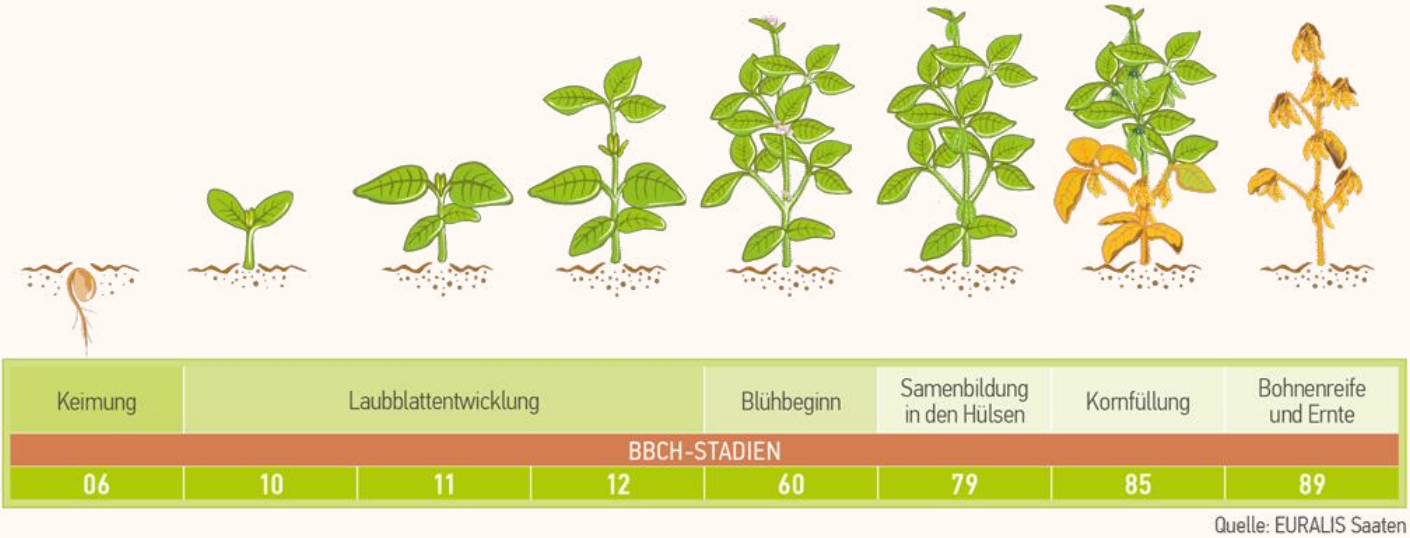
Edition No. 51 revised September 2018

Taifun Soy Info

Specialist information for soy producers and processors

Zentrum für Sojaanbau

Soybean growth stages and requirements



Growth stages American literature						
PU	VC	V1	V2	R1	R4 -R6	R8

Figure 1: Comparison of the European and American system of classifying the soybean growth stages (Euralis Saaten, Taifun).

In the literature the yield-formation of grain crops is divided into three phases (Murata, 1969):

1. Phase: Formation of organs for nutrient uptake and photosynthesis (vegetative growth)

2. Phase: formation of flower organs and "yield-containers" (generative phase)

3. Phase: formation, accumulation and relocation of the "yield-contents" (seed filling)

In Europe, the BBCH-scale is used to identify the phenological stages of plants. The scale is divided into macro stages, which in turn are differentiated into micro stages.

In America, the growth stages are divided into vegetative (V-stages) and generative/reproductive stages (R-stages). A comparison of the two systems is shown in Figure 1.

First of all, during vegetative growth, the soybean plants form nodes and leaves for photosynthesis. During germination (Fig. 2), the soil temperature must be at least 10 °C with sufficient water availability. After the cotyledons and the first leaf are fully developed (BBCH 10, Fig. 3), the energy reserves in the grain and the photosynthesis of the cotyledons supply the seedling with the necessary nutrients for approx. 7 - 10 days. In the process, the cotyledons lose about 70 % of their dry weight. The rate of photosynthesis depends on the photo-synthesis capacity of the leaves as well as on environmental conditions like solar radiation, CO_2-concentration, temperature and the availability of water and nutrients. Weeds, fungal or bacterial diseases as well as insect pests can affect the rate of photosynthesis directly e.g. by reducing the leaf area or indirectly e.g. by competition for water. In the growth stages 11 - 13 or V1 - V3, the first to third trifoliate leaf develop. In the V2-stage the active N2 - fixation begins. In the following stages Vn or 1n (where n stands for the nth fully developed trefoil) the root growth is about 1 - 2 cm per day.

