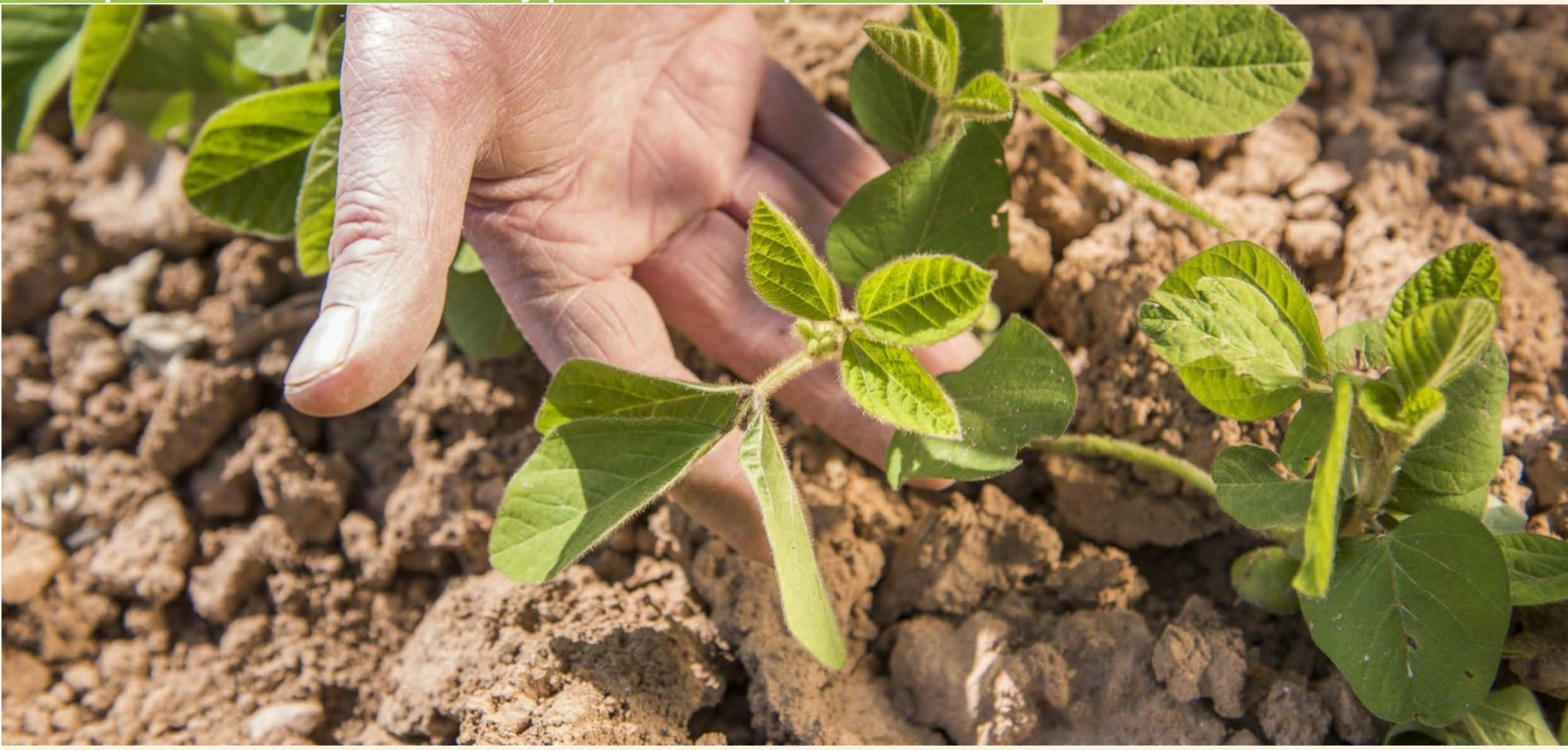
Edition No. 21 updated September 2018

Taifun Soy Info

Specialist information for soy producers and processors



Nutrient removal by soybeans

Soybean plants are plants with very good nutrient absorption and fertilization is usually not used in soybean cultivation. Although soy has a higher nitrogen requirement than, for example, corn, it can cover 50 - 60 % of its requirement by fixing atmospheric nitrogen (University of Iowa, 2007). In individual cases and certain deficient sites, the yield and quality of the crop can be increased by targeted fertiliser application.

Nutrient requirements

The composition of the nutrients within a soybean plant depends on soil fertility and is influenced by the nutrient ratio of the soil. However, under optimal conditions, all soybean plants have a similar composition, regardless of the site. Carbon, hydrogen and oxygen account for up to 90% of the dry matter, but they can only be accumulated if all other main and trace elements are available in sufficient quantities. In descending order, the essential macronutrients in the soybean plant are: nitrogen, potassium, calcium, magnesium, phosphorus and sulphur. In leaves and stems the distribution of nutrients is similar, with the exception that here magnesium is ahead of phosphorus. In the seeds, however, the order is as follows: nitrogen, potassium, phosphorus, sulphur, calcium and magnesium (Rao and Reddy, 2010). At harvest, large quantities of the nutrients absorbed by the plant are removed from the fields. Based on the complete quantity of absorbed nutrients, approx. 70 % N, 75 % P and 55 % K are removed from the field with the seeds (Texas Plant & Soil Lab, 2012). The remaining nutrients are returned to the soil by the harvest residues. Micronutrients are also essential for soybean nutrition, even if they are needed in much smaller quantities than macronutrients. Here in order of descending importance for soybeans: molybdenum, zinc, copper, chlorine, manganese, boron, iron.

