TEMPERATURE EFFECTS ON SOYBEAN EMERGENCE & DEVELOPMENT

Results from an MSPB-funded project provide some interesting estimates about how air temperature affects germination/emergence and vegetative development of soybeans. Experiments were conducted in sunlit plant growth chambers known as Soil-Plant-Atmosphere-Research (SPAR) units at Miss. State Univ. to study the influence of temperature on emergence and vegetative development of soybeans. In these studies, average daily air temperatures [(maximum + minimum air temperatures)/2] were used instead of soil temperatures because air temperature data are likely more available to producers.

Temperature and Seedling Emergence–Table 1. A study was conducted to determine how temperature will affect seedling emergence following germination, which is an important variable for producers who plant early. Results from this experiment are shown in Table 1. Notice in the table title the phrase "maximum days to soybean emergence" is used since it is assumed that average daily air temperatures will increase between planting and emergence, which should result in a slightly shorter time to emergence than the values shown in the table for each planting date.

Table 1. Effect of average air temperature* on maximum days to soybean emergence based on planting date at Stoneville and Tunica, Mississippi.**

	Stoneville		Tunica	
Planting date	Avg. air temperature	Days to emergence	Avg. air temperature	Days to emergence
Mar. 20	55.0	13.0	53.5	14.0
Mar. 30	58.0	12.0	56.0	12.5
Apr. 10	62.0	10.5	60.0	11.0
Apr. 20	65.5	9.0	63.5	10.0
Apr. 30	67.0	9.0	65.0	9.5
May 10	70.0	8.0	68.5	8.5
May 20	73.0	7.0	71.5	7.5

*Average air temperature [(daily max. + min.)/2] for each location.
**Using the equation Y (days to emergence) = 53.763 -1.0504x + 0.0056398x^2 (R^2 = 0.93), where x equals average air temperature. Rounded to nearest half number.

Seed germination was about 83% when temperatures ranged from 50 to 93° F., and declined significantly at higher temperatures. Thus, soybean seed will germinate over a wide range of temperature conditions.

Several points are worth noting based on the results shown in Table 1.

- Since no individual year will have average temperatures that mimic the above long-term averages, times to emergence in a given year will likely be slightly different from those shown above. However, the differences should be no more than 1 to 2 days more or less than the tabled values.
- The nearly 2° latitude difference between Stoneville and Tunica made little difference in time to emergence even though average air temperatures varied by 1.5 to 2°F. between the two locations.
- The longer times between planting date and emergence in early plantings provide a wider window for applying preemergence herbicides. Delaying these applications until closer to emergence rather than immediately following planting can provide valuable additional time for effective residual weed control following soybean emergence, especially since up to 2 weeks can pass between planting and emergence in early plantings.
- The longer time between planting and emergence in early plantings provides additional impetus to use effective soybean seed treatments to reduce/negate the potential threat from insect and disease pathogens that are in the soil and that will have longer to damage planted soybean seed and emerging seedlings.

Producers are encouraged to use these results in conjunction with the estimated average date of last frost at a given location to determine a safe planting date for soybeans at Midsouth locations.

An additional study using MG V soybean varieties AG 5332 (indeterminate) and Progeny 5332 (determinate) was conducted to determine the effect of average daily air temperature on vegetative development. Soybean seeds were allowed to germinate and emerge at 84/70°F day/night temperatures. Following emergence, five day/night temperature treatments of 70/53, 77/63, 84/70, 91/77, and 99/84°F were imposed to 58 days after sowing. Soil water and nutrient status was optimum during the measurement period.

Plant Height and Leaf Development–Tables 2 & 3. Leaves on the mainstem (V-stage; click here for soybean developmental stages) and plant height were recorded on nine plants in each of the five temperature treatments of each variety. New leaves were counted when they appeared as unfolded in the terminal. Plant height was measured from the cotyledonary node to the top-most unfolded leaf at weekly intervals.

Plant Height–Table 2. After each of the varieties had reached the V10 stage (10 nodes with fully developed leaves), plants of the determinate variety became increasingly taller than those of the indeterminate variety. In fact, when plants of each variety had reached 20 nodes, height of plants of the determinate variety were nearly 9 in. taller than those of the indeterminate variety. This greater height of plants of that determinate variety would necessarily contribute to their increased lodging.

