should include the 7.5 to 20 cm depths, which in turn may be affected by cultural practices.

The number of apothecia on the surface of irrigation furrows and adjacent cultivated rows were counted in a field of Great Northern #59 beans. Observations were made in each of two replicates of 16 continuous paired plots (90 cm length of row). The number of apothecia in the irrigation furrow was approximately 5 to 10 times greater than in the adjacent cultivated row. This difference may be due to the greater exposure of surface area of the soil profile which thus enables more apothecia to reach the soil surface, or to varying soil moisture conditions which affect sclerotial germination. Distribution of numerous apothecia in furrows may be important to the dissemination of ascospores by irrigation water, and suggests that effects of irrigation practices and row spacings on apothecial production should be investigated further.

Differences in plant growth habitat have been related to white mold severity (BIC, 1973), but they may also affect apothecial production. Architecture of the plant canopy may alter the surrounding microclimate which in turn may affect the level of apothecial production and subsequent ascospore infection. The number of apothecia on the soil surface beneath the canopy of 16 varieties in four random samples from each of four replicates (three rows, each 305 cm in length) was counted. An average of 19 apothecia was found beneath indeterminate varieties such as GN #59, GN 'Tara' or Scarlet Runner. On the other hand, an average of 6 apothecia was found beneath determinate varieties such as Charlevoix (Red Kidney) or Sanilac. Varieties with viny growth and dense canopies may provide more favorable micro-climatic conditions for the production of apothecia of the white mold fungus.

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BREEDING FOR IMPROVED PROTEIN QUALITY IN *PHASEOLUS* BEANS

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Recently considerable effort has been devoted to the selection of increased protein content in seeds of *Phaseolus* beans. It is probably opportune to consider whether such efforts are appropriate. Except for possible use in feeding ruminant livestock, increased protein content *per se* is perhaps not the most sensible breeding objective. High protein content is sometimes found to be inversely correlated genetically with yield, while protein content is itself subject to marked environmental influence (Lantz *et al*, 1958). A more rational alternative objective would appear to be to maximize production of high quality protein per unit area rather than to select for high protein content regardless of quality. This might well involve selecting for high yield of seed with a relatively low content of high quality protein.

The problems in carrying out this suggested breeding objective are considerable but no longer insuperable. It has been shown that the amino acid profile of seed protein is also subject to environmental influence (Lantz et al, 1958). It appears from the serological work of Kloz and Klozova (1968) and Kloz (1971) that the qualitative immunological response of seed protein in a given genotype is more or less constant. Variations in protein content and amino acid profiles of a genotype produced under different environmental conditions therefore most probably arise from differential production of protein fractions of constant composition rather than constant levels of production of fractions varying in composition. A first step in a more rational breeding programme would be to confirm this hypothesis and then to study the actual response in production of distinct protein fractions to variation in environmental conditions.

Serological studies have also shown that the immunoelectrophoretic patterns of different Phaseolus vulgaris genotypes are not uniform and reflect two situations. The first is whether a particular protein fraction is produced or not and the second is whether significant variation in the composition of homologous fractions occurs (i.e. whether polymorphic proteins are produced). Serological cross reaction could occur for example between homologous fractions with slight but detectable differences in electrophoretic mobility and of slightly different chemical composition.

The seed protein of Phaseolus can be considered conveniently under the groupings of albumins and globulins. The albumins include materials of enzymatic nature in which polymorphisms are well known. There are also numerous albumin fractions which can be identified, ten or more. The genetic control of these fractions is in some cases at least quite simple (Kloz, 1971) and manipulation of these characters in breeding programmes should not be unduly complex. It is essential however that individual fractions be separated and characterised and the extent of polymorphisms determined. The extent to which these polymorphisms affect amino acid profiles must also be established.

When this amount of progress has been made it should be possible to assess the contribution of each fraction to the overall profile and also to identify the most important contributors to the total sulphur amino acid content and that of tryptophan (the most significant limiting essential amino acids). Two approaches are possible, positive selection for the protein morph with the most desirable amino acid profile where a number of polymorphic forms occur and selection for the absence of fractions which contribute little to the total content of limiting essential amino acids.

