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Physico-chemical attributes of no-till *Brassica* crops cultivated after various cover crops

José LR Torres; Elaine D Ciabotti; Fernando RC Gomes; André LB Leal Junior; Dinamar MS Vieira; Luciene L Costa

Instituto Federal do Triângulo Mineiro (IFTM), Uberaba-MG, Brasil; jlrtorres@iftm.edu.br; elaine@iftm.edu.br; fernandorodriguesdacunha@hotmail.com; andrebenaventana@gmail.com; marcinha_0202@hotmail.com; luciene@iftm.edu.br

ABSTRACT

Cauliflower and cabbage require high amounts of nutrients in short periods of time; however, the intensive use of inorganic fertilizers can cause nutritional imbalances in these crops and reduce the quality of the final product. This study evaluated the chemical composition and yield of no-till cauliflower and cabbage grown on residues of various cover crops in Uberaba, Minas Gerais State, Brazil. The experimental design was randomized blocks with four cover crops (sunn hemp, brachiaria, pearl millet and fallow) and two main crops (cauliflower and cabbage). The treatments were evaluated on plots of 20 m² with four replications. The following traits were analyzed after harvest: moisture (MO), ash (ASH), lipid (LIP), crude fiber (CF), protein (PTN), carbohydrates (CARB), total soluble solids (TSS), total titratable acidity (TTA), pH, ascorbic acid (AA), head fresh weight (HFW), head dry weight (HDW) and yield. Cauliflower cultivated on sunn hemp residues produced high levels of LIP, PTN, CARB, TSS and TTA, whereas cauliflower cultivated on brachiaria and millet residues demonstrated high AA levels when compared to the treatment with sunn hemp residues. In the aerial part, cabbage presented significantly higher levels of CARB, TTA and AA when cultivated on brachiaria residues, whereas PTN levels were higher on sunn hemp residues. The cultivation of cauliflower and cabbage on cover crop residues affected positively most of the chemical attributes of the evaluated crops when compared to the fallow treatment, although the highest yield and AA levels were observed when the crops were cultivated on brachiaria residues.

Keywords: *Brassica oleracea* var. *botrytis*, *Brassica oleracea* var. *capitata*, crop residues, nutrient cycling, plant quality.

RESUMO

Atributos físico-químicos de Brassicas cultivadas sobre diferentes coberturas em plantio direto

A couve-flor e o repolho são plantas que necessitam de elevados aportes de nutrientes em curtos períodos de tempo; contudo, o uso intensivo de fertilizantes inorgânicos pode causar o desequilíbrio nutricional destas plantas e influenciar a qualidade do produto final. Neste estudo avaliou-se a composição química e a produtividade da couve-flor e do repolho cultivados sobre os resíduos de diferentes plantas de coberturas do solo em sistema plantio direto, no município de Uberaba-MG. Com delineamento de blocos ao acaso em esquema fatorial, utilizaram-se quatro plantas de coberturas (crotalária juncea, braquiária, milho e pousio) e duas culturas (couve-flor e repolho), com quatro repetições, em parcelas de 20 m². Após a colheita, as plantas foram levadas ao laboratório para avaliações da umidade, cinzas, lipídeos (LIP), fibra bruta (FB), proteínas (PTN), carboidratos (CHO), sólidos solúveis totais (SST), acidez total titulável (ATT), pH e ácido ascórbico (AA), massa fresca da cabeça (MFC), massa seca da cabeça (MSC) e produtividade (Prod). As plantas de couve-flor cultivada sobre os resíduos de crotalária juncea apresentaram maiores teores de LIP, PTN, CHO, SST e ATT, enquanto que nos resíduos de braquiária e milho, os teores de AA foram maiores quando comparados a crotalária. As plantas de repolho apresentaram valores significativamente maiores na sua parte aérea de CHO, ATT e AA quando cultivadas sobre os resíduos de braquiária, enquanto que para a PTN se destacou com o plantio sobre os resíduos da crotalária juncea. O cultivo da couve-flor e repolho sobre os resíduos de plantas de cobertura alteraram positivamente a maioria dos atributos químicos das culturas, quando comparados à área deixada em pousio, sendo que os melhores resultados de produtividade e AA ocorreram quando as culturas foram cultivadas sobre resíduos de braquiária.