The optimum temperature for maximizing plant height was 84°F for AG 5332 and 83°F for Progeny 5333 (data not shown).

Table 2. Soybean plant height and vegetative development.

	Number of nodes and plant height (in.)				
Variety*	**10**	**12**	**15**	**18**	**20**
AG 5332 (Indet.)	18.8	23.6	31.2	39.6	45.6
Progeny 5333 (Det.)	20.4	26.1	35.7	46.5	54.4
Difference	1.6	2.5	4.5	6.9	8.8

*AG 5332–MG V indeterminate; Progeny 5333–MG V determinate.

Leaf Development–Table 3. Average air temperature between 85° and 90°F provided an environment that resulted in the shortest time for leaf development and the highest rate of leaf development in both varieties. This indicates that in a soil environment with optimum resources, this temperature range should result in maximum soybean leaf development and growth. Average daily temperatures above and below this range obviously did not support maximum leaf development and growth.

Table 3. Days to leaf and leaf development rate per day for soybean grown under optimum water and nutrient conditions at varying temperatures. Data are average of AG 5332 (indeterminate) and Progeny 5333 (determinate).

Leaf development	**Temperature (°F)**						
	70	**75**	**80**	**85**	**88**	**90**	**95**
Days per leaf*	3.24	2.54	2.11	**1.93**	**1.94**	**2.00**	2.34
Rate per day**	0.33(0.31)	0.40(0.39)	0.44(0.47)	**0.46(0.52)**	**0.46(0.52)**	**0.46(0.50)**	0.45(0.43)

*Calculated as [39.93 - (0.884 x temp.) + (0.00514 x temp.^{2}); $R^2 = 0.94$]
**Calculated as [-2.58 + (0.069 x temp.) - (0.000391 x temp.^{2}); $R^2 = 0.97$]; Number in parentheses is 1/days per leaf from first row.
No leaf development at temperature below 54 °F.

Leaf Area–Table 4. Leaf area development was optimized at average air temperatures between 80°F and 85°F for the indeterminate variety AG 5332 and between 75°F and 80°F for the determinate variety Progeny 5333. Progeny 5333 accumulated greater leaf area at its optimum temperature range than did AG 5332.

Table 4. Leaf area development (square meter per plant)* for soybean grown under optimum water and nutrient conditions at varying temperatures.

Variety	Temperature (°F)						
	65	70	75	80	85	90	95
AG 5332 (Indet.)	0.592	0.756	0.862	0.911	0.905	0.843	0.725
Progeny 5333 (Det.)	1.084	1.247	1.344	1.348	1.286	1.151	0.940

*Calculated as: [-6.5986 + (0.1834 x temp.) - (0.001119 x temp.^{2}); $R^2 = 0.95$] for AG 5332 and [-7.8151 + (0.2339 x temp.) - (0.001492 x temp.^{2}); $R^2 = 0.97$] for Progeny 5333.

Overall Results and Their Application

- The determinate variety Progeny 5333 produced both taller plants (Table 2) and greater leaf area per plant (Table 4). However, it is well-known and substantiated by research that neither trait is associated with greater soybean seed yield. Therefore, neither trait should be used to select a soybean variety for highest yield potential. In fact, it is likely that both taller plants and plants with greater leaf area can be detrimental to yield potential if grown on soils that are known to support excess growth which can contribute to lodging and greater water use. (Click here for data that support this view).
- These results show that varieties with an equal maturity designation do not necessarily produce the same vegetative growth.
- These data show that soybean varieties with an equal maturity designation should be selected based on their growth and yield potential in environments that closely align with or mimic conditions of the location at which they will be grown. This means that variety trial data that will be used to choose a variety should be selected based on the latitude at which the data are collected and the soil texture at the site of the test.
- The role of the determinate vs. indeterminate trait in soybeans needs further investigation to ascertain its contribution to appropriate/needed soybean growth and development in Midsouth production systems.

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