SDSU Extension

# iGrow Soybean

BEST MANAGEMENT PRACTICES

## Chapter 53:
## Useful Calculations and Conversions

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There are many calculations that are conducted that impact economic returns and costs. The purpose of this chapter is to discuss and provide examples of agronomic calculations routinely determined. Additional problems are available in Clay et al. (2011).

**Table 53.1. Equations and other information typically used in calculations.**

| Soybean plant | Information |
|---|---|
| 1 bu = 32 dry qt = 35.238 l | |
| 1 bu = 1.244456 $ft^3$ | |
| 1 bu beans at 13% moisture typically = 60 lbs | |
| 1 bu beans at 0% moisture typically = 52.2lbs | |
| 2,500-3,000 soybean seeds/lb | |
| Seeding rate, 30-45 lbs/acre | |

| Volumes and areas | Information |
|---|---|
| Pyramid volume=1/3base x width x height | |
| Rectangle area = base x width | |
| Area of a circle = pi x $r^2$ | |
| Circle circumference = 2 x r x pi | |
| Volume of a sphere = (4/3) x pi x $r^3$ | |
| Volume of a cone = (1/3) x pi x r2 x height | |
| Volume of a cylinder = pi • $r^2$ • h | |
| Volume of a bushel=1.244 $ft^3$ | |

| Densities liquid fertilizer | Information |
|---|---|
| Density 0-60-0 14.4 lbs/gal | Chapter 21 |
| Density 10-34-0 11.64 lbs/gal | Chapter 21 |

| Fertilizer grades | Information |
|---|---|
| DAP 18-46-0 | Chapter 21 |
| Map 11-52-0 | Chapter 21 |
| KCl 0-0-60 | Chapter 21 |

| Nutrient Removal | Information |
|---|---|
| 0.84 lb $P_2O_5$/bu soybeans | Chapter 25 |
| 1.3 lb $K_2O$/bu soybeans | Chapter 26 |
| soybean stover, 8.8 lbs $P_2O_5$/ton | |
| soybean stover, 37 lbs $K_2O$/ton | |
| soybean stover, 6.2 lbs S/ton | |

| Areas and lengths | Information |
|---|---|
| 1 acre = 43560 $ft^2$ | |
| 1 section = 640 acres | |
| 1 chain = 66 ft | |
| 1 link - 0.66 ft | |
| 1 acre = 10 $chain^2$ | |
| 1 section = 6400 $chain^2$ | |
| 1 acre = 208.7 ft by 208.7 ft | |

## Soil temperatures, seeding rate, fertilizers, and salt-affected soils

**Problem 53.1. The surface soil (~1 to 2 inches) temperatures are 45ºF at 7:00 AM and 55ºF at 3:00 PM. Is the temperature warm enough to plant soybean seeds?**

**Answer:** The temperature average is 50ºF. This is below the minimum temperature of 55ºF. However, it is equal to the minimum temperature for corn of 50ºF.

**Problem 53.2. Calculate the seeding rate if the germination rate is 98%, purity is 96%, and seeding viro is 90%. The desired live population is 135,000 plants/a.**

$$\frac{135{,}000\ \text{plants at V2}}{\text{acre}} = \left(\frac{\text{seeding rate}}{\text{acre}}\right) \times \frac{0.98\ \text{germination rate}}{\text{seed}} \times \frac{0.96\ \text{pure seeds}}{\text{seed}} \times \frac{0.90\ \text{emergence}}{\text{seed}}$$

$$= \frac{159{,}500\ \text{seeds}}{\text{acre}}$$

**Problem 53.3. Determine the $P_2O_5$ recommendation for the soil with a Bray-1 soil test value of 10 ppm and a soybean yield goal of 60 bu/acre and a corn yield goal of 210 bu/acre. The fertilizer grade is 18-46-0. In using equations from page 5 of SDSU EC750 one gets:**

Use the soil test value (10) and yield goal (60 bu soybeans and 210 bu corn) to determine the two-year P rate, as shown below.

