

Predicting Soybean Reproductive Stages in Virginia

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Planting date and maturity affect the time and duration that soybeans remain in each reproductive stage. Being able to predict stages of reproduction would help growers plan necessary management practices well ahead of time and execute them at the right stage. This article provides research-based predictions of the onset and duration of each reproduction stage across multiple planting dates and relative maturities for both full-season and double-crop soybean production systems in Virginia.

Soybean development is categorized into vegetative and reproductive stages (Table 1). The vegetative stages, denoted as “V,” relate to the number of nodes on the main stem. The reproductive stages, denoted as “R,” relate to flowering, pod and seed formation, and maturation. Node counting starts with the unifoliate node, which is the first node above the cotyledon where true leaves develop. Reproductive stages begin with R1, when flowers appear on any node of the main stem, and end with R8, when plants mature.

Pod development and seed fill (which occurs during stages R3-R6) are the most vital development stages for high-yielding soybeans. Any stress, including water deficiency, high temperature, or pests can cause substantial yield loss. Many soybean management tactics (e.g., insect pest scouting, modeling for disease development, tissue sampling for diagnosis of nutrient deficiency, timely pesticide and foliar fertilizer application, irrigation scheduling, etc.) require proper development stage identification, an understanding of how the environment and pests affect the crop during these stages, and the ability to estimate when these



Indeterminate soybean flower.

stages will occur during the season. For example, nutrient deficiencies should be corrected with foliar applications before or soon after R2. Foliar fungicide application is recommended during pod set (R3-R4). Pod- and seed-feeding insects are most problematic from R3 through R5. In addition, many herbicide labels restrict applications after particular stages to avoid crop injury and/or pesticide residue in the harvestable crop. Plus, proper irrigation timing throughout the reproductive stages is critical to avoid drought stress. The VCE publication Soybean Growth and Development (<http://pubs.ext.vt.edu/CSES/CSES-134/CSES-134.html>) discusses in more detail these and other management practices associated with each stage (Holshouser and Ciampitti 2015).

Table 1. Soybean developmental stages (Fehr and Caviness 1977).

Stage	Abbreviated Stage description	Full stage description
Vegetative Stage		
VE	Emergence	Cotyledons above the soil surface
VC	Cotyledon	Unifoliolate leaves unroll and have no edge touching
V1	First-node	Completely developed leaves at the unifoliolate node
V2	Second-node	Completely developed trifoliolate leaf at the second node above the unifoliolate node
V3	Third-node	Three nodes with a fully-developed leaf on the main stem beginning with the unifoliolate node
Vn	nth-node	n number of nodes with a fully-developed leaf on the main stem beginning with the unifoliolate node
Reproductive Stage		
R1	Beginning bloom	One open flower at any node on the main stem
R2	Full bloom	Open flower at one of the two uppermost nodes on the main stem with a completely developed leaf
R3	Beginning pod	Pod 0.5-cm (3/16 inch) long at one of the four uppermost nodes on the main stem with a completely developed leaf
R4	Full pod	Pod 2-cm (3/4 inch) long at one of the four uppermost nodes on the main stem with a completely developed leaf
R5	Beginning seed	Seed 0.3-cm (1/8 inch) long in a pod at one of the four uppermost nodes on the main stem with a completely developed leaf
R6	Full seed	Pod containing full size green seeds at one of the four uppermost nodes on the main stem with a completely developed leaf
R7	Beginning maturity	One normal pod on the main stem has reached its mature pod color. Physiological maturity
R8	Full maturity	95% of pods have reached their mature pod color. Five- to 10-day drying period is required to reach harvest maturity

Data Acquisition

The onset of each reproductive stage for both full-season and double-crop soybeans was recorded from Virginia Official Variety Tests conducted at Orange, Painter, and Suffolk during 2014 to 2016. Soybean maturities ranged from maturity group III through maturity group V for full-season and maturity group IV through maturity group V for double-crop cropping systems. Cultivars were categorized into several relative maturity groupings (denoted as RMG) representing early, mid, or late maturities within each maturity group. Planting dates ranged from early-May to mid-June for full-season and mid-June to mid-July for double-crop systems. Planting dates were categorized into early, mid, and late parts of the month. This resulted in 40 planting-date RMG combinations for full-season and 18 planting-

date RMG combinations for double-crop soybean. Reproductive stages were predicted by regressing the time (days after planting, or DAP) required to reach each reproductive stage across the number of reproductive stages using a quadratic regression model that included planting date and RMG. Location was not included because it did not affect the DAP for each reproductive stage.

