928

Nutritive Value, Fermentation Characteristics and Aerobic Stability Assessment of Soybean (*Glycine max* L.)-Sorghum (*Sorghum bicolor* L.) Mixture and Soybean Treated with Molasses.

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Abstract

Soybean (*Glycine max* (L.) Merrill) produced mainly for grain has potential for use as forage (either hay or silage). A forage soybean (PR 22-3) produced high quality hay when baled 84-d after planting (R6 full seed development). Its potential to supplement protein in diets of ruminants as silage has not been evaluated. The objectives of this study was to assess crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF) concentrations, fermentation characteristics (pH, % lactic, acetic and butyric acid) and aerobic stability of ensiled soybean-sorghum (*Sorghum bicolor* L; SS) mixture (50:50) , soybean treated with molasses (SM) and soybean alone (control). Replicated soybean (R6) and soybean-sorghum plots were harvested at 84-days after planting. The harvested above-ground plants were chopped at 2-cm length and ensiled in 15-L micro-silos. Molasses was applied at 6% concentration of fresh soybean plant weight. Past twenty one days, the micro-silos were opened and representative fresh samples taken, dried and ground for nutritive value. Frozen samples were sent to the lab for fermentation characteristics analysis. Highest dry matter yield resulted (P<0.05) in SS mixtures (4.0 Mg ha-1). Soybean-sorghum silage presented lowest dry matter (DM; 32%), CP (16%) and NEl (1.13 Mcal kg-1) and higher NDF (56%) than either SM or control. However, SS improved fermentation characteristics resulting in lower pH (4.1) and NH3 (8.2%), and higher lactic acid (7.8%) than the control . There were differences in aerobic stability between ensiled soybeans with pH values of 4, 4.4 and 4.8 for SS, SM and control, respectively. In conclusion, SS silage mixture had higher DM yield, better fermentation (lower pH) than either SM or control and would be a good option to produce high quality soybean silage in the tropics.

INTRODUCTION

- Forage soybean lines evaluated in Puerto Rico exhibit high yield potential (>5000 kg ha^{-1} dry matter) baled at R6 phenological stage.
- Soybean baled at R6 stage can be used strategically throughout the year to supply high quality forage (Gallardo 2015), but its use as silage in the tropics is limited.
- A major limitation for soybean silage, however, is its low carbohydrate content and high protein concentration (Romero 2004).
- A soluble carbohydrate source (e.g., ground corn or molasses) is needed to improve silage fermentation characteristics.
- Soybean treated with 8% molasses reported 27.5% DM, 19.7% CP, 36.1% NDF, 0.86% Ca, 0.20% P and 70% TDN in silage samples(Tobía et al., 2006; Blount et al., 2009).

OBJECTIVE

- Assess crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF) concentrations, fermentation characteristics (pH, % lactic, acetic and butyric acid) and aerobic stability of ensiled soybean-sorghum (*Sorghum bicolor* L; SS) mixture (50:50), soybean treated with molasses (SM) and soybean alone (control).

METHODS

Location and experimental design

- This study was conducted at the Agricultural Experiment Station, Isabela, Puerto Rico.
- Annual rainfall totals 1675 mm per annum, with a mean average temperature of 25° C.
- Treatments were: Soybean (S), soybean+6% molasses (SM) and soybeans + sorghum (SS).
- PR 22-3 was established in rows (0.6 m between rows and 8-cm between plants).
- Soybean was harvested at R6 growth stage; forage wilted, chopped to an average size of 2 cm long and ensiled in micro-silos of 15 L capacity, performing a manual compaction.
- DMY (Mg ha^{-1}) was determined in a 4.8 m^2 area, and subsamples 500 g taken and dried in a forced air oven at 65° C for 72 hours.
- For nutritional variables and fermentation products; samples (500 g) were sent to the Dairy One Forage Lab.
- Aerobic stability was evaluated using silage samples (1500 g) for 7 days.
- Statistical analysis included a t-test for two independent samples, a completely randomized design (CRD) with four replicates and repeated measures in time for DMY, nutritional and fermentation characteristics and aerobic stability, respectively, using SAS 9.1® (SAS 2009).

Figure 1. Development of research.

RESULTS

Table 1. Percentage dry matter and yield, and proportion of forage in soybean (PR 22-3) harvested in the R6 growth stage.

Variables	Soybean	Soybean-sorghum
DM[1] (%)	29.3[a]	30.6[a]
DMY[2] (Mg ha^{-1})	2.1[b]	4.0[a]
Soybean-sorghum in DM[1]	100	34:66

[1]Dry matter; [2]dry matter yield. In the same row means followed by different letters indicate significant differences (p <0.05).

Table 2. Silage nutritional characteristics of soybean (PR 22-3) in R6 growth stage.

	DM[1]	CP[2]	ADF[3]	NDF[4]	TDN[5]	ENl[6]	RFV[7]
Variables			%			Mcal/kg	
S[8]	35.13[b]	23.25[a]	35.45[a]	44.00[a]	58.25[a]	1.31[a]	130[a]
SM[9]	38.15[a]	22.15[a]	33.95[a]	40.53[a]	58.50[a]	1.35[a]	144[a]
SS[10]	31.75[c]	16.18[b]	35.38[a]	55.70[b]	54.00[b]	1.13[b]	103[b]

[1]Dry matter; [2]crude protein; [3]acid detergent fiber and [4]neutral; [5]total digestible nutrient; [6]net energy for lactation; [7]relative value of forage; [8]pure soybean; [9]soybean + 6% molasses and [10]soybeans + sorghum. In the same column means followed by different letters indicate significant differences (p <0.05).

Table 3. Silage fermentation characteristics of soybean (PR 22-3) R6 stage.

	pH	Lactic A.	Acetic A.	NH_3-N[1]
Variables		%		
S[2]	5.00[c]	5.77[b]	4.02[b]	11.25[c]
SM[3]	4.45[b]	6.31[b]	2.89[a]	6.75[a]
SS[4]	4.13[a]	7.82[a]	2.88[a]	8.25[b]

[1]Ammonia nitrogen as a percentage of total nitrogen; [2]pure soybean; [3]soybean + 6% molasses and [4]soybeans + sorghum. In the same column means followed by different letters indicate significant differences (p <0.05).

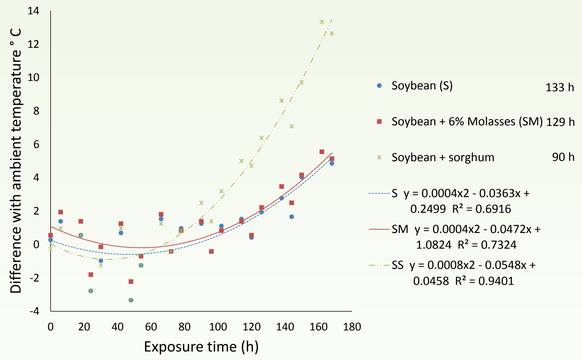

Figure 2. Aerobic stability, regression between aerobic exposure time and the difference between the observed temperature and environment in soybean silage R6 state.

CONCLUSIONS

- The addition of molasses appears to be the best option for soybean silage preparation, because it does not adversely affect CP, ADF, NDF nor energy level (TDN and NE).
- However, if maximum yield is desired the soybean-sorghum mixture is better option; SS silage had a higher protein concentration than that of traditional silages (maize and sorghum).
- The inclusion of molasses and sorghum in the forage mixture improved fermentation characteristics (adequate levels of pH, propionic acid, butyric acid and NH_3-N).
- Sorghum in the mixture, however, generated instability in the soybean silage causing further temperature increase and greater DM loss.

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