Soybean lbs $P_2O_5$/a = (1.55 - 0.14 x 10) x 60 = 9lbs $P_2O_5$/acre
Corn lbs $P_2O_5$/a = (0.70 - 0.044 x 10) x 210 = 54.6 lbs $P_2O_5$/acre

Based on these calculations, the P recommendation total is 63.6 lbs $P_2O_5$/acre

**How much DAP (18-46-0) should be applied?**

$$\frac{\text{DAP}}{\text{acre}} = \frac{63.6\text{lb}P_2O_5}{\text{acre}} \times \frac{100\text{lbs DAP}}{46\text{lbs}P_2O_5} = \frac{138\ \text{lbs DAP}}{\text{acre}}$$

**Problem 53.4. How much P will it take to increase a soil test P value from 3 to 11? The fertilizer grade DAP is 18-46-0.**

As a general rule, it takes from 10 to 30 lbs of $P_2O_5$ to increase soil test (Olsen or Bray) one soil test point. Using a median of 20 lb $P_2O_5$/point of soil test, to change a soil test from 3 to 11 (Olsen P) will require the addition of (11-3)*20 = 160 lb $P_2O_5$.

$$\mathbf{160}\ \textit{lb actual}\ P_2O_5 * \frac{\mathbf{1}\ \textit{lb DAP product}}{\mathbf{0.46}\ \textit{lb actual}\ P_2O_5} = \mathbf{348}\ \textit{lb DAP}$$

**Problem 53.5. You are planning on applying 10 lbs/a of N to a field. If the fertilizer source is 28-0-0 (which has a density of 10.9 lbs/gal), how much 28% should be applied?**

$$\frac{\mathbf{10}\ \textit{lb actual N}}{\textit{acre}} * \frac{\mathbf{1}\ \textit{lb UAN}}{\mathbf{0.28}\ \textit{lb actual N}} * \frac{\mathbf{1}\ \textit{gal UAN}}{\mathbf{10.9}\ \textit{lb UAN}} = \frac{\mathbf{3.3}\ \textit{gal}}{\textit{acre}}$$

**Problem 53.6. How much fertilizer should you apply in the following problem?**

In South Dakota, the nutrient that most often limits soybean yields is P. However, many South Dakota fertilizer retailers sell phosphorous as diammonium phosphate (DAP 18-46-0) or as mono-ammonium phosphate (MAP 11-52-0). Because each contains nitrogen, to effectively use the nitrogen, many producers who rotate between corn and soybeans put their DAP or MAP on the corn. Determining the P removal rates for a two-year rotation is shown below. Calculations showing how to determine the P rate based on a soil sample is provided in Problem 53.3 earlier in this chapter.

1. Calculate the P removal rate fro a soybean and corn crop. This calcuations assume that 1 bu of corn removes 0.38 of $P_2O_5$ and 1 bu of soybeans removes 0.84 of $P_2O_5$. Example is for 175 bu of corn and 55 bu of beans.

$$\frac{175\ bu\ corn}{acre} \bullet \frac{0.38\ lb P_2O_5}{bu\ corn} + \frac{55\ bu\ cbeans}{acre} \bullet \frac{0.84\ lb P_2O_5}{bu\ beans} = 112.7\ lb\ P_2O_5$$

2. Calculate the amount of DAP (18-46-0) needed to replace this P.

$$\frac{112.7\ lb\ P_2O_5}{acre} \bullet \frac{100\ lb\ DAP}{46\ lb\ P_2O_5} = 245\ lb\ DAP$$

3. Calculate the amount of N from the DAP that is available for the corn.

$$\frac{245\ lb\ DAP}{acre} \bullet \frac{18\ lb N}{100\ lb\ DAP} = \frac{44\ lb\ N}{acre}$$