Prediction of Reproductive Stages

The number of days needed for any RMG to advance to the next stage changed with planting date, regardless of whether the soybeans were grown in a full-season or double-crop system (Tables 2 and 3). In other words, soybean development cannot be predicted based solely on RMG or planting date, but both need

Table 2. Number of days after planting for soybean maturity groups III, IV, and V to reach the listed reproductive stages in Virginia under full-season conditions.

Relative maturity group	Planting date	Reproductive stage							
		R1	R2	R3	R4	R5	R6	R7	R8
		days after planting							
Mid III (3.4-3.6)†	Early May	44	53	63	75	87	100	114	129
	Mid May	50	55	62	71	81	94	109	126
	Late May	41	47	54	64	75	89	104	122
	Early June	36	44	52	62	72	84	97	110
	Mid June	36	41	48	57	68	82	97	115
Late III (3.7-3.9)	Early May	44	54	65	76	88	101	115	129
	Mid May	49	55	63	72	84	97	112	129
	Late May	42	47	54	64	76	90	107	125
	Early June	39	45	53	62	72	84	97	111
	Mid June	35	41	49	58	69	82	96	112
Early IV (4.0-4.3)	Early May	40	53	67	80	94	107	121	135
	Mid May	48	54	63	73	86	102	120	140
	Late May	41	46	54	65	78	95	114	135
	Early June	41	46	54	63	74	86	100	116
	Mid June	38	42	49	58	69	84	100	119
Mid IV (4.4-4.6)	Early May	40	53	67	81	95	110	124	139
	Mid May	49	55	63	73	86	102	120	141
	Late May	43	48	56	66	80	97	116	139
	Early June	42	48	55	64	75	87	101	116
	Mid June	38	41	48	57	69	85	103	125
Late IV (4.7-4.9)	Early May	40	54	68	83	97	111	125	139
	Mid May	49	55	64	76	90	106	125	146
	Late May	45	50	58	69	83	100	120	143
	Early June	48	51	57	66	77	91	107	127
	Mid June	39	43	51	60	73	88	105	126
Early V (5.0-5.3)	Early May	69	75	83	93	103	116	129	144
	Mid May	60	66	75	86	99	115	133	153
	Late May	51	58	66	78	92	109	128	151
	Early June	52	56	63	73	85	100	118	138
	Mid June	45	51	59	69	81	95	111	130
Mid V (5.4-5.6)	Early May	75	80	87	96	108	123	140	159
	Mid May	68	73	81	92	105	121	140	161
	Late May	60	66	74	84	97	112	130	151
	Early June	61	65	72	83	97	115	136	160
	Mid June	51	56	62	72	84	98	115	135
Late V (5.7-5.9)	Early May	81	82	88	96	108	124	143	165
	Mid May	71	75	82	92	105	121	139	161
	Late May	60	65	73	83	96	112	130	151
	Early June	61	65	72	82	96	114	135	160
	Mid June	55	57	63	72	84	100	119	141

† Only 10 mid-III varieties were included in this data set; therefore, caution is recommended when using results from this limited data.

Table 3. Number of days after planting for soybean maturity groups IV and V to reach the listed reproductive stages in Virginia under double-crop conditions.

Relative maturity group	Planting date	Reproductive stage							
		R1	R2	R3	R4	R5	R6	R7	R8
days after planting									
Early IV (4.0-4.3)	Mid June	39	46	54	64	75	88	102	117
	Late June	38	43	50	60	71	85	102	120
	Early July	38	41	46	54	64	77	93	111
Mid IV (4.4-4.6)	Mid June	40	46	54	64	75	88	103	119
	Late June	39	44	52	62	74	88	104	122
	Early July	36	40	46	55	65	79	94	112
Late IV (4.7-4.9)	Mid June	44	50	57	67	78	91	106	123
	Late June	40	45	53	63	75	89	105	123
	Early July	37	40	46	54	66	80	97	118
Early V (5.0-5.3)	Mid June	48	55	63	72	84	96	110	126
	Late June	45	50	58	68	80	95	113	132
	Early July	41	44	50	59	71	86	103	124
Mid V (5.4-5.6)	Mid June	59	64	72	80	90	102	115	130
	Late June	51	55	62	71	83	97	114	133
	Early July	47	50	56	64	75	88	104	122
Late V (5.7-5.9)	Mid June	59	64	71	80	90	102	115	130
	Late June	51	56	63	72	83	97	113	132
	Early July	46	50	56	64	75	87	102	119

to be considered together. For both cropping systems, days to flower (R1) generally decreased as planting date was delayed. The only exceptions were when maturity group III or IV varieties were planted in early May in full-season systems. This may be due to limited data for the early May planting date (only one early May planting date in three years). However, this trend did not continue through the later development stages. Delayed planting tended to reduce the total soybean-growing period. While this insures that soybean will reach maturity in a shorter growing season, less time until R1 results in less leaf area and less time in the pod and seed filling stages results in less yield.