Palavras-chave: *Brassica oleracea* var. *botrytis*, *Brassica oleracea* var. *capitata*, resíduos culturais, ciclagem de nutrientes, qualidade da planta.

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The nutritional quality of cauliflower and cabbage depends on various physical, chemical and sensory attributes. These plants present a high nutritional and commercial value, and

together with potatoes, tomatoes and lettuce are among the most consumed vegetables in Brazil (Carvalho *et al.*, 2013). They are typically cultivated in regions with cold or mild climate,

but there are cultivars appropriate for warmer regions.

Cauliflower, broccoli and cabbage are the most important *Brassica* crops cultivated in Brazil. They are excellent

sources of vitamin A, potassium, iron, calcium, fiber and phytochemicals rich in citric acid, ascorbic acid, and calcium salts (Manolopoulou & Varzakas, 2011). P-coumaric acid and rutin present in these plants strengthen the immune system, reduce the risk of heart attack and prevent various types of cancer (Oms-Oliu *et al.*, 2010).

Analyzing physico-chemical composition of noble parts of several crops, Storck *et al.* (2013) report the following levels of carbohydrates (CARB), crude fiber (CF), proteins (PTN), lipids (LIP), ash (ASH), and moisture (MO): 4.5, 2.4, 1.9, 0.2, 0.6, 92.8% in cauliflower, and 4.0, 2.9, 3.6, 0.3, 91.2% in broccoli, respectively. The same authors further emphasize that CARB content reflects the amount of calories, and thus low CARB levels in food are an advantage for weight reduction diets. Fibers help control the intestine, whereas PTN are crucial for the growth and development of the human body. Ash levels reflect the amount of minerals present in the food, which is usually around 1%. Moisture content depends on the degree of plant maturity and it is usually higher than 80%. On the other hand, LIP levels are minimal in these crops.

In cabbage, Ferreira *et al.* (2014) observed the following traits: total titratable acidity = 1.03%, carbohydrates = 2.77%, and total soluble solids = 5.56°Brix. The same authors state that the identification of plant nutritional composition can help create preparation techniques of several recipes. However, the maintenance of nutritional quality depends on the adoption of measures that control the production of the raw material (Chitarra & Chitarra, 2005).

The conventional production system of these vegetables is based on intensive soil preparation, highly soluble mineral fertilizers, and intensive use of agrochemicals (Silva *et al.*, 2012). Also, high genetic potential of modern cultivars make them highly dependent on such industrialized inputs.

These crops demand high amounts of nutrients (Oliveira *et al.*, 2005). However, Altieri & Nicholls (2003) point out that cultivation practices that involve

high amounts of inorganic fertilizers can cause nutritional imbalances in plants and reduce the quality of the final product.

A way to reduce the amounts of fertilizers and agrochemicals in the production of vegetables is the cultivation of cover crops. The residues of such crops release nutrients during the process of decomposition, which then become available for subsequent crops, and which also help suppress the germination of voluntary plants (Carvalho *et al.*, 2011).

Studying no-till broccoli (Neves *et al.*, 2014), cabbage (Perin *et al.*, 2015; Torres *et al.*, 2015), and cauliflower (Torres *et al.*, 2015) on residues of brachiaria and millet, the researchers observed an increase in head diameter and crop yield when compared to the conventional system.

Studies have also shown that brachiaria, sunn hemp, millet and fallow (spontaneous vegetation) are well adapted to the soil and climate conditions in the Cerrado, and that they produce high volume of green and dry cover, thus contributing considerable amounts of nutrients to the soil (Torres & Pereira, 2014).

