Botanic characterization of soybean for whole plant silage

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Introduction Although the main type forage for silage production is corn, the leguminous has been used to increase quality of diet based on grass silage. Among several leguminous cultivated in Brazil with potential to use as silage, soybean (*Glycine max* L Merrill) is highlighted for high crude protein and ether extract in the grain (Valadares et al., 2016), high digestibility of whole plant, consolidated cultivation worldwide (Gobetti et al., 2011), high grain yield and availability of cultivars adapted to all regions of the country (EMBRAPA, 2004). Studies focusing on viabilization of soybean silage for feeding ruminants have being done in several countries (Nayigihugu et al., 2002), Costa Rica (Tobiá et al., 2003), Canada (Vargas-Bello-Perez et al., 2008), China (Zhai et al., 2013), Japan (Touno et al., 2014), Italy (Spanghero et al., 2015), South Africa (Nkosi et al., 2016) and Brazil (Rigueira, 2015; Souza, 2008; Silva, 2010; Rosa, 2010; Souza, 2011). However neither of them focused on productive potential of the soybean plant to silage as well as on structural components of the plant whose dry matter content influence the silage quality (Mcdonald, 1991). The objective of this study was to characterize the botanical composition as well as to estimate the productive potential of soybean silage.

Materials and Methods The experimental design was completely randomized with 8 treatments (reproductive stages: RS1 to RS8) and 5 repetitions (composite sample of 10 plants from each 5 areas: 1 to 5). Were used the hybrid Agroeste® 3610 IPRO, with sowing density of 50 kg ha^{-1} (32 seeds per m^2) spacing of 0.45m between rows and 450 kg ha^{-1} of the formulation 2-20-10 (N-P_2O_5-K_2O) as base fertilization. The reproductive stages (RS) were characterized according to Fehr and Caviness (1977). In each RS it was sampled at 5 cm of height 10 soybean plants in five distinct experimental areas stablished. After the sampling, plants were botanically stratified and composite sample of leaf, stem, flower and pods from each area was obtained. Samples were dried at 60°C in a forced-air oven for 72 h, processed in wiley mill through a 2 mm sieve and analyzed for dry matter (DM, method 930.15; AOAC, 2000). The yield in kg of NM ha^{-1} was estimated based on weigh of the plant and calculated population density of 270.222 plants ha^{-1}. Data were analyzed using PROC MIXED of SAS (2010) using the statistical model: $Y_{ij} = \mu + T_i + e_{ij}$, wherein: $e_{ij} \approx N\ (0, \sigma_i^2)$); where, Y_{ij} is= the dependent variable; μ= is overall mean; e_i= is the fixed effect of RS (i= 1 to 8); e_{ij} is the= experimental error and σ_i^2= residual variance for each treatment. Differences amount RS were studied by LSD means test.

Results and Discussion There was reproductive stage effect of DM and NM mass production ($P < 0.001$). Highest DM mass yield was observed on RS 8, which was similar to stages 6 and 7. However, NM mass yield was similar amount RS, being lower only on RS 1 ($P < 0.05$). The yield behavior throughout the stages was influenced by botanical composition. Leaves, stem, and flower DM and NM proportion decreases ($P < 0.001$) and pod increases ($P < 0.001$) with RS increase. Bromatological profile of these components could also be determinant at the moment to set the harvest point of soybean for silage. According to Dias et al. (2010), soybean silage is

made in the RS5 and RS6 stages, as it is the moment there is higher DM accumulation. However, it is essential to observe the DM of whole plant to minimize losses of nutrients, undesirable fermentations and preserving original quality of the ensiled material (McDonald 1991).

Table 1 Yield and botanic characterization of whole soybean plant on different reproductive stages

Item	Reproductive Stages								*P-value*[1]
	RS1	RS2	RS3	RS4	RS5	RS6	RS7	RS8	
					Yield (T/ha)[4]				
DM[2]	4.16±0.36^{d}	6.06±0.09^{c}	7.89±0.56^{b}	8.13±0.48^{b}	8.86±0.77^{b}	12,4±1.09^{a}	12,3±0.83^{a}	18.0±2.63^{a}	<0.001
NM[3]	23.6±2.32^{b}	33.6±0.98^{a}	39.9±2.75^{a}	40.2±1.79^{a}	41.8±3.77^{a}	42.7±3.91^{a}	35.5±2.24^{a}	34,8±4.94^{a}	<0.001
					Dry Matter (g/kg)				
Leaf	231±7.51^{d}	234±6.35^{d}	246±4.22^{cd}	260±9.95^{bc}	276±7.61^{b}	350±6.81^{a}	419±30.7^{a}	-	<0.001
Stem	148±2.29^{g}	155±7.11^{g}	176±5.21^{f}	181±4.06^{e}	203±4.70^{d}	275±4.40^{c}	301±6.35^{b}	380±24.0^{a}	<0.001
Pod	-	-	223±5.12^{d}	173±8.26^{e}	129±7.19^{f}	296±3.39^{c}	379±7.04^{b}	612±8.50^{a}	<0.001
Flower	187±9.55	188±6.92	203±4.29	196±5.11	190±7.42	-	-	-	0.419
Whole Plant	177±3.17^{f}	181±5.73^{f}	198±3.43^{e}	202±3.48^{d}	212±5.34^{d}	291±3.33^{c}	346±4.05^{b}	519±16.5^{a}	<0.001
					Botanical Composition (g/kg NM of Plant)				
Leaf	346±8.54^{a}	326±5.65^{a}	304±7.73^{b}	267±5.00^{c}	237±7.81^{d}	82.4±8.01^{e}	18.6±6.71^{f}	-	<0.001
Stem	649±8.63^{b}	658±5.94^{b}	670±9.58^{ab}	694±8.11^{a}	656±12.8^{b}	464±20.5^{c}	430±27.7^{cd}	398±10.2^{d}	<0.001
Pod	-	-	4.24±0.92^{e}	25.9±3.89^{d}	103±8.85^{c}	454±16.3^{b}	551±27.2^{a}	602±10.2^{a}	<0.001
Flower	4.26±1.13^{c}	16.3±0.60^{ab}	20.8±2.18^{a}	12.8±1.64^{b}	4.09±1.28^{c}	-	-	-	<0.001
					Botanical Composition (g/kg DM of Plant)				
Leaf	452±5.41^{a}	421±11.0^{b}	379±12.7^{c}	344±6.57^{d}	308±10.9^{e}	99.0±8.88^{f}	22.1±7.25^{g}	-	<0.001
Stem	543±4.85^{b}	562±11.3^{b}	595±14.2^{ab}	622±8.06^{a}	626±11.4^{b}	439±20.9^{c}	375±25.7^{cd}	289±2.78^{d}	<0.001
Pod	-	-	4.69±0.90^{e}	21.7±2.59^{d}	61.7±4.33^{c}	462±16.7^{b}	603±27.5^{a}	711±2.78^{a}	<0.001
Flower	4.68±1.32^{c}	16.9±0.85^{ab}	21.3±1.99^{a}	12.2±1.33^{b}	3.60±1.10^{c}	-	-	-	<0.001

[1]Averages followed by different letters in the line differ ($P \leq 0.05$) from each other by the protected LSD test;
[2]DM = Dry matter; [3]NM = Natural matter; [4]Data obtained from weight populational density: 270.222 plant per hectare, T/ha= Tones per hectare.

Conclusion Reproductive stage RS6, showed high yield with minimum DM required for high quality of silage production, although studies involving profile fermentation of soybean silage and animal performance should be done to prove this assumption.