4. Subtract the N in the DAP from the overall N recommendation (assume soil test N recommendation is 150 lbs N/acre).

N rec. = 150 N/acre - 44 lbs from DAP

**Problem 53.7. How much gypsum should be applied to the following soil?**

The soil has a cation exchange capacity of 30 $mmole_c$/100 gm of soil. The laboratory analysis indicates that the exchangeable sodium percentage, ESP, is 10%. We want to treat the top 6 inches with gypsum so that the final ESP is about 5%. How much gypsum needs to be applied? Note that the atomic weight of Gypsum ($CaSO_4H_2O$) is 172 gm/mole which equals 86*10-3gm/$mmole_c$. We know that:

ESP = $mmole_c$ Na/100 gm soil/CEC ($mmole_c$ cations/100 gm soil), so at an ESP of 5% and 10% respectively

(0.05=Na/30 then Na = 1.5 $mmole_c$ Na/100 gm soil)
(0.1=Na/30 than Na = 3 $mmole_c$ Na/100 gm soil) and since 3-1.5=1.5

We need to exchange

$$\frac{1.5\ mmole_c\ Na}{100\ gm\ soil} * \frac{86 * 10^{-3}\ gm\ gypsum}{mmole_c\ Ca} * \frac{2 * 10^6\ lb\ soil}{acre\ 6\ inch\ soil} = \frac{2580\ lb\ gypsum}{acre\ 6\ inch\ soil}$$

Since there will be inefficient exchange of the Ca for Na, there needs to be an additional amount of gypsum, so 1.5 ton (3,000 lb) gypsum is recommended.

**Problem 53.8. Convert 2 dS/m EC measured using a 1:1 to saturated paste EC. The soil is sand.**

**The conversation equations are:**
A sandy soil has a course soil texture and therefore, the conversation factor for coarse textures should be used.

| | |
|---|---|
| Course soil (sand): | $EC_{saturated\ paste} = 3.01xEC_{1:1} - 0.06$ |
| Medium (silt loam): | $EC_{saturated\ paste} = 3.01xEC_{1:1} - 0.77$ |
| Fine (clay): | $EC_{saturated\ paste} = 2.6xEC_{1:1} - 0.95$ |

EC = 3.01 × 2.01-0.06 = 5.96 dS/m

**Problem 53.9. A soil sample is sent off to a laboratory for analysis. In this analysis, a saturated paste (approximately 100 g soil + 60 ml water) is made and equilibrated for 24 hours. The water is extracted by vacuum and the Na, Ca, and Mg is determined. The water analysis of a soil/water saturated paste is 2136 ppm Na, 2181 ppm Mg, and 3198 ppm Ca. What is its SAR?**

When doing this calculation, it is important to know that Na has a valance of +1, Ca has a valance of +2, and Mg has a valance of +2. The valances are used to convert mmol to mmolc.

**Step 1.** Convert ppm to mmolc/L. For this conversion 1ppm = 1 mg/L

$$\frac{\text{Na mmol}_c}{\text{L}} = \frac{\mathbf{2136}\text{ mg Na}}{L} \times \frac{\text{mmol Na}}{\text{23 mg Na}} \times \frac{\text{1 mmol}_c\text{ Na}}{\text{1mmol Na}} = \frac{\text{92.9 mmol}_c Na}{\text{L}}$$

$$\frac{\text{Mg mmol}_c}{\text{L}} = \frac{\mathbf{2181}\text{g Mg}}{L} \times \frac{\text{mmol Mg}}{\text{24.3 mg Mg}} \times \frac{\text{2 mmol}_c\text{Mg}}{\text{1mmol Mg}} = \frac{\text{179.3 mmol}_c Mg}{\text{L}}$$

$$\frac{\text{Ca mmol}_c}{\text{L}} = \frac{\mathbf{3198}\text{g Ca}}{L} \times\times \frac{\text{mmol Ca}}{\text{40 mg Ca}} \times \frac{\text{2 mmol}_c\text{ Ca}}{\text{1mmol Ca}} = \frac{\text{159.9 mmol}_c Ca}{L}$$

**Step 2.** Calculate SAR

$$SAR = \frac{\frac{mmol_c Na}{L}}{\left(\frac{\left(mmol_c Ca / L + mmol_c Mg\right)}{\mathbf{2}}\right)^{\mathbf{0.5}}} = \frac{\mathbf{92.9}}{\left(\frac{\left(\mathbf{179.3} + \mathbf{159.9}\right)}{\mathbf{2}}\right)^{\mathbf{0.5}}} = \mathbf{7.1}$$

You need to monitor Na inputs (see Chapter 48).

