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Decomposition rate of crambe phytomass on Haplortox under different soil management practices

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The aim of this study was to assess the decomposition rate of crambe straw under different soil management practices based on no-tillage system. The experiment was carried out at the experimental area of the Agronomic Institute of Paraná - IAPAR, regional center of Santa Tereza do Oeste, Paraná, Brazil. Treatments consisted of four soil management practices: Traditional No-tillage System - TNTS – Chisel Plowing Tillage System - CPTS – No-tillage System with Application of Gypsum - NTSG - and Quality No-tillage System - QNTS. The treatments were distributed in randomized order in parts subdivided on time with fifteen macro-plots of 20 m x 25 m. The assessments took place on 0 (zero), 7, 15, 30, 60, 90, and 120 days after crambe crop harvest. Decomposition was determined quantitatively through the analysis of the decomposition rate of crop residues using litter bags. Average loss of crambe phytomass was significantly different ($p>0.05$), mainly for CPTS and NTSG, around 0. 63% day^{-1} and 0. 71% day^{-1}, respectively. The longest half-life period (66 days) was observed on QNTS with bristle oat and white lupin consortium, and the shortest half-life period (45 days) was observed on CPTS.

Key words: *Crambe abyssinica*, litter bags, half-life period.

INTRODUCTION

The alterations on physical, chemical and biological properties of a soil that is intensively used for agricultural purposes can, and normally will, result in negative impacts on the natural balance of its ecosystem. The consequence is disequilibrium, which affects the decomposition of organic matter and nutrient cycling in the soil. In addition to the chosen method of soil management, the type of crop residue also has great influence on the rate of decomposition of organic matter. For Teixeira et al. (2009), the leguminous plants have a higher rate of decomposition compared cultures of grasses. Among the crops, crambe has great advantages

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such as low production cost, ruggedness, easy adaptability to low soil fertility and high tolerance to drought, does not require new machinery and equipment for cultivation (Neves et al., 2007). The crambe culture can still be an option for the "safrinha" after the summer crop harvest, to be more suited to the autumn and winter seasons. It is a precocious culture, with full cycle varying from 80 to 100 days, it depends on variety, sowing time and climate conditions (Onorevoli, 2012).

The degree of impact on the soil ecosystem is closely related to management practices adopted in agricultural production. Therefore, choosing the proper method for preparing the soil is a major step in maintaining and structuring its ecosystem. There are innumerous studies on different types of soil that point to the organic matter as the essential element for soil conservation. For instance, organic matter improves different factors such as soil aggregation, physical attributes, permeability and porosity. In addition, it increases cationic exchange, water retention, nutrient cycling, fertility, and total organic carbon stocks in the soil (Kong et al., 2005; Amado et al., 2006; Bayer et al., 2006; Calegari et al., 2008; Sá and Lal, 2009; Chioderoli, et al., 2010). For structuring the soil, it is highly important that soil organic matter (SOM) is conserved (Calegari et al., 2006). For better under-standing of the process of conservation of soil quality, the knowledge of the dynamics of decomposition of crop residue is fundamental (Kliemannet al., 2006). SOM protection must be grounded on a proper set of processes that favors its preservation and its contribution to the soil. Among those processes, cultivation method is the one that should receive greater attention.

From that perspective, choosing quality agricultural management and practices involves adopting the usage of cover crops. When the objective is to conserve the agro ecosystem soil through decomposition and cycling of nutrients of crop phytomass, the adoption of crop rotation with crops that produce large amounts of biomass, above 6 Mg ha^{-1} dry mass, is recommended (Nunes et al., 2006).

In order to carry out management practices that contribute to the maximum protection of the soil, to carbon accumulation and use of recycled nutrients by the succession of cover crops, outlining crop systems involves selecting the best succession of cover crops. The effectiveness of the process of preparing the soil is also related to the knowledge of the process of decomposition and cycling of nutrients from crop residue (Esther et al., 2013). Early studies with crambe culture (Crambe abyssinica Hoechst) were performed in the first decades of the twentieth century.

