
25Td+75Lc	0.1102	3.8570	51.1438
50Td+50Lc	0.0964	3.7596	44.4982
75Td+25Lc	0.0857	3.6851	35.7969
90Lc+10Pk	0.1171	3.9814	54.6506
45Td+45Lc+10Pk	0.1038	4.2558	43.8347
100Td	0.0772	3.6284	35.4348
100Lc	0.1284	3.9804	60.2453
SP36	0.0091	-	-

*) see Table 1

The soil used for experiments 1 and 2 was topsoil (0-30 cm) collected from Pagak village, South Malang District at the Upper Brantas watershed. According to Pratikno (2001), the characteristics of the soil (0-30 cm top layer as follows: pH 7.5, 1.039% C-organic, total N 0.137% total N, 20 mg available P / kg, 0.911 mg K/100 g, 34 811 me Ca /100g Ca, 5,629 me Mg/100 g, 1,324 me Na/100g and 23 285 CEC me/100 g. The soil parent material is composed of limestone, alluvium material and volcanic material

Results and Discussion

Quality of Tithonia diversifolia and Lantana camara pruning mixtures

Mixing *Tithonia diversifolia* and *Lantana camara* prunings resulted in a diverse mixture of pruning quality (Table 3). The content of N and P in *Tithonia diversifolia* and *Lantana camara* prunings increased with the increasing proportion of *Tithonia diversifolia* prunings in the mixture, while the C content increased with decreasing proportion of *Lantana camara* prunings in the mixure. The mixture of *Lantana camara* prunings and manure, and that of *Tithonia diversifolia* prunings and manure reduced the C / P ratio and lignin content. Lignin content decreased to less than 15% in all *Tithonia diversifolia* and *Lantana camara* pruning mixtures except in the treatment 90Lc +10 Pk that contained more than 15% lignin. Polyphenol content in pruning mixtures increased more than 4%. Polyphenols can protect proteins from rapid decomposition and active polyphenol that bind proteins in tissues of crop residues may play a greater role in inhibiting the decomposition of organic matter compared to the amount. To reduce the number of active polyphenols can be done by draining the rest of the plant at high temperatures (Kanmegne et al., 1995; Handayanto and Ismunandar, 1999).

Compared to pure *Lantana camara* prunings, *Tithonia diversifolia* and *Lantana camara* pruning mixtures increased the P content of more than 0.30% for all treatments. This value stimulated mineralization. P mineralization occurs if the P content in organic materials is greater than 0.25% (Stevenson, 1982; Neteeson and Henrot, 1995). The ratio C / P ratio in the pruning mixtures was than the he ratio C / P ratio in the *Lantana camara* prunings, but this was still higher than that of *Tithonia diversifolia* prunings. If the range of the ratio C / P in the pruning material is more than 300 there will be immobilization of P, if the ratio C / P is less than 200, mineralization will occur (Stevenson, 1982).

Table 3. Chemical composition of *Tithonia diversifolia* and *Lantana camara* pruning mixtures

Treatments*)	a	b	c	d	e	f	g	h	i	j	k
25Td+75Lc	46.41	3.72	12.48	0.35	132.60	35.65	12.24	34.97	6.45	18.43	53.40
50Td+50Lc	46.16	4.25	10.86	0.39	118.36	27.85	13.32	34.15	4.98	12.77	46.92
75Td+25Lc	41.77	4.78	8.74	0.43	97.14	20.32	10.42	24.23	5.06	11.77	36.00
90Lc+10PK	46.67	3.50	13.33	0.34	137.26	39.22	17.96	52.82	7.74	22.76	75.59
45T+45L+10Pk	42.23	3.95	10.69	0.41	103.00	26.08	12.50	30.49	6.55	15.98	46.46
100 Td	45.90	5.31	8.64	0.47	97.66	18.39	5.32	11.32	2.08	4.43	15.74
100 Lc	46.92	3.19	14.71	0.31	151.35	47.45	19.96	64.39	7.80	25.16	89.55

*) T = *Tithonia diversifolia*, L = *Lantana camara*, Pk = farmyard manure, a = C organic (5), b = N total (%), c = C/N, d = P total (%), e = C/P; f = C/N/P; g = lignin (%), I = polyphenol (%), j = polyphenol/P; k = (lignin+ polyphenol)/P.

