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Would BNF be sufficient for high-yielding soybeans and reducing yield gaps?

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Soybean yield depends on total nitrogen (N) uptake, N use efficiency, and N harvest index (NHI). Highest-yielding soybean cultivars show the largest N uptake when compared with low-yielding genotypes. Nitrogen uptake depends on biological N fixation (BNF) and soil N. A mean linear increase of 0.013 Mg of seed yield per kg increase in N in aboveground biomass and of 0.019 Mg of seed yield per kg increase in N derived from BNF has been observed in different databases. Agronomic management aimed at increasing crop productivity is positively associated with biomass production and the amount of N derived from BNF. On average, the relative contribution of BNF ranges between 45 to 75 % of total N uptake, and has shown maximum values of ca. 350 kg. Recent studies analyzing heavy-fertilized soybean crops showed the presence of an “N-gap” (difference between plant N demand of high-yielding soybean and N provided by BNF and soil). Higher BNF activity would close this “N-gap” but some meta-data studies showed a plant N content threshold of ca. 325 kg N ha^{-1}, after which BNF contribution is lower than plant N demand. This analysis also show that the “N-gap” increased more than proportionally when this contribution of BNF is above 50%. The role of soybean as a legume in the system can be quantified by the apparent N budget (ANB) (N-BNF minus N-seed). It is generally negative, and increases are observed when the proportion of BNF rises. There is still lack of information regarding this ANB when root N is included in the calculation. In summary, the “N-gap” should be addressed by deeply studying processes associated with the BNF contribution and improvement in environments with high N demand, nitrogen use efficiency and partition between vegetative and reproductive organs, and also, a precise estimation of BNF for above and belowground fractions.