

Decomposition and release of nutrients from crop residues on soybean-maize cropping systems

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ABSTRACT: Nutrients found in residues from agricultural cultures are important reserves for subsequent crops. The objective was to assess the decomposition and release of nutrients from different crop residues for subsequent soybean cultivation. The study was conducted in Mid-Northern Mato Grosso State, Brazil. The residual straw of cropping systems - maize, brachiaria and maize/brachiaria consortium - were sampled, weighted, disposed in litter bags and then distributed on the soil. The adopted experimental design followed the completely randomized arrangement with three repetitions. Treatments were determined based on harvest time, which was performed every 14 days within 140 days for maize, and within 154 days for brachiaria and for the consortium. The remaining dry matter and nutrients content, and half-time life were evaluated. Maize showed the highest straw dry matter yield (14,176 kg ha⁻¹), and the consortium recorded the biggest nutrient accumulation per hectare (K=172.2; N= 141.7 and Ca=56.0 kg ha⁻¹). Brachiaria straw presented the fastest decomposition rate (85%) and the highest nutrient release (K=99%; N=92%; Mg=98% and Ca=90% of total initial content). The total K released reached 150 kg ha⁻¹, which can fit the needs of soybean crops.

Key words: crop management; integrated; mixed systems; nutrient cycling

Decomposição e liberação de nutrientes de resíduos de culturas no sistema de cultivo soja-milho

RESUMO: Os nutrientes contidos nos restos culturais representam uma importante reserva para culturas subsequentes. O objetivo foi avaliar a decomposição e a liberação de nutrientes de diferentes resíduos de culturas para subsequente cultivo da soja. O estudo foi realizado na região Médio Norte do estado de Mato Grosso, Brasil. A palhada residual dos sistemas de cultivo; milho, braquiária e consórcio milho/braquiária foram amostrados, pesados e acomodados em litter bags e distribuídos sobre o solo. O design experimental foi o inteiramente casualizado com três repetições. Os tratamentos foram estabelecidos com base no tempo de colheita, realizado a cada 14 dias, em um período de 140 dias para o milho e 154 dias para a braquiária e consórcio, aonde foi avaliando a permanência da matéria seca e nutrientes e o tempo de meia vida. O milho apresentou a maior produtividade de matéria seca (14.176 kg ha⁻¹), e o consórcio o maior acúmulo de nutrientes por hectare (K=172,1; N= 141,7 e Ca=56,0 kg ha⁻¹). A braquiária apresentou a maior taxa de decomposição (85%) e a maior porcentagem de liberação de nutrientes (K=99%; N=92%; Mg=98% e Ca=90% do conteúdo inicial). A quantidade de K liberado pode ser de até 150 kg ha⁻¹ o que pode corresponder às necessidades da soja.

Palavras-chave: manejo de culturas; integrados; sistemas mistos; ciclagem de nutrientes

Introduction

The soybean-maize (*Glycine max-Zea mays*) succession cropping system is broadly adopted in Mato Grosso State (MT) and its crops cover approximate 3.4 million hectares (CONAB, 2015). Straw production in the state mainly results from maize residues, since producers rarely use cover plants, alone, or in consortium system. The maize/brachiaria (*Brachiaria ssp.*) consortium became an alternative, because it allows soil coverage and nutrient cycles in subsurface layers (Torres & Pereira, 2008), as well as increases mineral fertilization efficiency.

Weather effects on straw yield and maintenance are evident, as shown by Torres & Pereira (2008), according to whom *Brachiaria brizantha* yield varied between 6.0 and 2.1 t ha⁻¹ in the 2000/01 and 2001/02 crops, respectively. Although tropical regions face a hard time in straw production, vegetal residue decomposition in these regions is fast due to high temperatures and humidity throughout most of the year. Thus, it is extremely important knowing the amount and permanence time of straws belonging to the species used in rotation or consortium cultures (Pacheco et al., 2013). Lange et al. (2009) found that the straw decomposition rate of different species reached 30 kg ha⁻¹ day⁻¹ between May and November (174 days) in Minas Gerais *Cerrado* region; thus, showing that straw accumulation and maintenance in *Cerrado* is not an easy task.

