RELATION OF METHIONINE CONTENT TO PROTEIN LEVELS IN SOYBEANS[1]

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ABSTRACT

Widespread use of high-efficiency rations for poultry and livestock creates a demand for soybean meal because of its high protein content, relatively high protein quality, and the animal's tolerance. There is interest in breeding soybean varieties higher in protein, provided good nutritional quality can be maintained. The essential amino acid, methionine, is an important factor in such quality. Experiments were devised to separate, as far as possible, genetic and environmental factors that affect the protein content of the seed and the proportion of methionine in the protein. Methionine content was determined by a modification of the McCarthy-Sullivan colorimetric method, using sodium nitroprusside. Analysis of meal, representing a wide range of protein content, indicates that there is no significant tendency for methionine in the protein to decrease when protein content is raised.

Widespread use of rations high in protein and energy for poultry and livestock creates a demand for soybean meal. Soybean meal is fed primarily because of its high content of good-quality protein. More feed protein in the U.S.A. comes from soybean meal than from all other sources combined. Therefore, interest in the possibility of breeding soybeans for higher protein content is increasing.

In a breeding program, a favorable amino acid balance must be maintained. A program to breed corn of higher protein content was unsuccessful because the increase occurred in zein, a fraction already contributing to lysine deficiency (1). Roberts and Briggs (2) recently have reported that a highly purified portion of the 7S fraction of the acid-precipitable or globulin fraction of soybean proteins contains only 0.19% methionine. This raises the possibility that in breeding for higher protein in soybeans, we might make the methionine deficiency greater by increasing the proportion of this methionine-deficient globulin fraction.

This paper is concerned primarily with the effect of variations in the protein content of soybeans on the proportion of methionine in the protein, which affects nutritional quality. The nutritional quality of soybean protein is limited by a moderate deficiency in methionine. In a previous study (3) on soybeans, we found small but statistically significant varietal differences in the methionine content of the

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protein. Differences due to location were of greater magnitude, but generally too variable from year to year to be statistically significant.

Cystine is not an essential amino acid, but will supplement methionine to a limited extent. According to the proportions suggested by Nestler (4), there is generally sufficient cystine present to match the methionine content. However, if synthetic methionine were added, more of the cystine could be utilized. In a mixed ration, more cystine is likely to be available from other ingredients, since both corn and wheat are higher in cystine.

Corn protein is markedly deficient in lysine, but not in methionine. Soybean protein is quite adequate in lysine but moderately low in methionine. The two proteins tend to supplement each other in a mixed ration, although neither is high enough to make up completely for the deficiency of the other. Mertz *et al.* (5) recently reported a mutant gene in corn which may help to alleviate the lysine deficiency, but if so, lysine still would be deficient.

The following experiments were designed to show the effects of genetic and environmental factors on the relation of methionine content to protein percentage in soybeans.

Experimental

Methionine was determined by the McCarthy-Sullivan colorimetric method (6) as modified by Horn *et al.* (7) and by Krober (3). Protein in the seed was calculated as Kjeldahl nitrogen × 6.25 and expressed on a moisture-free basis. Soybean samples, grown under experimental field conditions, showed a wide range of protein content.

Figure 1 shows the results obtained in the analysis of 82 high-protein strains from the cross CNS-4 × Biloxi, grown at Gainesville, Florida. Percent methionine in the protein is plotted against percent protein in the seed. The regression line indicates a decrease of 0.008% methionine for each 1% increase in protein. Thus, in this test, methionine of the protein was substantially unaffected by protein level in the seed.

In a second experiment, 12 strains were analyzed from the cross D51-4877 × D55-4168, each grown on two different soil types at Stoneville, Mississippi. For results, see Fig. 2. The coefficients of correlation between percent methionine in the protein and percent protein in the seed were +0.56 and +0.58, respectively, for soybeans grown on heavy clay and on a loam, two distinctively different types of soil. Thus, soil type did not influence the methionine content of the protein, and the methionine content of the protein tended to be positively correlated with protein level in the seed.

