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Density and Losses in Pressed Bag Silos

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Abstract. *The objective of the study was to monitor the filling and emptying of bag silos at three research farms to determine the variation in density and losses in pressed bag silos. Twenty five bags were filled over the 2000 harvest season, and 15 of those bags have been completely emptied. Dry matter (DM) densities in alfalfa silages were approximately 200 kg/m^3 when the crop was at 40% DM, and densities declined approx. 3 kg/m^3-% DM in wetter crops. With one bagger, densities were 3 to 8% lower in corn silage whereas densities were 16 to 35% higher in another bagger. Densities declined 5 kg/m^3-% DM in wetter corn silages. Average DM losses were 8.4% gaseous/seepage loss and 5.8% spoilage loss for a total of 14.2% loss. The average spoilage and total losses were inflated by three bags with substantial spoilage (26 to 38% total loss). Removing those from the average reduced average total losses to 9.7%. Total losses increased with low feed out rates and with drier, more porous silages.*

Keywords. Silage, Silo, Silo Bag, Density, Dry Matter Loss, Forage

Introduction

The pressed bag silo is an increasingly popular method of making silage. It is relatively inexpensive. Storage size varies with the quantity of forage harvested. For farms that are expanding in herd size, silo capacity can be added with little capital cost. Small diameter bags allow small farms to consider making silage rather than hay. Finally, bag silos make it easy for farmers to inventory and manage silage, e.g., reserving high quality silage for the best animals.

While bag silos have been used for more than 20 years, relatively little research has been published on the performance of these silos. Losses are reputedly low with bag silos. Limited research results generally agree with that reputation. Rony et al. (1984) reported a 9.0% dry matter (DM) loss in a alfalfa:grass silage and 6.1% loss in corn silage. Storage time and feed out rate were not reported. Wallentine (1993) reported a 2.5% loss in corn silage also under unspecified conditions. In contrast, Kennedy (1987) found that losses in two bag silos were double those found in bunker silos.

Densities in bag silos are also difficult to obtain. Esau et al. (1990) indicated that wet densities were on the order of 700 kg/m^3. Assuming 35% DM, that would result in a dry matter density of 245 kg/m^3. Harrison et al. (1998) reported considerably lower DM densities for corn silage in 3 m diameter bags of only 43 to 51 kg/m^3. Holmes (1998) calculated DM densities based on filling weight records from several farms and reported a range of 146 to 251 kg/m^3. Most of the bags were either alfalfa or corn silage, and there were no obvious trends with crop or bag diameter.

Overall, there are limited data on losses from bag silos, and the densities reported are highly variable. This makes accurate economic assessment of bag silos relative to other types difficult. Information on densities and losses is also important to farmers with bag silos relative to feed inventory and management.

The objectives of this study were to monitor the filling and emptying of bag silos to measure densities and losses and to determine potential factors affecting both.

Materials and Methods

Three farms (Arlington, Prairie du Sac and West Madison) in the Madison area that are part of the University of Wisconsin Agricultural Research Stations have been making bag silage for several years, and all appear to be managing this type of silage well. At Arlington (Arl) and Prairie du Sac (PDS), bag silage is often made for research studies involving small numbers of cattle, and consequently feed out rates may be lower than recommended. At West Madison (WM), bag silage is made to be re-ensiled later in small tower silos on the Madison campus. These bag silos are emptied rapidly, typically one third of a bag in a day, and are resealed between emptying events.

The bagging machine used at Prairie du Sac was a 2.44 m (8 foot) Ag Bag model G6000. The West Madison and Arlington stations shared a 2.74 m (9 foot) Kelly Ryan model DLX. This provided us with the opportunity to compare densities from different operators using the same machine. Occasionally, the Arlington station rented a 2.74 m (9 foot) Ag Bag machine.

During the 2000 harvest season, all bag silos made at the three farms were monitored. This consisted largely of alfalfa and corn silages. All loads of forage entering the bags were weighed. While each load was emptied into a bag, a grab sample was taken consisting of a composite of several handfuls. After each load was pressed into the bag, the side of the bag was marked to indicate the distance filled by the load. The distances for each load were measured after the bag was completely filled.

The load samples were analyzed for moisture content by freeze drying. The remainders of samples were composited by field and date. These composite samples were analyzed for particle size distribution (ASAE Standards, 2000), crude protein (Leco FP-2000 analyzer), neutral detergent fiber (Goering and Van Soest, 1970), moisture and ash (500°C for 3 h).

At emptying, the weight of all silage removed from a bag was recorded. Any spoiled silage not fed was weighed and specifically identified as such on the emptying log. A grab sample from the face of each silo was taken periodically, one per filling load. Spoiled silage was sampled separately.

Samples from emptying were analyzed similarly to the load samples except for particle size distribution. In addition, the emptying samples were analyzed for pH and fermentation products (Muck and Dickerson, 1998).

Average densities for the bags were calculated based on weight ensiled, overall length and nominal diameter. Similarly, density variation by load along the bag length was based on individual load weights and bag length variation from load to load.

Core samples were taken at the face of several bags during emptying to measure density variation across the face. The coring equipment used is described in Muck and Holmes (2000). Up to seven cores were taken per bag, starting at the central vertical axis and sampling either to the right or left side of the axis.

Results and Discussion

Density

Over the course of the 2000 harvest season, a total of 25 bag silos were made at the three farms. A summary of the each bag is given in Table 1. All were filled rapidly with no longer than two days from the start of filling until sealing. The DM contents of the hay crop silages were generally drier than recommended (30 to 40% DM) whereas the corn silages were largely within that range. The bags used at the Arlington and West Madison stations were 60 m long and generally filled to capacity. Most of the bags at Prairie du Sac were 30 m long and often not completely utilized because the silage was being prepared for specific animal trials.

Average dry matter densities grouped by similar bagging conditions are shown in Table 2. Within hay crop silages, the highest densities were found with the Kelly-Ryan bagger when used at Arlington (233 kg/m^3) whereas the Kelly-Ryan at West Madison and the Ag Bag at Prairie du Sac averaged about 10% lower. In corn silage, the Kelly-Ryan averaged less than 200 kg/m^3, i.e., lower than that in hay crop silages. In contrast, the Ag Bag bagger at Prairie du Sac produced higher averages in corn than in hay crop. Also kernel processing at that farm reduced density.

One difficulty in comparing the averages in Table 2 is that DM content varied considerably among bags. A survey of bunker silo densities found that dry matter density increased with DM content (Muck and Holmes, 2000). If a similar trend occurred in bag silos, a comparison of averages may produce a false assessment of differences across crops, baggers, etc.

Average dry matter densities for individual bag silos in hay crop (alfalfa and red clover) silages and corn silages are shown in Figures 1 and 2, respectively. At all three farms and with both types of silage, dry matter density increased linearly with dry matter content. Linear regression of the data for individual farms resulted in slopes of 1.0 (PDS) to 5.0 (Arl) kg/m^3-% DM for hay crop silages with an average of 2.9 kg/m^3-% DM. The slopes were higher for corn silage, 4.2 (WM) to 6.2 (PDS-unprocessed) with an average of 5.3 kg/m^3-% DM. The slope for the Arlington corn results was calculated using all seven bags together because of the narrow range of DM contents within a specific bagger.

This increase in density with DM content was also observed within bags and was especially evident in hay crop silages where there were wider ranges of DM contents. Figure 3 is one example of variation in density by load within a bag from Arlington. The slope of the data in Figure 3 based on linear regression is 5.8 kg/m^3-% DM, a value similar to the slope found at Arlington across bags.