The Mid-Northern Mato Grosso State Region demands from 11.7 to 13.3 t ha⁻¹ of straw to keep the straw balance in planting systems (Sá et al., 2015). Straw is an important nutrient reservoir, which can be gradually, quickly, or even intensely made available (Rosolem et al., 2003). This leach is influenced by the activity of microorganisms found in the soil, by their quality (carbon/nitrogen (C/N) ratio) and amount, by the weather conditions - with emphasis on temperature and rainfall - and by the contact of straw with soil (Acosta et al., 2014). Nutrients leached by the straw, mainly potassium (K) - which presents short half-time life - are important to nurture the subsequent culture. These nutrients must be taken into account at the time to calculate the need of fertilization (Rosolem et al., 2003); however, there is uncertainty in estimating exactly how much of them will actually be available in time for the next crop (Rosolem et al., 2017).

K is easily leached by straw and has a peculiar behavior, because it is not a constituent of stable composites and does not belong to the structural composites in plants. Calcium (Ca) release is limited to the decomposition process, since it is mostly constituted by structural composites such as cell wall (Taiz & Zeiger, 2009). The easiness of K release in brachiaria and triticale (*Triticosecale wittmack*) straw was reported by Calonego et al. (2005), who found 7.5 and 9.0 kg ha⁻¹ K leach, respectively, through 30mm irrigation, 16 days after plant desiccation. However, rainfall close to 10mm was enough to promote the maximal release of promptly removable K, i.e., K found in leaf edges (Rosolem et al., 2003).

Nutrients leached by cover plant straw help enhancing the agricultural performance of the subsequent culture

(Ferreira Filho et al., 2013) and may boost soybean yield by 24%. The same study showed high K absorption and export, which resulted in its content reduction in the soil. Such reduction is seen as beneficial, since the reduction in this system is caused by export, i.e., grains are produced, but there is no leaching. The objective was to assess the decomposition and release of nutrients from different crop residues for subsequent soybean cultivation.

Material and Methods

Featuring the study area

The studies were conducted in two locations in the field, one in Sorriso County-MT (S= 12°31'06"; W= 55°40'22" and altitude 365 m) in the 2013/2014 crop, and the other in Sinop County-MT (S= 11°51'0"; W= 55°33'36", altitude 371 m) in the 2014/2015 crop. Climate data collected during the study are shown in Figure 1.

The climate in the region is classified as Aw, warm tropical, according to the Köppen classification. There are two well-defined seasons, rainy summer and dry winter. The soil in both locations is classified as Red-yellow Latosol (Embrapa, 2013a). Prior to setting the experiment, 10 soil sub samples were collected for subsequent homogenization and preparation of a composite sample, which was analyzed to have their chemical (Embrapa, 2009) and physical properties assessed (Embrapa, 1997; Table 1).

The decomposition and nutrient release of maize straw

The experiment set to assess maize (*Zea mays* L.) straw decomposition was implemented in 09/07th/2013, two months after the maize harvest in Sorriso County and followed a completely randomized design with three repetitions. Treatments were based on the factor "straw decomposition time", which was assessed every 14 days, counting from the day the experiment was implemented, thus totaling 11 harvest times, 140 days. Litter bags (0.25 m² area - 0.5 x 0.5 m, with 2 mm mesh) were used to represent each plot.

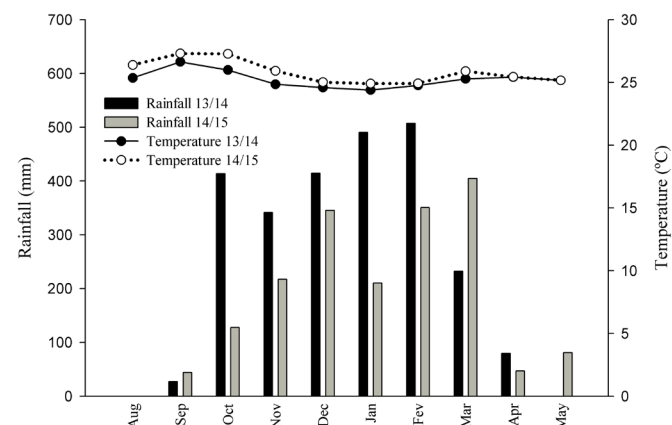


Figure 1. Cumulative rainfall and mean temperature in Sorriso, crop 13/14 (source: Mato Grosso Foundation) and Sinop, crop 14/15 (source: Federal University of Mato Grosso-Sinop).