The motivation of the production of crambe was its high concentration of erucic acid. The fatty acid can be used for the production of a wide range of products and byproducts, including lubricants, insulating paints, resins, surfactants (Gonzales and Cihacek, 1991). Thus, numerous studies began to be developed, however, in the 1960s, the oil crambe weakened front to products and petroleum by-products that have become economic again.

Currently, the new perspective, especially environmental, for new energy sources such as biofuels, the crambe back to be back to be studied due to its large oil production potential with good commercial characteristics, especially in Brazil. Among the oleaginous plants the crambe shown as a non-food annual crops most promising composing the commercial crops framework in the agricultural sector. This research was design on the premise that different species of crop present different rates of decomposition according to soil management practices and contribute in distinct ways to the increase of carbon in the soil and quality of SOM. The aim is to understand the dynamics of *crambe abyssinica* phytomass decomposition, as well as the influence of the management system by determining dry phytomass of this crop, and by doing so, providing data that may be valuable to farmers, technicians and other professionals when making decision on the best management practice to be taken into account.

MATERIALS AND METHODS

Experiment placement and description of environment

This study is part of a long duration experiment in soil management systems. The experiment was carried out in the Experimental area of the Agronomic Institute of Paraná - IAPAR, regional center of Santa Tereza do Oeste, Paraná, Brazil, coordinates 25º08' (S) latitude and 53º58' (W) longitude, average altitude 750 m above sea level. The climate characteristic of the region according to Köppen classification is Mesothermal-Humid Subtropical, Cfa, with averages superior to 22°C in the hottest month and inferior to 18°C in the coldest month. The region has no dry season defined, hot summers and occasional frost. Rainfall is abundant and well distributed along the year, annual average between 1,800 to 2,000 mm. Relative humidity around 75 to 80% (IAPAR, 2000). The landscape of the experimental area has a slightly undulated relief with average declivity of 3 to 8%. The soil is classified as dystropherric red Latossol (LVdf) of clayey texture (Donagema et al., 2011).

Background of the area

The assessment took place in experimental area in the institute formerly used for agricultural practices under non-tillage system for at least 18 years. The last liming record was of 3.0 Mg ha^{-1} of dolomitic limestone applied on the area in 2011. Table 1 shows the chemical analysis for soil fertility for each experimental stand prior to the installation of the experiment. Samples were collected in triplicates in layers of 0.00 to 0.20 m. Analysis based on methodology proposed by Pava et al. (1992).

Climatological review

For local climatological review during the period of experiment (March/2015 to December/2015), medium, maximum and minimal temperature and precipitation were measured on a daily basis. A

Table 1. Result of chemical analysis for each experimental stand in the beginning of the assessment for the present study on layers from 0.00 to 0.20 m.

Experimental stand (treatment)	pH	C	P	K	Ca	Mg	Al	H+Al	*S	*T	*V	*Al
		g dm^{-3}	mg dm^{-3}		----------------		cmol$_c$ dm^{-3}	----------------				%
1 (QNTS-1)	4.68	25.26	20.80	0.38	4.72	2.30	0.74	9.46	7.40	16.86	43.80	16.52
2 (QNTS-2)	4.70	21.29	12.61	0.41	4.04	2.18	0.40	8.27	6.63	14.89	43.30	9.90
3 (CPTS)	4.77	21.30	12.99	0.38	4.29	1.96	0.12	7.69	6.63	14.33	44.15	2.90
4 (QNTS-3)	4.50	19.28	14.97	0.30	2.83	1.43	0.33	8.86	4.55	13.62	32.44	7.40
5 (QNTS-4)	4.94	18.96	3.60	0.26	4.15	1.89	0.13	6.35	6.30	12.65	48.11	4.15
6 (NTSG)	4.63	18.05	8.95	0.27	3.20	1.53	0.31	7.26	4.99	12.54	37.74	10.00
7 (QNTS-5)	4.54	26.75	19.09	0.34	4.27	2.39	0.44	9.99	7.00	16.99	40.80	8.05
8 (SPDQ-6)	4.57	22.40	10.43	0.29	3.56	1.62	0.46	9.21	5.48	14.68	35.88	13.48
9 (TNTS)	4.27	22.01	11.53	0.22	2.40	1.02	0.83	21.47	3.64	14.27	24.62	24.60