The duration of the vegetative growth phase depends on the maturity group of the variety. In experiments with soybean varieties of different maturity groups, the later maturing varieties showed a higher biomass formation than the earlier maturing varieties due to their longer vegetative growth phase (Egli, 2010). In comparison, varieties of maturity group IV formed 44% more biomass in 23 days when sown in mid-May than simultaneously sown plants of maturity group I (Egli and Bruening, 2000).

The appearance of the first flowers (Fig. 4) determines **the start of generative growth** and the beginning of phase 2. In stages R1 or 61 (at the beginning of flowering) root growth is approx. 3 - 8 cm per day and the water requirement increases. This phase ends with the growth stage R 6 (see below). The pods now contain a green seed that fills pod capacity. At the end of phase 2 the water requirement of soybean plants is highest (see tables 1 and 2). If drought stress occurs now, the yield is reduced. This is mainly due to the fact that the plants form fewer side shoots and thus fewer pods. The flowering phase of soy lasts approx. 20 - 40 days, but more than 70% of the flowers are formed in less than half the length of the total period. Similarly, in a study by Egli and Bruening (2002), 70-80% of the pods were formed in only 12 days of a total pod-formation phase of 30-40 days. Varieties with determinate (limited) growth have a shorter pod-formation phase than varieties with undetermined (unlimited) growth. The number of seeds and pods in this phase is directly related to the rate of photosynthesis. An increased rate of photosynthesis (e.g. by increased CO2, light and/or water) also increases the number of pods and seeds (Hardman and Brun, 1971).

Table 1: Water consumption at late generative growth stages (Yonts, 2008).

Growth stage	Approximate number of days to maturity	Water consumption until maturity (mm)	Average water consumption (mm/day)
End of pod formation	37	229	6,2
Start of seed growth	29	171	5,9
End of seed growth	18	90	5,0
	0	0	0

Table 2: Soybean growth and water consumption (Tacker and Vories, 2017).

Plant Development	Water consumption (mm/day)
Germination and seedling	1 – 2,5
Rapid vegetative growth	2,5 –5
Flower and pod filling	5 – 8
Maturity until harvest	1 – 5

The beginning of the 3rd phase, **pod filling**, is the beginning of yield-formation (Fig. 5). Now root growth slows down - the root system is fully developed - and the maxima of plant height, node number and leaf area are reached (between R5 and R6). At the beginning of this phase no yield is formed, but the whole plant is programmed to produce yield. The pod filling phase usually lasts 30-40 days (R5 to R7), which is less than 40% of the total growth cycle (Egli, 2010). In addition to the current photosynthetic products, previously stored carbohydrates are also translocated. For soybeans, however, this relocation accounts for only about 15% of the total seed mass (for wheat, for example, it is 20-50%). During pod filling, nutrients from leaves, stems or husk tissue are also translocated into the seed. For N and P the translocation occurs mainly from the leaves. For K twice as much is translocated from the stems than from the leaf tissue. In the case of copper, half of the copper present in the leaves is translocated into the grains (see Fig. 7a and b).

Water stress during pod filling has a direct influence on yield. Even short-term water stress for only 3 days is sufficient to lead to smaller, earlier ripening grains and a lower grain yield. The inadequate water supply shortens the pod filling phase by accelerating leaf fall-off. This process is irreversible, even if water-availability is sufficient later on (Brevedan and Egli, 2003).

If drought persists in the 3rd phase, irrigation should not be started too late in order to minimize harvest losses. At 5 - 8 mm / day, the water requirement is highest during this phase (see tables 1 and 2). Too little nitrogen also shortens the pod filling phase and accelerates leaf aging. Physiological ripeness marks the end of the 3rd phase and the yield-forming process (Fig. 6).