Table 1. Chemical and physical properties of soils from the 0-20 cm layer used in the experiments in Sorriso and Sinop region.

	Sorriso	Sinop
Chemical		
pH	5.35	5.60
S.O.M. (g dm ⁻³)	37.80	34.00
P (mg dm ⁻³)	11.41	8.80
K (mg dm ⁻³)	82.75	67.00
Ca (cmol _c dm ⁻³)	3.01	2.58
Mg (cmol _c dm ⁻³)	1.34	0.46
H+Al (cmol _c dm ⁻³)	6.86	4.50
CEC (cmol _c dm ⁻³)	11.41	7.70
V (%)	39.04	41.60
Physical		
Clay (g kg ⁻¹)	542	544
Sand (g kg ⁻¹)	302	353
Silt (g kg ⁻¹)	156	103

pH (water); SOM, soil organic matter (oxi-reduction); P and K (Mehlich 1); Ca and Mg (KCl); H+Al (calcium acetate); CEC, cation exchange capacity; V, soil base saturation and particle size was measured using the pipette method.

The straw used in the experiment came from an area presenting productivity close to 9.000 kg ha⁻¹. A machete was used to fraction the straw, which was stored in litter bags, according to the methodology adapted by Kliemann (2006) and Torres & Pereira (2008). Each bag was added with a straw amount proportional to the amount of straw covering the area in the field. The initial phytomass was determined by means of random weighing in a 0.25 m² gauge (0.5 x 0.5 m); each area had its phytomass weighed 15 times. The maize sample was fractioned in 0.25 m pieces before it was taken to the litter bags, the amount of added dry mass per litter bag was 354.4 (± 0.1) g. The litter bags were placed on the soil, and fixed with rebar handles, so that it would be impossible to have them moved by external agents.

The collected material was left to dry in forced-ventilation oven, at 65 °C, until reaching constant weight, in order to set the dry mass of each harvest time. Subsequently, this material was sieved in 2 mm mesh for soil remnant removal. The vegetal mass was measured, ground in Willey mill, and the nutrient concentrations were determined. Nitrogen (N) analyses were performed through the Kjeldahl method (Embrapa, 2009) and carbon was set through muffle burning at 550 °C (Carmo & Silva, 2012). The other nutrients were analyzed through nitric perchloric acid extraction and determined in atomic absorption spectrometer based on the methodology by Malavolta et al. (1997).

Brachiaria and maize/brachiaria consortium straw decomposition and nutrients release

The experiment focused on brachiaria (*Brachiaria ruziziensis*) and maize+brachiaria consortium straw decomposition was implemented on October 01st, 2014 in Sinop-MT and followed a complete randomized design with four repetitions. Treatments were set based on the straw decomposition time every 14 days, thus totaling 12 harvest times, 154 days. Litter bags (0.25 m² area – 0.5 x 0.5 m / 2 mm mesh) were used to represent each plot.

Brachiaria straw came from a silage-maize/brachiaria consortium cropping system. The seeds were sown after the soybean harvest; only silage-maize cut was performed; brachiaria was left on the field and desiccated before its harvest. The consortium straw was collected from neighbor areas in the same field; although, in this case, only maize showing grain yield close to 6.000 kg ha⁻¹ was harvested. Maize/brachiaria straw remained in the area.

The methodology used to implement the study and to material collection and analysis was the one previously reported for maize straw decomposition. Maize and brachiaria were fractioned in 0.25m pieces before they were taken to the litter bags. The amount of consortium and brachiaria dry mass added per litter bag was 297.6 and 150.3 (± 0.1) g, respectively.

Statistical analyses

The data were adjusted to the exponential decay model: $PL = P_0 \exp(-kt)$, by Wieder & Lang (1982), in order to describe the nutrients deriving from straw decomposition and their release dynamics. PL is the amount of straw and nutrients found in the time t (kg ha⁻¹); P₀ is the potentially leached phytomass and nutrient fraction (kg ha⁻¹); and k is the nutrient release rate (g g⁻¹). The half-life time (T_{1/2} life) of the straw and nutrients was calculated through the formula $T_{1/2} \text{ life} = 0.693/k$, proposed by Paul & Clark (1989).

