INFORMATION BULLETIN on the

NEAR EAST WHEAT AND BARLEY IMPROVEMENT AND PRODUCTION PROJECT

September - December 1970
Volume VII – No. 3

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

AGP:FFC/NEWB/15

INFORMATION BULLETIN

on the

NEAR EAST WHEAT AND BARLEY IMPROVEMENT AND PRODUCTION PROJECT

September - December 1970

VOL. VII, No.3

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

Rome, 1970

FOREWORD

The importance of the nutritional quality of cereal proteins is now fully recognized. Studies on this subject are attracting the attention of plant breeders and cereal chemists who aim to breed and develop those varieties of cereals which have better grain and protein qualities. Such efforts will go a long way towards bridging the protein gap and improving the health of the masses suffering from malnutrition. To keep up the interest of plant breeders in the Near East Region and to acquaint them with recent research this issue of the Information Bulletin contains three papers devoted to this subject.

The first paper relates to the genetic upgrading of protein properties in cereals, millets and pulses and suggests methods for increasing their nutritional value. Studies with induced mutations in high-yielding genotypes of wheat and rice have shown that considerable variability for protein content can be generated artificially. The paper on gene control of protein production suggests that the breeders should make selections on the basis of absolute protein content per seed and not on the basis of per dry matter which is influenced by seed weight and in turn by environmental conditions. The last paper on this subject calls for precise and accurate measurement of nutritional values, expressed in terms of minimum quantities of essential amino acids, suggesting the need to develop such varieties which meet these requirements. The paper also discusses in detail the protein status of cereals as well as different methods used for determining the nutritional quality of cereal proteins.

In view of the great importance of this subject, cereal breeders of the Near East Region should modify their breeding, selection and testing programmes, giving proper weight to the improvement of grain and protein qualities and also taking the necessary steps to set up well equipped laboratories for this purpose.

The other papers deal with the summary reports of the two important yield nurseries - ISWYN and IWWPN, which are providing valuable high-yielding genotypes to the breeders. The paper on seed production and certification in Iraq shows the necessity of streamlining controlled seed production and distribution programmes if the areas under high-yielding varieties are to be expanded. Although the use of high-yielding varieties is on the increase, the farmers are not obtaining the full potential of these varieties. This is due to faulty production techniques which, if improved, can still raise the level of production by 40 to 50 percent.

There is no time to relax; we have to continue working hard in order to overcome the existing deficiencies and to solve the new problems which will arise from time to time.

Footnote: The views expressed in the articles are the authors, and are not necessarily shared by FAO.

CONTENTS

THE CHOICE OF STRATEGY FOR THE GENETIC UPGRADING OF PROTEIN PROPERTIES IN CEREALS, MILLETS AND PULSES 1/

by

M.S. Swaminathan, M.S. Naik, A.K. Kaul and A. Austin
Indian Agricultural Research Institute
New Delhi 12 (India)

SUMMARY

1. Examination of the amino acid profile of different fractions of endosperm proteins showed that as in maize, the alcohol-soluble fraction, which is the dominant component, has relatively a very low content of lysine in sorghum and several millets, excepting *Panicum miliaceum*. In these crops, a reduction in the prolamin fraction leads to an increase in the lysine content of the grain, as has been earlier observed in the spontaneous mutants Opaque-2 and Floury-2 of maize. Techniques for the rapid screening of varieties for prolamin content would therefore be very helpful in breeding programmes. *Pennisetum typhoides* also has a low lysine content in the prolamin fraction but this fraction is rich in tryptophan. The embryo was seven times as rich as the endosperm in the content of essential amino acids. Among minor millets, *Panicum miliaceum* is rich in lysine. The proteins of *Paspalum*, *Setaria* and *Eleucine* have a low digestibility due to a fibrous envelope in the seed. Reducing fibre content in the seed should therefore be an important goal of breeding. Selection of grains with large embryos is another method of improving quality.

2. In bread wheat and rice, an increase in protein content *per se* appears to be the most rapid method of enhancing the nutritive value of the grain. This is being done through regular breeding procedures. Studies with induced mutations in high-yielding genotypes have shown that considerable variability for protein content can be generated artificially. Since some of the induced variability appears to owe its origin to additive gene action, there is scope for selection advance. There is also scope for re-distributing the protein in rice grains in such a manner that milling will not reduce the protein content. Among the correlations tested there is to some extent a negative correlation between protein content and yield as well as resistance to bacterial blight in rice.

3. The removal of the neurotoxic principle β-(N) - oxalyl; α - β - diamino propionic acid, from the seeds of the grain legume *Lathyrus sativus* through mutation breeding appears to be a possibility. The character, however, behaves like a polygenic trait.

4. Examination of a large collection of *Cicer arietinum* and *Cajanus cajan* has not revealed much variability for protein content. Hence, some good cultivars have been treated with physical and chemical mutagens.

5. Triticale strains developed by chromosome doubling in the cross *Triticum durum* X *Secale cereale* have 18 to 20 percent protein and nearly 4 g lysine per 100 g protein. They have, however, several defects which are now being corrected through mutation breeding.

1/ Presented at the Symposium on Plant Protein Resources held in Vienna.

INTRODUCTION

Research on the genetic upgrading of protein quantity and quality in the major cereals, millets, pulses and feed and fodder crops at the Indian Agricultural Research Institute, New Delhi, covers the following aspects :

a) Standardization of techniques for the rapid screening of material.

b) Studies on the biosynthesis of storage proteins, amino acid profile of protein fractions and the standardization of selection criteria in breeding experiments.

c) Screening collections of recent and primitive cultivars for variability in protein properties and assessment of the effects of environmental parameters on protein content.

d) Genetic and cytogenetic analysis of the mode of inheritance of protein characters in cereal grains and study of correlations, in particular between protein content and yield.

e) Study of mutagen - induced variability in protein characteristics.

Some of the results have been published in a series of papers (1 to 5)[1/]. Some recent results are presented in this paper.

RESULTS

a) Standardization of techniques

The dye-binding capacity method and the microscopic section-scoring method are used for preliminary screening (see paper by Kaul et al in this Symposium). The genotypes selected in this way are subjected to detailed amino acid analysis in an automatic Technicon Analyser with a long column. Analysis for protein content is done using the micro-Kjeldahl method. For the estimation of metheonine in pulse crops like Cajanus cajan, Phaseolus aureus, P. mungo and Cicer arietinum, Sullivan-McCarthy's colorimetric method using glycine and nitropruside was found useful. In addition, a rapid method of estimating total sulphur in 100 mg samples has been standardized. The proteins were fractioned by the modified Merdel-Osborne method (1).

b) Studies on the characteristics of protein fractions and the development of selection criteria

(i) Value of fractionation studies

Cereal grain proteins are a very complex and heterogenous mixture of a large number of completely different types of molecules, the individual species of which have not yet been successfully identified or isolated. The techniques used for enzyme purification are not readily applicable to storage proteins due to the absence of any assay system for the latter. However, the identification of individual protein fractions responsible for the poor biological value of grain proteins is of immense practical value for research aimed at the genetic improvement of the nutritive quality of the proteins. This has been amply demonstrated in the case of maize, where the ethanol soluble zein fraction was known to be extremely deficient in lysine and tryptophan. A search for low zein mutants led Mertz, Bates and Nelson (6) to the discovery of high lysine mutants containing opaque-2 and floury-2 genes. The biochemical basis for this improvement was the decreased synthesis of zein with a coincident increase in the non-zein protein synthesis.

1/ See References on page 8.

In other species of cereals and millets a similar approach would be successful if the protein fractions possess gross amino acid imbalance. We have therefore isolated protein fractions from the major and minor millets grown in India and have attempted to identify the fractions responsible for the poor biological value of these grains.

(ii) Sorghum and Maize

Earlier work had shown that in *Sorghum* grains, the prolamin fraction is extremely deficient in lysine and trytophan (1). The observed similarity between the protein fractions of maize and *Sorghum* prompted us to examine in more detail the complete amino acid composition of individual protein fractions, obtained from two varieties, containing high and low lysine concentrations. The results are given in Tables 1 and 2.

The prolamin fraction from both the varieties had similar amino acid composition, which was characterized by large quantities of glutamic acid, proline and leucine accompanied by an extreme deficiency of glycine, basic amino acids, cysteine, methionine as well as tryptophan. As against this, the albumin and globulin fractions had a more balanced amino acid balance as evidenced by lower glutamic acid and proline and higher lysine and tryptophan contents. The leucine to isoleucine ratio was as low as 1.5 in these fractions. Raghuramulu, Rao and Gopalan (7) correlated the incidence of pellagra in populations consuming *Sorghum* with the abnormally high leucine to isoleucine ratio in the proteins. It is thus clear that it is the prolamin fraction which is responsible for the serious amino acid imbalance in this millet.

As regards maize, results of great practical significance have been obtained at the Indian Agricultural Research Institute by incorporating floury-2 and opaque-2 genes in hybrids. The amino acid composition of the successful new composites has been compared with that of Ganga-3 hybrid in Table 3.

The main effect of incorporating the new genes was to enhance the lysine content to 4 g as against only 1.5 g in Ganga-3. This was accompanied by a decrease in glutamic acid, proline and leucine. These desirable changes were brought about by depressing the zein concentration.

As in maize, the enrichment of the protein quality of *Sorghum* can be accomplished by developing new varieties low in prolamin content. This could also be achieved by selecting varieties having larger embryos, since most of the storage protein, prolamin, is concentrated in the endosperm.

(iii) Pearl Millet

In a number of varieties of pearl millet (*Pennisetum typhoides*) wide variation in protein (8-20), lysine (1.2 - 3.8) and tryptophan (0.7 - 1.7) were observed. The tiny embryo, which constituted only two percent of the total weight of grains, contained about ten percent of the total protein. Thus, the embryo was about seven times as rich as the endosperm on equal weight basis. In this millet also, prolamin and glutelin were the major protein fractions in all the varieties. The complete amino acid composition of individual protein fractions obtained from the hybrid HB-1 (Table 4) brought out striking differences. High tryptophan concentration in the prolamin fraction is noteworthy. In this respect, pearl millet prolamins differ markedly from those of *Sorghum* and maize. However, as regards having a high concentration of glutamic acid and proline and deficiency of lysine, it resembles zein. Albumins and globulins contained higher concentrations of basic and sulphur containing amino acids. In a fertilizer experiment, it was observed that the main effect of nitrogen fertilization was to enhance the prolamine content by about 40 percent. As a consequence, the additional protein synthesized was richer in tryptophan but poorer in lysine. This important difference in the proteins of pearl millet and those of other millets should be taken into account in breeding research aiming at the improvement of protein quality.