Overall, this effect of DM content on density is greater than that observed in bunker silos. Based on the results of Muck and Holmes (2000), the DM content effect on density in bunker silos increased with the square root of DM content and varied as a function of other factors. The maximum effect of DM content was approximately 3 kg/m^3-% DM assuming a filling rate of 25 t/h, continuous packing with a 20,000 kg tractor, and spreading the crop in 15 cm layers. Higher filling rates or layer thicknesses and/or small packing tractors reduce the effect of DM content on the resulting density.

Using the linear regressions, we calculated an estimated density for each condition in Table 2 at a constant crop DM content (40%), which was within or near the range of DM contents observed for both crops across the three farms. This allows a truer comparison, particularly across crops in this study. On this basis as seen in Table 2, the Kelly-Ryan at Arlington and the Ag Bag at Prairie du Sac produced similar DM densities in hay crop silages, just over 200 kg/m^3. When the Kelly-Ryan was used for hay crop silages at West Madison, densities were approximately 10% lower than those at Arlington were. Visually, the bags at West Madison looked somewhat smoother although Arlington's bags had few lumps and bulges. However, the operator at Arlington consistently achieved a higher density.

With the Kelly-Ryan, densities in corn silage were lower than those in alfalfa silage (3 to 8%). There was less difference between the two farms using the Kelly-Ryan (8%), but Arlington generally used kernel processing whereas West Madison did not. In contrast, the Ag Bag at Prairie du Sac produced considerably higher densities (16 to 35%) in corn silage than in hay crop silage. Unprocessed corn silage at PDS was consistently denser than processed (Fig. 2). Four of the five corn silage bags at PDS were produced for a trial comparing processed vs. unprocessed corn silage, one each at early and late maturity. The four bags were filled with corn from the same field, and the two bags of each maturity were filled within a day of each other. Consequently, the difference in density due to processing at PDS was not only consistent but also the result of a planned comparison.

One potential explanation for differences in density between hay crop and corn silages and between processed and unprocessed corn silages may be particle size. Based on bunker silo packing research (e.g., McGechan, 1990; Shinners et al., 1994), one might expect longer particle size to result in lower density. At PDS, the theoretical length-of-cut on the forage harvester for the processed silage was set at 25 mm *vs*. 19 mm for unprocessed. However, the unprocessed corn going into the bags had an average particle size in both cases that was 1.5 mm longer than the processed corn. Consequently, the higher densities in the unprocessed corn at PDS are contrary to expectations based on particle size.

However, comparisons of particle sizes and densities between corn and alfalfa using the same machine have followed expectations. At West Madison, the unprocessed corn silage was 1.9 mm longer than the alfalfa and slightly less dense. At Arlington, the processed corn silage going into the Kelly-Ryan was 2.2 mm longer and packed less densely than the alfalfa. Particle size analysis is not complete for the hay crop silages at Prairie du Sac. Thus to this point, particle size differences have been consistent with variation in density between crops.

The densities obtained in our study are similar to several in the literature. The estimation of 245 kg/m^3 from Esau et al. (1990) is higher than most in our study but in the range of our results. Our results are largely in the middle of the range (146 to 251 kg/m^3) reported by Holmes (1998). Only the results (43 to 51 kg/m^3) of Harrison et al. (1998) are substantially different from ours.

Harrison et al. (1998) compared processed and unprocessed corn silage using an Ag Bag bagger and found no difference in density with long chop length and a trend toward higher density in processed corn silage for medium chop length. These results are the opposite of those found with an Ag Bag bagger at Prairie du Sac.

The densities in our study are within the range found for bunker silos. Muck and Holmes (2000) surveyed 175 bunker silos. The range and average for hay crop silages were 106 to 434 kg DM/m^3 and 237 kg DM/m^3, respectively. The range was narrower but the average similar for corn silages (125 to 378; 232 kg DM/m^3). Thus, average densities in the bag silos in this study are 10 to 15% lower than the average densities in commercial bunker silos in this region.

Typical recommendations for feed out rates from bunker silos in the northern Midwest are 10 to 15 cm/d from the whole face. Based on average densities from our study, minimum feed out rates of 15 to 20 cm/d for bag silos might seem appropriate. However, average densities do not account for variability in density across the face of bag silos and the potential impact on feed out recommendations.

Seven core samples were taken to estimate within-bag density variation on five bags during emptying according to the pattern in Figure 4. Densities at the seven locations are listed in Table 3. Generally the highest densities were at locations B and C and the lowest densities at location A and F. On average A and F were approximately at 40% of the density at location C; however, this may be an underestimate of actual density at A and F because sampling with the 5-cm dia. corer was difficult in low density situations. Even so, the density of approximately the outer 30 cm is of substantially lower density than the center and lower portions of the face. Occasionally, such as at location D in the first silo from Prairie du Sac, areas that were expected to have a high density had low densities. Such random pockets of low density may explain pockets of mold in the middle of the face that our farm crews have seen in a few bags in the past. Overall, the low densities around the outer portion of the bag and the occasional low density pockets elsewhere suggest that higher feed out rates than indicated by average bag densities may be needed to minimize feed out losses. This will be explored further in the section on losses.

Finally in relation to density, our study observed three relatively similar bagging machines (machines with a backstop, cables that run outside the bag between the backstop and bagger, density affected by cable tension and the setting of the tractor brakes). Other models and makes differ in how the crop enters the bag, is pressed in, and how density is adjusted. These issues would be expected to influence average bag densities as well as density variation across the face. Certainly more research is needed to compare the performance of these different bagging machines.

Losses

To this point, 15 of the bag silos have been completely emptied. Dry matter losses for these bags are shown in Table 4. Losses are divided into two categories: gaseous/seepage losses and spoilage losses. The latter represents the silage removed from the bag but not fed whereas the former is a measure of difference between the amount ensiled and the total amount (good and bad) removed from the bag. Seepage losses occurred in only two bags, the two wettest (30 and 32% DM) corn silage bags from Prairie du Sac that had 10.1% and 11.5% gaseous/ seepage losses, respectively.

Gaseous/seepage losses ranged from –0.3 to 15.7% with an average of 8.4%. Spoilage losses were more variable. Eight of the silos had either no or virtually no spoilage (<150 kg DM). The other silos had up to 25.4% spoilage loss. Total losses ranged from –0.3 to 38.2% with an average of 14.2%.

Of the three bags with the highest spoilage losses, the corn silage bag at West Madison had bird damage on top that was not noticed until substantial spoilage had occurred. Curiously, the corn silage bags made next to it had minimal damage. In the other two bags with substantial losses, moldy silage did not appear to be related to plastic damage during storage. Removing these worst three silo bags from the averages had little effect on gaseous losses but reduced total losses to 9.7% (Table 4).

With such a large range of losses, we expected losses to be associated with factors such as feed out rate, density, DM content, porosity, lumpiness of the bag and type of base. While some trends are evident, a thorough analysis will not be done until all 25 bags are emptied.

Of the 15 bags, four were made on grass or soil whereas the rest were on asphalt. If the soil base decreased recovery of silage, it should result in higher gaseous/seepage losses based on the way those losses were calculated. All four bags were of alfalfa (one at Arl, three at WM). The average gaseous/seepage losses were 8.0% for these bags, which is similar to the overall average and less than those for alfalfa at Prairie du Sac. Three of the four bags did have substantial spoilage losses, but it seems unlikely the base had an effect on these losses.

Gaseous losses would be expected to increase with wetter crops, higher porosity and slower feedout rates. The gaseous/seepage losses are plotted against DM content, porosity and feed out rate in Figures 5 to 7, respectively. These losses did tend to decrease the drier the crop at ensiling (Figure 5). Also higher feed out rates tended to reduce gaseous losses as expected (Figure 7). The data from West Madison were not included in this figure because silages at that location were typically unloaded in two or three periods rather than on a daily basis. There was no trend with porosity (Figure 6) although visually, particularly by crop, losses tended to decrease with higher porosity, the opposite of what would be anticipated. Combining these three factors appeared to explain much of the variation in the Prairie du Sac data (the results on the right side of Figure 8) but not the Arlington data (the left side).