Results and Discussion

Straw accumulation and decomposition

The system accumulating the highest amount of straw was maize (alone), which showed initial quantification 14 t ha⁻¹ of culture residue in September 2013 (Table 2). According to the harvest map, the mean yield in the field was higher than 8 t ha⁻¹, and that of the plot - where the experiment was set - was close to 9 t ha⁻¹. This outcome resulted from soil correction, as shown in the soil analysis (Table 1), as well as from handling based on high technology (seeds and inputs).

Soil in Sinop's integration area presented lower fertility in September 2014, technology use was on the average and the year recorded water deficit. Thus, there was strong competition between maize and brachiaria, fact that has reduced the final mass accumulation in the system. Such scenario can be evidenced by grain yield close to 6 t ha⁻¹, which complies with results by Brambilla et al. (2009); brachiaria imposed intense competition with maize throughout the one-year period of low rainfall.

The decomposition of the assessed materials presented peculiar behavior. There were phases of stronger or milder decomposition when the materials were compared to each other (Table 2).

Brachiaria straw presented the highest accumulated decomposition values throughout time, and only 15% of the initial total remained on the field 154 days after implementation (DAI); half-life time was 80 DAI (Table 2). Lower C/N ratio, greater leaf/culm ratio close to 1.2 (Bauer

Table 2. Dry matter persistence and C/N ratio of vegetal residues (consortium, brachiaria and maize) throughout time, as well as the parameters in equation $P = P_0 e^{-kt}$ adjusted to dry matter, material half-life time values ($T_{1/2}$) and p value based on the applied model.

Days after implementation	Cover		
	Consortium	Brachiaria	Maize
Dry matter mass persistence (kg ha ⁻¹)			
0	11907	6011	14176
14	11022	5106	13129
28	9731	4937	12568
42	9209	4315	12518
56	8473	3763	11733
70	7294	3017	11358
84	6131	2783	11106
98	5477	2613	9958
112	5194	2548	9073
126	4659	2411	8308
140	3325	1866	6446
154	2896	911	-
C/N Ratio			
0	34	32	51
70	56	50	60
140	58	56	68
Statistical parameters			
P_0 (kg ha ⁻¹)	12368.684	6020.512	14482.914
K (g g ⁻¹)	0.0081	0.0087	0.0042
p value	0.0001	0.0001	0.0001
R^2	0.99	0.98	0.96
$T_{1/2}$ (days)	86	80	165

et al., 2011) and thinner material diameter in comparison to other assessed materials could be the possible causes of such condition. Thus, when only brachiaria is cultivated or in consortium cases, brachiaria straw becomes important for initial soybean nutrition.

Leonel et al. (2009) assessed a maize/brachiaria consortium and found leaf/culm ratio ranging from 0.8 to 1.3, which are values higher than those found in maize crops (0.6) by Balieiro Neto et al. (2012). The culm is naturally lignified, fact that justifies the higher brachiaria decomposition rate. Factors such as larger diameter of the maize culm comparison to brachiaria and more stable and diverse biota in brachiaria and in consortium can also change this rate.

The second highest decomposition rate was shown by the consortium due to the presence of brachiaria straw in the residue mix; thus, only 24% of the initial straw remained at the 154 DAI, with half-life time 86 days. Maize straw presented the longest stay length - half-life time 165 days. Factors such as C/N ratio (51), higher lignified material rate (culms and squirrels) and larger amount of initial material, besides the differentiated condition and conduction, may have influenced.

Accordingly, consortium promotes great nutrient distribution for soybean nutrition over time. This soybean crop is commonly sown after the second maize crop in the region. It is also important to emphasize that maize residues

stay for six months or more on the soil, so it is an excellent coverage.

The decomposition rate of the materials is influenced by rainfall and environment temperature. Decomposition can be reduced in drier and cooler regions. Thus, a high variability is seen in results of different climate conditions (Torres & Pereira, 2008; Calonego et al., 2012; Santos et al., 2014).