(iv) Minor Millets

Several species of what are known as minor millets constitute a major source of protein for the poorer sections of people in India, particularly in drought-affected areas. Genetic methods offer great scope in improving the quality of these proteins but hardly any serious attempts have so far been made in this direction. For a closer examination of the problem, the following species were selected :

1. *Eleusine coracana*
2. *Panicum miliaceum*
3. *Setaria italica*
4. *Panicum miliare*
5. *Paspalum scrobiculatum*
6. *Echinochloa colona*

Protein, lysine and tryptophan contents are given in Table 5. It is interesting to note that *P. miliaceum* was rich in lysine, the concentration being equal to that of FAO reference protein. The grains appear to be even superior to the lysine-rich maize composites. *Paspalum* contained more than 3 g lysine, which is equal to that of rice protein. Most of the other millets were deficient in lysine. As regards tryptophan, *Eleusine* was found to be a rich source but *Echinochloa* and *P. miliare* were very poor. As in major cereals, tryptophan was the second limiting amino acid in minor millets also.

Protein fractionation studies revealed that most of the minor millets contained a large proportion of unextractable protein. This refractory character may be due to the fibrous envelope in which the proteins are enclosed. The complete amino and profile of *Eleusine* and *Paspalum* given in Table 6 shows that in general, *Eleusine* resembles rice protein, while *Paspalum* is comparable to *Sorghum*.

Feeding experiments with albino rats with *Paspalum*, *Setaria* and *Eleusine* gave extremely low NPR (net protein ratio) and NPU (net protein utilization). Fortification with lysine, methionine and tryptophan singly was not of much benefit but all three together improved the growth rate. Chemical analysis did not reveal any acute deficiency of essential amino acids, as compared with other cereals. Studies *in vitro* demonstrated that the native proteins were extremely resistant to the action of papain. However, heat treatments such as autoclaving or boiling improved the digestibility considerably. This could be due to the destruction on inhibitors of proteolytic enzymes or to changes in the physical properties of the proteins. In the case of minor millets, therefore, genetic methods have to be aimed at reducing the fibre content and improving the digestibility of the proteins.

(v) Wheat

In wheat, the prolamin fraction gliadin is not as deficient in lysine as in maize. Recent studies by Booth and Ewart (8) with purified components of gliadin obtained from 70 percent extraction flour showed a lysine content of about 0.7 g per 100 g protein. In the crude prolamins isolated from whole grains of the variety Kalyan Sona we observed about 1.4 g lysine as against only 0.2 in zein. It is therefore obvious that the prolamin fraction of wheat is not as poor as zein. The amino acid composition is much more balanced. Hence, the quantity of protein in the grain can be increased without much detriment to quality. Work at I.A.R.I. has shown that even fertilizer treatments which increase the protein by 10-15 percent are effective in yielding a protein with balanced amino acid composition. It appears that moderate increase in the protein content by nitrogen application is desirable to obtain higher lysine and tryptophan concentrations. Genetic improvement of wheat proteins, therefore, offers much scope for evolving new varieties responsive to nitrogen and in which the additional protein synthesized is of better quality.

(vi) Rice

Among the cereals, rice proteins have the highest biological value. Cagampany et al (9) analysed several rice varieties for protein fractions and amino acid contents. The glutelin fraction accounted for more than 80 percent of the total protein. This fraction has a balanced amino acid composition and it contains almost 3 g lysine. Thus it may be quite feasible to increase the protein content of rice by genetic methods as well as by fertilization and at the same time obtain a balanced amino acid distribution.

(vii) Need for additional knowledge of storage protein biosynthesis

The above results have shown the diversity of characters of proteins from cereals and millets. However, certain common features are also discernible. The main physiological function of storage proteins is to supply amino nitrogen to the growing embryo during germination. Hence, in almost all cereal grains glutamic acid, aspartic acid and alanine, which are non-essential as far as human nutrition is concerned, account for more than half of the total nitrogen. The nutritional imbalance of the cereal grain proteins is thus a direct result of the physiological function for which they are synthesized in the seed. The proteins in the embryo of resting seed are more balanced in amino acid content. In the endosperm proteins also, the storage proteins synthesized during the last stages of maturation of the seed have poor biological value. It is interesting that in the unripe grain, lysine and tryptophan are present in substantial quantities but these are not incorporated into the storage proteins deposited in the endosperm. Genetic tools can therefore be used fruitfully to change the pattern of storage protein synthesis itself. However, very few attempts have so far been made to understand the mechanism of storage protein biosynthesis at the molecular level. Further, knowledge on this problem will no doubt help in achieving genetic modification of patterns of protein synthesis in the ripening grain. This could be the ultimate solution to the problem of amino acid imbalance in cereal grain proteins.

c) Variability in recent primitive cultivars

Extensive collection of Triticum aestivum, Oryza sativa, Zea mays, Sorghum vulgare, Pennisetum typhoides and several pulse crops have been screened for protein and lysine content. Very striking variations in protein content were found in the rice strains collected from the hills of Assam. Both climatic variables and the soil environment (particularly soil fertility) caused considerable fluctuation in protein content in cereals and millets. Such variation was particularly prominent in Sorghum vulgare. Pulse crops in general showed relatively more environmental stability with regard to protein content (Table 7). Unfortunately, in these crops, the variability so far observed for total protein content is limited except in Cajanus cajan where the protein content ranged from 16 to 25 percent in about 2 000 strains analysed. Considerable genetic variability, however, exists in pulses for methinine and total sulphur content. Since no negative association between methionine and protein contents has been observed, scope exists for improving the methionine content in the major pulse crops.

d) Screening of breeding material

In addition to cultivars, advanced generation selections considered promising from the agronomic standpoint are regularly screened for protein and essential amino acid content (Tables 8 to 10).

In bread wheat, the protein content varied from 10.0 to 18.6 percent in 234 selections with similar yield potential. Lysine content ranged from 1.07 to 3.46 percent, with a mean of 2.28 percent. Several strains (e.g. H.W.103, HS.1079-3A, 6335-1) were identified which had 15 to 17 percent protein content combined with 2.8 to 3 percent lysine.

In the maize breeding section of I.A.R.I. good progress has been made in the development of maize composites and hybrids having a higher lysine content through the incorporation of the Opaque-2 and Floury-2 genes. Protein and lysine values varying from 10.70 to 13.77 percent and 1.28 to 4.00 percent respectively were found in a wide range of white Opaque composites. In yellow opaque composites, the ranges of variation were 9.71 to 13.13 percent for protein and from 1.57 to 4.03 percent for lysine. The promising composites have a yield potential of about 85 percent of the best hybrids.

In India, whole ground (maize) meal is used for making chapati (unleavened pan-baked bread) or other preparations. The nutritive value of the meal (whole ground flour) is naturally determined by the relative size and proportion of the pericarp, embryo and endosperm, as these differ markedly among themselves in their chemical constituents and amino acid composition. The relative differences in the protein content of the different parts of the seeds of 12 varieties/hybrids are given in Table 9.

Grain Sorghum occupies an important position in the cereal economy of India being next only to rice in the area covered. Values varying from 8 to 21 percent for protein and from 0.72 to 3.37 percent for lysine were found in about 100 selections from recent breeding programmes. Based on the protein content, these were divided into (i) low (less than 10 percent protein), (ii) medium (10-12 percent), and (iii) high (more than 12 percent) protein groups. Sixty-three percent of the material was in the high protein group and 13 percent in the low protein group. The values for lysine varied from 1.24 to 3.37 percent with an average of 2.21 percent in the low protein group while in the high protein group the values varied from 0.72 to 2.95 percent with an average of 1.52 percent. In the medium group, the variation ranged from 1.19 to 3.31 percent with an average of 1.80 percent. Correlation studies showed a highly significant and negative correlation between protein and lysine content. It is worth pointing out that some strains like IS.4532 in the medium and IS.4952 in the high protein groups showed higher lysine values (3.22 percent and 2.95 percent respectively). These results suggest that by an extensive breeding and screening programme, it would be possible to select high protein *cum* high lysine material. As mentioned earlier, low leucine content is also important in view of the incidence of Pellagra in the areas where Sorghum is the staple and screening for leucine properties is in progress at the National Institute of Nutrition, Hyderabad.

Several newly developed strains of pearl millet (*Pennisetum typhoides*) had a good lysine content. The data for some of the strains presented in Table 10 show that several of them, such as 4120, 4121, 4123, 4128, 4142 and 4155, are either comparable or even superior to the standard hybrids HB-1, HB-2 and HB-3.

e) Genetics of Protein Quantity

In both wheat and rice the inheritance of protein quantity is polygenic. Additive genetic effect offers scope in bread wheat for developing high yielding-cum-high quality varieties, an observation also made recently by Chapman and Mc Neal (10). In order to identify the chromosomes which may be relatively more important in determining protein content, monosomic analysis using monosomics of Chinese Spring and Sonora 64 and Lerma Rojo, two semi-dwarf spring wheat varieties, was undertaken by Dr. M.P. Jha (unpublished). At the same fertilizer level, the protein content in Chinese Spring, Sonora 64 and Lerma Rojo was respectively 12, 16 and 15 percent. The differences in protein content between 41 and 42 chromosome F_1 plants as well as the range in protein content in the F_2 and F_3 progenies from monosomic F_1 plants were studied. The following results were obtained (Jha, Kaul and Raghaviah unpublished) :

The monosomic F_1 plants of eight chromosome lines, 1D, 2A, 3A, 3B, 5A, 6B, 7A and 7B in the cross Chinese Spring X Sonora 64 showed significantly higher grain protein in comparison to the disomic plants. In the cross Chinese Spring X Lerma Rojo such differences were observed in the chromosomes 1D, 3A, 3B, 6B and 6D. During two different seasons (1967-68 and 1968-69) a significantly higher protein content occurred in the F_2 progenies from 41 - chromosome F_1 hybrids of chromosomes 1D, 3A, 3B, 5A, 7A and 7B in Chinese Spring X Sonora 64. In the cross with Lerma Rojo, the critical chromosomes were 1D, 3A, 3B and 7D. Except in chromosomes 2A and 6B the seeds were well filled and the increased protein content could not be attributed to sterility. The data from monosomic analysis thus supports the genetic observation that several genes are involved in determining protein content. These genes also occur in all three genomes of Triticum aestivum.

f) Induced Variability for Protein Characters

Studies on the induction of mutations for the following characters are in progress:

i. Higher protein content and better protein distribution in the endosperm in rice.

ii. Higher protein and lysine content in bread wheat.

iii. Higher lysine and lower leucine content in Sorghum vulgare.

iv. Higher yield and protein content in Panicum miliaceum, which is rich in lysine.

v. Higher lysine content without lowering the tryptophan content in Pennisetum typhoides.

vi. Reduction in seed fibre content in good varieties of Paspalum, Setaria and Eleucine with a view to increasing the digestibility of the proteins.

vii. Increasing the content of methionine in good strains of Cajanus cajan, Cicer arietinum and Phaseolus sp.

viii. Improving high protein-cum-high lysine lines of Triticale (derived from crosses between Triticum durum and Secale cereale) for plant type fertility, endosperm filling, and seed colour and removal of hairs from the seed.

ix. Removal of the neuro-toxin, B-(N) - oxalyl, α - β - diaminopropionic acid, from the seeds of the pulse crop Lathyrus sativus. A wide range of mutagens, both physical and chemical, have been used. The M_2 generation from treatments with - rays, ethyl methane sulphonate, N-Nitroso methyl urea and N-methyl - N - Nitro - N - Nitroso guanidine in the wheat varieties Sharbati Sonora and Norteno is now being screened for variability in protein content. Both these varieties have normally 15 to 16 percent protein. Similarly, the M_2 and M_3 generations of the high-yielding Sorghum variety Swarna are being screened for variation in protein, leucine and lysine content.