C – Organic carbon - P – Available phosphorus - K – Exchangeable potassium - Ca – Calcium exchangeable - Mg – Magnesium exchangeable - Al – Exchangeable aluminum H+Al - Potential acidity - S* - Base sum - T* - Cations exchange capacity - V* - Base saturation - Al* - Aluminum saturation.

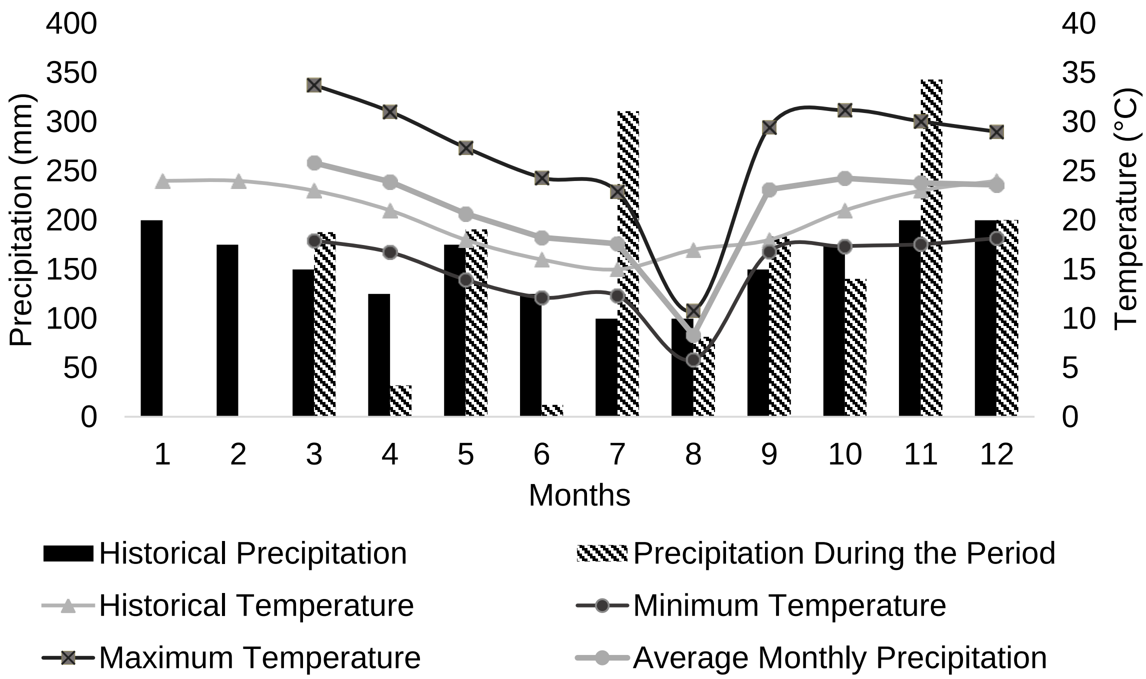

Figure 1. Average monthly precipitation, temperature for the period of 26 years (historical average) of Santa Tereza do Oeste – PR. Source: IAPAR 2000. Maximum, minimum and average temperature from March/2015 to December/2015.

dry bulb thermometer was used for recording temperature and a field pluviometer for precipitation. The results were compared to the historical data of the region according to IAPAR weather charts (2000). Figure 1 shows historical data for average precipitation and temperature in Santa Tereza do Oeste – PR for a period of 26 years (1972-1998), and climate data, including duration of research, average monthly precipitation, maximum, minimum and average temperature for the experimental period. The results of precipitation in the region on July, November and December exceed the averages on the historical data. According to Technical Bulletin of Paraná Meteorological System, for the year 2015, the pluvial average for November exceeded historical precipitation for the last ten years, reaching the 343 mm accumulated in that season (SIMEPAR, 2015). In addition, average temperature throughout the experiment was also above historical data.