Nutrient requirements of soy at the different growth stages

The nutrient requirements of soybeans during the growing season can also be divided into three phases (Bender et al., 2015):

1) slow absorption for 30 days after germination

2) highest uptake rate between full flowering (R2) and beginning of seed formation (R5)

3) reduced uptake during the late generative phases, i.e. seed ripening

Figures 7a and 7b show the detailed uptake of different macro- and micronutrients at different growth stages and separated for grain, flowers and pods, stems and leaf stalks as well as leaves. It is shown, for example, that almost ¾ of the K and Fe uptake occurs before the beginning of pod filling (R4). In contrast, the uptake of N, P, Ca, Mg, S, Zn, Mn, B and Cu is more evenly distributed between vegetative and generative phase, if the R4 stage is considered as the "boundary" between the two phases. Compared to the rapid nutrient uptake in maize, which takes place directly at the beginning of pollination (Bender et al., 2013), nutrient uptake of soybeans is a uniform process that continues throughout the entire vegetation period. Figures 7a+b also show very clearly the translocation of nutrients from other plant organs into the grains, which also begins with the R4 stage and for which a good water supply is essential.

Figure 2: VE, field emergence (Illinois Soybean Association, 2017).

Figure 3: VC stage (Taifun, 2015)

Figure 4: R2, full flowering (Taifun, 2016).

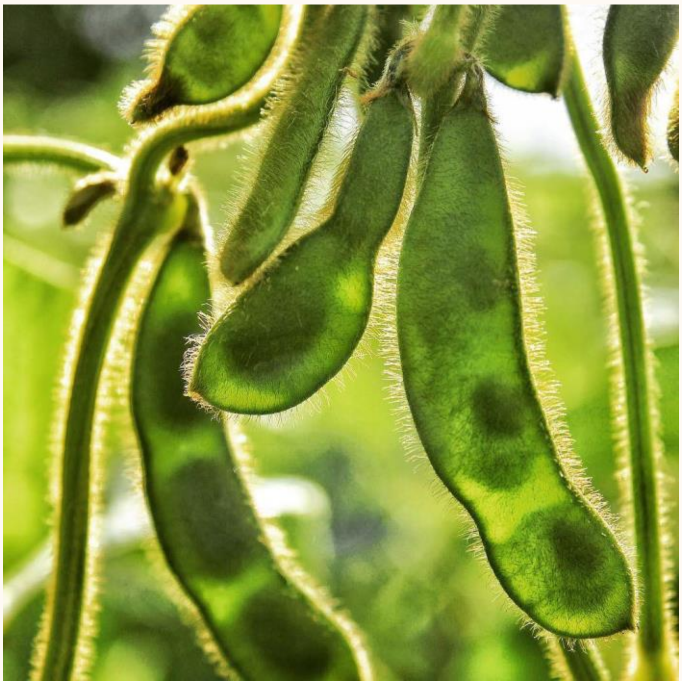


Figure 5: Pod filling (beanbeat.de, 2016).

Figure 6: Ripe soybeans (Taifun, 2015).