## Herbicides

**Problem 53.10. Calculate the active ingredient when spraying herbicides (lbs active ingredient over 160 a at 20 gal/a):**

The manufacturer's recommended rate of a product is 2 lb active ingredient (AI)/acre. A gallon of the product contains 6 lb AI. How many gallon/acre should be applied?

$$\frac{\mathbf{2}\ lb\ AI}{acre} * \frac{\mathbf{1}\ gal\ product}{\mathbf{6}\ lb\ AI} = \frac{\mathbf{0.33}\ gal\ product}{acre}$$

If the calibration of your spray indicates that you are applying 11.5 gal/acre, how many gallons of product and gallons of water should you load into a 300-gallon spray tank?

$$\frac{\mathbf{.333} gal\ product}{\mathbf{11.5}\ gal\ mix} * \frac{\mathbf{300}}{\mathbf{300}} = \frac{\mathbf{8.7}\ gal\ product}{\mathbf{300}\ gal\ mix}$$

And there will be 300 - 8.7 = 291.3 gal water.

**Problem 53.11. What is the output of a sprayer that has a nozzle output of 28 fluid oz in 29 seconds? The number of nozzles on the boom are 100 and they are spaced at 20 inches.**

$$\text{Sprayer output/nozzle} = \left(\frac{28\text{oz}}{29\text{ sec.}}\right) \times \left(\frac{\mathbf{1}gal}{\mathbf{128}oz}\right) \times \left(\frac{\mathbf{60}\text{sec}}{\mathbf{1}\text{min}}\right) = \frac{\mathbf{0.453}gal}{\text{min/}nozzle}$$

Sprayer output = 50 nozzles x 0.453 gal/(min)(nozzel) = 22.6 gal/min

## Plant Population and Emergence

To determine the plant population, the number of plants contained within an area is determined. For drilled soybeans, we recommend shortly after emergence, measure the row spacing, measure off 5 feet of row, and count all seedlings in the 5 feet of row. Do this at approximately 10 places in the field. The example below shows the calculations.

For broadcast seeding, we recommend that shortly after emergence, producers use a PVC counting frame that measures (inside diameter) 1 foot × 1 foot. The frame is randomly placed on the ground and all plants within the frame are counted. The average of about 10 random counts is used.

For planted beans, measure the row spacing and then measure off 20 feet of row, and count the seedlings per 20 feet of row. If the row spacing is 30 inches, the plant population is calculated as: (counted plants/(row spacing × length of row measured)).

**Problem 53.12.**

If an average of 93 plants were counted in 5 ft of row in a field where the drill row width was 7.5 inches, then the plant population is $\frac{93\,\text{plants}}{5\,\text{ft} \bullet 7.5\,\text{inches}}$. To convert this population to plants/acre, the ft • inch area must be converted to acres. An example is shown below:

$$\frac{9.3\,\text{plants}}{5\,\text{ft} \bullet 7.5\,\text{inches}} \bullet \frac{12\,\text{inch}}{\text{ft}} \bullet \frac{43560\,\text{ft}^2}{\text{acre}} \approx 130{,}000\,\text{plants/acre}$$

***Example broadcast:***

If an average of 2.9 soybean plants are counted per ft$^2$, then the population of the field is $\frac{2.9\text{ plants}}{\text{ft}^2}$.

