5-2009

Best Management Practices for Corn Production in South Dakota: Corn Growth and Development

Kurtis D. Reitsma
South Dakota State University

Sharon Clay
South Dakota State University, sharon.clay@sdstate.edu

Robert G. Hall
South Dakota State University

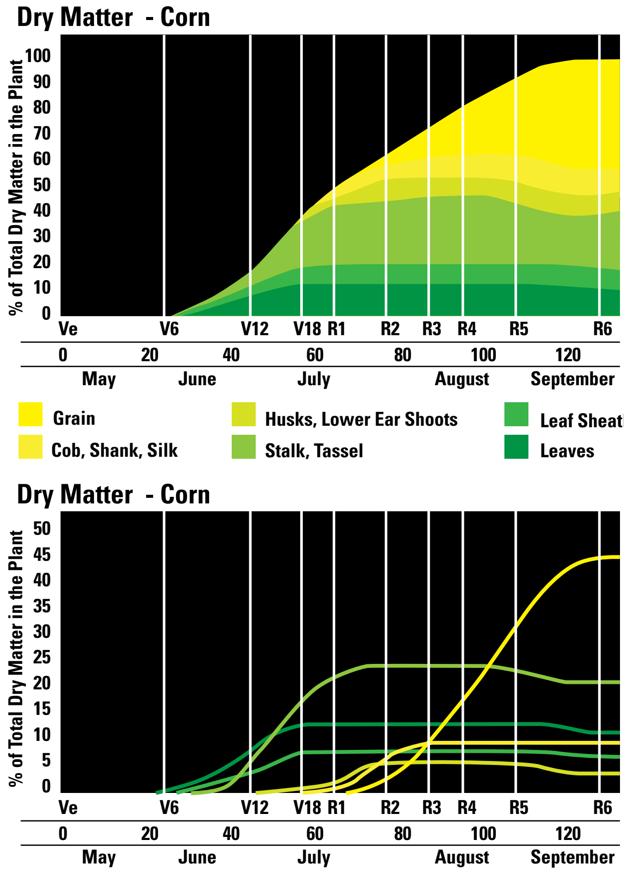
CHAPTER 1
Corn Growth and Development

Corn growth is influenced by cultural practices and available natural resources. The rate of growth and development changes during the season (fig. 1.1). In South Dakota, water and nitrogen (N) are important resources that limit yield. Other factors that reduce yield include disease, insects, weeds, and deficiency of other plant nutrients. For example, disease and insect infestations can reduce water and nutrient uptake or severely damage the plant to the point of yield loss. Weeds compete with the crop for water, nutrients, and light. Stress from temperature and water extremes affects nutrient availability, often increasing pest population and occurrence and ultimately reducing plant growth.

Many management decisions consider stage of growth and development of the crop. Three examples of this: 1) some pesticide products are labeled for use only at certain stages, 2) fertilizer applied at the right time can provide a greater crop response, and 3) water stress at grain fill is more critical than at other stages. Management efficiency can be improved by matching the crop need to the treatment. Understanding how a corn plant grows and develops is important for maximizing efficiency.

