Factors Affecting Bunker Silo Densities

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Introduction

Attaining a high density in a silo is important for two primary reasons. Firstly and most importantly, density and dry matter content determine the porosity of the silage. Porosity, in turn, sets the rate at which air can move into the silo and subsequently the amount of spoilage that can occur during storage and feedout. Secondly, the higher the density the greater the capacity of the silo. Thus, higher densities generally reduce the annual cost of storage per ton of crop by both increasing the amount of crop entering the silo and reducing crop losses during storage.

The factors affecting density in bunker and pile silos are not well understood. General recommendations have been to spread the crop in 15 cm layers and pack continuously with heavy, single-wheeled tractors. In a survey of alfalfa silage in 25 bunker silos, Ruppel et al. (1995) found that tractor weight and packing time (min/t as fed or min/m^2) were the most important factors affecting density. However, both factors only explained a small fraction of the variation observed, and layer thickness was not measured. The objectives in our study were to measure density in a wider range of bunker silos and correlate those densities with filling practices.

Methods

Twenty collaborating county extension agents in Wisconsin measured densities in over 160 bunker silos containing either haycrop or corn silage. Density was measured with a 5-cm diameter corer, taking cores at approximately chest height at four locations across the silage face. Core depth, distance from the top and distance from the floor were recorded. Cores and a grab sample were express mailed to the Center for determination of weight, dry matter content and particle size distribution.

A survey was filled out for each silo sampled. Information requested from farmers included: number of packing tractors, tractor weight, number of tires per tractor, tire pressure, tire condition, number of drive wheels, silage delivery rate, packing time per day, harvest time per day, filling time, filling technique, initial layer thickness, silo dimensions, maximum silage height, crop, crop maturity, and theoretical length of cut. These factors were then correlated with measured dry matter densities.

Results

The range of densities and dry matter contents observed in haycrop and corn silages are shown in Table 1. Ranges of dry matter densities were similar for both haycrop and corn silages. Densities on the low end suggested little packing whereas the highest densities were in the range observed in tower silos. Average dry matter densities were slightly higher than a recommended minimum density of 225 kg/m^3.

Preliminary analyses indicate that dry matter densities were most closely correlated with total tractor weight (Fig. 1) and initial packing layer thickness (Fig. 2). Use of rear duals or all duals on packing tractors did not have a large effect on density. Packing time per ton appeared to be less important than total tractor weight or layer thickness; however, this may have been due to an inverse relationship between silage height and packing time. Taller silos tended to receive less packing time per ton, but density increased with silage height, indicating more self-compaction in deeper bunker silos.

Another issue raised in the preliminary analyses was packing time relative to crop delivery rate to the silo. Packing time per ton was highest (1 to 4 min/t as fed) under low delivery rates (<30 t as fed/h) and generally declined with increasing delivery rate. Packing times were consistently less than 1 min/t as fed at delivery rates above 60 t/h in our survey. These results suggest that farmers using contractors for harvesting their silage crops probably will need to pay particular attention to spreading the crop in a thin layer and would benefit from using several packing tractors simultaneously.

Conclusions

Densities in bunker silos across Wisconsin were highly variable. Preliminary analyses of the results indicate that weight of the packing tractor, initial crop layer thickness and packing time per ton are the most important factors. Finally, the results suggest that continuous packing with a single tractor may not be sufficient to obtain a high density in silos receiving high delivery rates such as with custom harvesting.

Reference

Ruppel, K.A., Pitt, R.E., Chase, L.E. and Galton, D.M. 1995. Bunker silo management and its relationship to forage preservation on dairy farms. J. Dairy Sci. 78:141-153.

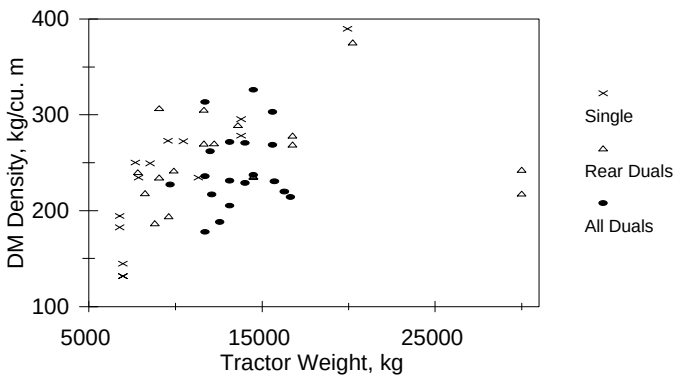

Figure 1. Silage dry matter density as related to total weight of packing tractors for silos with a 3.6 m wall height.

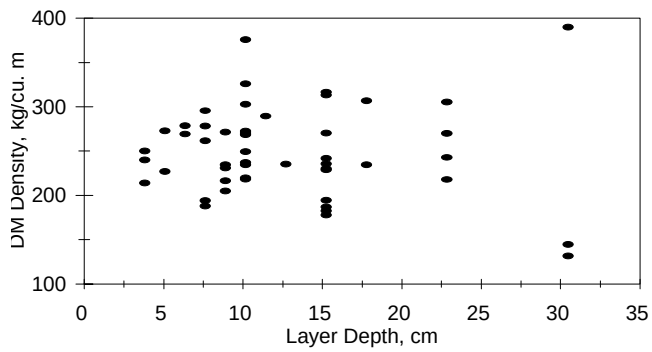

Figure 2. Silage dry matter density as related to crop layer thickness after initial spreading for silos with a 3.6 m wall height.

Table 1. Summary of core samples collected from 168 bunker silos.

	Haycrop Silage (87 silos)			Corn Silage (81 silos)		
Characteristic	Average	Range	Std. Dev.	Average	Range	Std. Dev.
Dry Matter, %	42	24-67	9.50	34	25-46	4.80
Wet Density, kg/m^3	590	210-980	175	690	370-960	133
Dry Density, kg/m^3	237	106-434	61	232	125-378	46
Avg. Particle Size, mm	11.7	6.9-31.2	3.8	10.9	7.1-17.3	2.0