Experimental design and description of treatments

The experiment was set in completely randomized design, composed of four soil management practices: Traditional No-tillage System - TNTS – Chisel Plowing Tillage System - CPTS – No-tillage System with Application of Gypsum - NTSG - and Quality No-tillage System - QNTS. Treatments were distributed in parts subdivided on time with nine macro-plots of 20 m X 25 m, among which six compose the QNTS treatment. The six treatments QNTS are composed of winter cover crops during off-season of commercial crops. Namely: QNTS-1 – with common oat (*Avena sativa L.*); QNTS-2 – with bristle oat (*Avena strigosa Schieb*); QNTS-3 – with rye IPR89 (*Secale cereale* L.); QNTS-4 – with bristle oat (*Avena strigosa Schieb*) and radish (*Raphanus sativus* L.) consortium; QNTS-5 – with bristle oat (*Avena strigosa Schieb*) and white lupin (*Lupinus albus*) consortium; and QNTS-6 – with bristle oat (*Avena strigosa Schieb*) and field pea (*Pisum sativum subsp. Arvense L.*) consortium. For TNTS treatment and witness treatment, soil management practice was the same as the adopted by local farmers, who use fallow system farming after summer season. For the CPTS, land was plowed at a depth of 0.30 m. For NTSG treatment, 3.0Mg ha^{-1} agricultural gypsum was applied a month following the beginning of the experiment.

Before setting the experiment, soybean had been cultivated at the location. After succession of crops and treatments management was as follows: a) QNTS treatments: winter cover crops/ soy/ crambe; b) CPTS, NTSG and TNTS: fallow/ soy/ crambe. Winter cover crop management, rolling and desiccation processes occurred at flowering stage. For commercial crops, however, the analytical determination occured only after a full cycle. Crambe seeds were sown on March 31, 2015, and analysis of phytomass production occurred at flowering stage on 15 July, 2015. The crop was harvested on 17 August, 2015, and the analysis for the present study began at the same day.

Evaluation and analytical determination

Decomposition was determined quantitatively through the analysis of decomposition rate of crop residue in seven periods, with five repetitions per period during decomposition. Four samples in 1 m^2 were collected for each treatment, totaling 4 m^2 per treatment. After collecting the material, it was sent to a laboratory where it was washed in running water, then in distilled water, dried in forced air stove at 65°C until reaching constant weight. The material was then weighed to determine organic matter. The decomposition of crambe crop residue was assessed through method proposed by Thomas and Asakawa (1993) using litterbags of 2 mm mesh and opening of 0.15 m x 0.15 m. Thirty bags containing the respective crop residue from each portion were distributed for each treatment. The quantity of crop residue in grams was proportional to the biomass of the dry matter produced in the treatment stand. The litterbags were randomly disposed on the soil surface of each experimental stand and collected in periods of 0 (zero), 7, 15, 30, 60, 90 and 120 day from the harvest of crambe.

The samples were sent to the laboratory where the exceeding dirtiness (soil and other vegetation that were not relevant for the analysis) was removed. Later, the remaining phytomass in the litterbags was dried. Analytical analysis was carried out for each period quantifying the remaining dry biomass of the species.