A cycle of recurrent irradiation and and selection is being practised to achieve the total elimination of the neurotoxin from Lathyrus sativus. From parental lines with a mean neuro-toxin content of 0.375 g/100 g of seed, Nerkar (unpublished) has obtained lines in the M_3 generation with 0.117 g/100 g of seed. These low neurotoxin lines have again been treated with mutagens.

In rice, considerable variation in protein and tryptophan content has been found in both indica (IR.8, Taichung Native-1) and japonica varieties (Tainan-3 and Taichung 65). Detailed studies of the amino acid profile of a mutant with 11.2 percent protein in Taichung-65, in contrast to the control value of 8.7 percent, revealed that there was an increase in the mutant of methionine, phenylalanine arginine and a decrease in cystine, leucine, isoleucine, tryptophan, aspartic acid and glutamic acid. It is of interest that in the high protein mutant of Tanaka and Tamura (11), a reverse situation prevailed leading to an increase in aspartic acid, glutamic acid, leucine and isoleucine. Thus, analysis of the amino acid composition of mutants may provide an insight into the correlated pathway involved in the biosynthesis of amino acids.

The high-protein mutants in rice generally tended to be more susceptible to bacterial blight. Also, the high-protein lines were invariably lower in yield potential, although some selections combining a good yield potential with over 10 percent protein content have also been made.

Rice proteins tend to get concentrated in the aleurone and sub-aleurone layers, a factor which leads to some loss of proteins during milling and polishing. Genotypic differences in the manner of protein distribution in the endosperm appear to exist. Also high protein lines have a better distribution.

* * *

REFERENCES

1. Swaminathan, M.S., Austin, A., Kaul, A.K. and Naik, M.S., New Approaches to Breeding 1969 for Improved Plant Protein. FAO/IAEA, 71.

2. Banerjee, S.K. and Swaminathan, M.S., Ind. J. Genet. Pl. Breeding, 26, 203. 1966

3. Kaul, A.K., Dhar, R.D., Swaminathan, M.S. and Ahnstrom, G., Curr. Sci. 38, 330. 1969

4. Kaul, A.K., Dhar, R.D. and Swaminathan, M.S., Curr. Sci. 38, 529. 1969

5. Siddiq, E.A., Kaul, A.K., Puri, R.P., Singh, V.P. and Swaminathan, M.S., Mutation Res. 1970 10, 111.

6. Mertz, E.T., Bates, L.S., Nelson, O.E., Science 145: 3629, 279. 1964

7. Raghuramulu, N., Rao, B.S.N., and Gopalan, C., J.Nutr. 86, 100. 1965

8. Booth, M.R. and Ewart, J.A.D., Biochim. Biophys. Acta. 181, 226. 1969

9. Cagampany, G.B., Crus, L.S., Espiritial, S.G., and Juliano, B.V., Cereal Chem. 53, 145. 1966

10. Chapman, S.R., and McNeal, F.H., Crop Science 10, 45. 1970

11. Tanaka, S., and Tamura, S., Japan. Agr. Res. Quart. 3 : 3. 1968

TABLE 1

Amino acid composition of Sorghum varieties

(g. amino acid/100 g. protein)

Variety	VC 10-2	M-35-1	IS 84	IS 3922-405	K 5	IS 3691
Protein %	12.44	12.50	9.31	11.81	10.68	10.50
Prolamin (% in protein)	28.5	27.2	31.7	34.9	33.3	43.1
Aspartic acid	5.42	4.98	6.12	5.32	6.12	6.66
Threonine	2.42	2.31	2.02	1.92	1.98	1.86
Serine	5.66	4.82	3.92	4.56	4.92	5.16
Glutamic acid	23.42	24.42	24.68	24.24	27.40	28.12
Proline	8.92	9.46	10.48	10.18	12.12	12.34
Glycine	4.12	3.68	3.46	4.01	3.12	3.32
Alanine	8.12	7.34	9.62	8.86	8.32	9.40
Valine	6.68	5.12	6.86	5.86	5.31	6.56
Cysteine	1.94	2.34	2.86	3.06	2.13	2.72
Methionine	1.46	1.98	2.34	1.40	1.92	1.36
Isoleucine	4.86	4.32	4.68	4.86	3.92	4.01
Leucine	12.02	12.42	12.86	13.32	14.48	13.92
Tyrosine	3.62	2.32	3.10	2.12	3.12	3.52
Phenylalanine	4.03	4.30	5.62	5.14	4.38	4.52
Ammonia	2.40	1.98	3.12	3.40	2.62	2.58
Lysine	2.72	2.56	2.02	2.31	1.42	1.51
Histidine	2.03	2.41	1.46	1.98	2.46	2.06
Arginine	4.68	4.59	3.68	3.49	3.20	3.41
Tryptophan	1.08	1.16	1.12	0.94	0.74	0.49

TABLE 2

Amino acid composition of protein fractions of two varieties of Sorghum

(g. amino acid/100 g. protein)

Variety	VC-10-2				IS 3691			
Protein fractions	Albumin	Globulin	Prolamin	Glutelin	Albumin	Globulin	Prolamin	Glutelin
Aspartic acid	16.52	7.62	4.40	4.10	15.81	8.44	4.58	6.24
Threonine	4.18	4.32	1.86	1.92	4.93	3.86	1.42	1.83
Serine	7.24	5.84	3.18	5.22	6.18	6.53	3.44	5.48
Glutamic acid	14.33	15.81	28.18	18.18	16.42	14.92	27.02	20.44
Proline	6.60	5.14	10.45	8.21	6.14	5.44	11.38	7.62
Glycine	8.82	5.49	1.63	3.41	9.88	6.10	1.88	2.88
Alanine	9.42	5.86	8.24	8.66	7.40	6.04	9.78	8.33
Valine	10.16	6.42	5.14	6.52	8.86	5.36	5.82	7.88
Cysteine	3.40	1.12	0.32	1.34	2.86	1.51	0.42	1.44
Methionine	2.82	2.34	0.88	1.22	2.91	2.69	0.71	1.11
Isoleucine	4.48	3.31	3.68	4.42	3.11	3.42	4.03	3.96
Leucine	6.92	5.42	16.34	8.94	6.81	5.89	17.58	9.42
Tyrosine	3.20	4.11	4.42	2.41	3.76	4.82	4.18	2.18
Phenylalanine	2.94	4.82	5.14	4.01	4.11	4.96	5.44	4.58
Ammonia	1.70	0.42	0.68	0.68	1.31	0.38	0.48	0.84
Lysine	4.86	3.92	0.24	3.68	4.44	3.12	0.28	2.78
Histidine	3.22	1.42	0.62	3.54	2.88	1.86	0.44	3.88
Arginine	8.58	6.49	0.82	5.43	9.92	6.68	0.86	5.12
Tryptophan	2.04	2.27	0.24	1.28	2.88	1.25	0.11	0.73

TABLE 3

Amino acid composition of maize varieties
(g amino acid/100 g of protein)

Variety	Ganga-3	Yellow opaque-2 composite	Yellow floury-2 composite	White opaque-2 composite	Fla.3H94 opaque-2	CM 104 opaque-2	Kisan floury-2
Protein %	10.27	10.62	11.56	11.48	9.93	10.04	9.73
Prolamin (% in protein)	38.4	25.2	25.9	18.2	16.4	22.2	31.8
Aspartic acid	6.85	7.28	6.48	7.53	7.32	6.32	7.62
Threonine	3.16	3.22	3.80	3.16	3.28	3.72	3.18
Serine	5.21	5.33	5.11	5.68	5.24	4.82	4.67
Glutamic acid	23.29	20.64	19.90	18.32	19.48	17.67	19.80
Proline	10.00	8.65	9.30	8.48	9.24	8.71	10.01
Glycine	2.67	3.55	3.20	3.46	3.78	3.50	3.02
Alanine	9.30	7.79	8.81	9.47	10.16	10.52	10.64
Valine	5.36	5.39	6.15	6.67	7.42	5.99	5.55
Cysteine	1.84	1.98	2.12	1.75	1.44	1.35	1.75
Methionine	1.49	1.77	1.43	1.89	1.38	1.52	1.55
Isoleucine	3.90	4.00	3.61	4.35	3.86	3.93	4.05
Leucine	17.24	11.36	11.60	10.74	11.48	13.06	12.99
Tyrosine	4.91	4.44	4.90	4.01	4.88	4.45	4.91
Phenylalanine	5.40	4.84	5.34	5.30	5.72	5.35	6.05
Ammonia	2.30	2.48	2.99	2.64	3.36	3.21	3.48
Lysine	1.64	3.45	4.07	4.17	4.22	3.97	3.24
Histidine	2.54	3.70	3.32	3.14	2.76	3.13	2.46
Arginine	3.26	3.90	4.86	5.16	3.95	4.71	4.30

TABLE 4

Amino acid composition of different protein frac ions of hybrid HB.I of *Pennisetum typhoides*

(Amino acid g/100 g protein)

	Protein fractions			
	Albumin	Globulin	Prolamin	Glutelin
Total proteins/ 100 g grain	1.81	2.31	2.64	3.04
Aspartic acid	12.46	11.42	7.48	6.36
Threonine	2.12	2.64	3.46	2.92
Serine	4.81	5.62	6.12	5.35
Glutamic acid	16.36	18.71	22.24	21.68
Proline	8.82	7.46	10.23	9.42
Glycine	7.35	4.12	1.23	2.74
Alanine	8.11	6.02	9.41	10.42
Valine	5.64	7.34	3.24	4.12
Cysteine	2.92	2.62	1.42	1.24
Methionine	1.94	2.12	1.02	1.38
Isoleucine	4.12	2.48	3.32	3.83
Leucine	6.11	5.62	12.06	10.18
Tyrosine	3.28	4.31	4.62	4.44
Phenylalanine	3.82	4.14	3.82	4.94
Ammonia	0.92	0.82	1.14	1.21
Lysine	3.92	3.78	1.66	2.14
Histidine	2.18	2.22	2.14	1.64
Arginine	4.36	4.82	3.04	4.92
Tryptophan	1.52	0.54	2.84	0.69