Nitrogen is quantitatively the most required nutrient. It is found in all amino acids, which in turn form building blocks for proteins, nucleic acids and chlorophyll. Soybean plants can cover their nitrogen requirements both with nitrogen from the soil as well as atmospheric nitrogen through symbiosis with the bacterium *Bradyrhizobium japonicum.* Large amounts of nitrogen fertilizer affect fixation of atmospheric nitrogen and is usually not required. Here, nitrogen in the form of nitrate interferes with the process of N-fixation by disturbing bacterial infection and nodule formation as well as the N-fixation itself. Further, nodule growth is also slowed down (Fujikake et al., 2002). The reason for this is the carbon hydrate degradation in the nodules, reduced O2 diffusion in the nodules and inhibition of feedbacks by by products of nitrate metabolism (Saito et al., 2014). In several experiments the effectiveness of bacterial strains and inoculants as well as the possibility of subsequent fertilization were investigated. Results of these experiments can be found here (in German):

www.sojafoerderring.de/anbauratgeber/aussaat/impfung/

Nitrogen uptake, fixation and fertilisation

A very detailed summary of over 630 published data sets by Salviagiotti et al (2008) describes the relationships between nitrogen uptake, fixation and fertilization. On average of all evaluated studies 50 - 60 % of the nitrogen requirement was covered by biological nitrogen fixation. In most cases the nitrogen removal by the seeds was higher than the amount of fixed N. The nitrogen balance (= amount of N in aboveground biomass minus amount of N removed from the field at harvest) was clearly negative in 80 % of the studies with an average value of -40 kg N/ha. However, if the amount of N in the subsoil plant parts (roots, nodules, root exudates) is included (with an estimated 24 % of the total N in the plant (Rochester et al., 1998)), the nitrogen balance is almost neutral with only -4 kg N/ha. In well irrigated stands, for example, the subsoil biomass is only about 15 % of the above-ground biomass (Salviagiotti et al., 2008). Here, however, it should also be noted that the subsoil N enrichment varies considerably and depends on many factors. In addition, N fixation can be optimised with some methods used in practice, such as the choice of a high-quality inoculant with highly effective bacterial strains, the choice of a high-yielding variety, good management and sufficient supply of other necessary nutrients except N, so that the nitrogen balance is significantly improved

.

Figure 1: Nodule formation in the inoculant trial. Taifun, 2017.

As a nitrogen-fixing plant, the nitrate leaching of soy is low at levels of 8 kg/ha NO3-N in 60 - 90 cm, 12 kg/ha NO3-N in 30 - 60 cm and 16 kg/ha NO3-N in 0 - 30 cm (Ministry of Rural Affairs, 2016). A comparison to other crops is shown in Table 1.

Crop	n	Area [ha]	Average value NO3-N [kg/ha]		
			0 - 30 cm	30 - 60 cm	60 - 90 cm
Soybeans	110	217	16	12	8
broad bean/ English bean/horse bean/horse bean/ broad bean	60	112	37	26	13
Grain peas	136	306	37	28	17
Clover grass, lucerne-grass mixture	166	328	11	5	3
Silage maize	2195	5218	26	15	10
Grain maize/CCM	978	1797	20	15	10
Winter common wheat	3794	8118	26	19	9
Winter Barley	1683	3806	23	16	9
Spring Barley	1332	2785	31	21	11
Winter oilseed rape	1448	3428	37	25	12

Table 1: Nitrate leaching from different crops (Ministry of Rural Affairs, 2016)

In order to be able to estimate the required nutrient quantities to achieve a certain yield target, the most important factor is the removal of nutrients by the removal of the main (grain) and secondary (straw) crop. To calculate the nutrient removal, the long-term yield averages of a site and no single high yields should be considered.

As nutrient removal depends on varieties, yields, sites and their soil properties, etc., the values given in the literature often vary.

In the *advisory bases for fertilisation in arable farming and grassland* (LTZ Augustenberg, 2011) the following values (Table 2) for soy are given according to test results from Baden-Wuerttemberg, Bavaria and Saxony:

Harvest products	Nutrient contents [kg/dt]			
Soybean	N	P2O5	K2O	MgO
Grain	5,8	1,62	1,94	0,3
Straw	1,5	0,38	1,56	0,64
Grain + straw	7,3	2,0	3,5	0,94

Table 2: Nutrient removal by soy (LTZ, 2011)

Due to the very high protein content of the grains, soybeans take more nitrogen from the field than other grain legumes (see Table 3), which means that the preceding crop effect is also somewhat lower than that of other grain legumes.