In order to describe crop residue decomposition rate, the exponential model $X = X_0\ e^{-kt}$, decribed by Wieder and Lang (1982), adjusted by Thomas and Asakawa (1993) was applied. Where X is the amount of dry mass (kg ha^{-1}) in time (days) t; X_0 is the fraction of dry mass potentially decomposable, and *k* is the constant of decomposition of the residue (g g^{-1} day^{-1}). According to the model, it is possible to do the regression analysis of the residue decomposition as well as determine the constant of decomposition (*k*) applying napierian logarithm (in) in: $k = \ln (X / Xo) / t$. With the value obtained from k, the half-life period (T(½)) of the dry mass and the nutrients in the remaining crop residue is calculated, that is, the necessary time for 50% of dry mass to be decomposed and nutrients released. To calculate the decomposed biomass half-life, the mathematical formula proposed by Paul and Clark (1989) was used, where $T (½) = \ln (2)/k$. Where T (½) is the half-life time for the decomposition of the biomass or liberation of the nutrients and *k* is the constant of decomposition of biomass.

Statistical analysis

The results of the present study were submitted to analysis of variance (ANOVA), applying the F test to identify the differences between the averages of treatments. For significant results, averages were compared through the test of Turkey at 5% probability ($p < 0.05$). Regression analysis related to decomposition of dry mass was carried out based on the formulations by Thomas and Asakawa (1993).

RESULTS AND DISCUSSION

Dry phytomass production and dynamics of crambe crop residue

Table 2 presents the values of the production of crambe dry mass, as well as its decomposition rate. There is statistical difference between the treatments studied for the production of dry phytomass. The highest amount was observed in treatment TNTS, with 3.716.46 kg ha^{-1}, this is the management practice commonly adopted by local farmers. Following are treatments QNTS-6, with average production estimated in 3.657.45 kg ha^{-1} using bristle oat and field pea consortium, and QNTS-4, estimated in 3.635,16 kg ha^{-1} using bristle oat as a cover crop. The treatments with lower amounts were treatments QNTS-1 and CPTS, with production estimated in 2.763.29 kg ha^{-1} and 2.831.15 kg ha^{-1}, respectively.

The production of dry matter in all the experimental stands was superior to what has been observed in the literature. Pitol et al. (2010), Heinz et al. (2011) and Mauad et al. (2013) showed values of dried phytomass of 1.742 kg ha^{-1}, 2.688 kg ha^{-1} and 2.837 kg ha^{-1}, respectively. The difference between the studies may be attributed to climate conditions, soil type, species, chemical condition of the experimental unit, seeding season, and stage and type of management practice. Decomposition rates of crambe crop residue varied according to treatment used. This result is possibly associated with the amount of residue generated, the topographic localization of the experimental stand, and management practice adopted. The highest decom-position rate is observed in treatment CPTS, with 0.71% day^{-1}. The same treatment however showed one of the lowest averages of mass loss per day because of initial low phytomass content, 20.18 kg ha^{-1} day^{-1}. With reduced volume of straw, daily loss was low when compared, for example, to treatment QNTS-6, which reduced its phytomass to approximately 25.51 kg ha^{-1} day^{-1} but reached a rate of 0.70 % day^{-1}. Similar to treatment CPTS, mass loss in treatment QNTS-2 was approximately

Table 2. Total production of dry phytomass of crambe crop; decomposed phytomass and remainings after 120 days, and decomposition rate.

