How much silage is in my stack? (1-49)

Many farmers need to know how much silage is stored in their finished stack, pit or bunker for feed budgeting, for selling or calculating contractor costs.

Calculating the weight of silage in the storage requires measurement or an estimation of:
   a) Storage volume (capacity) in cubic metres (m$^3$)
   b) Silage density in kg DM/m$^3$
   c) Dry matter %

The weight of silage in storage is then calculated using the following equation:

Silage weight (kg DM) = volume of stack or pit (m$^3$) x silage density (kg wet weight/m$^3$) x DM %

Estimating stack volume

Volume of the storage can be estimated by multiplying the dimensions of the storage: width by the length by the approximate height of the silage. Calculations would be simple if the silage was stored as a rectangle or square block. However, given that most silage storages are irregular shapes the dimensions have to be estimated, taking into account the taper on the top of the storage and the slope of the sides and ends.

The estimates will then be approximates of the length, width and height as shown in Figures 1 (bunker) and 2 (stack).

In Figure 1, the dimensions have been estimated at a length of 48 metres, width of 12 metres and height of 2.9 metres (the height at the highest point is about 1 metre above the top of the wall, so about 0.5m on average).

The volume of the silage in the bunker is therefore:

\[48 \times 12 \times 2.9 = 1670 \text{m}^3\]

In Figure 2, the dimensions have been estimated at a length of 20 metres, width of 3 metres and height of 3 metres.

The volume of the stack is therefore

\[3 \times 3 \times 20 = 180 \text{m}^3\]
Estimating Silage Density (Pasture and Maize silage)

Density of the 'settled' stack is affected by the dry matter (DM) content of the silage, chop length and degree of compaction, making estimation of density difficult.

Default values can be used. A rough rule of thumb allows for 600 kg of wet silage in one cubic metre of settled stack, which is, at an average of 33% DM, 200 kg DM/m$^3$.

It is important to remember that long chopped, poorly compacted or very wet silage will have a lower density, probably closer to 500 kg/m$^3$ wet silage while fine chopped or a well-compacted stack may be over 700 kg/m$^3$ wet silage.

A quick reference guide

Silage density can be estimated by using the DairyNZ Facts and Figures quick reference guide for storage space required below.

**DairyNZ Facts and Figures: Storage space required for grass and maize silage (page 26)**

<table>
<thead>
<tr>
<th>Silage storage</th>
<th>Tonnes DM multiplied by</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize stack</td>
<td>5.0</td>
<td>50 t DM x 5.0 = 250 m$^3$</td>
</tr>
<tr>
<td>Maize bunker</td>
<td>4.4</td>
<td>50 t DM x 4.4 = 222 m$^3$</td>
</tr>
<tr>
<td>Grass silage</td>
<td>5.7</td>
<td>50 t DM x 5.7 = 285 m$^3$</td>
</tr>
</tbody>
</table>

Using the above table, calculating volume in kg DM is easy:

\[
\text{Silage weight (tonnes DM)} = \frac{\text{volume}}{\text{multiplier provided in the table}}
\]

Using the quick reference guide for our example bunker storage in Figure 1:

\[
\text{Silage weight} = \frac{1670 m^3}{4.4} = 380 \text{ tonne DM}
\]

And for the stack in Figure 2:

\[
\text{Silage weight} = \frac{180 m^3}{5.0} = 36 \text{ tonne DM}
\]

A more accurate method

A more accurate method to determine the density in a stack is to measure it, remembering to do so at several locations and depths in the stack.

**Measure dry matter**

First you need to determine the dry matter % of the silage. Use the following method (this method can also be used to determine the dry matter of standing feed):

1. Take several core samples of silage from the stack
2. Take a dinner-plate size sample from your samples (approx. 100-150 grams) and chop into approx. 3-4 cm lengths (if not already at this length)
3. Tare (zero) a set of kitchen scales to the weight of a microwave-safe container
4. Weigh the sample of chopped silage in the container, measuring to the nearest gram. Record this as the **Initial Wet Weight**. Spread the material evenly over the container and place it in the microwave with a glass three-quarter full of water.

**Warning:** The glass of water prevents the forage sample from charring or igniting as it becomes completely dry. The water level must be maintained during microwave use and may have to be replaced with cold water if it starts to steam or boil to prevent absorption by the drying forage.
5. Dry on full power (high) for intervals of 3 to 5 minutes to begin with until the sample begins to feel dry (time depends on sample size, shortness of chop and initial DM content). Record the weight after each drying interval and repeat.

Samples should be turned and 'fluffed-up' after each drying interval to improve evenness of drying.

6. When the sample begins to feel dry, reduce the drying interval to between 30 seconds and one minute.

7. When the weight of the sample does not change after two or three drying intervals it is 100% dry (to within 1-2% units). Record this Final Dry Weight.

If the sample chars or burns, use the previous recorded weight. Occasionally the weight may increase if the sample absorbs some moisture from the glass of water; use the last recorded weight if this happens.

8. Use the following formula to calculate dry matter percentage:

\[
\text{Final Dry Weight (g)} \div \text{Initial Wet Weight x 100} = \% \text{ Dry Matter.}
\]

**Example:**

\[
50g \div 150g \times 100 = 33.3\% \text{ DM}
\]

**Measure density**

Once you have the dry matter percentage, you need to determine the stack density. Use the following method:

1. Use a corer to cut at least five squares or rectangles of known dimensions out of the stack and weigh them.

2. Take the average weight and use the following equation to determine density:

\[
\text{Density} = \frac{\text{weight of the silage sample}}{\text{volume of the sample}}
\]

**Example:**

A square block of silage from **Example 1 (the bunker)** has dimensions of 0.2m (length) x 0.2m (width) x 0.2m (height). This silage sample weighs 5.0 kg (wet weight) and has a DM content of 33.3% (as calculated above).

The volume of silage = 0.2 x 0.2 x 0.2 = 0.008m³

Density of silage = 5.0kg ÷ 0.008m³ x 33.3% DM = 208kg DM/m³

A rectangle block of silage from **Example 2 (the stack)** has dimensions 0.4m (length) x 0.2m (width) x 0.2m (height). This sample weighs 9 kg and has DM content of 33.3%.

The volume of silage = 0.4 x 0.2 x 0.2 = 0.016m³

Density of silage = 183kg DM/m³

**Calculate weight**

Once the volume, dry matter and density have been determined, the weight of the silage in the stack can then be calculated.

In the examples below, we use the volumes of **Example 1 (the bunker)** and **Example 2 (the stack)** together with the dry matter and densities calculated above.

**Example 1 (the bunker)**

- Volume of the stack = 1670m³
- Silage density = 208kg DM/m³
- Weight of the silage = 1670³ x 208kg DM/m³ = 347,360kg DM (347.4 tonne)
Example 2 (the stack)
Volume of the stack = Silage density = 183kg DM/m$^3$
Weight of the silage = 180m$^3$ x 183kg DM/m$^3$
= 32,940kg DM (32.9 tonne)

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