Effects of Drought Stress on Soybean Production

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This publication discusses 1) how drought stress affects potential soybean yields, 2) how to estimate potential soybean yields prior to harvest, and 3) alternate uses of drought stressed soybeans.

Soybeans are more flexible than corn in adapting to periods of moisture stress. As corn matures through tasseling to silking, moisture status becomes critical. In contrast, soybeans respond to moisture stress over a longer period of time and range of growth stages.

Soybean varieties adapted to South Dakota are of the indeterminant type, exhibiting a number of growth stages at the same time. When a plant begins the floral or reproductive stages (R1 to R8) it is still growing *vegetative stage) and can produce more leaves and stems. This wide range in growth stages allows soybeans to compensate for drought when growth has been reduced at other growth stages.

Soybean yield potential is affected by total number of pods per plant, number of beans per pod, and weight per bean (seed size).

The yield component affected depends on the reproductive (R) stage when stress occurs. The most critical stage for yield potential begins as the crop reaches the full pod stage (R4, pod is ¾ inch long at one of the four uppermost nodes on the main stem with a fully developed leaf).

Drought stress any time from R4 to shortly after R6 (beginning to seed, seeds are 1/8 inch long) will reduce yields more than the same stress in any other period of development. Within this period, the R45 (late pod formation) to about R55 (shortly before full seed) is especially critical, because flowering ceases and can no longer compensate for lost pods. The younger pods and stems are also more susceptible to aborting under stress than older pods and seeds.

Yield reductions at this time are mainly the result of a loss in total pods per plant. Should moisture become available after R55, seed size may compensate for yield reductions. However, seed size is genetically limited.

One method of estimating the yield potential of soybeans is to use the calculator that is found at the end of this publication. It will require collecting data from the field and plugging the numbers into the worksheet.

An estimate of yield potential may only be good for a short time. If the drought continues and causes additional pod abortion or prohibits seed filling, the estimate may no longer be valid. Generally, an estimate is more accurate when it is taken closer to crop maturity. An estimate prior to leaf loss may tell whether the crop should be harvested for grain or forage. A later one may show whether harvesting is justified.

Soybeans can be harvested as either hay or silage, although difficulties in curing the large stems of the plant make drying hay difficult.

Soybean hay varies widely in forage quality and palatability depending on leaf/stem ratio, coarseness of stem, and how well it is packaged and stored. A hay conditioner aids in drying the stems.
If used for silage, soybeans should be wilted down to 40 to 50% dry matter before chopping.

The optimum stage of development for harvesting soybean forage is when pods have formed and the lower leaves are just beginning to turn yellow.

Research from Ohio State University compared the forage quality of soybean and alfalfa silage (table). Palatability trials indicate that soybean forage is acceptable by livestock, although animals may sort the forage to a greater extent than alfalfa because of the coarseness of the stem. A greater amount of refusal can be expected.

### Development and Timing of Vegetative Growth, Flowering, Pod Development, and Seed filling of Soybeans

(University of Iowa)

<table>
<thead>
<tr>
<th>R Stage</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>R4</th>
<th>R5</th>
<th>R6</th>
<th>R7</th>
<th>R8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days</td>
<td>0</td>
<td>10</td>
<td>20</td>
<td>30</td>
<td>40</td>
<td>50</td>
<td>60</td>
<td>70</td>
</tr>
</tbody>
</table>

- **Seed Filling**
- **Pod Development**
- **Flowering**
- **Vegetative Growth**

### Forage Quality of Soybean and Alfalfa Silage. Adapted from Ohio State University.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Stage</th>
<th>Protein</th>
<th>ADF&lt;sup&gt;1&lt;/sup&gt;</th>
<th>NDF&lt;sup&gt;2&lt;/sup&gt;</th>
<th>P</th>
<th>Ca</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>early bud</td>
<td>22.4</td>
<td>31.1</td>
<td>35.2</td>
<td>0.44</td>
<td>1.02</td>
</tr>
<tr>
<td>Soybeans</td>
<td>early pod</td>
<td>1.2</td>
<td>40.6</td>
<td>48.6</td>
<td>0.39</td>
<td>1.30</td>
</tr>
</tbody>
</table>

1. ADF = acid detergent fiber, a measure of digestibility; the lower the ADF value, the higher the digestibility
2. NDF = neutral detergent fiber, a measure of forage intake; the lower the NDF value, the greater the intake.
ESTIMATING SOYBEAN YIELD PRIOR TO HARVEST

1. Determine the number of feet of row needed to make 1/1000 of an acre (please see below table).

2. Count the number of plants in 10 different randomly selected sample areas. (Please use the number of row feet listed above. Calculate the average. \( \text{Avg.} = \frac{1}{10} \text{ of row feet} \times 1000 \))

3. Count the number of pods per plant on 10 randomly selected plants from each sample area. Calculate the average. \( \text{Avg.} = \frac{1}{10} \text{ of pods per plant} \times 1000 \)

4. Calculate pods/acre by multiplying plant population by pods/plant. \( \text{A} \times \text{B} = \frac{\text{Pods per acre}}{\text{Plants per acre}} \times 1000 \)

5. Calculate seeds/acre by multiplying pods per acre by an estimate of 2.5 seeds/pod. \( 2.5 \times \text{C} = \frac{\text{Seeds per acre}}{\text{Pods per acre}} \times 2.5 \times 1000 \)

6. Calculate pounds/acre by dividing seeds/acre by an estimate of 2,900 seeds/pound. \( \frac{\text{D}}{2900} = \frac{\text{Pounds per acre}}{\text{Seeds per acre}} \times 2.9 \times 1000 \)

7. Estimate yield by dividing pounds/acre by 60 pounds per bushel. \( \frac{\text{E}}{60} = \frac{\text{Yield}}{\text{Pounds per acre}} \times 60 \)

LENGTH OF ROW EQUAL TO 1/1,000 ACRE

An accurate estimate of plant population per acre can be obtained by counting the number of plants in a length of row equal to 1/1,000 of an acre. Make at least three counts in separate sections of the field, calculate the average of these samples, then multiply this number by 1,000.

<table>
<thead>
<tr>
<th>Row width (Inches)</th>
<th>Length of single row to equal 1/1,000 of an acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>87.0 inches</td>
</tr>
<tr>
<td>7</td>
<td>74.0 inches</td>
</tr>
<tr>
<td>8</td>
<td>65.0 inches</td>
</tr>
<tr>
<td>10</td>
<td>52.0 inches</td>
</tr>
<tr>
<td>15</td>
<td>34.0 inches</td>
</tr>
<tr>
<td>20</td>
<td>26.0 inches</td>
</tr>
<tr>
<td>30</td>
<td>17.0 inches</td>
</tr>
</tbody>
</table>

*The number of seeds per pod and the number of seeds per pound may differ between varieties and years. The values listed above are averages and may need to be adjusted.

Worksheet adapted from Purdue Extension publication “Estimating Soybean Yields Simplified,” by Shaun Casteel, Purdue Extension Soybean Specialist.