Because there was little or no spoilage in half the silo bags emptied to date, one would not expect to see a good correlation between spoilage losses and some management factor. Figures 9 to 11 show spoilage losses relative to dry matter content, porosity and feed out rate, respectively. All of the silages with spoilage losses above 5% had DM contents above 40%, and all but one had a porosity above 60%. For both factors, there were a similar number of silages with no spoilage loss so little spoilage is possible under these conditions. However, these results suggest that high dry matter, high porosity silages are more likely to develop and contain moldy silage.

With gaseous/seepage losses and spoilage losses having opposite trends in relation to DM content and porosity, total losses were poorly correlated with both factors. The best correlation with total losses was with feed out rate (Figure 12). Combining various factors, the best factor was porosity divided by feed out rate (Figure 13). Mathematical analysis of losses at the bunker silo face during emptying (Pitt and Muck, 1993) has suggested that such a factor should be correlated with dry matter loss.

A more complete correlation of these factors with dry matter losses will be performed when all 25 bags have been emptied. Additional cases will hopefully strengthen some of the trends seen. In general, the factors correlated with losses in the current study reasonably agree with factors used to predict silo storage and feed out losses in other silo types (Pitt and Muck, 1993; Buckmaster et al., 1989).

The losses for many of our bag silos are similar to those reported elsewhere. Rony et al. (1984) reported losses of 9.0% and 6.4% for an alfalfa/grass and corn silage bag, respectively. Wallentine (1993) observed a 2.5% loss in corn silage. We observed bags with losses in this range, but we also had bags with substantially greater losses.

One of the reasons for studying losses at Prairie du Sac and Arlington was that their bags are often used for research studies and fed out at lower than recommended rates, which should increase losses. Of the bags emptied so far, the lowest feed out rates (~20 cm/d) have been at Prairie du Sac, and the results (Figure 12) suggest that such low rates can lead to higher losses. The bags opened at Arlington to date have been fed out at 50 to 60 cm/d, and losses have been 10% or less for two of the three.

Another issue from our results is that substantial losses can occur in bag silos. Three bags of 15 had major losses (>25%). In one case, bird damage and an unknown time between the event and repair was most likely the culprit. In the other two, the farm crews noted no unusual damage to the plastic, and so presumably these high losses were related to porous, drier silages as well as a low feed out rate in one case. Thus while it is possible to obtain low losses in bag silos that are similar to those in tower silos (i.e., 10% or less), there is substantially greater risk in bag silos for major losses. Good management (harvesting between 30 and 40% DM, operating the bagger to get a smooth bag of high density, monitoring routinely for and patching holes, and feeding out at a minimum of 60 cm/d) is essential to obtain low losses from bag silos. Our results provide evidence that deviation from those practices come with a cost.

Conclusions

Our study followed the filling and emptying of 25 silos bags made at three research farms. The primary baggers were a 2.7 m dia. Kelly-Ryan DLX and a 2.4 m dia. Ag Bag G6000.

- Dry matter densities based on the nominal diameters of the bags were approximately 200 kg/m^3 for alfalfa silage at 40% DM. Densities decreased with wetter crops at a rate of approximately 3 kg/m^3 per percentage unit decrease in DM content.
- Dry matter densities in corn silage were 3 to 8% lower with the Kelly-Ryan and appeared to be related to longer particle sizes in the corn silage. Densities with the Ag Bag were 16% higher with processed corn silage and 35% higher with unprocessed corn silage compared to hay crop silage. For both baggers, densities decreased with wetter chopped corn at a rate of approximately 5 kg/m^3 per percentage unit decrease in DM content.
- Operators affect density. The Kelly-Ryan was used at two farms, and one farm consistently averaged 8 to 10% higher densities than the other did.
- Core samples taken at the face of bags during emptying found considerable variation in density. The outer 30 cm on the top and upper sides had densities on average 40% of those in the center and lower portions, suggesting the need for higher feed out rates than might be anticipated for similar average densities in bunker silos.
- Dry matter losses have been measured on the 15 bags that have been completely emptied so far. Average DM losses were 8.4% gaseous/seepage losses and 5.8% spoilage losses for a total of 14.2% loss.
- Approximately half the bags had little or no spoilage loss whereas three bags suffered severe losses of 16 to 25% spoilage loss. Removing those three bags from the average had

little effect on gaseous losses but reduced spoilage and total losses to 1.9% and 9.7%, respectively. These are losses similar to those in tower silos.

- Gaseous/seepage losses were higher in low DM silages and at low feed out rates (20 cm/d).
- Spoilage losses were primarily associated with drier, porous silages although not all dry and porous silages had visible spoilage. One of the bags suffering major losses had bird damage that was not immediately detected and repaired.
- Overall, the variation in losses appears to confirm that deviations from good management (harvesting between 30 and 40% DM, operating the bagger to get a smooth bag of high density, monitoring routinely for and patching holes, and feeding out at a minimum of 60 cm/d) result in greater losses.
- Finally, more research is needed on other makes and models of silo baggers because of the diversity of mechanisms used for making bag silage and their potential effect on density and losses.

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Table 1. Description of the bag silos monitored in 2000.

Date Fill Started	Date Sealed	Farm	Bagger	Crop	Dry Matter Content, %	Dry Matter Ensiled, t	Bag Length, m
05/24/00	05/26/00	W[1]	KR 2.7	Alfalfa	58.8	71.8	51.6
06/08/00	06/09/00	W	KR 2.7	Alfalfa	50.9	67.2	53.3
06/27/00	06/29/00	A	KR 2.7	Alfalfa	42.3	69.5	52.3
06/29/00	06/30/00	A	KR 2.7	Alfalfa	42.7	67.2	51.4
07/08/00	07/08/00	P	A 2.4	Alfalfa	48.8	14.9	15.2
07/08/00	07/08/00	P	A 2.4	Alfalfa	50.9	14.5	14.5
08/02/00	08/02/00	A	KR 2.7	Alfalfa	44.6	69.0	50.3
08/03/00	08/04/00	A	KR 2.7	Alfalfa	48.7	72.5	48.2
08/24/00	08/25/00	W	KR 2.7	Alfalfa	34.7	50.1	49.7
08/25/00	08/25/00	P	A 2.4	Red Clover	41.9	14.9	15.6
09/07/00	09/07/00	P	A 2.4	Corn	29.8	24.1	24.7
09/08/00	09/08/00	P	A 2.4	Corn	31.7	23.9	26.5
09/13/00	09/15/00	W	KR 2.7	Corn	37.8	55.5	55.2
09/14/00	09/15/00	W	KR 2.7	Corn	37.3	52.7	53.5
09/18/00	09/19/00	W	KR 2.7	Corn	43.7	63.8	55.5
09/19/00	09/20/00	P	A 2.4	Corn	37.2	24.0	23.9
09/21/00	09/22/00	A	A 2.7	Corn	36.7	46.6	47.3
09/21/00	09/21/00	A	A 2.7	Corn	37.0	55.5	52.8
09/25/00	09/25/00	A	A 2.7	Corn	37.1	58.2	53.7
09/25/00	09/25/00	A	KR 2.7	Corn	41.4	62.8	55.0
09/26/00	09/26/00	A	KR 2.7	Corn	38.4	65.8	57.0
09/27/00	09/28/00	A	KR 2.7	Corn	35.7	38.8	39.3
09/27/00	09/27/00	A	KR 2.7	Corn	40.4	41.4	33.7
09/27/00	09/28/00	P	A 2.4	Corn	41.4	45.5	39.6
09/28/00	09/29/00	P	A 2.4	Corn	41.7	41.8	31.6

[1] Farm: A – Arlington, P – Prairie du Sac, W – West Madison; Bagger: A – Ag Bag, KR – Kelly-Ryan, number is nominal diameter (m).