Figures 2A, B and C show that the accumulated decomposition is closely related to rainfall, because increased rainfall events lead to higher decomposition rates, vice-versa. Initially, fast decompositions take place even in

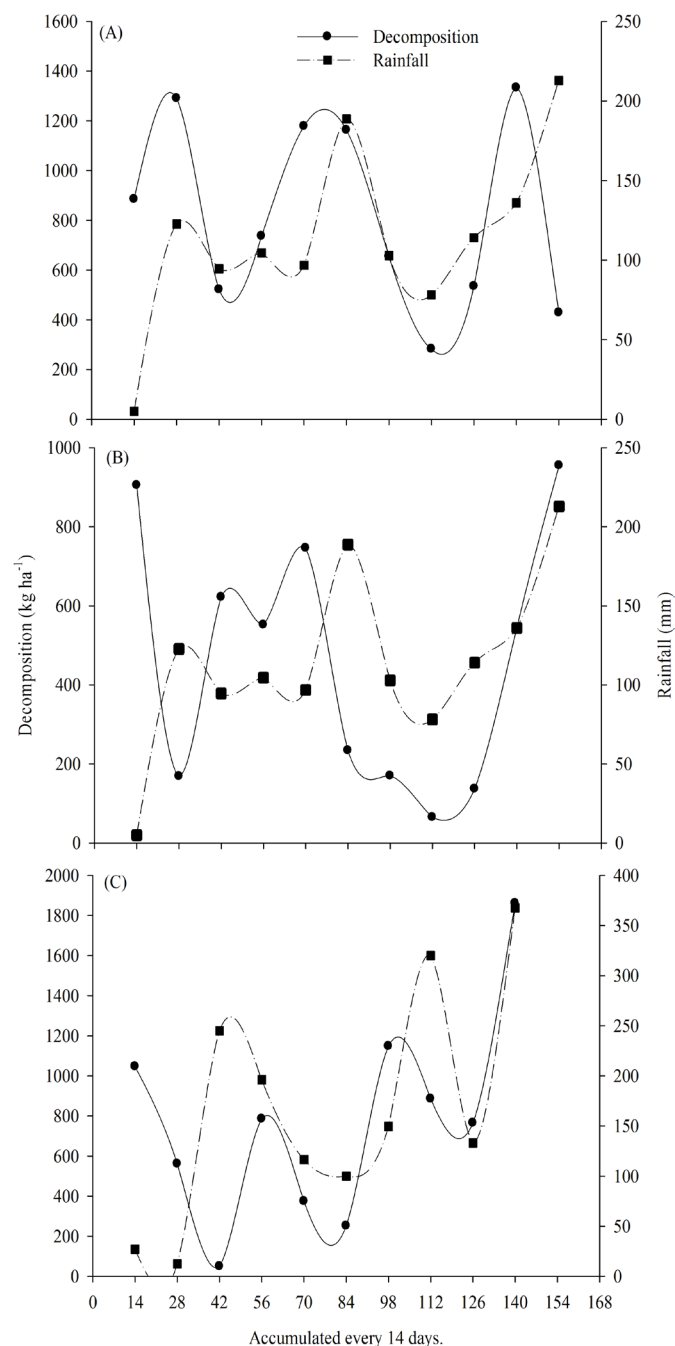


Figure 2. Straw decomposition evolution based on accumulated rainfall every 14 days, in consortium (A), brachiaria (B) and maize (C).

face of short rainfall due to features such as lower C/N ratio and finer materials. As time goes by, only more lignified materials of lower decomposition remained, and it delayed the decomposition process. Good system aeration influences the decomposition rate, and such aeration may be linked to rainfall intensity, rather than to the total rainfall values represented in millimeters. Torres & Pereira (2008) studied the decomposition of cover plants and showed C/N ratio differences in the same plant, in different years, as well as how it influences the decomposition rate. Thus, the results reflected behavioral trend changes every new agricultural year, under every studied situation.

The decomposition rates of the consortium material on the field and of maize used alone (in maize straw treatments), followed the rainfall events taking place within a week, or on a previous fortnight. Such fact justifies the hypothesis that the unit to be kept in the “soaked straw” strongly influenced the biological activity and accelerated the decomposition of more lignified materials through the so-called “sponge effect”; thus, helping decomposition.

The accumulation and release of straw nutrients

The highest nutrient accumulations were shown by the consortium, except for the magnesium (Mg) content in maize, because of its high content in the soil (Sorriso County) in which the maize was cultivated (Table 1). K was the element presenting the highest concentration in maize and in the consortium; whereas the highest N concentration was found in brachiaria straw (Table 3). Therefore, the lowest nutrient

accumulation per hectare was shown by the brachiaria straw, because of the lower straw yield in the system; although, different concentrations of these elements were found in the literature (Calonego et al., 2012 and Mendonça et al., 2015).