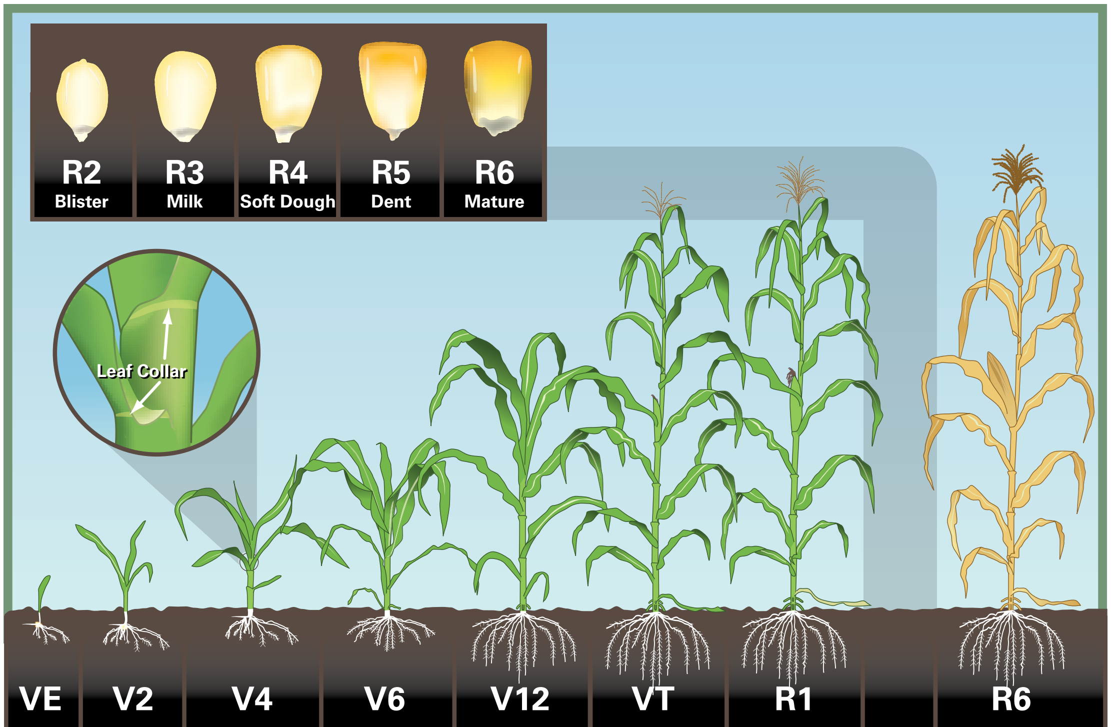
Corn growth and development is divided into vegetative and reproductive stages. The "leaf collar" counting system is a common approach for identifying vegetative growth stages (fig. 1.2). Vegetative growth stages refer to the number of leaf collars up to tasseling (fig. 1.3). Reproductive stages begin at silking (R1) and end at maturity or "black layer" (R6).

Figure 1.1. Dry matter accumulation of corn



(Adapted from Ritchie et al. 1997)

Figure 1.2. Progression of corn growth and development using the leaf collar system

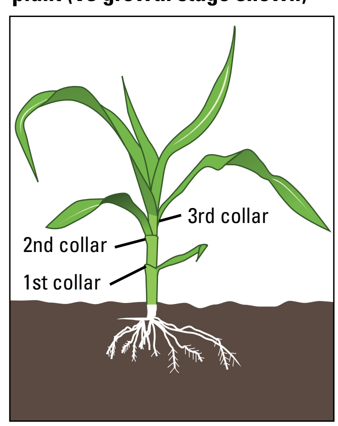


Vegetative Stages		**Reproductive Stages**	
VE	Emergence	R1	Silking
V1	First leaf	R2	Blister
V2	Second leaf	R3	Milk
V(n)	nth leaf	R4	Dough
VT	Tassel	R5	Dent
		R6	Maturity (Black Layer)

Emergence (VE) to Six-Leaf Stage (V6)

Under warm, moist conditions, corn will germinate and emerge 4 to 6 days after planting. Optimal temperature and soil water are critical at this time. Because seed needs to imbibe water to germinate, if soil water is limiting, emergence can be delayed. In residue-covered soils or if spring air temperatures are low, germination may be slow due to cool soil temperature. Soil temperatures at or below 50°F hinder seed germination. Shallow planting (<1½") into warmer soil can accelerate emergence but may result in other problems.

Figure 1.3. Leaf collars on corn plant (V3 growth stage shown)



(Courtesy of Colorado State University)

The first leafy structure that appears is the coleoptile (“spike”), followed by true leaves. Warm, moist, and well-aerated conditions promote vigorous growth and development. New leaves are produced at a single “growing point” near the tip of the stem. The growing point is below the surface of the soil for up to 4 weeks after planting. When the growing point is below the soil surface, the crop usually survives light frost or minor hail. However, the plant is most susceptible to flood damage during this stage.