Table 2. Average dry matter densities across similar silo bags within a farm.

Farm	Number of Bags	Average DM Content, %	Average DM Density, kg/m^3	Est. DM Density[1] at 40% DM, kg/m^3	Comments[2]
Hay Crop					
Arlington	4	44.6	233	210	KR
Prairie du Sac	3	47.2	209	202	A 2.4
West Madison	3	48.1	206	184	KR
Corn					
Arlington	3	36.9	176	194	Processed, A 2.7
Arlington	3	40.1	196	194	Processed, KR
Arlington	1	35.7	167	194	Unprocessed, KR
Prairie du Sac	3	36.7	218	235	Processed, A 2.4
Prairie du Sac	2	35.7	246	272	Unprocessed, A 2.4
West Madison	3	39.6	177	179	Unprocessed, KR

[1] Based on linear regression of DM density vs. DM content results within a row with the exception of the Arlington corn results, which were grouped together.

[2] A – Ag Bag, KR – Kelly-Ryan, number is nominal diameter (m).

Table 3. Dry matter densities (kg/m^3) at various locations across the face of five bag silos.

Bag Information[1]	Location[2]						
	A	B	C	D	E	F	G
PDS-Hay-AB	47	285	191	40	203	112	125
PDS-Hay-AB	132	178	271	193	198	123	162
Arl-Hay-KR	43	271	326	262	235	151	210
Arl-Corn-KR	79	146	174	181	187	67	171
WM-Corn-KR	116	236	223	138	148	63	158
Average	83	223	237	163	194	103	165
Relative, %	37	94	100	71	83	42	72

[1] Farm: Arl – Arlington, PDS – Prairie du Sac, WM – West Madison; Bagger: AB – Ag Bag, KR – Kelly-Ryan.

[2] Locations refer to letters in Figure 4.

Table 4. Dry matter losses from the first 15 bags silos completely emptied.

Crop	Location[1]	Bagger	Empty Start Date	Empty End Date	Gaseous/ Seepage Loss, %	Spoilage Loss, %	Total Loss, %
Alfalfa	Arl	KR	02/12/01	05/15/01	12.8	25.4	38.2
Alfalfa	PDS	AB 2.4	03/26/01	06/06/01	10.5	0.0	10.5
Alfalfa	PDS	AB 2.4	03/27/01	06/06/01	10.3	16.6	26.9
Alfalfa	WM	KR	12/19/00	04/24/01	3.8	6.6	10.4
Alfalfa	WM	KR	10/31/00	11/10/00	5.5	10.6	16.1
Alfalfa	WM	KR	03/21/01	03/27/01	10.0	0.0	10.0
Corn	Arl	KR	10/17/00	01/25/01	2.9	1.3	4.2
Corn	Arl	KR	01/22/01	05/06/01	10.2	0.2	10.4
Corn	PDS	AB 2.4	10/27/00	03/30/01	6.4	0.0	6.4
Corn	PDS	AB 2.4	10/27/00	03/26/01	7.8	0.0	7.8
Corn	PDS	AB 2.4	10/27/00	03/27/01	10.1	0.0	10.1
Corn	PDS	AB 2.4	10/27/00	03/06/01	11.5	3.6	15.0
Corn	PDS	AB 2.4	11/23/00	04/02/01	15.7	0.1	15.8
Corn	WM	KR	01/02/01	03/28/01	-0.3	0.0	-0.3
Corn	WM	KR	02/09/01	04/13/01	8.7	21.9	30.6
Average					8.4	5.8	14.2
Average without worst 3 bags					7.9	1.9	9.7

[1] Farm: Arl – Arlington, PDS – Prairie du Sac, WM – West Madison; Bagger: AB – Ag Bag, KR – Kelly-Ryan.

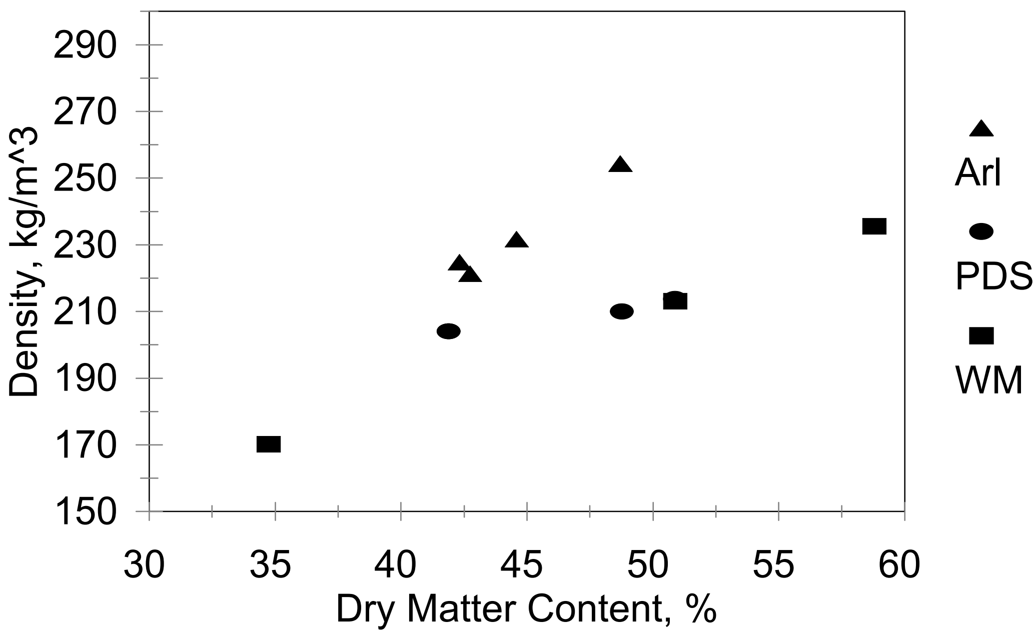

Figure 1. Average dry matter densities of hay crop silages made in bag silos at different dry matter contents and farms (Arl – Arlington, PDS – Prairie du Sac, WM – West Madison).

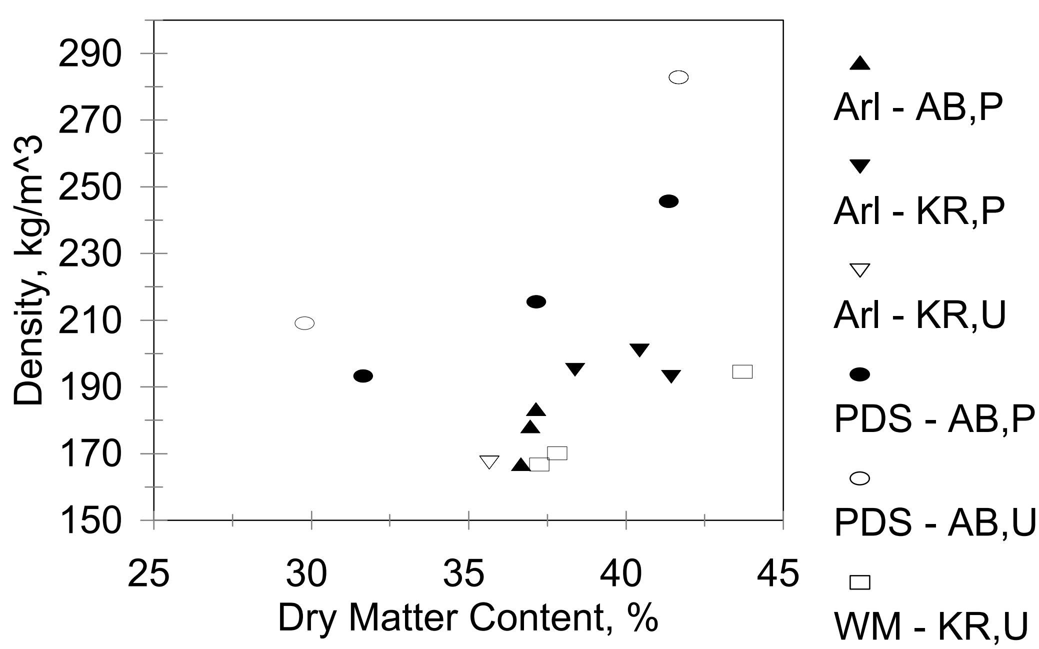

Figure 2. Average dry matter densities of corn silages made in bag silos at different dry matter contents, farms (Arl – Arlington, PDS – Prairie du Sac, WM – West Madison), machines (AB – Ag Bag, KR – Kelly-Ryan) and kernel processing (P – processed, U – unprocessed).