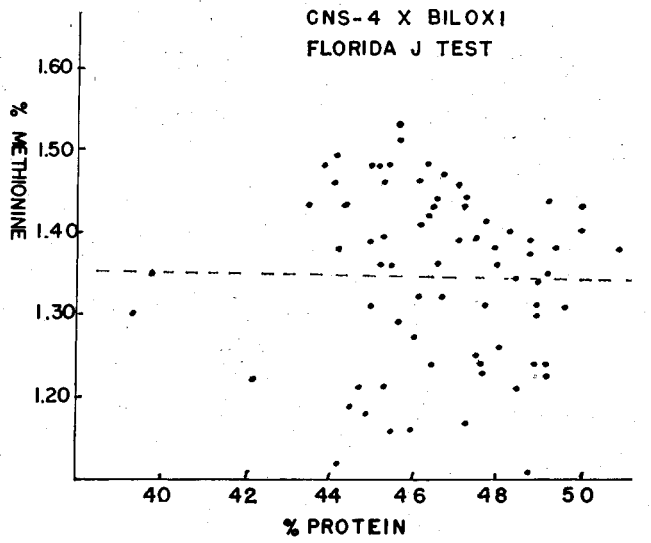

Fig. 1. Relation between methionine in the protein and the protein content of high-protein strains from a single cross.

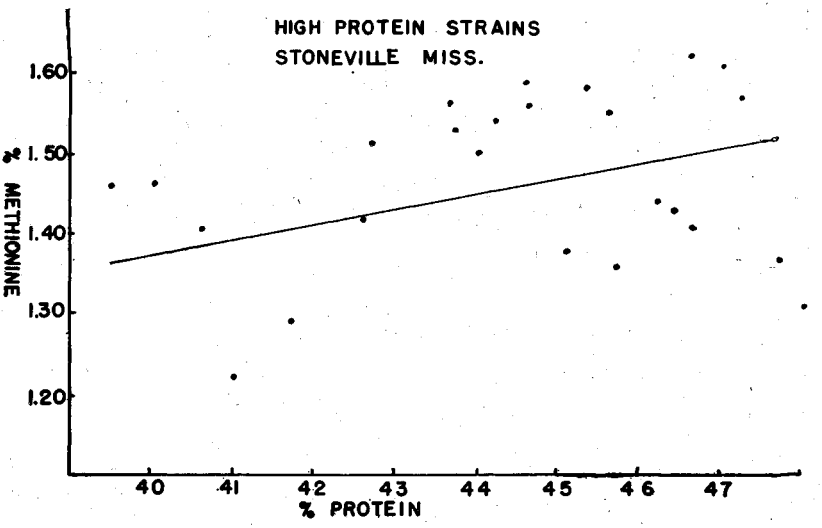

Fig. 2. Relation between methionine in the protein and protein levels differing because of genetic factors.

In the next group of samples, two soybean strains, one of which produced nodules on the roots and the other did not, were grown at four nitrogen levels at Ames, Iowa. These two lines were practically

identical in performance when grown on soil high in nitrogen. When grown on soil low in nitrogen, the nodulating strain performed almost the same as on high-nitrogen soil, but the nonnodulating strain gave low yields and the seed produced was low in protein.