Another way to add nutrients to the soil is the use of organic fertilization via animal manure or vermicompost. *Brassicas* respond well to organic fertilization when used as a substitute for mineral fertilizers, which can contribute to the sustainability of the production of vegetables in the Cerrado (Silva *et al.*, 2012).

Some studies have evaluated agronomic performance of *Brassica* crops cultivated under no-till system, but there are only few evaluations of physico-chemical changes in these crops when grown on cover crop residues. These parameters are important from the nutritional point of view, as well as for processing, storage and transport. In this context, this study evaluated the chemical composition and yield of no-till cabbage and cauliflower cultivated on the residues of various cover crops, in the municipality of Uberaba, Minas Gerais State, Brazil.

MATERIAL AND METHODS

This study was conducted from December 2012 to September 2013 in the experimental area of the Federal Institute of Triângulo Mineiro (19°39'19"S, 47°57'27"W, altitude 795 m), located in the municipality of Uberaba.

The soil of the experimental area was characterized as Dystrophic Red Latosol (Embrapa, 2006) of medium texture, and smooth & undulating relief. The 0.00-0.20 m soil layer contained: 210 g clay/kg, 710 g sand/kg, 80 g silt/kg, pH CaCl₂ 5.5; 76 mg/dm³ of P(resin); 2 mmol_c/dm³ of K⁺; 22 mmol_c/dm³ of Ca²⁺; 10 mmol_c/dm³ of Mg²⁺; 17 mmol_c/dm³ of H⁺Al, and 19 g/dm³ of organic matter, V = 67%. According to the Köppen classification, the climate in the region is classified as Aw-tropical, with hot and rainy summer and cold and dry winter. The annual averages of rainfall, temperature and relative humidity in the region are: 1,600 mm, 22.6°C and 68%, respectively (Uberaba in data, 2009). During the study period, precipitation occurred in the months of April (167.7 mm), May (97.9 mm), June (37.1 mm), and July (14.8 mm). Precipitation in November (190.4 mm) and December (224.7 mm) was lower than usual, which is not common in the region.

The experimental design was randomized blocks with four cover crops: sunn hemp (*Crotalaria juncea*); brachiaria (*Urochloa brizantha* cv *marandu*), millet ADR 500 (*Pennisetum glaucum*), fallow (spontaneous vegetation with predominance of Poaceae); and two main crops: cauliflower cv Sharon and cabbage cv Astrus plus. The treatments were carried out on plots of 20 m² (4.0x5.0 m) with 4 replications.

Prior to the experiment, the area was plowed, harrowed and planted with soybeans. The crop was harvested at the end of March 2012. After soybeans harvest, the area was left fallow until the implementation of the experiment. In December 2012, cover plants (brachiaria, sunn hemp and millet) were sown with row spacing of 0.45 m and 50, 25, and 50 seeds per meter, respectively. In March 2013, when more than 50% of

the plants reached maximum flowering, the cover crops were desiccated with 1440 g/ha of glyphosate + 600 g/ha of paraquat.

To evaluate dry matter (DM), samples were collected from an area of 2 m² per plot, then dried at 65°C for 72 hours and weighed. Seven days after desiccation, the cover plants were cut with brush cutter close to the soil and left on soil surface.

Cauliflower cv Sharon and cabbage cv Astrus plus are the most popular cultivars among the producers in the region of Triângulo Mineiro, and therefore their seeds were acquired. Seedlings were produced in polystyrene trays of 128 cells containing the commercial substrate Plantmax®. At the beginning of April 2013, the seedlings (10-15 cm high) were transplanted to pits spaced 0.8x0.4 m apart. Three central rows were used for crop evaluation.

The plants were irrigated daily, keeping the soil moisture close to the field capacity. The irrigation system was based on fixed conventional spraying nozzles spaced 9 meters apart and flow of 560 L/h. Irrigation time was approximately 20 minutes. Weeds were removed manually.

Before transplanting of the seedlings, half of the recommended fertilizer dose (10 t/ha) with organic compound (composted cattle manure) was applied into the pits.