To convert this population to plants/acre, the ft$^2$ area must be converted to acres. An example is shown below:

$$\frac{\mathbf{2.9}\,plants}{ft^2} \bullet \frac{\mathbf{43560}\,ft^2}{acre} \approx \mathbf{126{,}000}\,plants/acre$$

**Problem 53.13. Calculate the % emergence – if the % germination is 96%, percent pure seed is 99%, the seeding rate was 150,000 seed/acre, and measured population was 125,000 plants (at V2)/acre.**

$$\text{Seeding rate} = \frac{\text{Desired plant population}}{\frac{\%\text{ germ.}}{100} \times \frac{\%\text{ pure seed}}{100} \times \frac{\%\text{ emergence}}{100}}$$

$$\mathbf{150{,}000}/acre = \frac{\mathbf{125{,}000}/acre}{\mathbf{0.96} \times \mathbf{0.99} \times \frac{\%\text{ emergence}}{100}}$$

$$\frac{\%\text{ emergence}}{100} = \frac{\mathbf{125{,}000}/acre}{\mathbf{0.96} \times \mathbf{0.99} \times \mathbf{150{,}000}/acre} = \mathbf{87.7}\%\text{ emergence}$$

The apparent emergence was 80% [100x(1-(150,000-125,000)/150,000)]. The emergence and apparent emergence values are very different and can lead to different interpretations. Low emergence can result from poor seed viability, soil crusting, or a number of other factors.

**Problem 53.14. Assuming a standard bushel of 13% moisture content soybeans weigh 60 lb, what will this standard bushel weigh when dried to 10% moisture?**

When the grain is delivered to an elevator, often the payment is calculated based on the number of bushels of grain delivered. Different grains have different conversion factors. Because the moisture percentage is based on wet weight, the calculations are not straight forward and required several steps. Examples and needed equations are below.

$$\text{\% Grain moisture} = \left(\frac{\text{Water Weight}}{\text{Water Weight} + \text{Dry soybean weight}}\right)100\%$$

$$\text{water weight} = \left(\frac{\frac{\text{\%moisture}}{100} \times \text{Dry soybean weight}}{1 - \text{\%moisture}/100}\right)$$

1 bushel soybean at 13% moisture weighs 60 lbs
1 bushel soybean 0% moisture weights 52.2 lbs

To solve this equation, water weight + dry soybeans = 60 lbs is needed. The dry grain weight is now determined by solving both equations simultaneously. This is accomplished by replacing Water Weight + Dry Soybeans with 60 lbs and rearranging the equation. After this is done, the water weight is calculated to be 7.8 lbs, from which the dry weight can be determined (60 lbs-7.8 lbs = 52.2 lbs).

To determine the weight of a bushel of soybeans that has been dried down to 10% moisture, we use the same equation. These calculations are below:

$$\mathbf{10}\%\text{Moisture} = \left(\frac{\text{WaterWeight}}{\text{Water Weight} + \text{Dry Soybeans}}\right)\mathbf{100}\%$$

Rearrange and substitute 52.2 lbs of dry soybean for Dry Soybeans, which results in the equation:

$$0.10\left(\text{Water Weight} + 52.2\text{lbs}\right) = \left(\text{Water Weight}\right)$$

$$\text{Water Weight} = \frac{0.1 \times 52.2\text{lbs}}{1 - 0.1}$$

Based on these calculations, the water weight is determined (5.8 lbs/bu). This value is added to the dry corn weight to determine the weight of a bu of soybeans that has been dried to 10% moisture content. The bushel of 13% soybeans, dried to 10% moisture content now weighs 58 lbs (58lb = 52.2+5.8 lbs).

**Problem 53.15. What is the estimated yield if the plant population is 140,000 plants/acre, there are 72 beans per plant, and there are 3,600 seeds per lb?**

$$\frac{140{,}000\,\text{plants}}{\text{acre}} \bullet \frac{72\,\text{beans}}{\text{plant}} \bullet \frac{1\,\text{lb beans}}{3{,}600\,\text{kernels}} \bullet \frac{1\,\text{bushel beans}}{60\,\text{lb beans}} = 46.7\,\text{bu/acre}$$

Crop yield estimates are very useful for marketing and planning purposes. Since plant population has been determined at plant emergence, the next step is to determine the average number of pods per plant and then determine the average number of beans per pod. Using this information we are able to calculate the number of beans per acre. Data from the seed testing laboratory at SDSU indicated that soybeans should fall between 2,800 and 4,400 beans/lb. The calculation is based on 1 lb of soybeans containing 3,600 seeds.