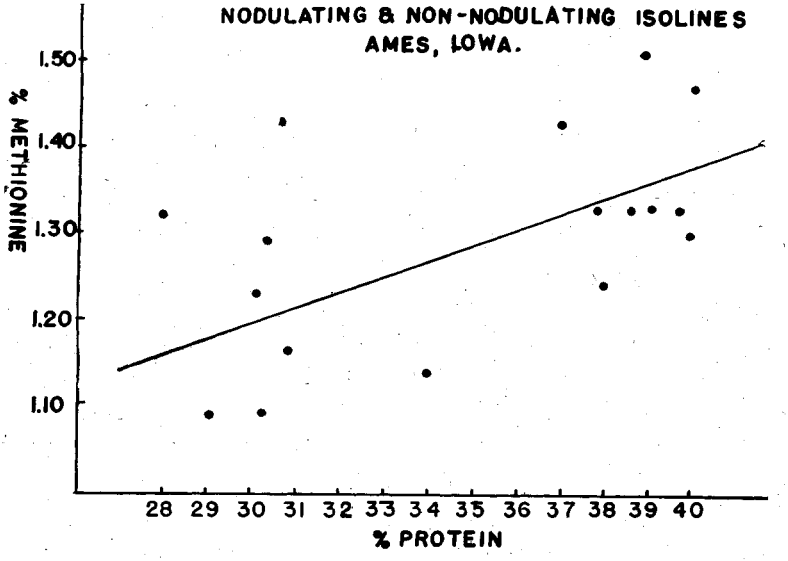

Fig. 3. Relation between methionine and changes in protein content due to nitrogen fertility levels.

As shown in Fig. 3, the protein content of the seed ranged from 28 to 40% and methionine in the protein from 1.1 to 1.5%. The correlation between methionine in the protein and protein in the seed was +0.52*, showing a tendency for the higher-protein seed to have higher methionine also.

The next experiment was also designed to minimize genetic effects in order to study environmental effects. The samples are all the same variety, Hardee, grown at the same location and in the same season. Yields varied from 5 to 45 bu. per acre and the oil content from 20 to 26%. The protein content varied from 28.6 to 45.5%, because of 1) the use of different strains of *Rhizobium* in inoculation, or 2) lack of inoculation. Methionine in the protein varied from 1.3 to 1.7%.

When methionine in the protein was plotted against protein in the seed (Fig. 4), it became evident that methionine decreased with increasing protein content in samples which were below 37% in protein. However, in samples above 37% in protein, the regression line shows

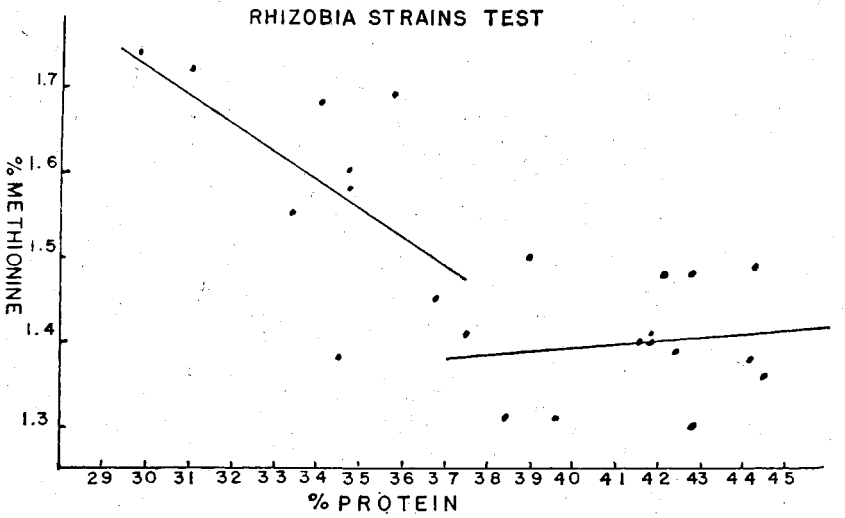

Fig. 4. Relation between methionine and protein levels differing because of the use of different strains of *Rhizobia*.

a slight tendency for methionine in the protein to increase with increasing protein.

Discussion

These four experiments included soybean seed samples with as wide a range of protein content as can ordinarily be found. The results indicate no significant tendency for methionine in the protein to decrease with increasing protein in the seed. In fact, there was more of a tendency toward a positive relationship, which is favorable to the development of high-protein strains of good nutritional quality.

Some progress has been made in breeding soybeans for higher protein content. The present study indicates that methionine in the seed generally increases proportionately as protein is increased.

Acknowledgments

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