Decomposition of organic matters

Pruning decomposition was measured by the amount of CO_2 released during the incubation of 8 weeks. Decomposition patterns varied depending on the proportions *Tithonia diversifolia* and *Lantana camara* prunings in the mixture (Table 4). At week 8, the highest amount of CO_2 release occurred in the 75Td +25 Lc pruning mixture, while the lowest was in the Lc +10 +45 45Td mixture. Except in the 45Td Lc +45 +10 Pk, mixing *Lantana camara* with *Tithonia diversifolia* and with manure accelerated decomposition of *Lantana camara* prunings, but reduced the decomposition rate of *Tithonia diversifolia* prunings. Based on the value of the decomposition rate constant (kD), the decomposition rate of organic material mixture was in the order of; Td > 75Td +25 Lc > Lc 50Td +50 > +75 25Td Lc > Lc 45Td +45 +10 Pk > Pk +10 90Lc > Lc.

Table 4. CO_2 evolution at 1, 2, 4, 6 and 8 weeks after incubation of *Tithonia diversifolia* and *Lantana camara* pruning mixtures.

Treatment *)	C added (mg/kg soil)	CO_2 evolved (mg/kg soil)					Decomposition rate constant (kD) per week
		1 week	2 weeks	4 weeks	6 weeks	8 weeks	
25Td+75Lc	51.1438	0.55	2.37	4.21	7.41	10.79	0.0187
50Td+50Lc	44.4982	0.75	1.99	2.94	4.87	6.89	0.0190
75Td+25Lc	35.7969	1.07	2.65	5.13	8.65	13.21	0.0367
90Lc+10Pk	54.6506	0.14	2.57	4.30	6.78	10.12	0.0099
45Td+45Lc+10Pk	43.8347	0.23	1.24	1.76	2.42	3.63	0.0149
100Td	35.4348	2.15	4.90	10.06	15.90	17.75	0.0417
100Lc	60.2453	0.09	0.95	2.45	3.94	5.65	0.0002

*) see Table 1

Total CO_2 released from *Tithonia diversifolia* and *Lantana camara* pruning mixtures at week 1 significantly correlated negatively with polyphenols but not significantly correlated with other parameters of quality of the pruning mixtures (Table 5). This suggests that the increase in polyphenol content in the pruning mixtures reduced the rate of pruning decomposition. In prunings with high polyphenol content indicates the number fraction resistant material weathered the prunings due to formation of a bond between the phenol with N - mineralized in the form of nitrous oxide (Tian et al., 1992). The significant correlation between total P and CO_2 release at week 1, 2, 4, 6 and 8 suggested that the increase in the total content of P - prunings will increase the amount of CO_2 released from organic matter. The decomposition rate (kD) that had a positive correlation due to an increase in CO_2 releases also indicated an increase in the rate of decomposition. This is consistent with the statement Hairiah et al. (2000), that the speed of weathering of a type of organic matter is determined by the quality of these prunings materials. Quality of the prunings was related to the supply of P than is determined by P concentration in the prunings. The critical value of P in organic material is about 0.25%. If the P content is less than 0.25% the quality of organic materials is considered low and the organic materials decomposes slowly.

At week 1, 2, 4, 6, and 8, the CO_2 release was negatively correlated with C / P ratio, lignin, polyphenols, lignin / P ratio, polyphenols / P ratio and lignin + polyphenol / P ratio. This suggests that the decrease in the content of lignin, polyphenols, the ratio of lignin/P, the ratio of polyphenols/P and the ratio of (lignin+ polyphenol)/P increased the rate of decomposition. Tian et al. (1992) stated that the high content of polyphenols in plant tissue may decrease the decomposition of organic matter due to the formation of phenol bond with N-mineralization in the form of nitro. Polyphenols can protect proteins from rapid decomposition and active polyphenol content in crop residues binding proteins play a role in inhibiting the decomposition of organic matter compared to the amount. Critical limit polyphenols < 4%, if higher than the critical value then the process of decomposition is slow (Hairiah et al., 2000).

Table 5. Correlation coefficient between CO_2 evolution and composition of pruning mixtures

Composition of pruning mixtures	Coefficient of correlation (r) with CO_2 release and decomposition rate constant (kD)					
	1 week	2 weeks	4 weeks	6 weeks	8 weeks	kD
Total P	0.594	0.357	0.318	0.424	0.577	0.718
C/P ratio	-0.141	-0.120	-0.131	-0.041	-0.131	-0.350
Lignin	-0.733	-0.814	-0.811	-0.783	-0.817	-0.787
Polyphenol	-0.898*	-0.682	-0.583	-0.700	-0.787	-0.760
Lignin/P ratio	-0.716	-0.709	-0.692	-0.696	-0.767	-0.779
Polyphenol/P ratio	-0.826	-0.601	-0.518	-0.626	-0.742	-0.768
(lignin + polyphenol)/P ratio	-0.548	-0.651	-0.693	-0.664	-0.710	-0.767

Data presented in Table 4 show that the decomposition rate (kD) of *Tithonia diversifolia* and *Lantana camara* pruning mixtures is lower than that the pure *Tithonia diversifolia* prunings. The slow decomposition rate of the pruning mixture was presumably due to the high polyphenols in fresh *Lantana camara* prunings used in the experiments. Fresh prunings were taken from areas that have low soil fertility, resulting in suspect materials prunings of South Malang area has a high content of polyphenols.