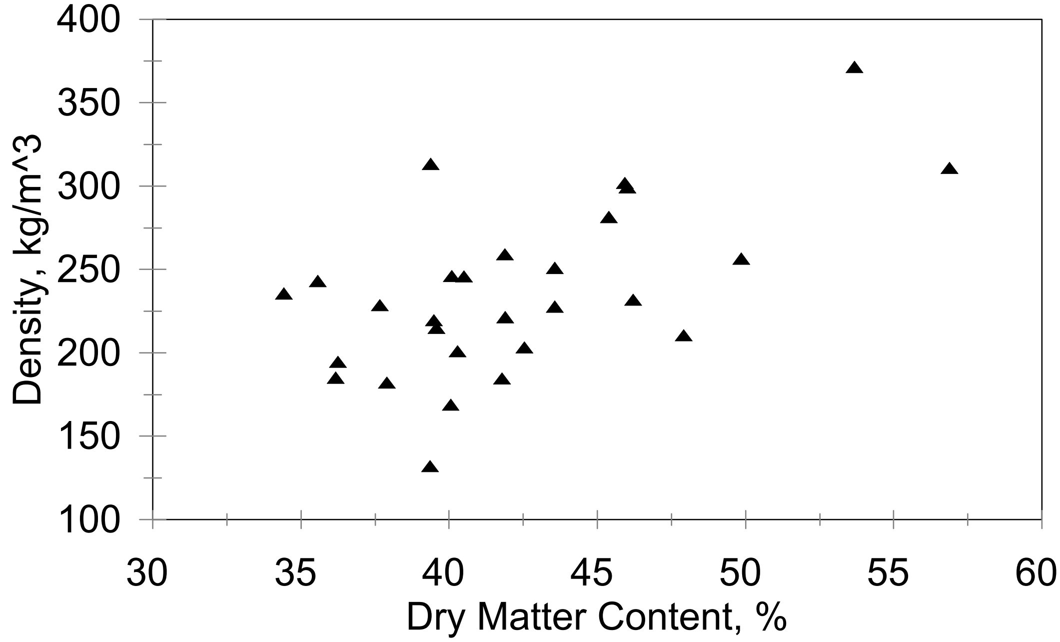

Figure 3. Dry matter densities of individual loads within an alfalfa silage bag made at Arlington with a Kelly-Ryan bagger.

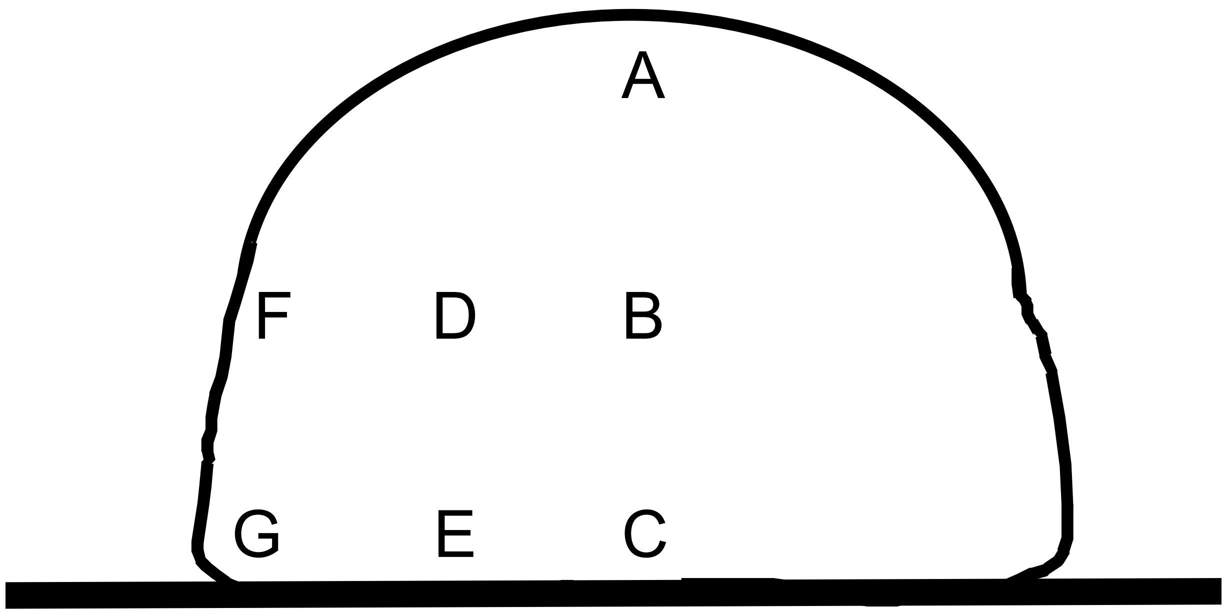

Figure 4. Location of core samples taken at the face of bag silos during emptying. Locations A, C, E, F and G were 15 cm from the plastic wall. Locations A, B and C were along the vertical axis. Locations B, D, and E were at midpoints between other cores.

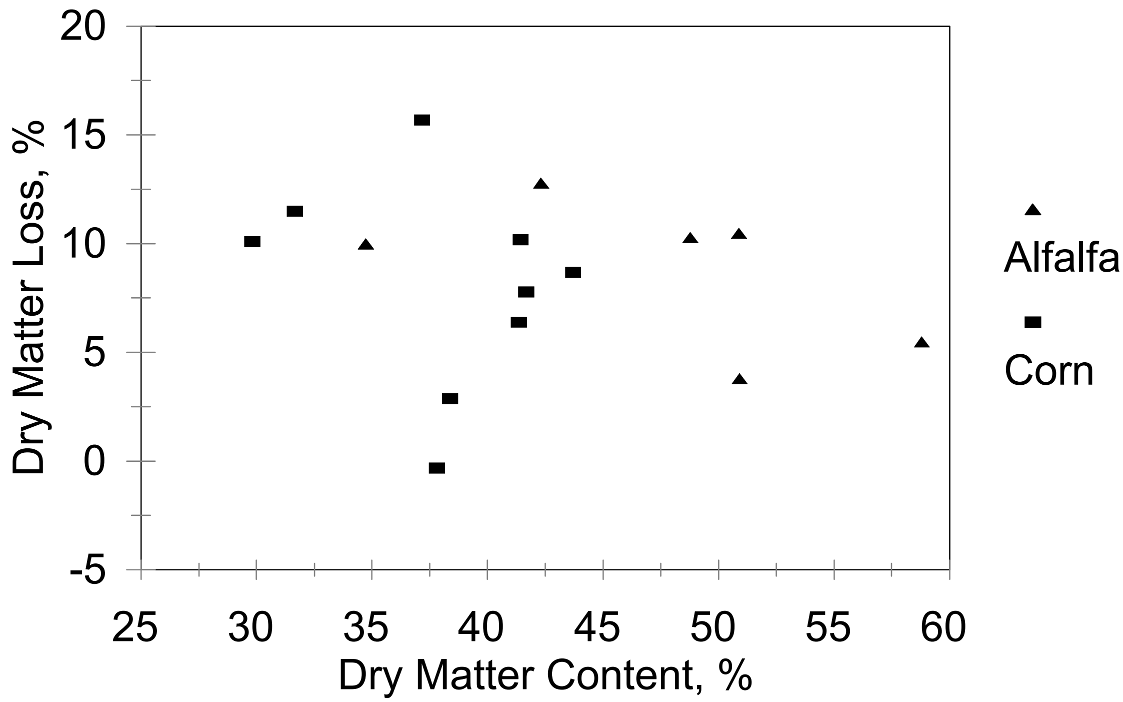

Figure 5. Gaseous/seepage losses as correlated with crop dry matter content.