Mineral fertilizer dose for the crops was based on soil analysis and the recommendation of the Soil Fertility Commission of the State of Minas Gerais (1999). Half of the dose was applied and the other half was expected to come from decaying plant residues of the cover crops. Both cauliflower and cabbage were fertilized with the following doses: 100 kg/ha of P₂O₅, 100 kg/ha of K₂O, and 150 kg/ha of N, which were split into 3 applications: at planting, 30, and 45 days after planting. Also, 1 g of boric acid (17.5% B) per pit was applied.

Cauliflower was harvested when the inflorescences were completely developed, the flower buds were still united and compact, and the heads were firm. Initiated 90 days after sowing, the harvest lasted 30 days with evaluations carried out every three days. Cabbage

was harvested when the firmness of the heads reached commercial acceptance, which began 100 days after sowing and lasted 20 days.

After harvest, all plants were taken to the laboratory of food analysis at the IFTM, Campus Uberaba, for evaluations of moisture (MO), lipids (LIP), crude fiber (CF), proteins (PTN), carbohydrates (CARB), total soluble solids (TSS), total titratable acidity (TTA), pH, ascorbic acid (AA), head fresh weight (HFW), head dry weight (HDW), and yield. Evaluations of the traits were carried out using the following methods: MO= gravimetric method; PTN= Kjeldahl method for nitrogen determination in food following the methodology described by AOAC (2005); CF= gravimetric method after digestion in acid medium using the methodology of the Adolfo Lutz Institute (2008); LIP= the Soxhlet method (gravimetric) based on the amount of the material solubilized by the solvent; AA= the Tillmans method (AOAC, 2005). The fixed mineral residue was determined by calcination of the sample in muffle at 550°C, until obtaining clear ash.

Total titratable acidity and acidity in predominant acid were determined using the methodology of Instituto Adolfo Lutz (2008), pH using pH meter with sample at 25°C; TSS by electronic refractometry, CARB by calculation of difference, and total caloric value by calculating the caloric value of each constituent of the food. The analyzes of PTN, CF and LIP were done on dry samples; later indices were calculated for fresh matter. The remaining analyzes were carried out on fresh samples 24 hours after harvest, keeping them refrigerated and packed in five layers of nylon bags during this period, following the methodology described by AOAC (2005).

The data were submitted to analysis of variance, using the statistical program SISVAR. The F test was applied for significance and the means were compared by the Tukey test at 5% probability.

RESULTS AND DISCUSSION

Dry matter production in the

treatment with millet (8.6 t/ha) and fallow (8.6 t/ha) were equal, but higher ($p<0.05$) than in the treatment with brachiaria (6.5 t/ha) and sunn hemp (4.6 t/ha), respectively.

These crops are commonly used for the production of DM in the Cerrado. In the summer, brachiaria, millet, and sunn hemp produce 6.0-13.0 t/ha, 7.0-12.0 t/ha, and 4.0-9.0 t/ha of DM, respectively, while in the winter their yields decrease to 2.0-3.0 t/ha, 2.0-4.0 t/ha, and 3.5-5.3 t/ha, respectively (Torres *et al.*, 2008), and 2.1-5.5 t/ha for fallow at any time of the year (Carvalho *et al.*, 2011; Torres & Pereira, 2014).

High content of DM in cover crops provides excellent soil cover, which can alter soil moisture and temperature, maintain or increase organic matter content, and consequently influence nutrient cycling because of residue decomposition, mainly N and K due to their high mobility in soil and plants (Torres *et al.*, 2008; Crusciol & Soratto, 2009; Vargas *et al.*, 2011).

Head fresh weight (1.0 and 1.2 kg), head dry weight (73.4 and 74.1 g) and yield (7.3 and 8.2 t/ha) of cauliflower were higher ($p<0.05$) than on the fallow treatment when cultivated on brachiaria and sunn hemp residues (Table 1). For cabbage, HFW (2.8 kg), HDW (0.65 g) and yield (19.2 t/ha) were higher ($p<0.05$) when grown on brachiaria residues. This is probably due to rapid decomposition and cycling of nutrients left by brachiaria and sunn hemp, as verified in studies carried out on the same site (Torres *et al.*, 2008; Torres & Pereira, 2008, 2014).