**Problem 53.16. If you have 21 soybeans/ft behind the combine, what was your yield loss during combining?**

To estimate combine yield losses, it is assumed that there will be about 3,600 beans per pound (for small and large beans use 4,400 beans/lb and 2,800 beans/lb, respectively). Yield loss can be measured by randomly placing a 1-foot square on the ground after combining and then counting the kernels contained within the square. To obtain a good estimate, this should be done at numerous locations. Once the beans are counted, the count/ft$^2$ are converted to bu/acre by using the appropriate conversion factors. For example, if 21 beans/ft$^2$ are found behind the combine, the yield loss is 4.2 bu/acre. The calculations are below.

$$\text{Yield Loss} = \left(\frac{21\,\text{beans}}{\text{ft}^2}\right)\left(\frac{43560\,\text{ft}^2}{\text{acre}}\right)\left(\frac{1\,\text{lb}}{3{,}600\,\text{beans}}\right)\left(\frac{1\,\text{bu}}{60\,\text{lb}}\right) = \frac{4.2\,\text{bu}}{\text{acre}}$$

$$\text{note that}\left(\frac{21\,\text{beans}}{\text{ft}^2}\right)\left(\frac{1\,\text{bu}/\text{acre}}{5\,\text{beans}/\text{ft}^2}\right) = \frac{4.2\,\text{bu}}{\text{acre}}$$

In many years in South Dakota, there are pods close to the ground. if the header cuts the stem above the pod, we refer to the pods left behind as in-row loss. To determine the magnitude of this loss (in30-inch rows), count the beans in 4 foot of row. This will be beans/(4 feet by 30 inches) or beans/(10ft$^2$). Again use 5 beans/ft$^2$ = 1 bu/acre. It may be possible to reducce the loss of pods close to the ground by rolling the field (Chapter 16).

As a rule of thumb, assume that 5 beans/ft$^2$ = 1 bu/acre.
As a rule of thumb 50 beans left after cutting on stems in 30-inch rows is 1 bu/acre.

**Problem 53.17. Calculate the speed of the reel in the combine based on the following information.**

The reel on the combine header should be traveling at 10% to 25% faster speed than the ground speed of the combine. The speed of the reel can be measured by following the following procedure.

1. Measure the diameter of the reel, outside to outside. Our reel is 4 foot, 9 inches in diameter (4.75 ft).
2. With the combine running at normal field rpm, count the revolations the reel makes in a minute. We put a red flag on one of the bars to make our counting easier. We counted 24.25 revolutions in a minute.
3. Calculate the velocity of travel at the tipe of the reel in (mph) miles per hour. (Note: The circumference of the cirlce is calculated as pi x diameter or 3.14159 x 4.75.)

$$\frac{24.25\ \text{rev}}{\text{minute}} \times \frac{4.75\text{ft} * 3.14159}{\text{rev}} \times \frac{60\ \text{minutes}}{\text{hour}} \times \frac{1\ \text{mile}}{5280\ \text{ft}} = 4.11\ \text{mph}$$

4. Since we typically combine at 3.5 mph, we need the end of the reel to be traveling somewhere 10% to 25% faster speed than the ground speed of the combine, so (3.5+3.5x0.1 and 3.5+3.5x0.25) is 3.85 to 4.37 mph. Our reel is traveling 4.11 mph so the reel meets the criteria.

## Soybean Storage in a Cylinder

To determine how much soybean can be stored in a cylinder, the volume of the bin must be determined. Many grain storage systems are cylinder in shape and the volume is determined using the equation for a cylinder and the volume of a bushel (Table 53.1).

