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SORGHUM PROTEIN QUANTITY AND QUALITY

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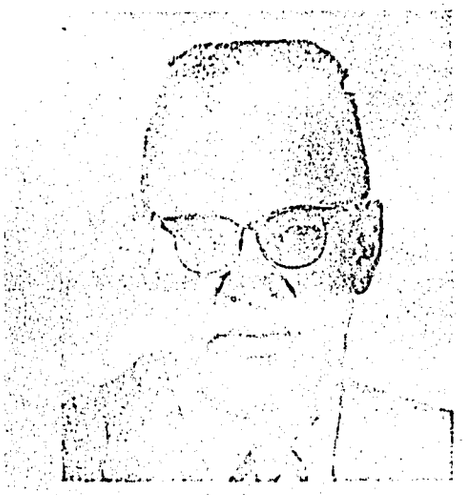
Studies on Protein Quantity and Quality at Purdue University are being supported by U.S.A.I.D. on a project entitled "Inheritance and Improvement of Protein Quality and Content in *Sorghum vulgare* Pers." This project is midway through a five year program and is intended to serve sorghum improvement programs around the world in addition to the information being of direct importance in the U.S. Progress reports are issued every six months and are sent to all interested research workers.

Sorghum improvement programs are now simultaneously concerned with yield and nutritional quality. The yield increases being seen in new hybrids no longer need to be accompanied by decrease in protein amount and nutritional quality. In 1958 replicated plot yields of 13,000 lbs. of grain per acre were found and now farm yields are being obtained repeatedly in the range of 11,000 to 12,000 #/A or more. Now replicated plot yields of 15,000 to 20,000 #/A are being found only the protein percentage can be significantly increased from the present 10 or 12% to a range of 15 to 20%. A total range of 7 to 26% protein has been found in the grain.



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Most significant increases in all cereal crop variety and hybrid yields in the past have been accompanied by significant decreases in protein percent with 1.5 to 2% loss being common. Sorghum studies in progress at Purdue show a negative correlation of $r = -.61$ of yield with protein percent in certain widely diverse material. The present situation in sorghum may offer advantages over cereal grains since the high protein sources are already naturally existing in a very wide array of diverse inbred lines in the world collection. Thus when hybrids are made among these diverse high protein types considerable heterosis for yield is seen and while the overall trend is for decrease in protein the relationship is not absolute and many hybrids are observed with protein percent as high as the parents or even slightly higher. Even if the hybrid is significantly lower in protein percent than either parent the absolute

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level may be considerably above present levels. For example a 17% x a 17% may have an F_1 of 15% but that is considerably above the past experience of crossing a 12% x a 12% and getting a 10% protein F_1.

In the past as protein percentage was increased in corn for example there was a significant decrease in lysine and other limiting amino acids such as threonine, tryptophane, methionine, cystine, isoleucine and leucine. Purdue studies show that the negative correlation of protein percent and lysine was present but at the very low level of $r = -.12$. Other studies in progress show $r = +.21$ thus it is relatively easy to get significant protein increases and simultaneously increase the lysine significantly. We now prognosticate that the usual level of 1.5% + lysine in the protein to 2.5 or 3% or more in the whole grain. These same studies by Campbell showed a significant but relatively small effect on protein percent by 4 levels of nitrogen including residual, 100, 200 and 400 lbs. per acre, a range of 11-16% protein at residual N up to 12-17% with 400 #/A.

To date there have been no strong negative relationships of lysine with the other limiting amino acids. Almost always the other limiting amino acids tend to go up with significant increases in lysine. Great ranges in variability exist for each including <1% to 3.8% lysine, 2.5 a 35% threonine, .34 to 4.5% tryptophane, 1.5 to 2.75% Methionine = cystine (total 5 bearing amino acids), 3.7 to 4.5% isoleucine, and 10.2 to 15% leucine Ratios are important as well as amounts of amino acids eg. high ratio of isoleucine to leucine is desirable.

Biological tests have been limited to date but rat feeding trials have shown wide variability in gains of rats on a 9% protein diet and in percent digestibility. The rat gains varied from 4.4 to 15.8 gm and PER's had a range of .18 to .91. Digestibilities vareid from 45 to 77%.

Most of the sorghum analyses to date have been on whole kernels in contrast to the primary emphasis on endosperm analyses and mutants in corn.

Embryo sizes in sorghum are now being investigated in the contrasting protein types. Embryos vary from 9.7 to 14.1% of the dry matter of the seed. The oil content which is almost all in the embryo varies from 1.2 to 5.7% oil in the seed. A variety with 10% embryo in the seed had 3.4% oil and one with 14% embryos had 5.4% oil. The variation in the embryos in amount of protein is considerable with preliminary results showing 22 to 36% protein and lysine 4.1% and above.

In years ahead it is definitely prognosticated that these new high protein levels and improved amino acid compositions can be combined with new high yield levels in combine height grain sorghums for U.S. usage.

For the immediate future however the vast proportion of the best yields and qualities are in the 5 to 9 foot height class. Further experimentation may reveal some continuing inherent advantages of these taller plants. Trials to date show that taller plants of the few inbreds tested have yield advantages. This same phenomenon seems to hold true for the highest yielding most heterotic hybrids. Studies are now

underway on vertical "planting geometry" or patterns of mixing various height plants as well as spacing and density studies. Studies in 1968 at Purdue showed that head size, which is directly affected by density and patterns of planting, may directly influence protein content with the smaller heads having more protein.

The present highest yields and best protein amounts and qualities are seen in the 5 to 9 foot height hybrids are already in useful form for many locations overseas that are not concerned with machine harvest. At these locations the job remaining is one of finding best adaptations, maturities and necessary resistances. In the U.S. some of the shorter ones of these new types may be grown for grain and combines adapted for higher capacities and heights if the projected yields of over 300 bu/acre can be achieved consistently.

A prognosticated use of these new taller, most productive, improved protein and lodging resistant hybrids will be for silage. The big booms have come to sorghum in the U.S. with the grain sorghum hybrid development beginning in 1954 and the ensueing male-sterile sorghum x sudan and ms sudan x sudan hybrids for pasture and green chop. The use of these grassy types for silage is generally a mis-management. For best silage additional energy is needed and these new types of sorghum hybrids promise higher grain yields with improved protein content. The green leaves persist until suitable grain maturity which should be a somewhat immature digestible stage and not hard grain that passes through animals undigested. These yield and quality advantages over corn should be exhibited widely since the vast bulk of corn silage has less grain of lower protein content and brown leaves to a high proportion.

Thus the third big "boom" in the U.S. in sorghum development and utilization could be these new lodging resistant, high grain yielding, and improved protein types for silage. It is possible that patterns of mixed heights may be used—these are still strictly in the experimental stage. The use of the grain alone without adequate utilization of the remainder of the plant is a wasteful practice that would be drastically changed if this third U.S. sorghum "boom" comes to pass.