K was the easiest element to be removed from the plant material, because, by the end of the experiment, almost 100% of it had already been removed (table 3). Such behavior is explained by its lack of participation in plant structures, along with rain water; however, much of the K content can be absorbed by the plants when there is plant cultivation and no K excess in the soil.

The time needed to leach half of the K content was 16, 21 and 31 days for brachiaria, consortium and maize, respectively. Quite controversial results are found in the literature about K leach time. Torres & Pereira (2008) showed that K's half-time life in brachiaria straw was 56 and 78 days in a study conducted in Minas Gerais *Cerrado* for two consecutive years. Santos et al. (2014) observed K's half-life time of just 13 days in Bahia *Cerrado*. Many authors attribute K leach speed in the material to local rainfall rates (Calonego et al., 2005; Torres & Pereira, 2008; Santos et al., 2014). However, Santos et al. (2014) highlight that this variable is quite dependent on material type and on weather conditions; thus, comparisons must be carefully performed in order to work as reference.

Although all materials have leached almost the same K percentage at the end of the experiment, it is worth observing that 90% of the accumulated total was leached at 55, 73 and

Table 3. Initial concentration of the elements: calcium, magnesium, nitrogen and potassium, and their persistence in the residues of the cultures (consortium, brachiaria and maize) throughout time (days after implementation, DAI), as well as the parameters in equation $P = P_0 e^{-kt}$, which were adjusted to the amount of each element in the residues, of their half-life times ($T_{1/2}$) and p value in the adopted model.

DAI	Cover											
	Consortium				Brachiaria				Maize			
	Ca	Mg	N	K	Ca	Mg	N	K	Ca	Mg	N	K
	Concentration initial values (g kg ⁻¹)											
	4.70	1.52	11.90	14.46	4.71	1.58	12.28	10.57	3.78	2.94	8.01	11.44
	Elements' persistence in the straw (kg ha ⁻¹)											
0	56.0	18.1	141.7	172.1	28.3	9.5	73.8	63.6	53.5	41.7	113.5	162.2
14	44.4	16.2	121.7	154.7	23.9	8.0	62.4	51.5	49.9	37.7	101.8	122.1
28	38.4	13.2	68.1	60.0	21.9	6.2	54.2	13.2	40.2	35.8	83.8	105.1
42	33.3	10.8	61.4	52.7	18.9	4.5	40.4	5.5	36.9	34.9	77.6	70.2
56	30.8	7.8	55.2	14.9	16.1	3.2	30.4	4.1	35.8	32.6	72.4	42.2
70	26.4	5.6	43.0	9.5	11.4	1.7	22.3	3.0	32.9	31.1	70.1	32.8
84	21.3	4.4	36.8	8.0	10.2	1.5	19.2	2.5	32.2	30.4	67.9	20.6
98	20.2	3.9	32.9	6.5	9.6	1.3	18.0	2.3	28.9	26.1	59.0	15.1
112	16.8	3.2	31.2	6.0	8.8	1.3	16.3	2.1	26.3	22.9	52.1	9.7
126	13.7	2.3	28.6	4.2	8.4	1.2	15.5	1.7	22.6	20.8	47.1	8.8
140	9.0	1.4	21.0	2.8	6.0	0.8	12.8	1.2	17.2	15.8	34.8	4.5
154	7.8	1.2	17.4	2.3	2.9	0.2	6.2	0.5	-	-	-	-
	Statistical parameters											
P ₀ (kg ha ⁻¹)	54.341	19.318	136.289	187.130	28.732	9.922	75.290	67.994	52.586	42.432	110.176	167.805
K (g g ⁻¹)	0.0111	0.0161	0.0156	0.0328	0.0113	0.0198	0.0147	0.0427	0.0068	0.0053	0.0070	0.0223
p value	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000
R ²	0.99	0.99	0.97	0.97	0.99	0.99	0.99	0.97	0.98	0.96	0.98	0.99
T _{1/2} (days)	62	43	44	21	61	35	47	16	102	131	99	31

104 DAI in brachiaria, consortium and maize, respectively. The material decomposition can be partially explained by greater leaf/culm and lower C/N ratio in the first residues, fact that facilitate the decomposition of the material.