TABLE 5

Protein, lysine and tryptophan contents of minor millets

	Variety	Protein %	g/100 g protein	
			Lysine	Tryptophan
Eleusine coracana	IE 903	6.23	2.13	1.44
	IE 902	7.54	2.56	1.26
	IE 901	7.97	2.63	1.36
	IE 832	8.81	2.89	1.32
	IE 831	9.52	3.00	1.16
Panicum miliaceum	IPm 1640	11.60	4.35	1.10
	IPm 1639	12.19	4.15	1.18
Setaria italica	ISe 711	10.02	2.29	0.81
	ISe 263	11.56	2.58	1.05
	ISe 3	12.26	2.70	1.12
Panicum miliare	IPe 420	6.89	2.21	0.52
	IPe 103	7.54	2.03	0.61
	IPe 386	7.75	2.15	0.66
	IPe 108	7.81	1.51	0.68
Paspalum scrobiculatum	IPs 141	11.12	3.09	0.98
	IPs 26	11.56	3.55	0.92
	IPs 19	12.62	3.78	1.14
	IPs 158	13.13	3.20	1.14
Echinochloa colona	IEc 230	11.19		
	IEc 231	12.25		
	IEc 1080	12.65		

TABLE 6

Complete amino acid analysis of Eleusine and Paspalum

(g amino acid/100 g protein)

Amino acids	Eleusine - IE 841	Paspalum - IPs 394
Protein %	7.68	11.17
Aspartic acid	9.84	6.43
Threonine	3.74	2.68
Serine	6.74	4.17
Glutamic acid	22.16	35.18
Proline	6.82	9.24
Glycine	5.92	4.64
Alanine	6.48	5.35
Valine	5.82	4.68
Cystine	1.42	1.04
Methionine	1.32	1.84
Isoleucine	4.56	3.16
Leucine	9.21	10.48
Tyrosine	5.64	4.14
Phenylalanine	5.74	5.63
Ammonia	1.65	1.40
Lysine	2.98	3.58
Histidine	2.59	2.11
Arginine	8.22	3.95
Tryptophan	1.16	0.92

TABLE 7

Variability for protein content in various pulses grown at several locations in All-India Coordinated Trials 1968-69 (% crude protein content rounded to nearest complete figure)

Crop	Number var. x loc.	Mean (% protein)	1 σ (% protein)	Variation (range) due to Genotype (% protein)	Location (% protein)
Cicer arietinum	18 x 11	19	1.5	3	9
Cajanus cajan	11 x 5	22	1.8	2	4
Phaseolus aureus	18 x 8	18	1.0	2	4
Phaseolus mungo	10 x 5	25	1.6	3	6
Lens esculentus	8 x 10	24	2.2	2	6
Pisum sativum	20 x 8	24	2.8	3	7

TABLE 8

Ranges in the values of protein and lysine in advanced generation breeding materials of wheat (based on 234 selections)

Protein group %	Number of samples in each group	% frequency	mg lysine/100 g whole meal: Range	mg lysine/100 g whole meal: Mean	Lysine g/100 g protein: Range	Lysine g/100 g protein: Mean
10 - 11	4	1.7	222 - 355	305	2.19 - 3.36	2.96
11 - 12	11	4.7	222 - 408	329	2.00 - 3.41	2.83
12 - 13	35	15.0	205 - 424	312	1.60 - 3.46	2.50
13 - 14	34	14.5	234 - 421	334	1.70 - 3.38	2.50
14 - 15	30	12.8	222 - 448	347	1.50 - 3.06	2.50
15 - 16	54	23.1	221 - 475	342	1.40 - 3.12	2.22
16 - 17	36	15.4	173 - 486	320	1.07 - 3.00	1.94
17 - 18	29	12.4	192 - 483	324	1.11 - 2.83	1.87
18 - 19	1	0.4	346	346	1.86	1.86

TABLE 9

Varietal differences in the protein content in maize endosperm, embryo and pericarp (% protein on oven dry basis)

Variety/hybrid	Endosperm	Embryo	Pericarp
Ganga 5	10.98	21.78	5.40
Ganga 5 (op)*	11.52	20.79	5.94
Ganga 101	11.52	22.40	6.84
Ganga 101 (op)	10.71	19.98	7.20
Ganga Safed 2	9.63	19.26	7.40
Ganga Safed 2 (op)	9.99	21.96	8.55
Ganga 3	9.90	21.10	6.84
Deccan	9.54	20.25	6.75
Deccan (op)	9.90	21.60	6.60
Ranjit	11.20	21.24	6.84
Himalayan 123	10.44	22.32	6.84
White op. 2	11.07	23.55	8.37
Yellow op. 2	11.16	21.69	7.11

* op = open pollinated

TABLE 10

Variation in protein and lysine contents in some selections of *Pennisetum typhoides*

Strain number	Protein %	mg lysine/100 g flour	Lysine g/100 g protein
4120	11.73	390	3.32
4121	13.39	426	3.19
4122	14.75	355	2.40
4123	12.28	426	3.46
4124	15.44	421	2.72
4128	14.00	510	3.64
4130	13.70	275	2.00
4131	14.10	275	1.95
4133	10.90	275	2.52
4137	14.50	284	1.95
4142	12.80	399	3.11
4155	12.98	399	3.07
4187	13.72	244	1.77
4188	13.00	257	1.97
HB.1	11.32	302	2.66
HB.2	15.35	333	2.16
HB.3	13.53	421	3.11

TABLE 11

Protein content in 21 monosomic lines of Chinese Spring Variety of wheat

Chromosome	Protein % in Genome A	B	D
1	12.2	14.0	14.0
2	13.5	13.7	14.0
3	13.6	14.0	14.2
4	14.2	13.5	13.0
5	14.0	14.2	14.0
6	14.3	14.0	13.2
7	12.6	13.2	12.8
Disomic control	12.0%		

TABLE 12

Protein content in the parents F_1 and F_2 of monosomic lines

Material	Grain Protein Content (%) F_1	F_2
Chinese Spring x Sonora 64		
1D	19.6	16.5
2A	18.0	15.1
3A	18.6	18.0
3B	20.0	17.2
5A	21.0	17.4
6B	17.8	13.0
7A	19.9	16.6
7B	19.0	16.4
Disomic	14.6	14.0
Chinese Spring x Lerma Rojo		
1D	18.6	16.8
2A	16.0	14.4
3A	19.0	16.7
3B	17.4	16.5
6B	17.7	13.4
7D	18.5	16.2
Disomic	15.0	14.6

ROLE OF PRODUCTION TECHNIQUES IN THE EXPLOITATION OF HIGH YIELDING VARIETIES OF CEREALS 1/

by

Abdul Hafiz
Regional Consultant, FAO Wheat and Barley
Improvement and Production Project

SUMMARY

High-yielding varieties represent an unprecedented opportunity of rapidly improving the nutritional status of many developing countries and, at the same time, of reducing their growing dependence on imported foodstuffs. With the introduction of high-yielding varieties of cereals, the use of fertilizers has become increasingly popular with the farmers, but they are not obtaining the full potential of these high-yielding varieties, mainly because of faulty production techniques. These varieties have special cultural requirements of their own. Work carried out on different cereals has shown the importance of good husbandry practices in increasing the per acre yield and the net profit which then results from reduced production costs. It is suggested, therefore, that special efforts should be made to improve production techniques through experimentation, training and extension.

1/ Presented at the FAO Wheat Seminar held in Ankara, Turkey, 29 April - 13 May 1970.

INTRODUCTION

During the last two decades cereal improvement work has made great strides in the development of high-yielding, fertilizer responsive, disease and lodging resistant semi-dwarf varieties of much wider adaptability. These new varieties possess very high yield potential of 8 to 12 tons/ha and are now available and being extensively utilized in many countries, including the Near East Region.

High-yielding varieties (HYV) offer an unprecedented opportunity to improve rapidly the nutritional status of many developing countries and at the same time reduce their growing dependence on imported foodstuffs. Over the decade 1955/57 to 1965/67, net imports of cereals into developing countries increased tenfold from 1.2 to 12 million tons. The extended use of HYV of cereals would also contribute greatly to the gross national product and economic growth.

PRESENT SITUATION AS REGARDS THE EXTENDED USE OF HYV

Many countries in the Region have developed or identified a number of HYV of wheat, which are now being extended into farmers' fields in some of the countries. During 1968/69 India had 4.4 million ha under HYV, Pakistan 2.6 million ha, Afghanistan 150 000 ha, Iran 40 000 ha, Turkey 800 000 ha, Iraq 10 000 ha, Tunisia 12 000 ha, and Morocco 5 000 ha, while other countries like Lebanon, Syria, Saudi Arabia and Algeria also had large demonstrational plantings under these varieties. In the UAR substantial quantities of seeds of Giza 155, a new HYV, were distributed to the farmers (60 000 tons for the 1969/70 crop season). It has been estimated that during 1968/69 about 7.9 million ha were sown under HYV in the Near East Region, resulting in an additional wheat production of about 7.9 million tons worth US $553 million. The areas under HYV are expected to increase progressively every year and many governments of the Region have already prepared action programmes.

The introduction of HYV of rice has made some countries self-sufficient and even surplus producers. West Pakistan increased rice production by about 50 percent and expects to have a surplus of 1½ to 2 million tons a year during the fourth Five-Year Plan (1970/75) after meeting domestic requirements.

In the UAR the total rice production increased by 60 percent between 1954 and 1964 due to the adoption of a new improved variety called 'NAHDA', and by more than three times until 1969 (from 830 000 tons in 1954 to 2.57 million tons) through the extended use of improved varieties and fertilizers. In Iraq, production increased by 73 percent in 1967 and 81 percent in 1968 by using the seeds of better varieties and fertilizers.

Similarly, the use of maize hybrids or composite varieties, as well as hybrids of sorghum and millets, is increasing in some of the countries. Efforts are being made to have the production of seeds meet the requirements of the farmers.

In spite of all these efforts, however, it has been often noticed that the farmers are not obtaining the full potential of a HYV. This is due mainly to faulty production techniques which, if improved, could help to increase yield levels by 40-50%, resulting in reduced production costs and more benefits to the farmers, the consumers, and the country as a whole.

IMPORTANCE OF PRODUCTION TECHNIQUES

A good deal of work has been in progress to find out the optimal cultural requirements of new varieties. For example, in the case of the semi-dwarf wheat varieties, it has been found that the following factors are of great importance if the real potential of these varieties is to be obtained :

If these varieties are sown deep, their emergence is delayed by as much as four to five days and the seedlings are lax with lower vigour and this continues all the way to the heading stage. Hence these varieties are to be sown shallower, not exceeding 4-5 cm.

2. The best sowing date for many of the semi-dwarf wheat varieties, particularly those of short duration, is considerably later than the date recommended for the longer maturing tall varieties. One of the worst things to do to a short duration type wheat is to sow it too early. Under the conditions of high temperature during early growth, the plant does not tiller well and appears to go quickly into the reproduction phase.