Corn roots do not explore a significant volume of soil during early growth stages, but the roots do develop rapidly as the plant develops. Corn has two root types: seminal and nodal. Seminal roots are those that emerge immediately after germination and cease growth at V3 but continue to function throughout the life of the plant. Nodal roots are initiated at formation of the first node (V1) and continue to develop until kernel blister. By the V6 growth stage, nodal roots become the major supplier of water and nutrients.

If soil conditions are cool and wet early in the growing season, nutrient deficiencies, especially phosphorus (P), are common. The application of starter fertilizer will usually prevent this problem. If fertility levels are sufficient, early season nutrient deficiencies often disappear and usually do not reduce yield.

Scouting fields and taking action to control weed problems is crucial during early growth. Excessive weed populations can lead to significant yield loss, even if the plants and weeds are not directly competing for resources.

Six-Leaf (V6) to Eight-Leaf (V8) Stage

In South Dakota, corn usually reaches the V6 growth stage by early to mid-June. At the V6 stage, ear shoots begin to develop and the growing point is aboveground, increasing the potential for significant frost or hail damage. Fields should be scouted for N deficiencies, corn rootworm, and other root-pruning insects just prior to corn entering the V6 stage. Side-dressing N is most effective when applied between V6 and V8. Early control of root-pruning insects can reduce damage, but control options are limited; the best option is to plant resistant or genetically modified hybrids. If weeds are controlled with cultivation, cultivate at or near V6 to avoid root pruning.

Nine-Leaf (V9) to Twelve-Leaf (V12) Stage

At V10, the plant is growing rapidly, with new leaves appearing every 2 to 3 days. The plant requires substantial amounts of water and nutrients to maintain this growth rate. Stress from pests, heat, and lack of nutrients and/or water can slow development and reduce yield.

Twelve-Leaf (V12) to Tassel (VT) Stage

Hybrid maturity selection plays an important role at the V12 stage, when the potential number of kernels per ear and ear size are determined. Earlier-maturing hybrids will progress through these stages in a shorter time, resulting in smaller ears compared to later-maturing hybrids. If water and nutrient availability can support a higher population, yield differences between early hybrids and late hybrids can be equalized by increasing plant density or by increasing the population of earlier-maturing hybrids.

Stress between V12 and VT can reduce yields. Severe hail storms that strip leaves and break tassels can result in complete crop loss.

Silk (R1) Stage

At R1, the silks emerge and capture pollen shed from the tassel. Pollen captured by the silks fertilizes ovules on the cob within 24 hours, developing into kernels. Pollen shed typically occurs during early or mid-morning, when moisture and temperature conditions are favorable. This stage is one of the most crucial reproductive stages. Dry (low humidity) and hot (>95°F) conditions result in reduced fertilization and serious yield reductions. With no fertilization, ears are barren.

Insect pests, such as corn rootworm beetle (adult), destroy silks through feeding and can reduce yields (see fig. 1.4). To minimize losses, fields should be scouted for corn rootworm beetles at silking (R1) and controlled if populations exceed economic thresholds.

Figure 1.4. Silk clipping

Severe silk clipping will reduce yield.

(Photo courtesy of Mike Catangui, South Dakota State University)

Potassium (K) uptake is complete at silking, but N and P uptake continues. If N and P are limiting, the plant will attempt to compensate by moving these nutrients from older leaves into upper leaves or the developing grain. At this stage, N- and P-deficiency symptoms can be observed in lower leaves. Unfortunately, nutrient application at this or later growth stages will not make up for these deficiencies.