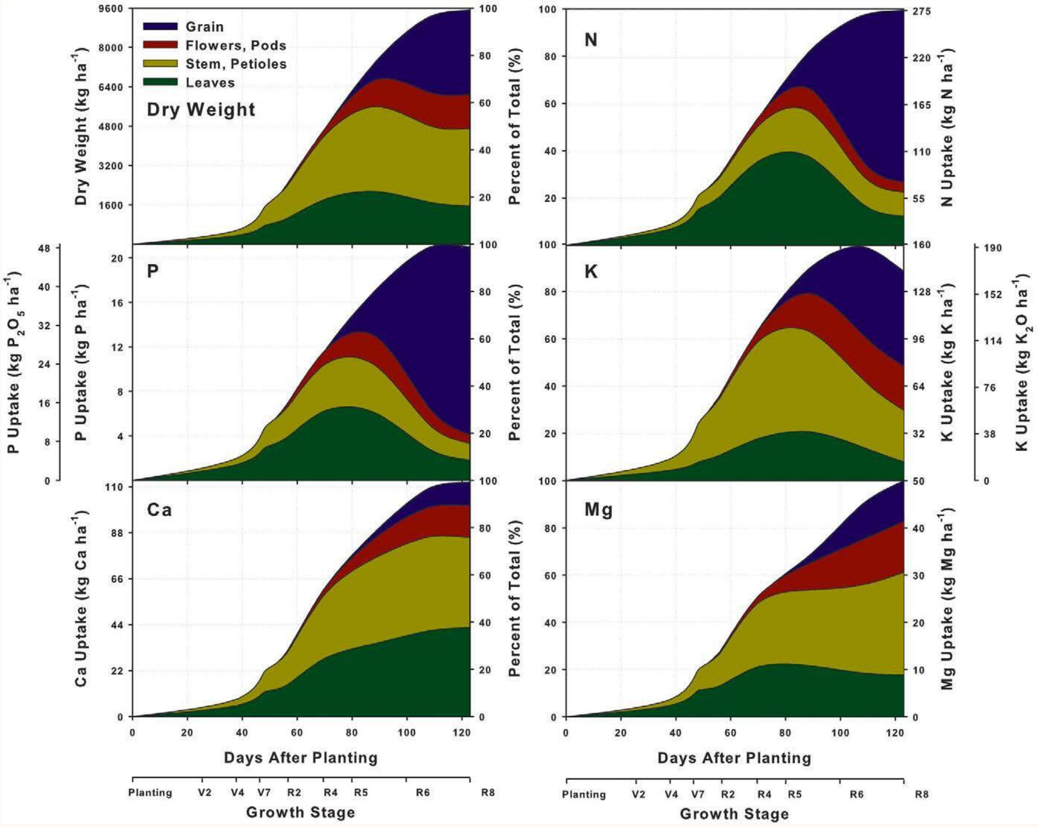


Figure 7a: Uptake of N, P, K, Ca and Mg from two soybean varieties at three locations in the years 2012-2013 at different growth stages for different above-ground plant parts (Bender et al., 2015). All parameters were measured in dry matter with an average yield of approx. 3480 kg/ha.