3. Semi-dwarf wheat varieties have more efficient use of fertilizers, i.e. 1:20-30 as compared to conventional tall varieties 1:10-12 (fertilizer : grain ratio).

4. These varieties require first irrigation earlier than conventional varieties. The irrigation should be applied 21 to 25 days after sowing, i.e. at the crown root initiation stage, in order to get more tillering and higher levels of production. On the whole, the total requirements of water are also higher than needed by the conventional varieties.

Hence, to make maximum use of the semi-dwarf wheats, they must be sown at the right time, using the right methods, applying higher doses of fertilizers, and giving adequate irrigation water. If any of these factors is lacking, there is a big drop in the yield. Similar results have been obtained in many countries of the Near East Region.

Some interesting results have been achieved in Kenya by comparing good husbandry (early planting, a full and even stand and clean weeding, until tesseling) with bad husbandry (planting four weeks late, half the recommended population and one late weeding) on maize. It has been clearly shown that by adopting good husbandry practices, which do not cost extra, the per acre yields can be at least doubled, while the use of inputs like hybrid seed and fertilizers does not pay at all in the absence of good husbandry practices. When the two (good husbandry and inputs) were combined together, yields increased to 35.8 bags per acre and extra profits to 532 sh/acre. The interactions also showed up startlingly. Fertilizers and hybrid seed with bad husbandry increased yield from 8.8 to 14.6 bags - or 21.2 bags (Table 1). This shows the great importance of good husbandry. Similar trend of results was obtained from an economic survey carried out in the Trans Nozia district of Kenya on 109 farms (Table 2).

TABLE 1

Summary of Results comparing good husbandry with bad husbandry on Maize in Kenya

Treatment	Yield/acre	% Increase	Extra cost/acre	Extra gross income/acre	Extra gross profit/acre
	bags		Sh.	Sh.	Sh.
BH + LM without F	8.8	-	Nil	Nil	Nil
BH + H + F	14.6 (5.8)	66	132/40	162/40	30/-
GH + LM without F	21.8 (13.0)	148	67/-	364/-	297/-
GH + H + F	35.8 (27.0)	307	224/-	756/-	532/-

GH = Good husbandry
BH = Bad husbandry
LM = Local material (varieties)
F = Fertilizers

TABLE 2

Main results of survey carried out on maize cultivation in Kenya

1.	Profit/acre in Sh.	Average 84/-	Worst farmer minus 269/-	Best farmer 410/-
2.	Production/acre in bags	Good growers 20.6	Poor growers 9.6	Best growers 27.4
3.	Cost of production/bag in Sh.	Average 25/23	Range 15/96 up to 115	
4.	Cost of production/acre in Sh.	20 good farmers spent 16sh more than poor group	Best individual spent 54 sh more than poor group	

Taking into consideration the harvesting cost, the twenty poorest growers actually spent more on growing the crop than the individual best. Thus, the great importance of good husbandry (suitable production techniques) is quite evident for increasing the per acre yield as well as the net profit and in reducing the cost of production.

STEPS TO BE TAKEN FOR IMPROVING PRODUCTION TECHNIQUES

Since the use of proper production techniques and good husbandry methods is so important, the following steps are essential :

Experimental

Since each variety has its optimal cultural requirements, the breeders and agronomists must carry out suitable cultural experiments on the agronomic requirements of such varieties at the experimental farms. These experiments should include seed-bed preparation, seed rate, date and method of sowing, fertilization, weeding and irrigation requirements. These experiments should be well designed and laid out by taking all the necessary precautions in the selection of the site, sowing, harvesting and taking of necessary data. On the basis of these experiments, demonstration plots should be laid out in progressive farmers' fields in different cereal growing localities of the country.

Extension

The above-mentioned demonstration plots should be laid out by the research personnel (production agronomist attached to the breeding section) in cooperation with the Extension Service, because only the research workers are fully informed about the requirements of these varieties. They are in a better position, therefore, to plan and lay out the demonstration plots. These should be large-scale plots and data on the cost benefit ratio should also be recorded in order to find out the real value of the new varieties in farmers' fields. Farmers' Days should also be arranged to educate the farmers in new techniques.

Training

It has been noticed that research workers and extension staff usually have very little practical experience in large-scale production of cereals. It is therefore essential that some training centres be arranged within the country or in the Region. These persons could then be given practical training for a period of six to eight months in all the different aspects of cultivation techniques, including levelling of the fields, preparation of the seed-bed, cultivation, lay-out of the water channels, sowing with drills, mechanical application of fertilizers, weeding, control of pests and diseases, harvesting, combining and storage of the grains. This training should also be arranged for farmers in different countries.

In order to achieve the full potential of HYV, steps should be taken by FAO and other international agencies to arrange training centres for the people working in the Near East. This could also be achieved if a permanent centre were established in a suitable country of the Region where such persons could be sent every year to receive in-service training.

REFERENCES

Allan, A.Y. Good husbandry in maize growing, Kenya Weekly News, Feb. 17, 1967.

Allan, A.Y. Maize diamonds, Kenya Farmer, Jan. 1968.

Allan, A.Y. Is it profitable to grow maize ? Trans Nozia Supplement, 1968.

Wright, B.C. Agronomic requirements of the new dwarf wheats, Information Bulletin on the Near East Wheat and Barley Improvement and Production Project, Vol.V, No.3, 1968.

WHEAT AND BARLEY IMPROVEMENT IN IRAQ THROUGH THE SEED PRODUCTION AND CERTIFICATION PROJECT 1/

by

A.A.K. Soghaier
FAO Project Leader, Baghdad, Iraq

SUMMARY

The FAO/FFHC Seed Production and Certification Project was started in Iraq in 1966 at a total cost of US $984 000 with a view to establishing a 'system' for the production, certification and distribution of quality seeds of improved and high-yielding varieties. This Project took a number of steps in establishing the system through seed production, seed certification (seed testing, field inspection), seed processing (a plant with a capacity of 5 000 tons per season of three months was established), seed distribution, extension and publicity, training and fellowships, and seed legislation. The Project helped to produce substantial quantities of high-quality seed which greatly extended the cultivation of high yielding varieties of wheat with very good results. Encouraged by these results, the Government has earmarked a sum of US $14 million in the next Five-Year Plan (1970-75) extending these activities to cover not only wheat and barley, but also many other crops.

1/ Presented at the 9th FAO Ad Hoc Conference on Wheat and Barley Improvement and Production in the Near East, held at Beirut, Lebanon, 1969.

INTRODUCTION

Wheat and barley are the most important crops in Iraq, both in the rainfed and irrigated areas. They occupy about half the arable land, provide 94 percent of the total food grains and furnish half the calorie and protein requirements of the people. Of the two crops, wheat is more important as it forms the staple food and all the production is consumed locally. Barley is also of considerable importance as an export crop.

The average annual area put under wheat is about 1.3 million hectares, producing about 708 000 tons with an average yield of 546 kg/ha, while barley occupies an average annual area of 1.1 million ha producing 933 000 tons with an average yield of 844 kg/ha. The total annual seed requirements for both crops is estimated at 250 000 tons.

In recent years barley exports have decreased and wheat imports, to meet local requirements, have become a regular feature in Iraq's trade. This has been attributed to the very low yields caused by poor fertility, inefficient farming practices and, above all, the low quality of seed used by farmers.

Keen to increase the production of these crops through raising the yield per unit area, and realizing that the cheapest, quickest and easiest way to achieve this is through the use of quality seed of high-yielding varieties, the Government of Iraq requested assistance from FAO to implement a Seed Improvement Project under the Freedom of Hunger Campaign (FFHC) which could assist in organizing the seed production, certification and distribution activities of these crops. The project was started in June 1966 for an initial period of three years at a total cost of $984 000. The FAO contributions ($270 000) were utilized to provide two international experts, finance four fellowships, and supply special equipment mainly for seed processing and seed testing. The government contributions ($714 000) were allotted for payment of local personnel, buildings, agricultural equipment, supplies and operational costs.

Due to the success accomplished by the project during the first three years it was extended for another year at a total cost of $292 000.

The project was first attached to the Directorate General of Agricultural Research and in 1968 it was transferred to the Directorate General of State Farms, which operates seven farms with an area of about 20 000 ha.

PURPOSE AND LINES OF APPROACH

The main purpose of this project is to help the Government in establishing a 'system' for the production, certification and distribution of quality seed of improved and high-yielding varieties of wheat and barley. To achieve this purpose the project had to implement the following measures :

- Introduce a plan for the systematic production of the various classes of seed and ensure the highest possible degree of purity.

- Introduce seed certification, including the production of certified seed through contract growers, field inspection and seed testing, and for the latter establish a well-equipped seed testing laboratory.

- Establish a seed processing plant for cleaning, treatment, bagging and storage of seed.

- Recommend standards, rules and regulations pertaining to seed production, certification and distribution for implementation by the government and for the establishment of a Seed Act.

- Assist in implementing field demonstrations, in collaboration with the Agricultural Extension Service, to familiarize the use of quality seed among farmers.

- Extend training to local counterpart personnel (through in-service training, national training courses and awarding of FAO fellowships) in the various phases of seed improvement.

PROGRESS AND ACCOMPLISHMENTS

1. Seed Production

A seed production programme covering all seed classes was worked out and adopted. This programme was amended to meet the future requirements of the next five-year plan (1970-1975).

Since its initiation in 1966 the project produced directly about 1 350 tons of pre-basic and basic seed (breeder and foundation) which provided the seed requirements for the state farms to produce certified seed. It also provided technical supervision for the production of about 10 500 tons by the state farms and about 2 000 tons by the contract growers of certified seed for distribution. During the current season the project produced about 500 tons of basic seed and supervised the production of about 5 000 tons of certified seed.

2. Seed Certification

Seed testing: In 1966 a modern seed testing laboratory was established by the Government at Abu-Graib Research Station at a cost of $45 000. The project provided supplementary seed testing equipment at a cost of $7 000. This equipment included seed dividers, moisture testers, balances, microscopes, germinators, samplers, vita scope and several other items. This well-equipped laboratory is now serving the entire country and can handle thousands of samples of different crops each year.

Field inspection: Field inspection of state farms' fields was first started in 1967. In 1968/69 all wheat and barley fields under basic and certified seed were inspected. Procedures and standards were established for this purpose. Due to shortage of staff in the project to cope with this activity it was assigned to the agricultural extension agents after they had received sufficient training in this work.

Seed Production through Contract Growers: In 1967/68 the first attempt was made to grow certified seed through progressive contract growers. The programme covered fifteen growers with relatively limited acreage. In 1968/69 this programme was intensified to cope with the crash programme introduced by the Government to produce sufficient quantities of MexiPak wheat seed for distribution in 1969. This programme was implemented by the Agricultural Extension Service under the technical supervision of the project. The number of farmers participating in this programme was about 260.