In studies conducted under similar climate and soil conditions, Morais Junior *et al.* (2012) observed that cauliflower cv. Sharon reached HFW of 1.5 kg and yield of 30.7 t/ha, which is higher than in our study. For cabbage, the values ranged from 2.1 to 2.8 kg, which is higher than 1.3 kg reported by Oliveira *et al.* (2005) and similar to 2.3 kg reported by Vargas *et al.* (2011), all grown on sunn hemp residues.

Cauliflower cultivars with larger and heavier heads are more valued on the market, as they fall into the upper classes of the classification standards for commercialization. Various weights

Table 1. Agronomic characteristics: HFW= head fresh weight; HDW= head dry weight; and head yield of cauliflower and cabbage on different cover crop residues. Uberaba, IFTM, 2013.

Cover crops	Cauliflower			Cabbage		
	HFW (kg)	HDW (g)	Yield (t/ha)	HFW (kg)	HDW (g)	Yield (t/ha)
Brachiaria	1.0 a	73.4 a	7.3 a	2.8 a	0.65 a	19.2 a
Sunn hemp	1.2 a	74.1 a	8.2 a	2.1 b	0.66 a	14.7 b
Millet	0.9 b	60.4 b	5.9 b	2.4 b	0.53 b	16.8 b
Fallow	0.8 b	54.6 b	5.3 b	2.1 b	0.46 b	14.8 b
F	2.395*	1.741*	2.392*	2.265*	2.203*	2.263*
CV (%)	22.00	19.40	22.01	14.91	19.78	14.92
DMS	0.05	12.97	1.76	0.16	0.11	2.20

*Significant, 5% (significativo, 5%); means followed by same letters in the column do not differ ($p < 0.05$).

have been reported for this trait, however the ideal HFW is considered to be 1.0-2.0 kg for this cultivar. According to Monteiro *et al.* (2010), the same does not occur for cabbage, since the standards demanded by the Brazilian consumer market are between 1.0 and 1.5 kg of HFW.

Physico-chemical analysis of cauliflower revealed significant differences ($p < 0.05$) among cover crops. The levels of LIP (0.16%), PTN (1.36%), CARB (5.66%), TSS (4.99°Brix) and TTA (2.98%) were significantly different ($p < 0.05$) when the crop was grown on sunn hemp residues (Table 2). This was probably due to high levels of available N in the soil, which had previously been fixed by this crop, as verified in other studies (Torres *et al.*, 2008; Carvalho *et al.* 2011; Perin *et al.*, 2015). However, pH (5.76), AA (2.62 mg/100 g) and CF (1.28%) were not

affected by cover crops. Also, ash levels did not differ among the cover crops.

Crude fiber content in cauliflower ranged from 1.28 to 1.95%, and the highest level was recorded for plants cultivated on brachiaria residues (1.95%). This is still lower when compared to 2.4% reported by Storck *et al.* (2013), who analyzed fiber content in several foods and observed levels ranging from 0.72 to 16.02%. These authors state that such variations occur due to high variability of CF content in foods.

Lipid content in cauliflower ranged from 0.12 to 0.16%, and the highest content was found in plants cultivated on sunn hemp residues. However, they were still below the 1.0% registered by Gondim *et al.* (2005). This is probably due to the fact that fruits and vegetables are not natural sources of LIP, which are highly energetic molecules found

in plant and animal tissues. Lipids carry electrons, transport substances involved in enzymatic reactions, make up the biological membranes, and store energy (Somerville *et al.*, 2000).

