SOYBEAN YIELD LOSS BY GROWTH STAGE

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Drought Stress in Soybean

Moderate to severe drought stress afflicted much of Wisconsin's soybean crop in 2007. In soybean there are two growth periods for which soil moisture is critical for optimum growth and development: at planting and during the reproductive stages from bloom through pod fill. The time period from stand establishment to bloom is not as critical. Drought stress during this time period will often shorten internodes; however yield loss rarely occurs. In Wisconsin the main reproductive growth in soybean occurs from early July to mid-September. Soybean in this phase use about 1/4 to 1/3 inch of water per day. Lack of sufficient water can cause flowers and young pods to abort reducing the number of seeds per plant. Also, soybean plants reduce the size of their leaf pore openings to reduce the loss of water vapor. This also reduces the intake of carbon dioxide and the manufacturing of photosynthates which slows plant growth. When normal soil moisture returns, normal growth is resumed. This ability to reduce metabolic activity allows plants to tolerate dry spells without dying or harming their ability to resume growth when normal moisture returns.

In most years, water is not a major factor limiting the yield of soybean on medium and fine textured soils in Wisconsin. Research conducted between 1996 and 2000 at the Arlington Research Station shows no yield difference between irrigated and non-irrigated soybeans. However there was significantly more biomass (total plant weight) per acre in the soybeans that received regular irrigation. The extra biomass was concentrated in the leaf and stem portion of the plants, and not in the seeds.

Managing soybeans for drought tolerance involves using the same sound growing practices that would normally be used for high yields. Soil fertility, especially pH levels are important for good root growth and proper nodulation. Low soil pH inhibits nodulation and uptake of essential micronutrients which make soybeans more susceptible to drought injury. Healthy soybean plants will also have deep root growth which enables to plant to take advantage of deeper moisture supplies. Where hardpans or compacted zones are a problem, deep tillage should be used to break these up and allow root growth into subsoil moisture. Conservation tillage can help the crop withstand the effects of drought by providing residue cover to reduce soil moisture evaporation. Long term conservation tillage also improves soil tilth which helps rainfall infiltration and water movement. Finally, narrow row spacings should be used since the canopy formed by the plants increases competition with weeds and acts as a barrier to evaporative soil moisture losses.

If drought has severely affected pod set and seed fill, and if livestock feed is needed, soybeans can be harvested as a forage for ensiling. Highest protein and yields are obtained from soybean harvested at the R6 to R7 growth stage. Harvesting soybeans for forage between the R1 and R5 stage will result in a very high quality silage, but dry matter yields will be reduced significantly. Forage quality will be reduced from R5 soybean forward if a conditioning process is used during harvest. Conditioning will cause significant seed shattering.

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Germination

In 2007, **v**ariable and delayed emergence in conventional (more common) and no-till soybean raised several questions across the Midwest. If soybean was planted into dry soil and had not imbibed water (seed did not swell) then there is little to no concern for growers. Once a significant rainfall event occurs the soybean will imbibe water, germinate, and emerge as normal. For yield estimates we would assign the day it rained as the new planting date.

The more difficult question to answer was how viable was the soybean seed once imbibition and/or germination has begun. The critical seed moisture content for soybean is 20% moisture. A soybean seed that has imbibed water, has a split seed coat, or has an emerged radicle will continue to germinate and grow as normal once the seed is re-hydrated if the seed (germ) remains above 20% moisture (Senaratna and McKersie, 1983). If the moisture content within a soybean seed falls to 10% then a dramatic difference exists among the different seed germination stages. If the seed has imbibed water for 6 hours (I am assuming this means the seed has swelled but the seed coat has not broken) then the seed is dehydrated to 10% moisture, germination is not affected. If the seed has imbibed water for 12 to 24 hours (seed coat broken, but prior to radicle emergence then germination is reduced to 60 to 65%. If the radicle has emerged and seed moisture levels drop to 10% then no survivors can be expected. To test seed viability growers can conduct a simple germination test. First excavate 100 soybean seeds and wrap them in a damp paper towel. Place these seeds in a warm location and after 24 to 36 hours count the number of seeds that have germinated. Remember that a typical soybean percent germination is 90%.

Frost Damage

Unlike corn, the growing point on a soybean plant is exposed to the environment when it emerges. Soybean plants can withstand temperatures down to 28°F. When inspecting a soybean plant for frost injury, first inspect the hypocotyl region (the area above ground but below the cotyledons). If the hypocotyl region is water soaked or discolored, then the plant is dead. If the hypocotyl and cotyledons remain green, but the unifoliate leaves appear dead, then the plant will most likely survive. Soybean axillary buds develop at each leaf axil, including the cotyledon axils. If these axils survive, the plant will continue to grow.

Cotyledon Loss

When soils are crusted, the soybean hypocotyls will swell and increase the force it exerts to break through the crust. If that force is too great, the hypocotyl can snap, killing the plant. The cotyledons can be damaged during emergence in a crusted field. If a plant loses one cotyledon yield loss is rare, but if a plant loses both cotyledons, yield could fall by 2-7 percent.

Defoliation

Yield loss associated with defoliation or hail varies based on growth stage and % defoliation; however stem and leaf area loss during seed development and grain fill (R5 to R 6.5) is the most destructive (Table 1). During this time period pods can be removed from the plant either from hail or through pod abortion caused by significant leaf loss. Direct damage to the pods can also lead to increased disease incidence and seed germinating in the pod.

Wheel Track Damage

Sprayer wheel traffic can damage soybean plants and reduce yield from first flower (growth stage R1) through harvest. Research suggests that an adequate soybean stand (more than 100,000 plants per acre) planted in late April though mid-May can compensate for wheel tracks made when a field is sprayed at R1 (Hanna et al., 2007). Yield loss can occur, however, when wheel

Table 1. Yield loss associated with soybean leaf defoliation based on soybean growth stage.

Growth stage	50	60	70	80	90	100
	---% Yield loss---					
R3	8	11	14	18	24	33
R4	12	16	22	30	39	56
R5	17	23	31	43	58	75
R6	14	18	23	31	41	53
R6.5	4	5	8	13	18	23

Adapted from National Crop Insurance Publication 6302, Soybean Loss Instructions

tracks are made at R1 or later in thin soybean stands (less than 100,000 plants per acre) or late planted soybeans. Regardless of stand, plants could not compensate for wheel tracks made at R3 (early pod development) or R5 (early seed development).

Soybeans planted in narrow rows (≤15 inches) always experienced yield loss in the wheel track area. However, yield loss did not increase when multiple trips were made along the same wheel tracks. The amount of yield lost due to wheel-track damage decreased as spray boom width increased (Table 2). Larger spray booms required fewer passes through the field by the spray rig. This decreased the number of wheel tracks in the field and reduced the amount of damage caused to the soybean crop by the wheels. Additional sprayer trips made using existing wheel tracks caused no additional yield loss at any location.

Table 2. Estimated impact of boom width on grain yield loss due to wheel-track damage in soybean at the Davis-(DPAC), Northeast-(NEPAC), and Southeast-(SEPAC) Purdue Agricultural Centers.

	Boom width (feet)			
	30	60	90	120
	-------------------------------------Yield loss (%)-------------------------------------			
DPAC 2005	5.5	2.8	2.1	1.4
DPAC 2006	6.7	3.4	2.6	1.7
NEPAC 2006	4.3	2.1	1.6	1.1
SEPAC 2005	3.2	1.6	1.2	0.8
Average	4.9	2.5	1.9	1.3

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