Harvest products	Nutrient contents [kg/dt]			
Grain pea (26 % RP in dm)	N	P2O5	K2O	MgO
Grain	3,6	1,1	1,44	0,2
Straw	1,5	0,3	2,60	0,5
Grain + straw	5,1	1,4	4,5	0,7
Field bean (30 % RP in dm)	N	P2O5	K2O	MgO
Grain	4,1	1,2	1,4	0,2
Straw	1,5	0,3	2,6	0,4
Grain + straw	5,6	1,5	4	0,6

Table 3: Nutrient removal by grain pea and field bean (TLL, 2010)

The following (converted) values (kg/dt) for soybeans are found in the US American literature (Iowa State University, 2007):

Harvest products	Nutrient contents [kg/dt]			
	N	P2O5	K2O	MgO
Grain	7,0	1,53	2,54	0,61
Straw	2,17	0,54	1,53	0,61
Grain + straw	9,17	2,07	4,07	1,22

Table 4: Nutrient depletion by soy in the American literature (Iowa State University, 2007)

However, many studies (especially from the USA) report that more nitrogen is available in maize cultivation after soy than in pure maize monoculture. However, this is not a real nitrogen "gain", but can be attributed to the mineralization of the nitrogen in the crop residues and the improved mineralization of organic matter.

This is because the crop residues of soy have a lower C/N ratio than those of maize. In some cases, 30 - 50 N kg/ha can be saved. In addition, soy leaves a very good soil structure due to its strong roots and easily degradable litter.

The time of the highest nutrient requirement is also decisive for the full exploitation of the yield potential. Table 5 shows that 2/3 of the nutrients are absorbed after flowering. At grain filling soybean plants have the highest nutrient requirement. In the further development, nutrients from older parts of the plant are also relocated to support seed growth.

Stage of development	N [%]	P2O5 [%]	K2O [%]
Field emergence to blossom	30	30	33
Flowering until pod formation	25	25	34
Pod formation until maturity	45	45	33

Table 5: Nutrient accumulation at different stages of development (Potash and Phosphate Institute, 1998)

Sources

Fujikake H., Yashima, H., Sato, T., Ohtake, N., Sueyoshi, K. and T.Ohyama, 2002
Rapid and Reversible Nitrate Inhibition of Nodule Growth and N2 Fixation Activity in Soybean (Glycine max (L.) Merr.). Soil Science and Plant Nutrition 48 (2), 211-217

Iowa State University, 2007.
Soybean Nutrient Requirements,
http://crops.extension.iastate.edu/soybean/production_soilfert.html

LTZ Augustenberg, 2011.
Consultation bases for fertilisation in arable farming and on grassland in Baden-Württemberg, p. 84.

LTZ Augustenberg, 2010.
Information sheets for environmentally sound land management No. 26, humus balancing.

H. Marschner, 1995.
Mineral Nutrition of Higher Plants. Academic Press, San Diego, CA, USA.

Ministry of Rural Affairs, 2016.
SchALVO Nitrate report Results of the 2015 sampling, P. T25.

Rao, A. S. und S. Reddy, 2010.
Nutrient Management in Soybean in:
The Soybean (ed. G. Singh),
CAB International, 161-190.

Rochester, J. J., People, M. B., Constable, G. A. und R. R. Gault, 1998.
Faba beans and other legumes add nitrogen to irrigated cotton cropping systems.
Australian Journal of Experimental Agriculture 38, 253-260.

Saxon State Office for Environment, Agriculture and Geology, 2008.
Crop rotation principles in organic farming.
http://orgprints.org/15100/1/Fruchtfolge_Internet.pdf

Saito, A., Tanabata, S., Tanabata, T., Tajima, S., Ueno, M., Ishikawa, S., Ohtake, N., Sueyoshi, K. and T. Ohyama, 2014
Effect of Nitrate on Nodule and Root Growth of Soybean (Glycine max (L.) Merr.). International Journal of Molelucar Sciences, 15, 4464-4480.

Salvagiotti, F., Cassman, K.G., Specht, J.E., Walters, D. T., Weiss, A. and A. Dobermann, 2008.
Nitrogen uptake, fixation and response to fertilizer N in soybeans: A review. Field Crops Research 108 (1), 1-13.

Texas Plant & Soil Lab, 2012.
Soybean – Plant nutrition and sampling.

Thuringian State Institute for Agriculture, 2010:
Guideline for the efficient and environmentally friendly production of field beans and grain peas

W. Vogt-Kaute, 2011.
The soybean - a grain legume with a future?! (part two).

For comprehensive information on all aspects of soy cultivation visit:

www.sojafoerderring.de

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

Taifun Zentrum für Sojaanbau

Funded by the Federal Ministry of Food and Agriculture on the basis of 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