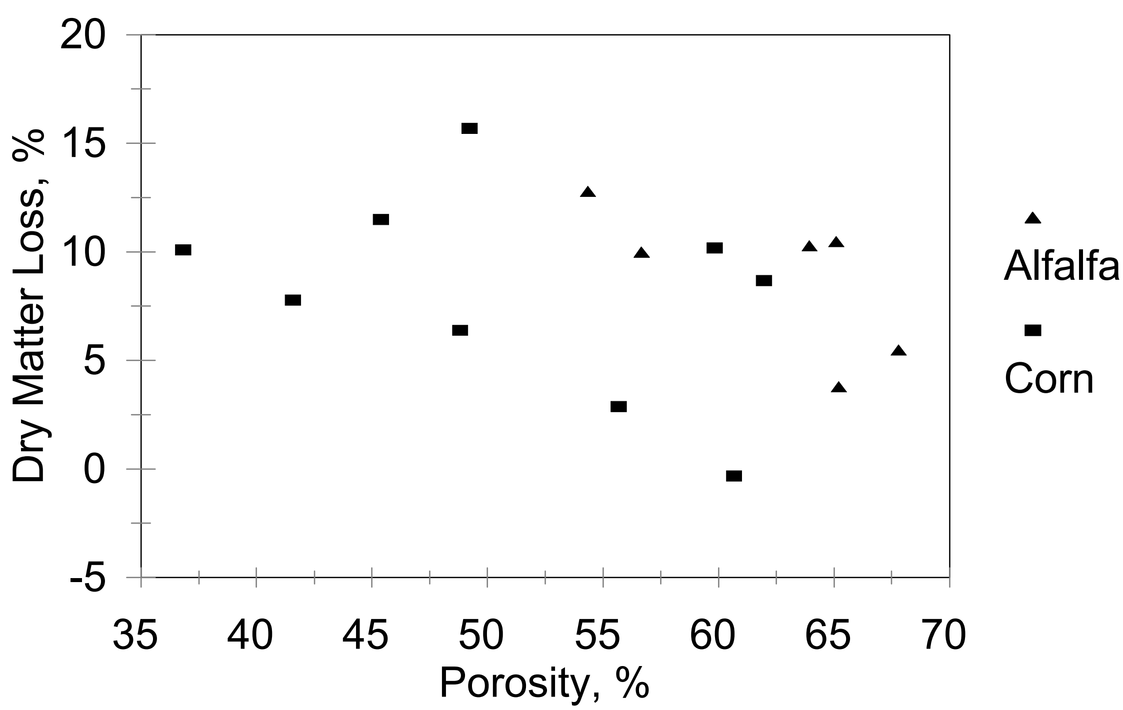

Figure 6. Gaseous/seepage losses as correlated with silage porosity.

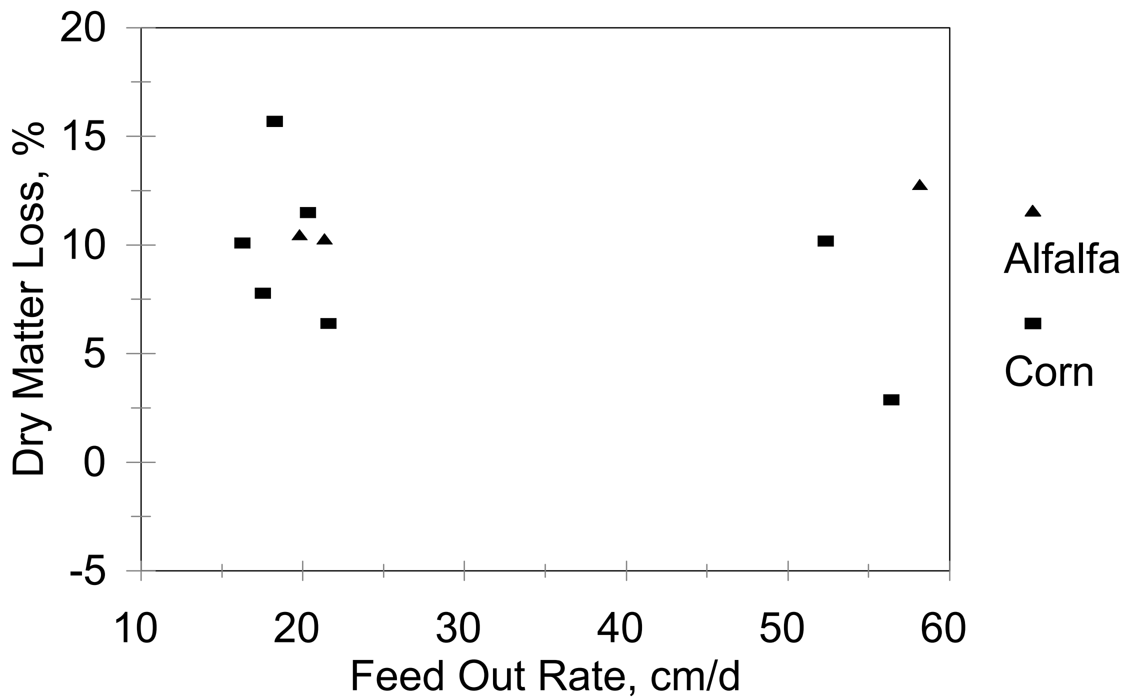

Figure 7. Gaseous/seepage losses as correlated with feed out rate.

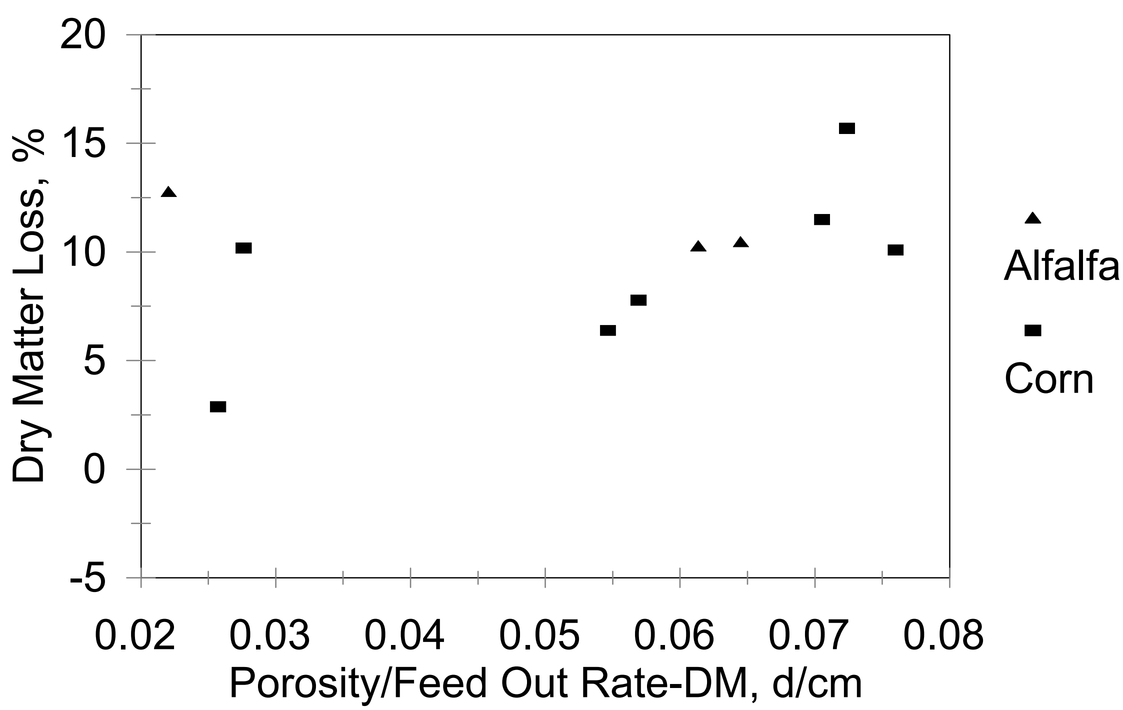

Figure 8. Gaseous/seepage losses as correlated with porosity divided by feed out rate and DM content.