Duration of Reproductive Stages

The duration of the flowering period (R1-R3) was sometimes longer for maturity group III and IV soybean cultivars (mostly indeterminate soybean)

than maturity group V soybean cultivars (mostly determinate soybean), but depended on planting date (Tables 4 and 5). The flowering period differed little among planting dates for full-season soybean except for the early-May planting; but decreased with delayed planting for double-crop soybeans. The pod set period (R3-R4) did not differ among RMGs; but tended to be one to four days longer for early than late planting. Of the periods listed in Table 4 and 5, seed filling (R5-R7) is the most important. The length of seed filling directly relates to yield, and yield usually increases with longer seed-filling periods. The duration of the seed-filling period usually decreased by one to three days with each earlier RMG. Total duration of reproductive stages (R1-R8) of any RMG was shorter for the double-crop than the full-season soybean. Similarly, delaying full-season planting until early or mid June, and double-crop planting until early July, tended to reduce the reproductive period.

Table 4. Predicted duration of reproductive stages for full-season soybean in Virginia.

Relative maturity group	Planting date	Reproductive stage			
		R1-R3	R3-R5	R5-R7	R1-R8
days					
Mid III† (3.4-3.6)	Early May	20	23	27	85
	Mid May	12	20	28	76
	Late May	13	21	29	81
	Early June	16	20	24	74
	Mid June	14	20	26	76
Late III (3.7-3.9)	Early May	21	24	27	86
	Mid May	14	21	28	80
	Late May	13	22	31	84
	Early June	14	19	24	72
	Mid June	14	20	27	77
Early IV (4.0-4.3)	Early May	27	27	27	95
	Mid May	14	24	33	91
	Late May	13	24	35	94
	Early June	14	20	26	75
	Mid June	11	21	31	81
Mid IV (4.4-4.6)	Early May	27	28	29	99
	Mid May	14	24	34	92
	Late May	12	24	36	96
	Early June	13	20	26	74
	Mid June	10	22	34	87
Late IV (4.7-4.9)	Early May	29	28	28	99
	Mid May	16	25	35	97
	Late May	13	25	37	98
	Early June	9	20	30	79
	Mid June	12	22	33	87
Early V (5.0-5.3)	Early May	14	20	26	76
	Mid May	15	24	34	94
	Late May	15	26	36	99
	Early June	12	22	32	86
	Mid June	14	22	31	85
Mid V (5.4-5.6)	Early May	11	21	32	84
	Mid May	13	24	35	93
	Late May	13	23	33	90
	Early June	11	25	39	100
	Mid June	11	21	32	84
Late V (5.7-5.9)	Early May	7	21	34	84
	Mid May	11	23	34	90
	Late May	13	23	34	91
	Early June	10	25	39	98
	Mid June	8	21	34	86

† Only 10 mid-III varieties were included in this data set; therefore, caution is recommended when using results from this limited data.

Table 5. Predicted duration of reproductive stages for double-crop soybean in Virginia.

Relative maturity group	Planting date	Reproductive stage			
		R1-R3	R3-R5	R5-R7	R1-R8
days					
Early IV (4.0-4.3)	Mid June	15	21	27	78
	Late June	12	21	30	82
	Early July	8	18	28	73
Mid IV (4.4-4.6)	Mid June	15	21	28	80
	Late June	14	22	30	84
	Early July	10	19	29	76
Late IV (4.7-4.9)	Mid June	14	21	28	79
	Late June	14	22	30	84
	Early July	9	20	32	81
Early V (5.0-5.3)	Mid June	15	21	27	78
	Late June	13	23	32	88
	Early July	9	21	32	82
Mid V (5.4-5.6)	Mid June	13	19	25	72
	Late June	10	21	31	81
	Early July	9	19	29	75
Late V (5.7-5.9)	Mid June	13	19	25	71
	Late June	11	21	30	80
	Early July	10	18	27	72



R3 stage soybean (top) and R5 stage pod (bottom).

Summary

These prediction tables of soybean reproductive developmental stages, constructed from data across a wide range of RMGs and planting dates, should help growers schedule numerous crop management practices. Growers could also use these tables to help position soybean seed filling for longer days (i.e., more photosynthesis per day), or to avoid drought or high-temperature stress that typically occurs during certain times of the year (growers should review their farm's weather history). The tables could also help farmers to select RMGs that mature before frost, especially for double-crop soybean. In conclusion, these prediction tables should assist farmers, Extension agents and specialists, crop advisers, and researchers ensure timely crop management for maximum economic soybean yields.

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