A high-quality straw must present high nutrient concentration and amount, as well as synchronize nutrient release and the subsequent culture growth. Results show that maize straw and consortium provide sufficient K to soybean demand; 114 kg K is necessary to produce 3600 kg of grain, on average (Embrapa, 2013b). K release in these materials meet the soybean demands. Soybeans absorb most of the K content (~ 80%) 53 days after sowing at maximum accumulation 105 days (Zobiolo et al., 2012). This synchronism is very important to potassium fertilization management, since potassium fertilization can be concentrated in maize (it is more responsive) without affecting K availability for soybean. Brachiaria has smaller K amount, thus only straw-origin K is not enough to fulfill all soybean needs.

According to Rosolem et al. (2003), there is great K release until 17mm rainfall. the material gets soaked and only leaches K accumulated in the edges. Internal K contents demand time to be leached; thus, K release is influenced by material diameter. The amount of K remaining in the crop residue decreased as rainfall increased. Much more rain is needed to leach out a similar amount of K than finer structure species, for example soybean, due to the structure of different maize plants (Oltmans & Mallarino, 2015).

N recorded longer permanence in the straw, and its concentration changed from straw to straw. This variation was higher in brachiaria (Table 3), possibly due to its dilution effect on maize and to the higher dry mass yield (Table 2). However, the amount of accumulated N per hectare was similar between consortium and maize (Table 3). The half-life time of this element in consortium, brachiaria and maize straw was 44, 47 and 99 days, respectively. It means that consortium and brachiaria straw presented almost the same N leach, ~90% than the 63% leach shown by maize at the end of the experiment.

These higher release rates can be explained by the lower C/N ratio (Table 2), and by the greater leaf/culm ratio in brachiaria, since leaves decompose more easily and have higher N concentration. Thus, initially, N was more rapidly leached, but the release time got more stable as more lignified the remaining materials were. Although release remained slow throughout time, which was a benefit to the subsequent soybean culture, the release in maize was slower because of its lower concentration and lower leaf/culm ratio.

Calonego et al. (2012) found leach rate in maize and brachiaria straw almost equal to N leach (41%) after 135 days in São Paulo State. Mendonça et al. (2015) assessed different grass species grown in consortium system with maize and found higher N leach rates at the first 30 DAI, as well as subsequent stabilization of it. It was justified by Perin et al. (2010) and Pinto et al. (2016), who found N release correlated to C release (decomposition of residues) in two

phases: i) fast decomposition of structural components of easy decomposition (< C/N); ii) slow decomposition of more resistant materials (> C/N).

The consortium, and maize used alone, have basically presented the same Ca accumulation per hectare and slower release of it in maize straw (Table 3). Brachiaria and consortium (~83%), straws presented the highest Ca leach percentage and were followed by maize (62%). Half-time was 61, 62 and 102 days, respectively. The release followed the decomposition, because Ca (which is not easy to be removed) is the main cell wall constituent (Brady & Weil, 2013). Such result was found by comparing the total Ca leached from brachiaria, consortium and maize straw presenting material decomposition percentages 85, 76 and 55%, respectively.

The highest Mg leaches were shown by brachiaria and consortium (95 and 91% of the total), respectively. The half-life time was 35 and 43 days in these two straws; whereas it was 131 days in maize (Table 3). This half-life times result from the easier decomposition of brachiaria plant material; however, maize was the straw releasing the highest Mg amount (in total numbers) – in Kilograms per hectare -, due to its high concentration (almost the double of the other materials) and larger dry mass volume. Approximately 70% of the Mg content is found in cell vacuole (Marschner, 1995), fact that makes its leach faster; the remaining Mg is part of structural composites. According to Brady & Weil (2013), 20% of the Mg content is part of the chlorophyll molecules; thus, 90% of it is of easy removal when the chlorophyll molecules found in less lignified structures are taken into account.

There is no relation between concentration and nutrient total amount, and leach, for there are many climatic (amount and rainfall intensity) and morphological factors (plant material diameter, leaf/culm relation), as well as factors inherent to the function of the element in the plant (structural, transportation) that controls the release of these nutrients.

Conclusions

Maize straw showed slower decomposition than Brachiaria or consortium in soil: half-life time of 162 days.

Maize straw showed gradual release of nutrients to subsequent crops due to the slower initial decomposition.

K release from the straw is faster in comparison to N, Mg and Ca: half-life time shorter than 31 days in the evaluated materials.

Maize and consortium straw can provide approximately 150 kg ha⁻¹ of potassium, which is the amount required for soybean cultivation.

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