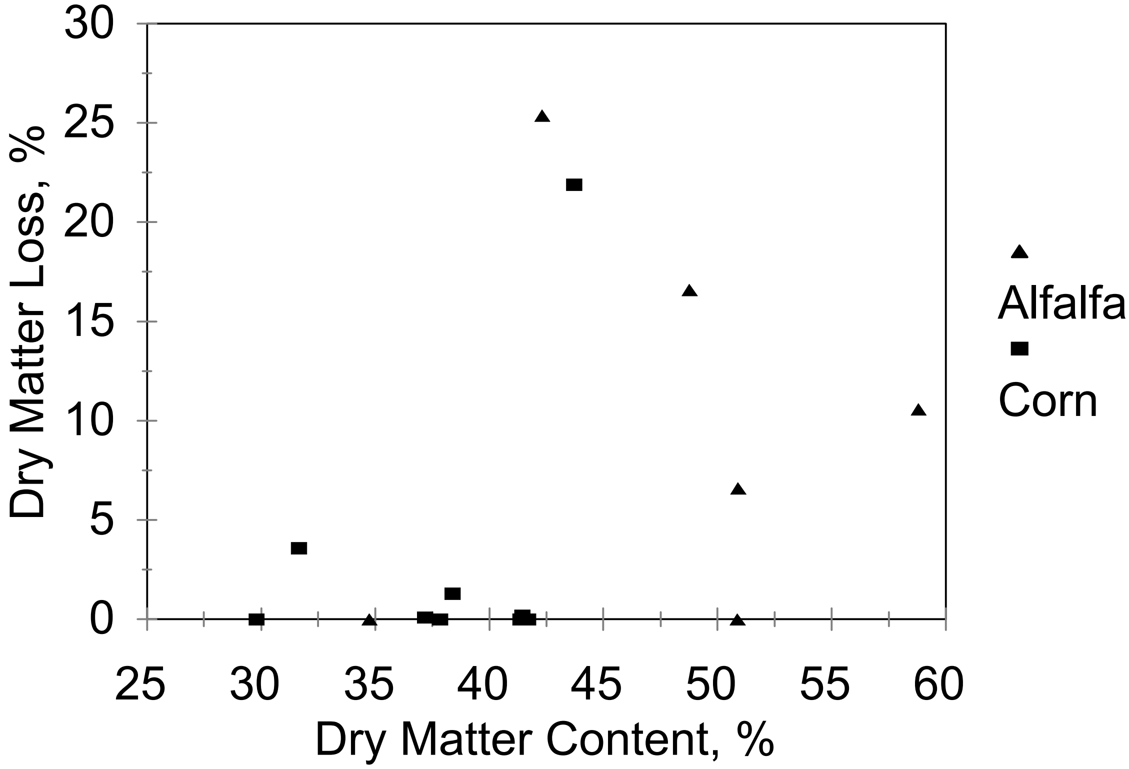

Figure 9. Spoilage losses as correlated with crop dry matter content.

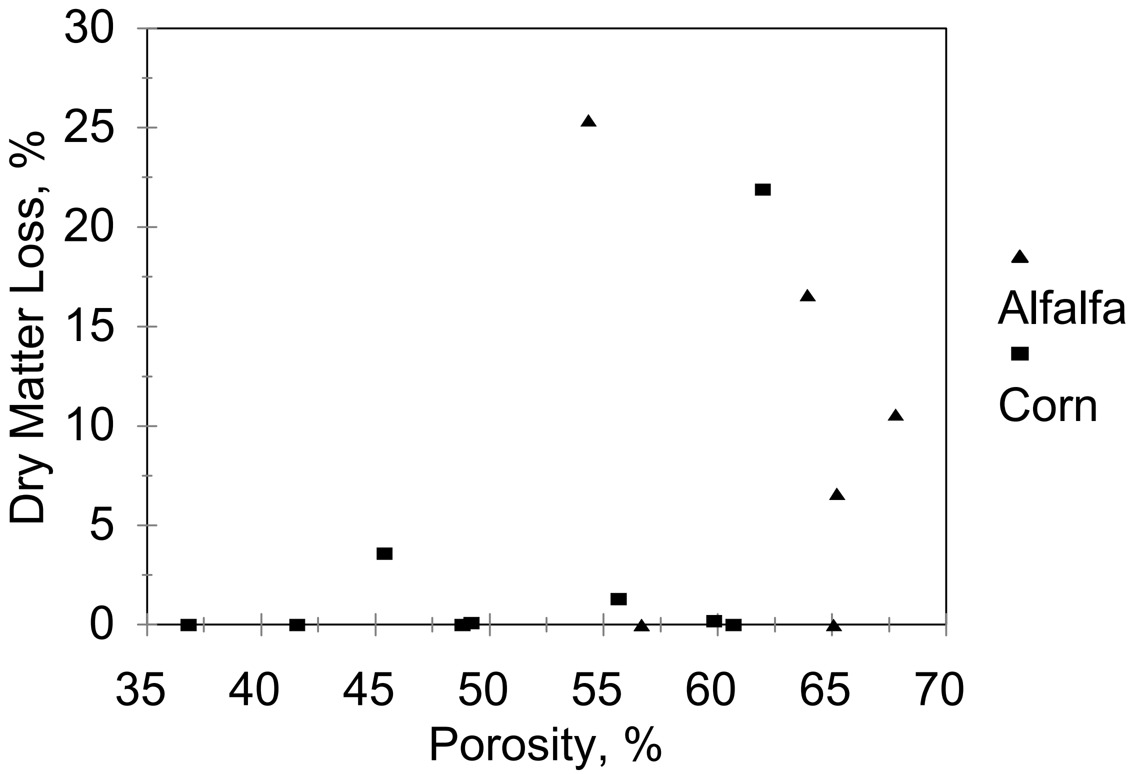

Figure 10. Spoilage losses as correlated with silage porosity.