Available P

During the 8 weeks of incubation, the amount of P mineralized increased with the increasing proportion of *Tithonia diversifolia* prunings in pruning mixtures. Cumulatively, after 8 weeks of incubation the amount of available P in the soil due to application of *Tithonia diversifolia* and *Lantana camara* decreased in comparison to that of application of pure *Tithonia diversifolia* prunings, but increased when compared with that of application of pure *Lantana camara* pruning (Table 6). Application of *Lantana camara* and *Tithonia diversifolia* prunings with manure also increased the amount of available P compared to application of pure *Lantana camara* prunings. The release of P from *Tithonia diversifolia* and *Lantana camara* pruning mixtures run slowly in week 1 but increased gradually at week 2, 4, 6 and 8. This is probably due to the immobilization of previously released P by microorganisms that decompose low quality organic materials (Henrot and Hamadina, 1995).

Rate constant of P mineralization (kP) of the organic materials was in the order Td > Lc 75Td +25 > +50 50Td Lc > Lc 45Td +45 +10 Pk > Pk 90Lc +10 > +75 25Td Lc > Lc. If the cumulative amount of available P (Table 6) was correlated with composition of *Tithonia diversifolia* and *Lantana camara* pruning mixtures (Table 2), it is known that total P had a positive significant correlation coefficient at weeks 1 and 8, whereas at weeks 2, 4 and 6 total P correlated positively with the quality of the prunings. The highest correlation coefficient (r) at week 8 was for P total and the lowest was for C / P ratio.

The cumulative amount of available P significantly correlated negatively with lignin content and ratio of lignin / P at week 1, significantly correlated negatively with the content ratio C / P at week 2 and significantly correlated negatively with the ratio of polyphenols / P at weeks 1 and 8 (Table 7). This indicates that the low P content in the prunings reduced P mineralization. According Hairiah et al. (2000), P mineralization will occur if the total P content is more than 0.25% or 2500 mg/kg. A high total P content leads to rapid P mineralization, whereas low P contant (lower than 0.25%) leads to P imobilization (Neeteson dan Henrot, 1995). At week 1, 2 and 8, the ratio C / P, lignin, lignin / P ratio, polyphenols / P and the ratio of (lignin + polyphenol) / P negative correlated with available P . This suggests that the decrease in the ratio C / P, lignin, lignin / P ratio and polyphenols / P ratio will increase the mineralization rate.

Table 6. P mineralized from *Tithonia diversifolia* and *Lantana camara* pruning mixtures for 8 weeks incubation.

Treatment *)	P mineralized from pruning mixtures (mg/kg soil)					P mineralization rate constant (kP) per week
	1 week	2 weeks	4 weeks	6 weeks	8 weeks	
25Td+75Lc	18.89	38.19	60.51	93.49	112.10	0.0467
50Td+50Lc	19.32	39.18	61.27	94.29	112.80	0.0961
75Td+25Lc	19.90	39.90	62.16	95.16	113.65	0.1990
90Lc+10Pk	18.32	38.46	60.45	93.47	111.92	0.0515
45Td+45Lc+0Pk	19.37	39.49	61.63	94.34	112.78	0.0758
100Td	28.83	52.19	76.00	111.03	129.16	0.2004
100Lc	17.02	38.14	59.21	93.30	111.70	0.0004

*) see Table 1

Table 7. Correlation coefficient between available P and composition of pruning mixtures

Composition of pruning mixtures	Coefficient of correlation (r) with available P and P mineralization rate constant (kP)					
	1 week	2 weeks	4 weeks	6 weeks	8 weeks	kP
Total P	0.953*	0.974**	0.995**	0.968**	0.960**	0.822
C/P ratio	-0.682	-0.912*	-0.868	-0.735	-0.735	-0.575
Lignin	-0.890*	-0.579	-0.710	-0.698	-0.751	-0.623
Polyphenol	-0.853	-0.639	-0.696	-0.761	-0.803	-0.718
Lignin/P ratio	-0.954*	-0.717	-0.822	-0.800	-0.839	-0.683
Polyphenol/P ratio	-0.949*	-0.797	-0.846	-0.873	-0.901*	-0.771
(lignin + polyphenol)/P ratio	-0.825	-0.648	-0.764	-0.722	-0.750	-0.666

Maize growth and P uptake

Growth of maize was measured on the basis of changes in plant height at 1, 2, 4, 6 and 8 weeks after planting. Application of the 75Td + 25Lc pruning mixture resulted in the greatest plant height at 8 weeks, while application of the 25Td +75 Lc pruning mixture resulted in the lowest plant height (Tabel 8).