In the case of the globulins the work of Tombs (1965) and Tombs and Lowe (1967) has shown that there is scope in the peanut for genetic manipulation of the polypeptide constituents of storage globulin. The interest of this work is enhanced by the fact that the polypeptides which can be manipulated genetically differ in sulphur amino acid content. Since the globulins form the greater part of bean seed storage protein,

exploration of polymorphisms of these proteins is essential and also of the genetic control of such polymorphisms as can be detected.

The execution of this proposed breeding strategy depends on being able to fractionate seed storage protein satisfactorily and to characterise these fractions adequately. There have been, of late, considerable improvements both in the range and efficiency of protein extraction and separation techniques. Sun et al (1974) have identified two distinct globulins and have shown that the apparently anomalous behaviour of globulins in the separative procedures followed has been due to polymerization and depolymerization. Winfield at Southampton has been able to extract and purify albumin fractions which correspond in number fairly well with identifiable immunoelectrophoretic arcs of the same genotypes produced by Kloz and Klozova (1968) and Kloz (1971). It is hoped to establish exact correspondence between separated fractions and those arcs.

The biochemical basis for more efficient selection techniques for improved protein quality is now being established rapidly. Development of simplified techniques for evaluating selection lines should follow once the critical fractions have been identified and characterized. A further comment on selection objectives is perhaps appropriate at this point. It is sometimes thought to be desirable to eliminate, as far as possible, anti-digestive factors in beans (protease inhibitors, phytohaemagglutinins, etc.). It would probably be foolish to do this without evaluating their contribution to the overall amino acid profile. The soybean which is nutritionally the best balanced grain legume in amino acid composition has the most formidable array of anti-digestive factors. It would be retrograde to select for reduced nutritional value in this way, when anti-digestive factors are largely removed in normal processing.

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IMPLICATION OF BEAN PATHOGEN CONTAMINATION OF IRRIGATION WATER

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Further studies in western Nebraska have confirmed the dissemination of Xanthomonas phaseoli (bean common blight) and Whetzelinia (Sclerotinia) sclerotiorum (bean white mold) in irrigation water reported in the 1973 BIC Report. From surveys conducted during 1972-1974, distinct dispersal patterns of these two pathogens have emerged. X. phaseoli was only recovered in August in runoff water from bean fields having common blight infection or in ditches receiving this water. On the other hand, sclerotia of W. sclerotiorum were recovered from all types of waterways including main canals as well as irrigation runoff. Sclerotia were also found throughout the season during 1973 and 1974.

The limited movement of X. phaseoli may be explained by the poor survival of this bacterium in water. Laboratory studies demonstrated that X. phaseoli populations declined in deionized water until after 20 hr no viable cells could be recovered. With a flow rate of 0.6 - 0.9 m/sec (3-4 ft/sec), however, even survival for a few hours would allow distribution of bacteria into nearby fields. Bacterial dissemination in infected tissue is being studied.

The recovery of W. sclerotiorum can be correlated with incidence and severity of white mold disease as well as irrigation timing and frequency. The light white mold infection in 1971 resulted in few sclerotia recovered in early 1972, whereas the severe epidemic in 1973 correlated with frequent late August, 1973 and early June, 1974, sclerotial detection. Mode of germination of sclerotia can distinguish recent from previous season's sclerotia. Newly-formed sclerotia only germinate myceliogenically on any medium whereas sclerotia conditioned for 3 or more months in soil germinate to form apothecia on water agar. The wide distribution of W. sclerotiorum in waterways can be explained primarily by sclerotial longevity. In a previous study sclerotia remained viable for at least 3 years in soil. Recent results show survival for at least 10-21 days in flowing water. Due to their lack of distinguishable morphological or physiological characteristics, ascospores were not detected in irrigation water. Their important role in the epidemiology of white mold in Nebraska has been demonstrated in previous studies, and a role in water dissemination would be predicted. In recent studies, these spores remained viable for at least 5 days in deionized water.

With the critical need for irrigation water, reuse of agricultural runoff appears to be a necessary component of irrigation strategy. The