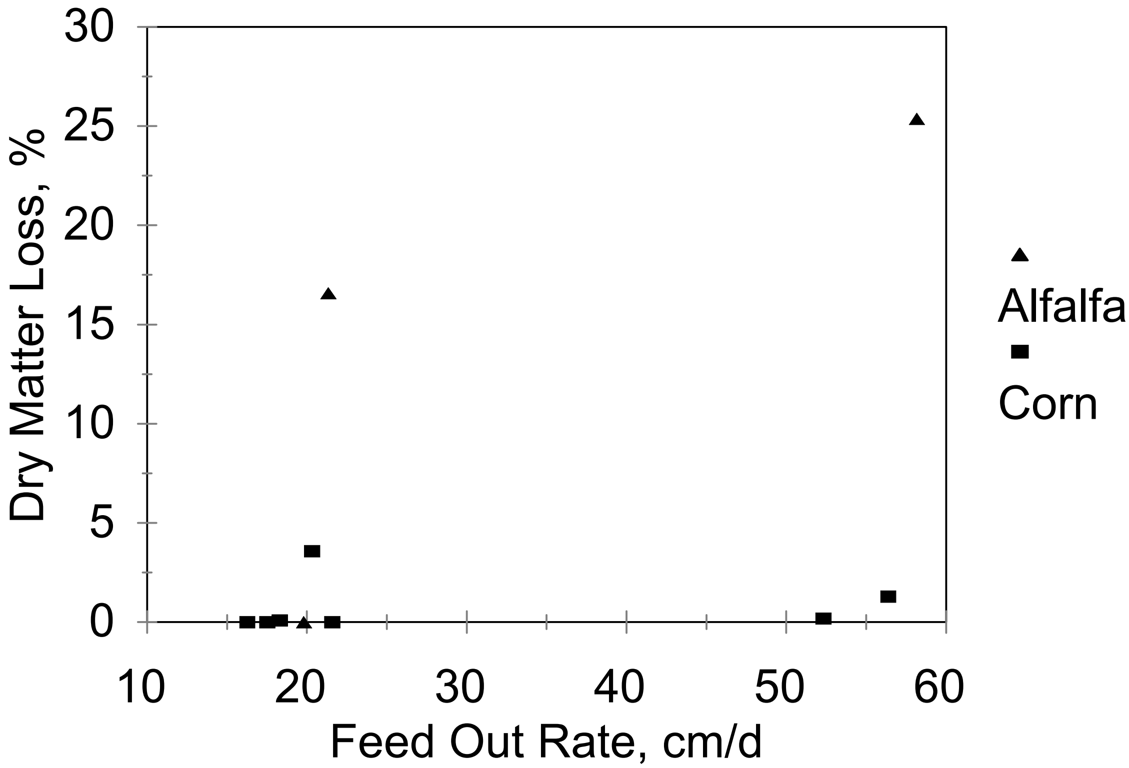

Figure 11. Spoilage losses as correlated with feed out rate.

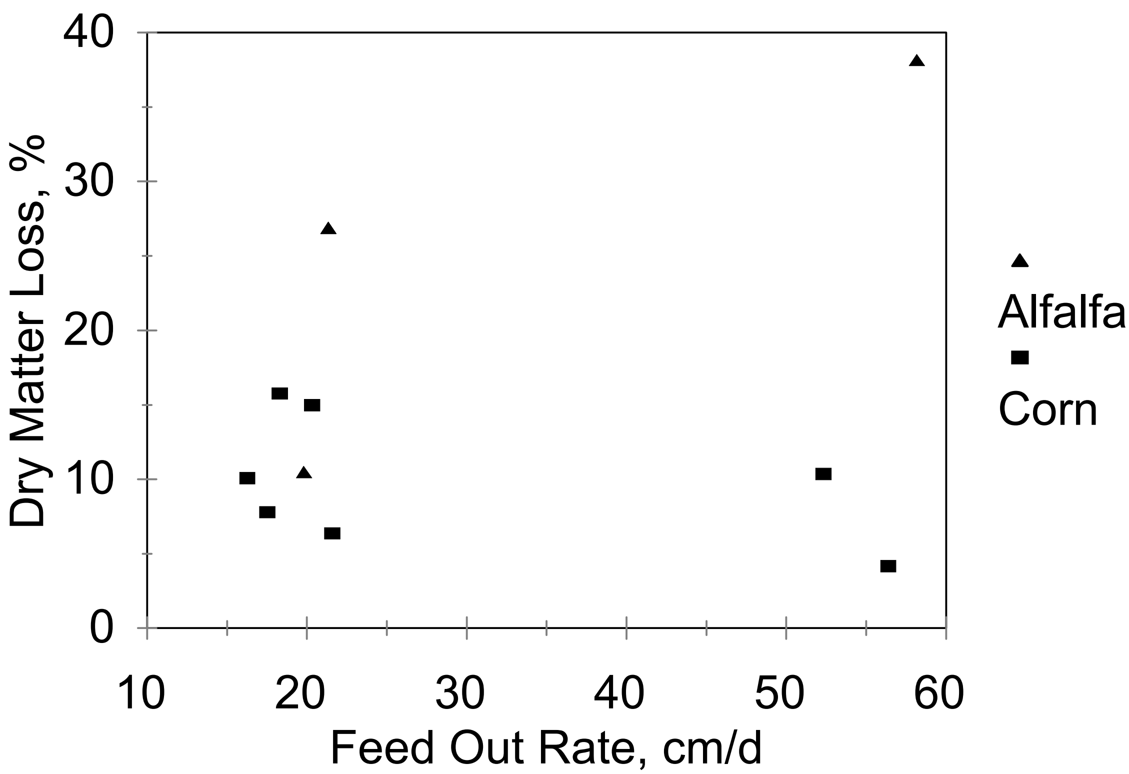

Figure 12. Total losses as correlated with feed out rate.

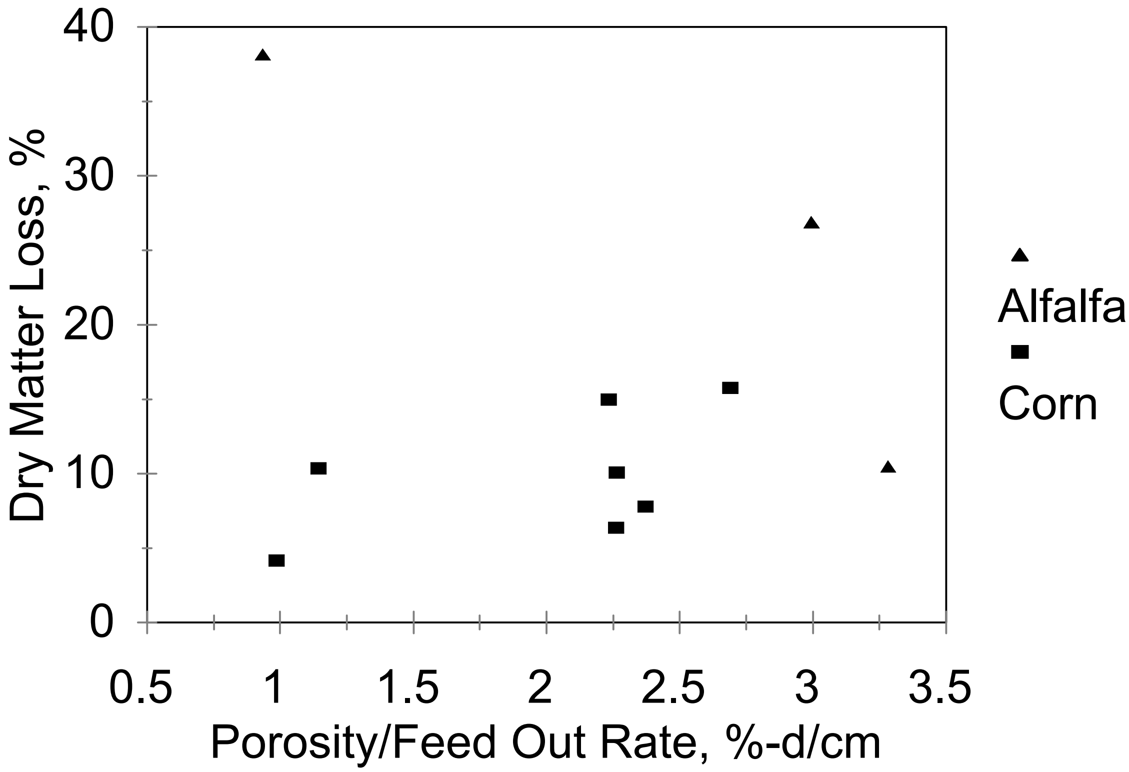

Figure 13. Total losses as correlated with porosity divided by feed out rate.