Soybean Seed Composition: Changes in Protein and Amino Acids Over Four Decades

K-STATE Research and Extension

Department of Agronomy | MF3552 | Crop Production

Introduction

Soybeans are a major protein source and provide 70% of global plant-based protein meal for animal feed. Soybean meal quality is defined by seed protein concentration and the relative composition of essential and nonessential amino acids.

In past decades, breeding increased soybean yield potential. Unfortunately, yield improvement has been linked to a reduction of seed protein concentration. Insufficient crop nitrogen uptake could limit protein maintenance. As yield increased, the nitrogen demand increased as well. It is possible that biological nitrogen fixation could not keep up with the higher nitrogen demand.

Because amino acids are the building blocks of protein, it would be expected that their concentration would decrease in parallel to that of protein; however, it is unknown if all amino acids decreased at the same rate. Therefore, experiments were designed to evaluate how amino acids decreased over time, and if a high-nitrogen environment could alter protein or amino acid changes with yield improvement.

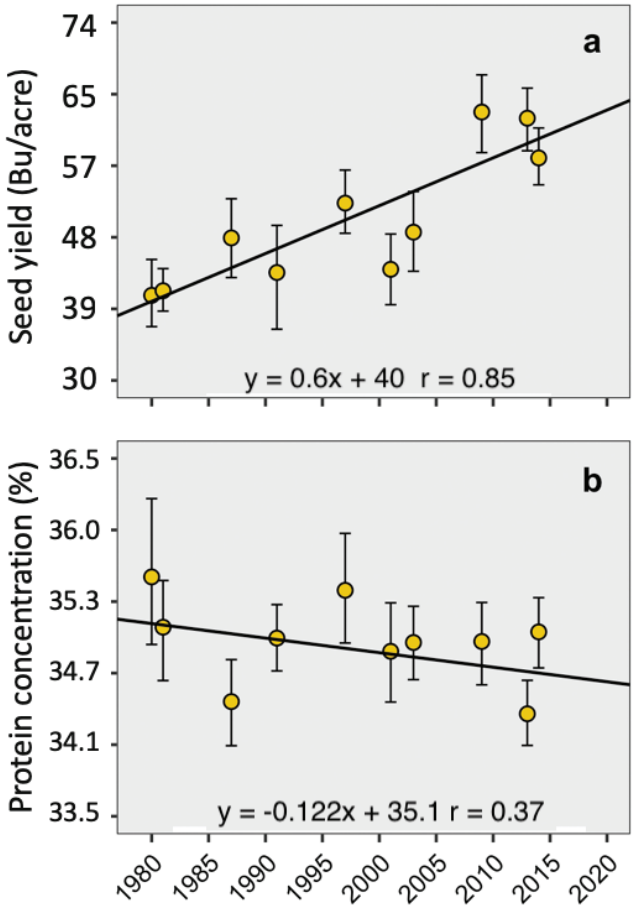

Figure 1. *Relationship between seed yield (a) or protein concentration (b) with the year of release of varieties from 1980 to 2014. Observations represent the average between control and nitrogen-fertilizer treatments (due to lack of nitrogen effect).*

Results

Field studies were established in Rossville, Kansas, in the 2016 and 2017 growing seasons, using 13 soybean varieties released from 1980 to 2014. Soybeans were tested with high-nitrogen fertilization and control conditions (0N, without nitrogen fertilizer, and with inoculant). These studies evaluated yield, protein, the two most abundant non-essential amino acids, glutamic and aspartic acids, and the 10 essential amino acid concentrations (leucine, lysine, phenylalanine, valine, isoleucine, threonine, histidine, cysteine, methionine, and tryptophan).

Soybean yield improved 0.6 bushel per acre due to the variety year of release. Seed yield ranged between 40 and 61 bushels per acre, with an estimated yield increase of approximately 50% from 1980 to 2014. Protein concentration decreased at a rate of 1.22% per year (Figure 1). Increasing nitrogen availability in the soil with nitrogen fertilizer did not change the overall negative trend for protein.

Nonessential glutamic acid concentration decreased at a rate of 0.021 gram per kilogram per year, with a decrease

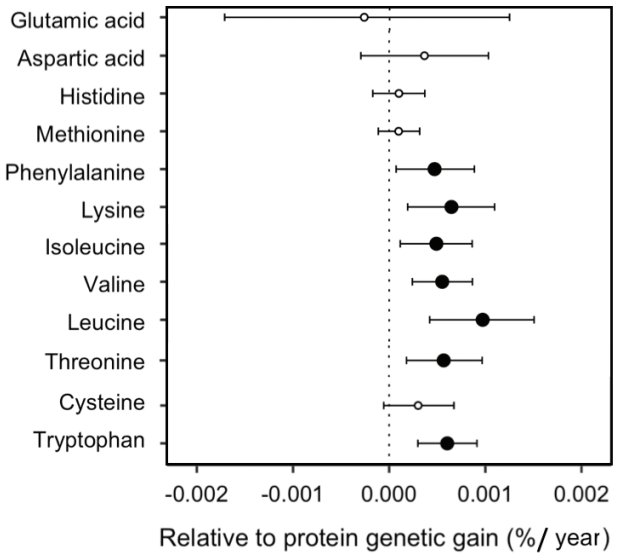

Figure 3. *Genetic gain of amino acid concentrations relative to protein. Black solid points represent the amino acids with significant relative shifts, whereas the empty points are nonsignificant.*

of 1.22% over the time frame. Aspartic acid decreased by 1.07% at a rate of 0.012 gram per kilogram per year. Similar to yield and protein results, the nitrogen fertilizer treatments did not affect the concentration of amino acids over time (Figure 2).