Analyzing chemical composition of cauliflower inflorescence, Storck *et al.* (2013) found 1.9% of PTN and 4.5% of CARB, which is higher than recorded in our study (1.36 and 5.66%, respectively). The same authors emphasize the importance of PTN contents in food, since it is a fundamental nutrient for the growth and development of the human body. CARB levels show low calorie content in the plant, which can be an advantage in alimentation since these plants can be used in any type of diet.

In a study carried out by Ornellas (2007), the author points out that broccoli and cauliflower are morphologically similar, whose nutritional value varies according to the part of the plant, and which contains on average 1-3% of PTN and 4-24% of CARB.

Regarding TSS content (expressed in °Brix), the value of 4.99 observed for cauliflower on sunn hemp residues is probably related to high levels of available N and K provided through biological fixation and later through decomposition process and nutrient cycling, as proven by Torres *et al.* (2008) and Torres & Pereira (2008).

Soluble sugars present in fruits and vegetables in combined forms are responsible for sweetness, flavor and color, which may vary due to climatic factors, variety, soil and water addition during processing (Santos *et al.*, 2004).

Table 2. Physico-chemical characteristics: MO= moisture, ASH= ash, CF= crude fiber, LIP= lipids, PTN= proteins, CARB= carbohydrates, TTA= titratable acidity, TSS= total soluble solids, pH and AA= ascorbic acid of cauliflower grown after different cover crops. Uberaba, IFTM, 2013.

Cover crops	MO (%)	ASH (g)	CF (g)	LIP (%)	PTN (%)	CARB (%)	TTA (%)	TSS (°Brix)	pH	AA (mg/100g)
Brachiaria	92.3a	0.92a	1.95a	0.12b	1.30a	3.45c	2.43b	3.66b	5.81b	5.26a
Sunn hemp	90.2a	1.31a	1.28b	0.16a	1.36a	5.66a	2.98a	4.99a	5.76b	2.62c
Millet	92.3a	0.85a	1.49ab	0.15a	1.13c	4.11b	1.84c	3.83b	5.86b	5.26a
Fallow	91.7a	1.09a	1.80ab	0.12b	1.25b	4.05b	1.88c	3.25b	6.00a	3.95b
DMS	1.82	0.48	0.61	0.05	0.11	1.87	1.12	0.68	0.23	2.42
CV (%)	0.83	25.6	20.7	19.9	3.6	17.2	13.2	6.16	1.61	13.5

Means followed by same letters in the column do not differ ($p < 0.05$).

Table 3. Physico-chemical characteristics: MO= moisture, ASH= ash, CF= crude fiber, LIP= lipids, PTN= proteins, CARB= carbohydrates, TTA= titratable acidity, TSS= total soluble solids, and AA= ascorbic acid of cabbage grown after different cover crops. Uberaba, IFTM, 2013.

Cover crops	MO (%)	ASH (g)	CF (g)	LIP (%)	PTN (%)	CARB (%)	TTA (%)	TSS (°Brix)	pH	AA (mg/100g)
Brachiaria	92.6a	0.06a	0.92a	0.04a	1.15b	5.21a	5.59a	5.65a	6.37a	21.0a
Sunn hemp	92.8a	0.06a	0.84a	0.05a	1.33a	4.86a	4.76b	5.62a	6.34a	8.93b
Millet	93.4a	0.05a	0.82a	0.05a	1.15b	4.48a	4.93b	5.41a	6.38a	8.87b
Fallow	93.1a	0.06a	0.80a	0.06a	1.16b	4.48a	4.19c	5.31a	6.43a	4.48c
DMS	1.34	0.34	0.45	0.03	0.08	1.38	0.82	0.51	0.17	1.78
CV (%)	0.91	10.90	5.45	11.50	1.25	5.40	3.75	4.69	6.02	12.50

Means followed by same letters in the column do not differ ($p < 0.05$) (letras iguais na coluna não diferem, 5%).

Sunn hemp residues decreased pH and increased TTA for cauliflower relative to the control treatment, which according to Fernandes *et al.* (2008) can be considered normal for this crop. These authors point out that as the harvest period approaches, citric acid and acidity levels decrease. They also emphasize that pH tends to increase with the decrease of the acidity in some crops.