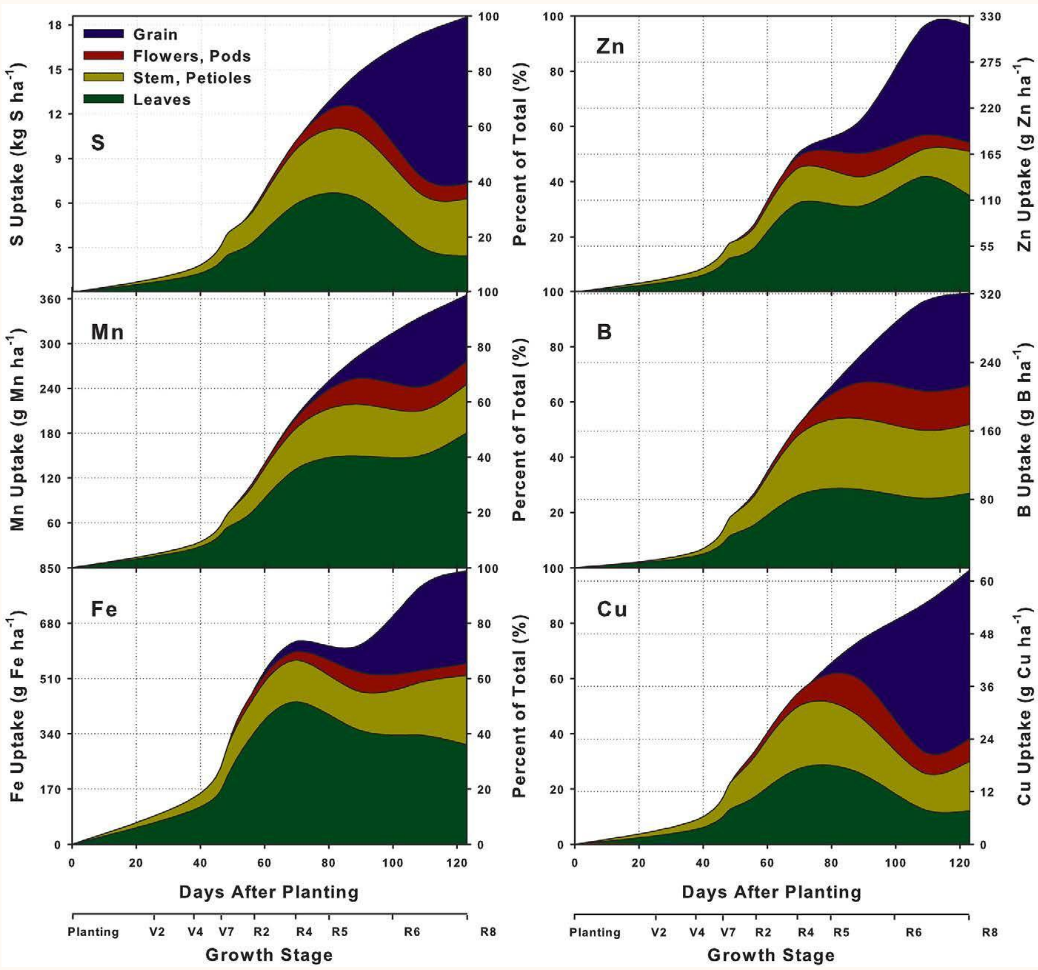


Figure 7b: Uptake of Zn, Mn, B, Fe and Cu from two soybean varieties at three locations in the years 2012 - 2013 at different growth stages for different above-ground plant parts (Bender et al., 2015). All parameters were measured in dry matter with an average yield of approx. 3480 kg/ha.

Sources

Bender, R. R., Haegele, J. W. und F. R. Below, 2015. Nutrient Uptake, Partitioning, and Remobilization in Modern Soybean Varieties. Agronomy Journal, 107 (2), 563-573.

Bender, R. R., Haegele, J. W., Ruffo, M. L. and F. E. Below, 2013. Nutrient Uptake, Partitioning and Remobilization in Modern, Transgenic Insect-Protected Maize Hybrids. Agronomy Journal, 105, 161-170.

Brevedan, R. E. und Eglo, D. B., 2003. Short periods of water stress during seed filling, leaf senescence and yield of soybean. Crop Science 43, 2083-2088.

Egli, D. B., 2010. Soybean Yield Physiology in: The Soy- bean (ed. G. Singh), CAB International, 113-141.

Egli, D. B. und Bruening, W. P., 2000. Potential of early-maturing soybean cultivars in late plantings. Agronomy Journal 92, 532-537.

Egli, D. B. und Bruening, W. P., 2002. Flowering and fruit set dynamics during synchronous flowering at phloem-isolated nodes in soybean. Field Crops Research 79, 9-19.

Hanway, J. J. und C. R. Weber, 1971. Accumulation of N, P and K by soybean (Glycine max (L.) Merrill) plants. Agronomy Journal, 63 (3), 406-408.

Hardman, L. L. und Brun, W. A., 1971. Effects of atmospheric carbon dioxide enrichment at different development stages on growth and yield components of soybeans. Crop Science 11, 886-888.

Murata, Y., 1969. Physiological Responses to Nitrogen in Plants. Physiological Aspects of Crop Yield, Madison, WI, USA, 235-259.

Tacker, P. and Vories, E, 2017. Arkansas Soybean Handbook, Chapter 8, Irrigation. www.uaex.edu.

Yonts, C.D., 2008. Predicting the last irrigation of the season. NebGuide G1871. University of Nebraska-Lincoln Extension

For comprehensive information on all aspects of soy cultivation visit:

www.sojafoerderring.de

Imprint
Author: Kristina Bachteler
Editorial assistance: Martin Miersch
Publisher: Taifun-Tofu GmbH
Bebelstraße 8 | 79108 Freiburg | soja@taifun-tofu.de
Tel. 0761 152 10 13

Taifun Zentrum für Sojaanbau

Funded by the Federal Ministry of Food and Agriculture based on a resolution of the German Bundestag within the framework of the BMEL Protein Crop Strategy.

ptble Projektträger Bundesanstalt für Landwirtschaft und Ernährung

Gefördert durch: Bundesministerium für Ernährung und Landwirtschaft

aufgrund eines Beschlusses des Deutschen Bundestages