Table 8. Height of maize plant at 1, 2, 4, 6 and 8 weeks after planting

Treatment *)	Plant height (cm)				
	1 week	2 weeks	4 weeks	6 weeks	8 weeks
Control	27.88	42.00	65.75	99.00	117
25Td + 75Lc	22.83	35.25	61.00	98.25	104
50Td + 50 Lc	27.63	43.63	74.50	96.00	116
75Td + 25 Lc	26.95	38.88	71.25	98.38	121
90 Lc + 10 Pk	23.63	38.25	68.50	94.25	112
45Td + 45 Lc + 10 Pk	25.05	42.25	72.38	93.25	108
TSP	27.08	41.00	64.25	95.00	119

*) see Table 1

Results of analysis of variance showed that application of *Tithonia diversifolia* and *Lantana camara* pruning mixtures did not significantly affected P uptake by maize at week 8. The highest P uptake (19.04 mg / kg) was observed for 75Td+25Lc treatment. In comparison with P uptake of the control treatment (16.49 mg / kg), application 75Td+25Lc pruning mixture increased P uptake by 15.46%. The lowest P uptake (17.07 mg / kg) was observed for 25Td +75Lc that increased 3.53% compared to the control treatment. Uptake of P for the SP36 treatment only increased 8.71% compared to the control treatment. Although application of *Tithonia diversifolia* and *Lantana camara* pruning mixtures, pure *Lantana camara* prunings, and manure, as well as application of pure *Tithonia diversifolia* prunings and manure resulted in lower P uptake by maize than application of pure *Tithonia diversifolia* prunings, application of the pruning mixtures resulted in greater P uptake compared to application of pure *Lantana camara* prunings (Table 9).

According to Myers et al (1994) the term 'synchrony' indicates the suitability according to the time of availability of nutrients and nutrient needs of the crop. If the nutrients are not in accordance with the time when the plants need, there will be a nutrient deficiency or excess of nutrients, although the total amount of the provision is equal to the total number of plant needs. However, the inverse of the P uptake data above, P use efficiency data by maize plants showed that the highest P efficiency was for 25Td+75Lc compared to the other treatments.

Table 9. P uptake by maize at 8 weeks after planting

Treatment *)	P uptake (mg/kg)	% increase
Control	16.49	
25Td+75Lc	17.07	3.53
50Td+50Lc	18.88	14.49
75Td+25Lc	19.04	15.46
90Lc+10Pk	17.51	6.21
45Td+45Lc+10Pk	18.74	13.63
100Td	19.11	15.89
100Lc	16.99	3.03
TSP	17.93	8.71

*) see Table 1

Based on data presented in Table 10, the efficiency of application of organic matter was in the order of 25Td+75Lc > 90Td+10Pk > Urea > 45Td+45Lc+10Pk > 50Td+50Lc > 75Td+25Lc. Although the 75Td +25Lc treatment had high rates of decomposition and P mineralization, its synchronization level was lower than that of 25Td +75Lc which had lower rates of rates of decomposition and P mineralization. This is because of the release of P from the 75Td+25Lc prunings mixture which had high quality, did not coincide with the time of maize required P for its growth. This made the released P was not optimally utilized by maize, and this element was then subjected to leach out from the soil.

Tabel 10. Efisiensi penggunaan P bahan organik dan TSP oleh Tanaman Jagung setelah 8 minggu

Treatment *)	Efficiency (%)
25 Td+75 Lc	84.77
50 Td+50 Lc	83.26
75 Td+25 Lc	83.25
90 Lc+10 Pk	84.35
45Td+45 Lc+10 Pk	83.39
SP36	83.74

*) see Table 1

Conclusion

Mixing *Tithonia diversifolia* and *Lantana camara* prunings increased the decomposition and mineralization rates of *Lantana camara* prunings, but reduced the decomposition and mineralization rates of Tithonia diversifolia prunings. Mixture of 25% *Tithonia diversifolia* and 75% *Lantana camara* prunings increased 77.54% P uptake by maize.

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