3. Seed Processing

Since 1966 the project has ensured that all quantities of different seed classes produced either by the state farms or the contract growers were properly cleaned before distribution. This simple activity created an excellent reputation for the seed distributed through the Government and within a very short time the farmers demand for seed far exceeded the available supply.

One of the project's major contributions is the establishment of a seed processing plant at Sweira farm. The construction work was started in February 1968 and was completed in April 1969. Installation of machinery took place in May 1969 and was finalized in early October. The plant will be inaugurated on 30 October 1969. The cost of the building ($325 000) was part of the government contributions and FAO provided the equipment and electrical installations at a cost of $120 000. The processing and storage capacity of the plant is about 5 000 tons per season (three months). The plant, which is fully automatic, is fitted with different equipment for weighing, reception, storage, discharge and transfer, cleaning, grading and treatment of seed, aspiration and dust exhaust system, electric control and switch board and other additional minor equipment.

4. Seed Distribution

Several attempts were made to organize the seed distribution activity. According to the system now established certified seed is available for sale to all farmers; however priority is usually given to members of the agricultural cooperatives. The varieties and their seed quantities available each year with the Directorate General of State Farms, together with their provisional prices, are communicated to the Directorate General of Agricultural Cooperatives immediately after harvest. The entire seed quantities are provisionally reserved for the latter Directorate until 1 September to enable it to compile and confirm the quantities required by its agricultural cooperative societies. After that date the remaining quantities are offered for sale to any farmer. Seed is sold to cooperatives against cash payments or against bank guaranties, and to all other farmers on a cash basis. The seed is usually offered for sale at the government state farms. However, during the current year (1969) the seed of MexiPak wheat is being offered for sale also at the fourteen agricultural extension district offices.

5. Extension and Publicity

These activities are conducted in collaboration with the agricultural extension service and cover mainly the sowing of field demonstrations in farmers' fields to demonstrate and familiarize the use of quality seed of high yielding varieties among farmers. In 1966/67 nineteen field demonstrations were organized and the number was increased to 175 in 1967/68 with very good results. In 1968/69 the number was further increased to about 2 000 fertilized demonstrations which were sown with the new MexiPak wheat variety to spread its use among farmers. These demonstrations were conducted throughout the wheat producing areas.

The project has also maintained other publicity activities aimed at popularizing the use of quality seed among farmers. These activities included the holding of Field Days at some selected field demonstrations, press releases, press and bulletin articles, radio and TV talks and interviews, and the showing of films.

6. Training and Fellowships

During the last three years the project offered training to national counterpart personnel in different forms. This included (1) in-service training of staff assigned to the project in seed production, testing, field inspection and seed processing, (2) awarding of four FAO fellowships for training abroad (Lebanon, USA, Denmark and Sweden) in seed production, seed testing, field inspection and seed processing, and (3) conducting national training courses in seed certification (in 1966 one 3-day course, in 1968 three 2-day courses and in 1969 four 2-day courses). Most of the trainees were agricultural extension agents dealing with the seed certification activities. In addition, one 2-week course in seed testing was organized in 1968 for the senior graduating class at the College of Agriculture, Baghdad University, and a 3-month (part time) course in seed testing and certification was offered in 1968/69 to the graduating class at the Higher Institute of Agriculture, Baghdad University. In all, about 200 trainees attended the above courses.

7. Seed Legislation

Standards, rules and regulations covering a wide range of the various aspects of seed production and certification have been prepared for submission to the Government. Similarly, a provisional draft of the 'Seed Act' for Iraq has been completed for recommendation to the Government. A seed processing manual to assist in running the seed processing plant is under preparation.

8. Other General Activities

The project personnel lend active assistance to the Ministry of Agriculture and its Directorates in the preparation and implementation of schemes and projects of related natures. Advice is also given on agricultural policy matters and the preparation of long-term plans.

FUTURE OF THE PROJECT

The present project is believed to have laid down the foundations for an expanded seed production and certification programme capable of handling sufficient quantities of quality seed of most major field crops. Such a programme could ensure the achievement of self-sufficiency in wheat and other crops and even of exportable surpluses in the near future. Convinced of this fact, the Government of Iraq has included in the next five-year plan (1970-75) a scheme for seed production, certification and distribution at a total cost of $14 million. The Government also contemplates requesting expert assistance from FAO under the United Nations Development Programme (Special Fund) to help in the implementation of its ambitious five-year scheme.

According to this scheme the quantities of certified seed of major crops to be produced on government farms and through contract growers, and the percentages which these quantities represent compared to the country's total annual seed requirements, are shown below :

Quantities of Seed to be Produced during 1970-75

Crop	1970/71		1971/72		1972/73		1973/74		1974/75	
	ton	%	ton	%	ton	%	ton	%	ton	%
Wheat	12 450	10.0	15 575	12.5	18 775	15.0	21 950	17.5	24 946	20.0
Barley	660	0.5	1 152	1.0	1 722	1.5	2 300	2.0	2 870	2.5
Linseed	15	2.5	30	5.0	90	10.0	150	25.0	180	30.0
Rice	225	2.0	444	4.0	662	6.0	892	8.0	1 111	10.0
Sesame	5	2.0	14	5.0	27	10.0	41	15.0	54	20.0
Mash	172	30.0	273	50.0	379	80.0	371	80.0	386	80.0
Peanuts	5	-	25	5.0	50	10.0	75	15.0	100	20.0
Cotton	920	100.0	930	100.0	1 148	100.0	1 148	100.0	1 178	100.0
Sunflower	500	100.0	600	100.0	800	100.0	900	100.0	1 000	100.0

In addition to the present seed processing plant located in the centre of Iraq, two more plants will be established - one in the north during the second year of the plan and one in the south during the fourth year - at a total cost of $840 000.

PRELIMINARY REPORT ON THE 1968/69 INTERNATIONAL SPRING WHEAT YIELD NURSERY

by

K.W. Finlay, International Maize and
Wheat Improvement Centre, Mexico

SUMMARY

The International Spring Wheat Yield Nursery (ISWYN), consisting of 49 varieties (plus one local check) from Argentina, Australia, Brazil, Canada, Chile, Colombia, India, Italy, Kenya, Mexico, Pakistan, Sudan, Taiwan, UAR and USA, was planted at 52 stations in 29 countries (including 27 stations in 16 member countries of the Near East Wheat and Barley Project). The detailed results are being analyzed by CIMMYT. The data presented in this paper give the overall mean yield of 52 stations. Again the Mexican varieties (including those supplied by Sudan and India) have occupied the top yielding positions. Pitic 62, which had so far occupied the first position, has gone down to number 2, being replaced by (LR64 x N10B)An[3] - although the difference in yield is not statistically significant. The other high-yielding varieties are from Argentina, Chile and Egypt, while as usual the USA and Canadian varieties have given the lowest yields, probably due to their sensitivity to daylength and tall growing habit. The summarized results are given in the table.

Preliminary yield summary table of the 5th International
Spring Wheat Yield Nursery, 1968-69

Mean yields kg/ha and rank

Entry No.	Variety or cross	Origin	Over all mean yield 52 stations kg/ha	rank
23	(LR64 x N10B) An^3	Sudan	3132	1
1	Pitic 62	Mexico	3112	2
32	Penjamo 62	Mexico	3078	3
6	Siete Cerros	Mexico	3044	4
4	Son 64 x Kl Rendidor	Argentina	2980	5
28	LR64A	Mexico	2965	6
48	PV 18 Indus	India	2962	7
34	Inia 66	Mexico	2935	8
22	Son 64 x TzPP-Nai 60 (A)	Argentina	2926	9
13	Huelquen	Chile	2893	10
41	(TzPP-S64)(LR64A-TzPP x An_E)(A)	Mexico	2878	11
7	Noroeste 66	Mexico	2848	12
46	(TzPP-S64)(LR64A-TzPP x An_E)(B)	Mexico	2814	13
5	Giza 155	Egypt	2808	14
3	Nainari 60	Mexico	2786	15
35	Tobari 66	Mexico	2772	16
30	Nar $"S"^2$ x Pj "S"	Chile	2767	17
16	Son 64A x Ske-LR64A	Argentina	2752	18
14	Crespo	Colombia	2734	19
18	LR 64 x Son 64	Mexico	2710	20
39	Napo 63	Colombia	2686	21
45	Norteño 67	Mexico	2672	22
27	V 878	India	2657	23
44	36896-Cj 54^2 x Yt 54A (H)	Sudan	2654	24
17	Sonora 64	Mexico	2618	25
31	Line 1418-34630 Line 1231 x 23 Line 1274-111 (L)	Sudan	2606	26
8	Victor I	Italy	2589	27
36	Triple Dirk	Australia	2585	28
25	NP 881	India	2575	29
40	C 306	India	2565	30
47	Mengavi	Australia	2532	31
19	Ciano 67	Mexico	2497	32
37	NP 824	India	2463	33
11	NP 852	India	2300	34
38	Gaboto	Argentina	2294	35
20	C 591	India	2286	36
10	Carazinho	Brazil	2280	37
2	Gabo	Australia	2269	38
9	Bonza 55	Colombia	2263	39
43	C 273	Pakistan	2245	40
33	Chris	USA	2228	41
24	Kloka WM 1353	Germany	2226	42
49	4265 H.D. 3=(Md-K-Y) x (Wis-Sup)	Kenya	2192	43
15	Taichung 31	Taiwan	2136	44
12	Crim	USA	2116	45
21	Justin	USA	1732	46
42	Manitou	Canada	1648	47
26	Selkirk	Canada	1583	48
29	Thatcher	USA	1441	49

PRELIMINARY REPORT ON THE FIRST INTERNATIONAL WINTER WHEAT PERFORMANCE NURSERY

by

P.J. Mattern, V.A. Johnson and J.W. Schmidt,
Department of Agronomy, University of Nebraska, Lincoln

SUMMARY

This is the first preliminary report of data obtained in 1969 from the First International Wheat Performance Nursery 1/. It includes a summary of yield data as well as those relating to various agronomic characters - winter survival, flowering, plant height, lodging and grain protein. The Russian variety Bezostaia occupied the first position (45.2 q/ha) followed by Blueboy from the USA (43.5 q/ha), San Pastore from Italy (41.1 q/ha) and Sturdy from the USA (40.5 q/ha). Bezostaia has been introduced as a winter wheat in some of the Near East countries.

It is hoped that the nursery will lead to early identification of superior winter wheat genotypes for use in breeding wheats with improved nutritional quality and provide valuable information on adaption limits of cultivars.

1/ This was prepared by the Nebraska Agricultural Experiment Station in cooperation with the US Department of Agriculture, CIMMYT and FAO.