Treatment	Phytomass			Decomposition rate	
	Produced†	Decomposed (%)	Remaining	$kg\ ha^{-1}\ day^{-1}$	$\%\ day^{-1\dagger}$
	---------------------- $kg\ ha^{-1}$ ----------------------				
QNTS-1	$2.763.29^{c\ (\pm 272)}$	2.155.92 (78)	607.36^{ab}	17.97^{e}	$0.65^{\pm 0,01}$
QNTS-2	$3.635.16^{a\ (\pm 351)}$	3.039.84 (84)	595.33^{ab}	25.33^{b}	$0.70^{\pm 0,01}$
QNTS-3	$3.517.26^{a\ (\pm 85)}$	2.862.78 (81)	654.48^{ab}	23.86^{b}	$0.68^{\pm 0,02}$
QNTS-4	$3.497.59^{a\ (\pm 409)}$	2.837.23 (81)	660.36^{ab}	23.64^{b}	$0.68^{\pm 0,01}$
QNTS-5	$3.300.42^{abc\ (\pm 340)}$	2.606.90 (79)	596.06^{ab}	20.72^{d}	$0.66^{\pm 0,01}$
QNTS-6	$3.657.45^{a\ (\pm 370)}$	3.061.39 (84)	596.06^{ab}	25.51^{a}	$0.70^{\pm 0,00}$
TNTS	$3.719.46^{a\ (\pm 180)}$	2.902.28 (78)	817.19^{a}	24.19^{b}	$0.65^{\pm 0,02}$
CPTS	$2.831.15^{bc\ (\pm 80)}$	2.422.16 (86)	408.99^{b}	20.18^{d}	$0.71^{\pm 0,01}$
NTSG	$3.446,89^{ab\ (\pm 172)}$	2.588.77 (75)	858.12^{a}	21.57^{c}	$0.63^{\pm 0,02}$

† - Average standard deviation (±). Averages of treatments followed by the same lowercase letter show no significant difference on Turkey test at 5% of probability.

25.33 kg ha^{-1} day^{-1}, representing a decomposition rate of 0.70 % day^{-1} of the dry mass produced. By the end of the 120 days of experiment, treatment CPTS decomposed 86% of the dry mass produced. This treatment presented the highest percentage rate of decomposition. What may explain the low productivity and the accelerated process of degradation of straw as a cover crop is that in the present treatment chisel plowing management system was adopted. As a result, crop residue is in direct contact with the soil due to low protection and to the fact that the soil had already decomposed the organic matter contained in it. Hence, the material in it is more susceptible to microbial attack even more exposed to decomposition agents.

Lowest decomposition rates were observed in treatments NTSG, QNTS-1 and TNTS, respectively. Besides management practice adopted, the succession of crops may possibly have contributed in different ways to the local soil ecosystem, reducing or increasing the decomposition rate of the succeeding crops. For treatment NTSG, mass loss was approximately of 21.57 kg ha^{-1} day^{-1}, which represents a decomposition rate close to 0.63% dia^{-1}. After 120 days, treatment NTSG reduced its initial mass of cover straw in approximately 75%. For treatments QNTS-1 and TNTS, with common oat and fallow, mass loss was of 17.97 and 24.19 kg ha^{-1} day^{-1}, respectively. Those were the lowest losses observed during the period studied. Decomposition rate for treatments QNTS-1 and TNTS were of 0.65% day^{-1}, decomposing by the end of the process 78% of the initial volume produced (Table 2).

The results from the present research support those of Mielniczuk and Martin-Neto (2000), who observed in their study the influence of management practices on organic matter decomposition rate. They noticed that decomposition rate on soils not revolved mechanically was lower (0.029 ano^{-1}). The usage of single crops (*Pisum sativum* subesp. arvense) show faster decomposition (0.0752 dia^{-1}) due to the chemical composition of the residues and of the relation C/N (Doneda et al., 2012). In addition, the organic matter decomposition reaction is modified according to the barriers and protection of the SOM (Marín et al., 2011). They contribute to exemplify the high rates of decomposition due to higher reactive oxidation by macro and micro biota of the soil for treatment CPTS in opposition to treatment QNTS-6, for example. It is worth pointing that for the period of study there were atypical climatological events. With the high amount of rainfall, the material was left at constant humidity possibly favoring the high rates of decomposition. The results also show that different management practices, specially the use of chisel plowing, have a direct impact on the duration of soil protection.