The volume for a cylinder is v = pr2h; volume of a bushel is 1.244 ft3. π is approximately equal to 3.14159 and r is the radius (2 • r = diameter).

**Problem 53.18. How many bushels of soybeans can be stored in a cylinder that has a diameter of 26 feet and height of 24 feet?**

The amount of grain stored in cylinder-shaped bin is calculated by dividing the volume of the bin by the volume of a bushel. The volume for a bushel is 1.244 $ft^3$. By substituting a value for the radius (half the diameter) into the cylinder equation, the storage capacity per bin is determined.

$$\frac{\pi \bullet 13^2 \bullet 24\text{ft}^3}{\text{bin}} \bullet \frac{1\text{bu}}{1.244\text{ft}^3} = \frac{3.14159 \bullet 13^2 \bullet 24}{\text{bin}} \bullet \frac{1\text{bu}}{1.244\ \text{ft}^3} = \frac{10{,}243\text{bu}}{\text{bin}}$$

**Hint:** Whe doing these calculations, check the units.

**Problem 53.19. How many soybeans are in a pile that has a shape of a cone?**

The equation for a cone and radius are:

$$\text{Volume cone} = \frac{\pi \times r^2 \times \text{height}}{3}$$

$$Radius = \frac{circumference}{\mathbf{2} \times \pi}$$

The height can be estimated using variety of approaches.

**Approach 1:** One approach is to use a clinometer or an Abney level. Using either instrument the % slope is defined by the equation, % slope=100% x rise/run.

The run is the radius of the bottom of the pile plus the distance that you and the clinometer are from the edge of the pile. If the radius is 400 feet and you are 100 feet from the edge of the pile, how high is the pile if a clinometer is used to determine that the slope is 20%?

**Solution:** Then the rise is:

$$\%\,slope = \frac{rise}{run} \times \mathbf{100}\%;$$
$$rise = \frac{\%\,slope}{\mathbf{100}\%} \times run$$
$$rise = \mathbf{0.2} \times \mathbf{500} = \mathbf{100}ft$$

Then the volume is:

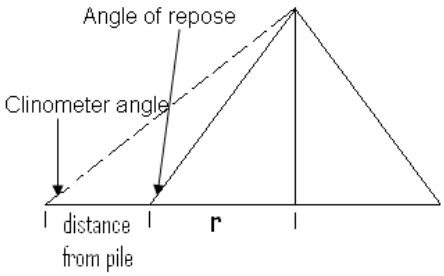
$$\text{Volume cone} = \frac{\pi \times r^2 \times \text{height}}{3}$$
$$\text{Volume cone} = \frac{3.14 \times 400^2 \times 100}{3} = 16.67 \times 10^6\,\text{ft}^3$$

**Approach 2:** Use the angle of repose to estimate slope. Different grains have different angles of repose.

| Crop | Angle (AR) | Tangent (tan(AR)) |
|---|---|---|
| Barley | 28 | 0.53 |
| Corn (Shelled) | 23 | 0.42 |
| Oats | 28 | 0.53 |
| Soybeans | 25 | 0.47 |
| Sunflowers | 27 | 0.51 |
| Wheat | 25 | 0.47 |

(Adapted from Wilke & Wyatt, 2002 and Grain Drying Storage, and Handling Handbook, MWPS-13)

**Angles of repose that**
**Typically result from piling grain**




Measuring volume of
a grain pile

**Solution**

Circumference = $\pi 2r$ = 100ft

$r = {}^{100ft}\!/_{2\pi} = 15.9$ ft

Because than $\theta$ = opposite/adjacent, Tan 25º = height/15.9 ft

0.47 × 15.9 = height

Height = 7.473 ft

Volume = $1/3\ \pi r^2$height

Volume = $1/3 \times 3.14 \times (15.9\ ft)^2 \times 7.473\ ft = 1978\ ft^3$

Volume = $1978\ ft^3 \times 1\ bu/1.244\ ft^3$ = 1590 bu soybeans

## References and additional information

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