Summary of agronomic data for cultivars grown in the First International Winter Wheat Performance Nursery in 1969

Cultivar	Origin	Winter Survival %	Rank	Flowering Days fr. Jan. 1	Rank	Plant Height cm.	Rank	Lodging %	Rank	Grain Protein Content %	Rank	Grain Yield q/ha	% of Bezostaia
No. sites:		11		16		17		13		16		16	
Bezostaia	USSR	90.0	24	140	8	98	8	20.3	10	13.3	25	45.2	100.0
Blueboy	USA	92.3	8	143	17	97	7	15.5	6	13.6	23	43.5	96.3
San Pastore	Italy	90.0	24	135	1	96	6	12.3	3	13.4	24	41.1	90.9
Sturdy	USA	90.8	19	138	4	83	2	6.5	1	14.2	14	40.5	89.7
Timwin	"	91.3	16	142	14	88	3	24.7	14	14.2	14	39.9	88.4
Parker	"	91.0	17	139	6	102	11	19.6	9	14.3	12	39.7	88.0
Fertodi 293	Hungary	91.8	12	142	16	118	25	30.6	18	14.7	9	39.3	86.9
Benhur	USA	91.8	12	136	2	103	12	20.8	11	14.3	12	38.5	85.3
Scout 66	"	93.5	2	140	8	113	21	47.5	27	14.0	18	38.4	85.0
Yung Kwang	Korea	92.3	8	140	8	105	14	32.8	20	14.2	14	38.1	84.3
Arthur	USA	90.4	21	139	5	101	10	24.0	13	14.0	18	38.1	84.3
Gage	"	93.1	5	143	17	109	18	33.6	22	14.4	11	37.1	82.1
Stadler	"	91.5	15	139	5	111	19	29.0	17	13.1	26	36.9	81.6
Heine VII	Germany	88.8	27	149	25	98	8	17.5	8	14.8	8	36.7	81.2
Lancer	USA	92.5	7	144	20	111	19	41.8	24	13.9	20	36.6	81.0
Shawnee	"	90.2	23	142	14	113	21	25.9	15	13.7	21	36.5	80.8
Riley 67	"	91.0	17	140	8	107	15	32.4	19	14.1	17	36.3	80.5
Yorkstar	"	90.8	19	146	22	103	12	22.3	12	12.5	28	35.8	79.2
Bankuti 1201	Hungary	93.9	1	143	17	125	28	47.4	26	15.0	7	35.6	78.9
Triumph 64	USA	92.2	10	136	2	108	17	46.6	25	14.6	10	35.6	78.8
NB67730	"	93.3	3	141	13	120	27	47.5	27	16.4	3	34.8	77.1
Atlas 66	"	84.8	28	144	20	118	25	33.2	21	17.4	1	33.4	74.0
Purd. 28-2-1	"	90.3	22	140	8	117	24	26.7	16	16.5	2	32.9	72.9
Winalta	Canada	93.2	4	146	22	114	23	41.5	23	13.7	21	32.2	71.3
Cappell Desprez	France	90.0	24	151	26	93	4	14.6	5	16.1	4	32.0	70.9
Gaines	USA	92.8	6	148	24	76	1	16.4	7	12.8	27	30.7	67.9
Felix	Netherl.	91.6	14	153	27	93	4	10.0	2	15.2	6	29.6	65.5
Odin	Sweden	91.9	11	154	28	107	15	12.5	4	15.7	5	26.7	59.2

GENE CONTROL OF PROTEIN PRODUCTION IN CEREAL SEED 1/

by

E.A. Favret, L. Manghers, R. Solari,
A. Avila and J.C. Monesiglio
Instituto de Fitotecnia, INTA,
Castelar, Argentina

SUMMARY

In order to improve the protein quantity and quality of cereal grains it is important to study the inherited factors that control their synthesis irrespective of environmental effects. With this in view, studies were carried out on mainly wheat and barley cultivars and some intraspecific crosses. The studies made related to quantity of protein per seed and grain protein quality by using the methods described. The results obtained are presented in tables and graphs. Some interesting conclusions have been drawn from these results, suggesting that the breeders should make selections on the basis of absolute protein content per seed and not on the basis of percentage per dry matter which is influenced by seed weight and in turn by environmental conditions.

1/ Paper no. Gen.439 of the Research Centre in Agronomic Sciences, INTA, Castelar, Argentina.

INTRODUCTION

The need to improve protein quantity and quality in cereal grains implies the knowledge of those inherited factors that control their synthesis, the discrimination of the environmental effect and to determine the best way of carrying out the corresponding selection. Some researches carried on in our Institute during recent years have helped to solve these problems.

MATERIAL AND METHODS

The tested material consisted chiefly of wheat and barley cultivars and some intraspecific crosses, according to the genetic and analytic procedures already published (1) (2).

The quantitative analysis has been made following the Micro-Dumas method with a Coleman 29 unit. Proteins from prolamine fraction have been separated by electrophoresis and electrofocusing (3). For the amino acid analysis a Beckman Automatic Analyzer 120B was employed, following the Spackman, Stein and Moore method. As a biological unit for analysis in all possible cases, whole individual grains were used.

RESULTS AND CONCLUSIONS

a) Quantity of protein per seed

1. As has been previously pointed out (4) the genetic appraisal of the character protein content per seed is more stable than that referred to its percentage on dry matter. The weight and volume of the grain are subjected to strong environmental influences and are negatively correlated to the percentage of protein. The absolute values, on the contrary, vary in a lesser degree.

   This can be observed in Fig.1 where N/ seed content is compared in relation to agronomic yield of three wheat varieties during two different years (1964 and 1968) chosen for their extremely opposite yields. The higher yield per hectarein 1964 was due to an increase in grain size and number; however N/ seed values remain constant.

   Likewise, it is observed that a difference exists within each spike in a single variety of barley M. Heda (Fig.2), both for N/ seed as well as for kernel size, basal ones and those at the apex being smaller. The variance for both characters is larger between spikes of a same plant rather than between grains of a same spike, which could be reasonable due to the fact that the different spikes of a same plant ripen at a different time.

   Thus it can be stated that every variety can synthesize a maximum protein content. There exist among varieties different maximum values of synthesis, as seen in Table 1. It is possible to observe that for dry seed weight, varieties and lines of barley differ statistically in a significant manner, which is also evident for N/seed content. As there exists a positive correlation between both characters, the percentage of N per dry matter remains statistically insignificant, except in a single line. Varieties with lighter seeds are favoured when the last approach is utilized.

   Sixty-seven forms of barley collected in Ethiopia (5) were analyzed with the same criterium and in this case a high positive correlation between grain weight and N/seed content was found (Fig.3b).

   It is observed that if the data were taken on the basis of the percentage of N/dry matter the mentioned correlation would remain unnoticed (Fig.3a). Values ranging from 0.5 to 2 mg of N/seed have been obtained in barley forms for that collection. On the other hand, cultivated malt barley varieties doe not present the former correlation (Fig.3d) and far from that if the percentage of N/dry matter is considered, the correlation becomes negative (Fig.3c), probably because the selection of this cereal made during this century followed the requirements of the malting industry that demanded large grains with a high amount of starch, a high diastatic power and a very low content of non-soluble proteins.

The positive correlation between grain weight and N/seed content is likewise restored by means of artificially induced mutations. Treatments of M. Heda variety allowed the obtaining of mutants, either with larger grain and higher protein content (M.C.64 and M.C.61), or with a larger grain and a similar protein content (M.C.62) than the motherline, and finally a mutant with a small grain and an equal capacity of synthesis (M.C.63) as seen in Fig.4. A percentage increase on dry matter can be then obtained, both increasing as well as decreasing grain size.

2. The protein quantity of a grain in a given variety depends on the length of time of development and on the synthesis speed. M.Heda variety and two of its mutants, M.C.63 and M.C.64, were compared during the development of the grain until its point of ripeness (Fig.5). In this case, it is observed that the three genotypes present a more or less similar speed of synthesis and consequently the difference in their final quantity resides in the extension of the synthesis period.

Two could be the causes that prolong the synthesis period of the M.C.64; a higher amount of green matter and its longer time of activity. This becomes evident when the leaf blades of M.C.64 and its motherline are individually analyzed. It is observed in Fig.6 that M.C.64 lengthens its period of activity and the total green matter weight per flag leaf is also higher than in the motherline.

Since the protein content per leaf follows a parabolic function, in which its maximum coincides with the moment in which its moisture starts to decrease, it is evident that the declining content of the protein indicates a hydrolisis and a translocation of the amino acids towards the upper part of the plant, that is, the spike. The same occurs with the lower leaves. To conclude, the M.C.64 grains receive during a longer period the raw material required for the synthesis of their own protein. 1/

This fact would appear to point out that the mother genotype plays an important role in the amount of protein produced by the grain. To observe this aspect we have studied a cross of M.C.64 x Spiti variety (middle sized grain). In this case, grain weight is a character of simple inheritance and a single pair of genes is enough to explain the segregations observed in F_2 and F_3 generations. Moreover, it has been possible to establish that the said gene pair is linked to the gene for 2 and 6 row-spike, indicating that it is located in chromosome 2 (4).

As was previously mentioned, protein content depends on seed size. In consequence, the action of the M.C.64 gene resembles a case of pleiotropy since a same gene conditions both characters but in reality it is a single manifestation expressed at two levels. F_3 families presenting extreme and intermediate values for seed weight, corresponding to the three expected genotypes were chosen and the N/seed content determined. Results are presented in Table 2 where it is possible to observe that the variance is similar for the three genotypes and not statistically different. Since grains from heterozygous plants must segregate the three genotypes it is concluded that the N/seed content is the result of the influence of the genes carried by the mother plant.

These results agree with the previous established fact that bigger grain size is conditioned to a greater and longer supply of raw material from maternal tissues. On the other hand, Nelson (6) has suggested the same maternal influence in corn.

1/ So far, the other source of N coming under a mineral form through the radicular absorption, has not yet been studied and for the moment it is considered similar for the mutant and the motherline.

b) Grain protein quality

1. Quality is a concept that must be always clarified. It is also necessary for stating the breeding objectives. From a nutritional point of view, it is considered appropriate in cereals to make reference to the relative concentration of indispensable amino acids for a diet, whether human or animal. Likewise, it also depends on the way it is dispensed, simply raw or previously cooked; as a rule, in the second manner it is more digestible.

However, determinations of this nature are not adapted to the selection over a high number of individuals, therefore an approach specifying the different protein complex fractions can still be useful.

The differentiation of proteins according to their solubility, such as Osborne postulated in 1890 (7), could be convenient if it is recalled that the hydrosoluble fractions (globulines and albumines) are those that possess a higher proportion of essential amino acids. On the contrary, prolamines and glutelines are of a low quality. Generally these non-soluble water fractions are the most important in quantity and constitute the storage proteins of the endosperm. 1/

A quick method, if possible performed with one grain, would ease mass selection of the best quality genotypes. The Udy method determines the concentration of basic amino acids and is convenient provided the data on the total protein content is available. Lysine, arginine and histidine are present mainly in the hydrosoluble fractions.