Half-life of crambe crop residue

Table 3 shows the coefficient of equation proposed by Wieder and Lang (1982), adjusted by Thomas and Asakawa (1339), as well as the coefficient of determination of exponential regression and the half-life of the crop residue. The kinetics of crop residue decomposition showed initially a decaying behavior followed by a more constant phase and a slight decay at the end (T120). Half-life of the material (T (½)) started reducing again by the end of November and beginning of December due to high precipitation. The high humidity content on the soil promoted decomposition and consequent reduction of T (½). Differences for T (½) were highly observed on treatments CPTS and QNTS-5. CPTS, with soil revolving, resulted in reduction of approximately 20 days in T (½). As has been noted, soils that undergo management practices that include revolving tend to decompose faster crop residue (Bayer et al.,

Table 3. Coefficient of regression of crop residue decomposition $X = X_0 \exp^{(-kt)}$ (Wieder e Lang, 1982), coefficient of determination (R^2) and half-life of the material T (½) = 0,693/k of crambe crop residue.

Treatment		QNTS-1	QNTS-2	QNTS-3	QNTS-4	QNTS-5	QNTS-6	TNTS	CPTS	NTSG
X_0		2.190.40	2.920.10	2.954.10	2.752.50	2.920.80	3.128.70	3.275.10	2.309.40	3.026.70
R^2		0.93	0.94	0.98	0.94	0.97	0.97	0.98	0.96	0.97
T7	*k*	0.042^{a}	0.039^{abc}	0.035^{abc}	0.042^{a}	0.030^{c}	0.039^{abc}	0.030^{c}	0.042^{ab}	0.032^{bc}
	T(½)	16	18	20	17	23	18	23	17	22
T15	*k*	0.035^{a}	0.032^{abc}	0.031^{abc}	0.034^{ab}	0.026^{c}	0.034^{ab}	0.028^{abc}	0.030^{abc}	0.027^{bc}
	T(½)	20	21	23	20	27	21	25	23	25
T30	*k*	0.021^{ab}	0.020^{ab}	0.020^{b}	0.022^{ab}	0.017^{b}	0.022^{ab}	0.018^{b}	0.028^{a}	0.018^{b}
	T(½)	33	34	34	31	41	32	38	25	40
T60	*k*	0.017^{ab}	0.018^{a}	0.016^{ab}	0.017^{a}	0.012^{c}	0.018^{a}	0.014^{bc}	0.018^{a}	0.014^{bc}
	T(½)	42	38	43	40	58	38	51	38	51
T90	*k*	0.012^{cde}	0.013^{bcde}	0.014^{abc}	0.013^{bcd}	0.011^{e}	0.014^{ab}	0.013^{bcde}	0.015^{a}	0.011^{de}
	T(½)	59	55	50	53	66	49	54	45	62
T120	*k*	0.013^{cde}	0.013^{cd}	0.014^{bc}	0.014^{bc}	0.011^{e}	0.015^{ab}	0.013^{cde}	0.016^{a}	0.012^{de}
	T(½)	55	52	49	50	62	46	55	43	60

Lowercase letters in the lines do not show significant difference by Turkey test at 5% probability. T7 – 7 days after the beginning of the experiment; T15 – 15 days after; T30 – 30 days after; T60 – 60 days after; T90 – 90 days after; T120 – 120 days after; *k* – coefficient of decomposition (g $g^{-1}day^{-1}$); T(½) – half-life period (day); X_0 – initial decomposable mass (kg ha^{-1}).