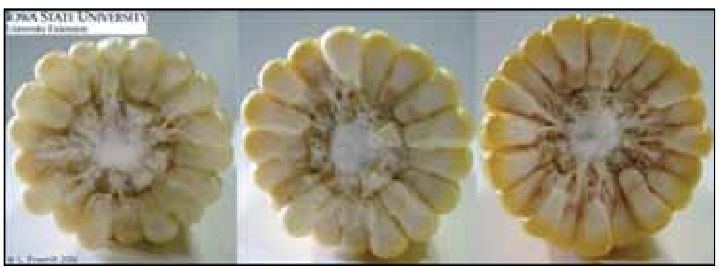
Blister (R2) to Maturity (R6)

After pollination, kernel formation begins. The kernel appears as a "blister" at the R2 growth stage. Starch begins to accumulate in the kernel as the plant initiates a period of kernel fill. Grain fill proceeds rapidly and the kernels take on a light yellow color as they enter the "milk" stage (R3). Although not as critical as the R1 stage, stress at this time can reduce kernel size and weight, and some kernels may still abort. As the kernels mature to the the dough (R4) stage, they change from a milky consistency to soft and sticky. At R4, the kernels have accumulated nearly half of their mature weight (fig. 1.5).

From R2 to R6, grain moisture content declines from 85% at R2 to approximately 55% at R5 (dent). Irrigation should cease at R2. Additional water at or after R2 does not enhance yield, slows dry-down, and may encourage stalk and grain diseases. A hard frost at R5 can kill the plant, thus stopping kernel development. Corn killed by frost prior to black layer (R6) usually has a low test weight and a slower dry-down rate. Selecting a hybrid that matures 2 to 3 weeks before fall frost reduces these risks. If early frost kills the plant, the crop can be harvested and ensiled as high-moisture grain for animal feed.

At "black layer" (R6), the area near the tip of the mature kernels appears dark. At R6, the grain is mature, with moisture contents between 30 to 35% (fig 1.6). If the crop is harvested for grain, allowing the crop to dry in the field reduces drying costs; but if left in the field too long, there is an increased chance of harvest loss. At 15% moisture, corn can be stored safely for up to 6 months. For long-term storage, to avoid spoilage, corn should be dried to 12% moisture .

Figure 1.5. Progression of kernel development



L to R: less to more developed.
(Photo courtesy of Iowa State University)

Hybrids have subtle differences in growth and development (with respect to number of leaves, ears, maturity, dry-down, and other traits). Early harvest is rarely profitable, due to drying cost or dockage. Corn can be left in the field if stalks maintain strength and if ear drop is not a problem. Harvest loss from lodging and ear drop can be significant in fields damaged by European corn borer or Western bean cutworm. In these situations, timely harvest to reduce harvest loss should be weighed against drying cost. Scouting to assess stalk condition, ear retention, and grain moisture is recommended.

Figure 1.6. Corn kernel at maturity (R6)

(Photo courtesy of Iowa State University)

The Federal Crop Insurance Corporation (FCIC) follows a variation of the leaf collar system for staging corn; a leaf is counted when 40 to 50% of the leaf is exposed. Table 1.1 provides comparisons between the two systems.

Table 1.1. Comparison: leaf collar and FCIC[1] corn growth staging systems for a 120-day (RM[2]) hybrid