Essential amino acids leucine, cysteine, and tryptophan were not affected by year of release. The remaining essential amino acids decreased with rates ranging from 0.006 to 0.001 gram per kilogram per year (Figure 2). When changes in amino acids are calculated in proportion to the protein decline, it is notable that some essential amino acids decrease at a lower rate. The nonessentials acids: glutamic and aspartic acid, along with the essential amino acids: histidine, methionine, and cysteine, presented a similar shift relative to protein (Figure 3 on page 1).

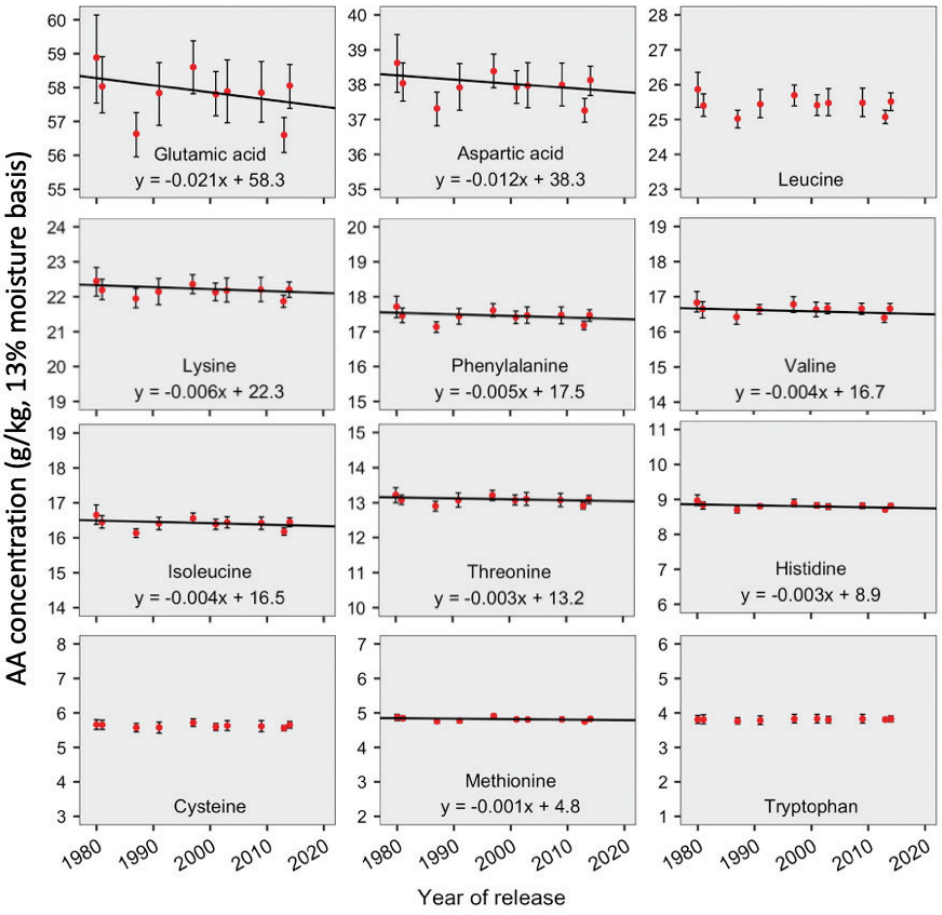

Figure 2. *Relationship between amino acids and the year of release of soybean varieties from 1980 to 2014. Observations represent the average between control and nitrogen-fertilizer treatments (due to lack of nitrogen effect).*

Conclusion

Soybean varieties released over the last 4 decades displayed a yield increase linked to a reduction in protein concentration. Nonessential amino acids, constituting the seed bulk nitrogen reservoir, followed a similar decreasing trend with protein. Concentrations of some essential amino acids did not change over years or decreased at lower rates. Future progress in yield should not overlook seed nutritional value.

Ignacio Ciampitti
Associate Professor
Farming Systems
Kansas State University

Seth Naeve
Associate Professor
Soybean Agronomist
University of Minnesota

Andre F.B. Reis
Post-doctoral Researcher
Kansas State University

Luiz M. Rosso
Graduate Student
Kansas State University

K-STATE Research and Extension

UNITED SOYBEAN BOARD

Publications from Kansas State University are available at: *bookstore.ksre.ksu.edu*

Kansas State University Agricultural Experiment Station and Cooperative Extension Service
K-State Research and Extension is an equal opportunity provider and employer. Issued in furtherance of Cooperative Extension Work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Director of K-State Research and Extension, Kansas State University, County Extension Councils, Extension Districts. MF3552 | January 2021