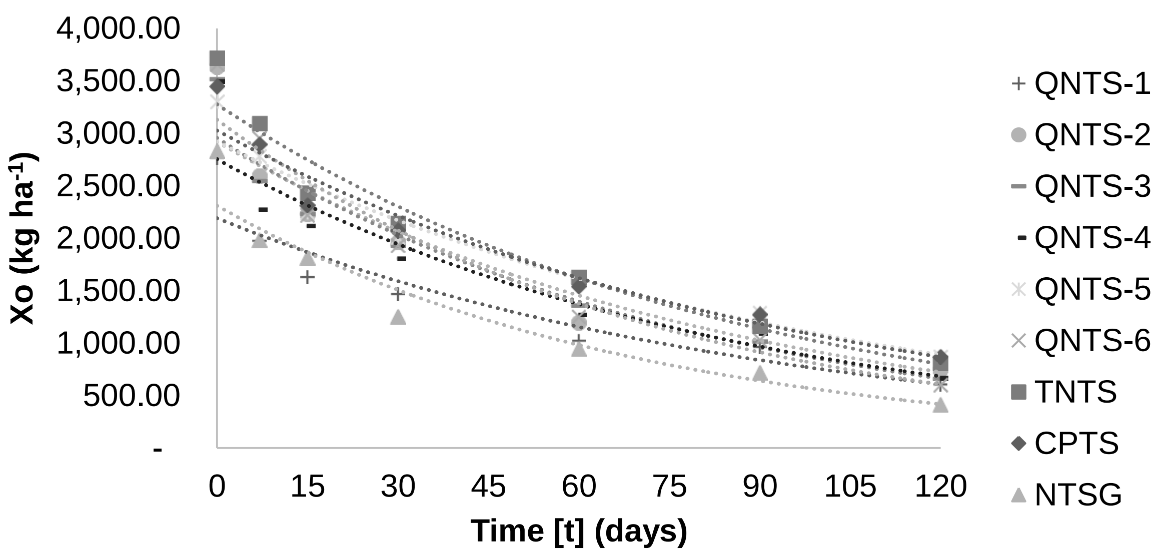

Figure 2. Exponential tendencies of crambe crop residue decomposition after 120 days of experiment.

2000). When management system is more intense with mechanical revolving, the soil foster higher rates of oxidation, and that is one negative result for it which reduces the amount of organic matter in the soil (Barros et al., 2015).

After 60 days of experiment, the values of decomposition reached approximately 51 to 67%. The highest rates of decomposition were seen on the first 15 days, when about 37% of the residue had already been decomposed. The low amount of cover straw disposed on the field little protected the soil. Thus, the exposure of the residue to the decomposition agent was higher, what consequently favored the rapid decomposition of crambe crop residue. In essence, soil microbiologic activity, and consequently, decomposition, suffers great influence from the type of crop or management practice applied to the soil (Meena et al., 2014). Figure 2 shows tendency lines for each treatment from the 120th day after implementing the experiment. The residue tends to decompose faster soon after crop residue management.

Data show that mass loss tends to balance after 45 to 60 days after the implementation of decomposition tests. Such an occurrence can be explained by the strong influence of carbon and nitrogen ratio (C/N) of the species. At the start of the decomposition nutrients potassium, phosphorus, nitrogen, calcium and magnesium are released rapidly, leaving a higher concentration of carbon, which causes the material to become recalcitrant and therefore pass to resist longer decomposing the remaining waste. According to the researchers Rheinheimer et al. (1998), the C / N ratio, the chemical composition of plant residues also changes the decomposition process. Santos et al. (2009) also affirm in their studies that the higher the C/N ratio, cellulose content, hemicellulose, lignin and polyphenol is a slower decomposition of biomass.

Conclusion

Different cover crop species contribute with different decomposition rates according to management practice adopted for the soil, especially soil revolving practice, which leads to accelerated decomposition. The dynamics of crambe crop decomposition presented different results according to treatment management. Decomposition rates of crop residue remained in the range of 0.63% day^{-1} to 0.71% day^{-1} of decomposable mass, and T(½) suffered a reduction of about 20 days with CPTS. Decomposition rate was also affected by the amount of residue generated by the crop. The highest the amount, the highest the decomposition rate of the residue.

Conflict of Interests

The authors have not declared any conflict of interests.

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