FCIC	Leaf Collar	Description	Days/ Stage	GDUs/ Stage	Days after seeding	GDUs after seeding
		---Emergence – Vegetative Stages---				
-	V0	Seeding to germination	5 – 10	100 – 150	5 – 10	100 – 150
-	VE	Coleoptile opens	2 – 4	66	7 – 14	166 – 216
V2	V1	1st leaf collar	3	66	10 – 17	232 – 282
V3	V2	2nd leaf collar	3	66	13 – 20	298 – 348
V4	V3	3rd leaf collar	3	66	16 – 23	364 – 414
V5	V4	4th leaf collar	3	66	19 – 26	430 – 480
V6	V4	4th leaf collar	3	66	19 – 26	430 – 480
V7	V5	5th leaf collar	3	66	22 – 29	496 – 546
V8	V6	6th leaf collar	3	66	25 – 32	562 – 612
V9	V7	7th leaf collar	3	66	28 – 35	628 – 678
V10	V7	7th leaf collar	-	-	-	-
V11	V8	8th leaf collar	3	66	31 – 38	694 – 744
V12	V9	9th leaf collar	3	66	34 – 41	760 – 810
V13	V10	10th leaf collar	3	66	37 – 44	826 – 876
V14	V11	11th leaf collar	3	66	40 – 47	892 – 942
V15	V12	12th leaf collar	3	66	43 – 50	958 – 1,008
V16	V13	13th leaf collar	3	66	46 – 53	1,024 – 1,074
V17	V14	14th leaf collar	3	66	49 – 56	1,090 – 1,140
V18	V15	15th leaf collar	2	48	51 – 58	1,138 – 1,188
	V17	17th leaf collar	2	48	55 – 62	1,234 – 1,284
	V18	18th leaf collar	2	48	57 – 64	1,282 – 1,332
	V19	19th leaf collar	2	48	59 – 66	1,330 – 1,380
	V20	20th leaf collar	2	48	61 – 68	1,378 – 1,428
	V(n)	*n*th leaf collar	-	-	-	-
	VT	Tassel extended – no silks	4	100	65 – 72	1,478 – 1,528
		---Reproductive Stages---				
Silked	R1	Silked – pollen shed	4	100	69 – 76	1,578 – 1,628
Silks brown		Silks 75% brown	5	125	74 – 79	1,703 – 1,753
Pre-blister		No fluid in kernels	4	100	78 – 85	1,803 – 1,853
Blister	R2	Kernels are watery	4	100	82 – 89	1,903 – 1,953
Early milk		Kernels begin to yellow	4	100	86 – 93	2,003 – 2,053
Milk	R3	Kernels yellow; no solids	5	100	91 – 98	2,103 – 2,153
Late milk		Kernels contain semi-solids	4	100	95 – 102	2,203 – 2,253
Soft dough	R4	Kernels pasty	5	100	100 – 107	2,303 – 2,353
Early dent		Kernels begin to dent	5	100	108 – 115	2,403 – 2,453
Dent	R5	Kernels soft but dented	5	125	113 – 120	2,528 – 2,578
Late dent		Kernels dented but drying	5	125	118 – 125	2,653 – 2,703
Nearly mature		Kernel embryo not hard	5	125	123 – 130	2,778 – 2,828
Mature	R6	Black layer	5	125	128 – 135	2,903 – 2,953

All values are approximations, as the values may vary over years, production environments, and locations.

[1] Federal Crop Insurance Corporation (FCIC), operated by the United States Department of Agriculture, Risk Management Agency

[2] Relative maturity (RM)

(Adapted from USDA-FCIC, Corn Loss Adjustment Standard Handbook, 2007.)

Additional Information and References

Corn Production. 2007. Iowa State University, Agronomy Extension. http://www.agronext.iastate.edu/corn/.

Nielson, R.L. 1996. Drought & heat stress effects on corn pollination. Purdue University, Agronomy Department. West Lafayette. http://www.agry.purdue.edu/ext/corn/news/articles.96/p&c9635.htm.

Ritchie, S.W., J.J. Hanway, and S.J. Lupkes. 1997. How a corn plant develops. Special Report No. 48. Iowa State University of Science and Technology, Cooperative Extension Service. Ames. http://www.agronext.iastate.edu/corn/production/management/growth/.

United States Department of Agriculture, Federal Crop Insurance Corporation. 2007. Corn loss adjustment standard handbook. FCIC-25080 (11-2006). http://www.rma.usda.gov/handbooks/25000/2007/07_25080.pdf.

WeedSoft© crop growth stage learning module; Corn. 2007. University of Nebraska, Lincoln. http://weedsoft.unl.edu/Publications.htm.

Reitsma, K.D., S.A. Clay, and R.G. Hall. 2009. "Corn growth and development." Pp. 3–8. In Clay, D.E., K.D. Reitsma, and S.A, Clay (eds). Best Management Practices for Corn Production in South Dakota. EC929. South Dakota State University, South Dakota Cooperative Extension Service, Brookings, SD.

Support for this document was provided by South Dakota State University, South Dakota Cooperative Extension Service, South Dakota Agricultural Experiment Station; South Dakota Corn Utilization Council; USDA-CSREES-406; South Dakota Department of Environment and Natural Resources through EPA-319; South Dakota USGS Water Resources Institute; USDA-North Central Region SARE program; Colorado Corn Growers Association; and Colorado State University.