Ascorbic acid content in cauliflower cultivated on brachiaria (5.26 mg/100 g) and millet (5.26 mg/100 g) residues was significantly higher when compared to sunn hemp (2.62 mg/100 g) residues and fallow (3.95 mg/100 g), which could have increased protection against oxidation in this crop, as also observed by Coultate (2004).

Analysis of cabbage leaves demonstrated significant differences ($p < 0.05$) among evaluated cover crops. Protein level (1.33%) was low ($p < 0.05$) when the crop was grown on sunn hemp residues, whereas TTA (5.79%) and AA (21.0 mg/100 g) levels were high ($p < 0.05$) on brachiaria residues relative to other cover crops (Table 3).

Regarding PTN, its level was significantly high ($p < 0.05$) when the crop was cultivated on sunn hemp residues (1.33%). For the other cover crops, its levels ranged between 1.15 and 1.16%, but still between 1 and 3%, as highlighted by Ornellas (2007). High availability of N in the soil provided by sunn hemp probably increased protein concentration in cabbage, since N favors photosynthesis and stimulates cell division, thus increasing total protein content in the plant (Marschner, 1995).

Levels of TTA (5.59%) and AA (20.96 mg/100 g) were high ($p < 0.05$)

when the crop was cultivated on brachiaria residues relative to other cover crops, which were 4.19-4.93% for TTA and 4.48-8.93 mg/100 g for AA.

These TTA levels express total hydrogen content, while pH reflects the concentration of ionized hydrogen in the fruit or vegetable pulp, which can lead to large variations in TTA without appreciable variations in pH (Chitarra & Chitarra, 2005). During storage periods, when TTA and pH are high, there is probably a higher concentration of citric acid and AA in undissociated form.

The highest levels of PTN (1.33%) in cabbage also occurred in treatment on sunn hemp residues, probably due to high availability of N (Torres *et al.*, 2008) and K (Torres & Pereira, 2008). According to Vallverdú-Queralt *et al.* (2012), cabbage naturally presents high nutritive value and high concentrations of calcium, PTN and AA, especially when higher concentrations of N are available in the soil.

Regarding TSS content expressed in °Brix, no significant difference was observed. However, the levels found in our study were higher than those reported by Rinaldi *et al.* (2009), who found soluble solids content ranging from 2 to 5°Brix in minimally processed cabbage. Also, analyzing the composition in minimally processed white cabbage (*Brassica oleracea*), Ferreira *et al.* (2014) observed TTA of 1.03%, CARB of 2.77% and TSS of 5.56°Brix.

Cabbage produced high level of AA (21.0 mg/100 g) when grown on brachiaria residues. This characteristic favors the maintenance of identity and quality standards (IQS) of a product

to be consumed for a longer period. Manolopoulou & Varzakas (2011) also found that IQS of cabbage was maintained for 14 days when stored at 0°C, and for 7 days when stored at 5°C. According to Oms-Oliu *et al.* (2010), some substances, among them AA, are antioxidants, which prevent enzymatic browning, loss of taste and aroma, maturation of tissues and loss of nutritional quality.

Cultivation of cauliflower and cabbage on residues of cover crops positively altered most of the chemical attributes of the crops when compared to the fallow treatment, with the best yield and AA levels observed when the crops were cultivated on brachiaria residues.

The cultivation of cauliflower and cabbage on brachiaria, millet and sunn hemp residues showed promising results, since they positively altered most of the chemical attributes of evaluated crops. The best productivity and chemical attributes occurred when the crops were cultivated on brachiaria residues.

When cultivated on sunn hemp residues, cauliflower produced significantly higher levels of LIP, PTN, CARB, TSS and acidity, while on brachiaria and millet residues AA levels were higher than in other treatments.

Regarding cabbage, its cultivation on brachiaria residues significantly increased acidity and AA, whereas for PTN the best cover crop was sunn hemp.

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