However, the determination of another amino acid representing the other fractions could produce with the former a relation useful in plant breeding. Proline is usually found in the prolomines and can be detected in paper or thin-layer chromatography and easily separated from the other amino acids by developing with ninhydrine.

The relationship between basic amino acids and proline is interesting, as seen in Table 3, in which it varies according to the species under consideration. In barley its value fluctuates around 1 and it must be increased if a better quality is called for.

The analysis of mutant forms shows that when an increase in the quantity of protein per seed is obtained as a result of a change in weight, the former relation decreases (Fig.7), which is in accordance with the fact that the production of prolamines in the seed takes place after the other fractions are formed and in consequence tend to decrease the quality of the total protein.

In this aspect, the situation is analogous in wheat because the selection for varieties well adapted for baking has made prevalent those rich in gluten. In corn, increase in protein content carries also to the same result (unpublished results).

2. Although useful for breeders, the former ideas do not indicate the expected genetic change. Consequently it is advisable to attempt to identify the factors that provoke appearance or disappearance of the various protein constituents in the different fractions.

The enzymes for part of the albumine fraction are present genetically as isozymes, their absence being lethal for the seed or seedling development. On the other hand, isozymes would not appear to produce big differences as far as quality is concerned. It is favourable that their presence be found at the maximum possible concentration.

1/ Corn mutant opaque-2 is a good instance that shows the decrease of the non-soluble water fractions with a concomitant increase of the water-soluble ones, provoking an improvement of grain quality (6).

TABLE 1

Statistical analysis of seven barley lines in respect of N per dry matter content (%), seed weight (mg) and N/seed content (mg). Arrows indicate the grouping of varieties without statistically significant differences (P = 0.01) according to Duncan's test.

		KOZAN	BEKA	H. SPONT.	M.C. 20	L 6	M.C. 64	L 36
N %		2.2	1.9	2.2	1.8	2.2	2.2	2.7
	$\Sigma \delta^2$	2.2	1.5	0.5	0.4	0.6	2.1	4.3
Seed weight (mg)		29.3	32.7	31.9	38.5	46.8	48.0	49.7
	$\Sigma \delta^2$	167.0	464.1	256.2	625.3	578,1	222.0	394.6
N/ seed (mg)		0.3	0.6	0.7	0.7	1.0	1.1	1.4
	$\Sigma \delta^2$	0.3	0.3	0.2	0.3	0.3	0.8	1.4

TABLE 2

N/seed means and variances of the three genotypes for seed weight in M.C.64 x Spiti bar cross.

		Seed weight plant (mg)		
		67.1	52.7	42.7
N/seed (mg)	$\bar{x}$	1.80	1.29	1.11
	σ^2	0.037	0.037	0.027
No. of analyzed seeds		10	20	10

TABLE 3

Relation between basic amino acids and proline in different cereal species.

Species	Basic aminoacids : proline ratio
Barley	1.00
Sorghum	1.00
Wheat	1.10
Corn	1.22
Pye	1.37
Oats	2.50
Rice	2.60
Egg	4.00

TABLE 4

Association between protein pattern in a barley cross (Malteria Heda x Rupee) determined by gel electrofocusing and gel electrophoresis.

		Gel electrofocusing (pH 5-8) Band pI=6 - 6.5		
		Presence like Heda	Absence like Rupee	Total
Starch gel electrophoresis pH 3.2	Pattern like Heda	6	2	8
	Intermediate pattern	11	7	18
	Pattern like Rupee	1	9	10
	Total	18	18	36

FIG.1 - Relation between agronomic yield (kg/ha) and N/seed content (mg) in two different crops (1964 and 1968), for three different varieties and three replicates.

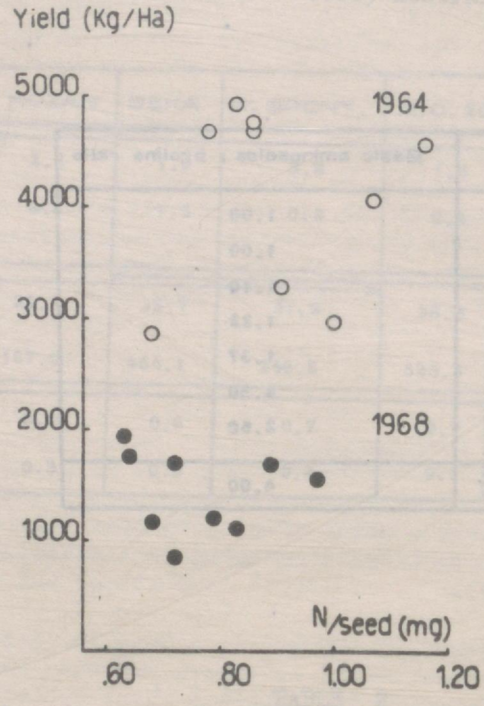


FIG.2 - Seed weight and N/seed content in relation to its position in two spikes of Malteria Heda barley.

- ● Seed weight (mg)
- o N/seed content (mg)

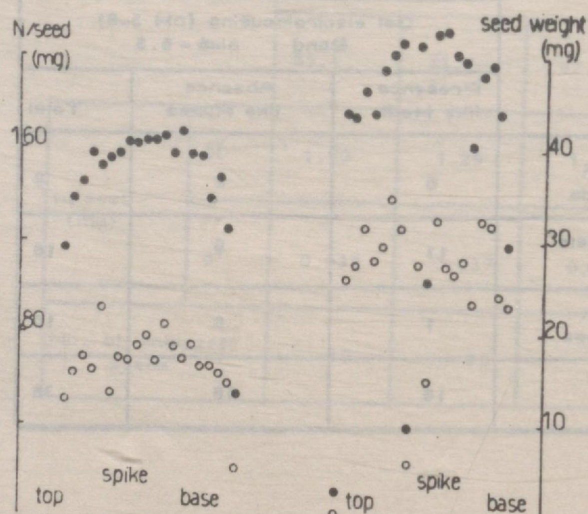


FIG.3 - N/dry matter (%) (a,c) and N/seed content (mg) (b,d) plotted against seed weight (mg) from an Ethiopian collection (a,b) and cultivated varieties (c,d) in barley.

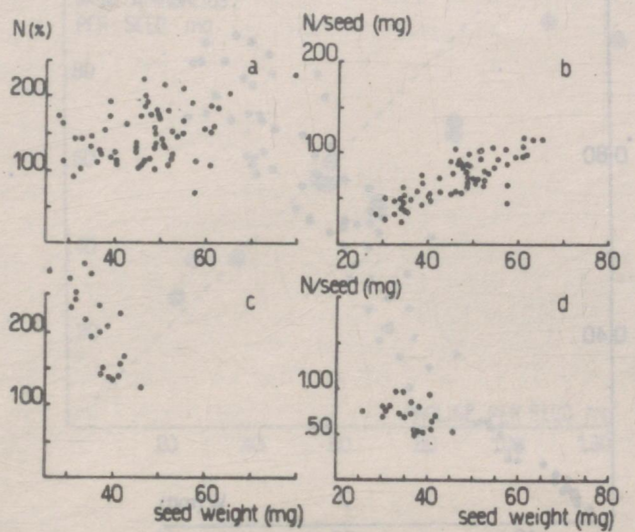


FIG.4 - Seed weight (mg), N/seed content (mg) and N content (%) in Malteria Heda barley and four of its mutants.

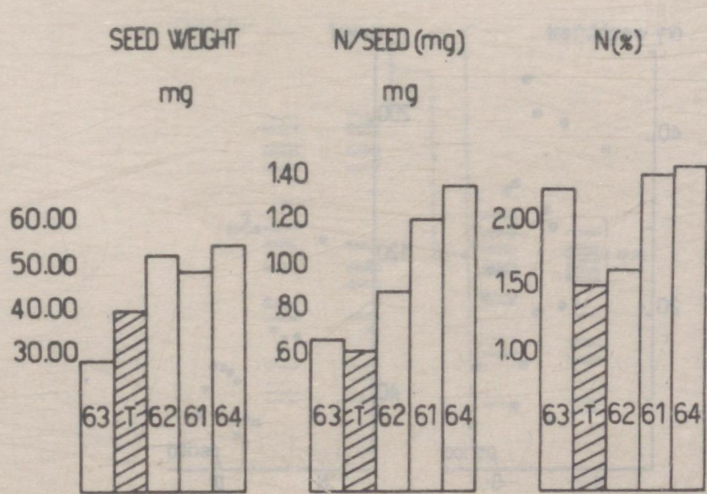


FIG.5 - N/seed content (mg) in function of seed weight during the development period.

● Malteria Heda barley ● M.C. 63 ● M.C. 64

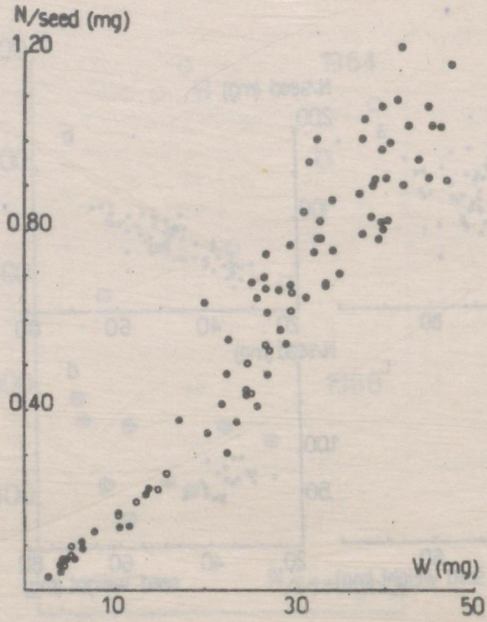


FIG.6 - Dry weight and N content per leaf in ● Malteria Heda barley and M.C. 64 ● .

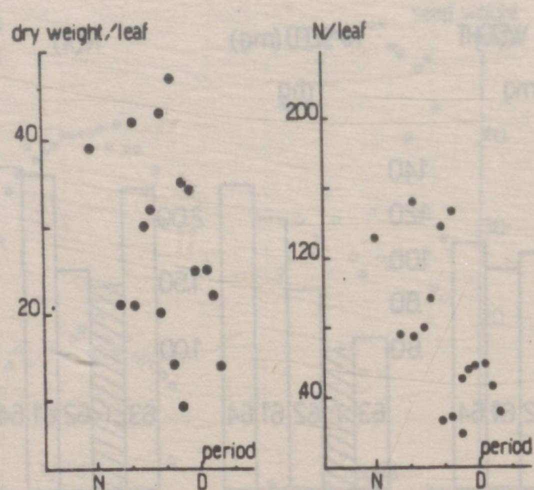


FIG.7 - Basic amino acids content (mg) in function of proline content (mg/seed) in several barley varieties and mutants.

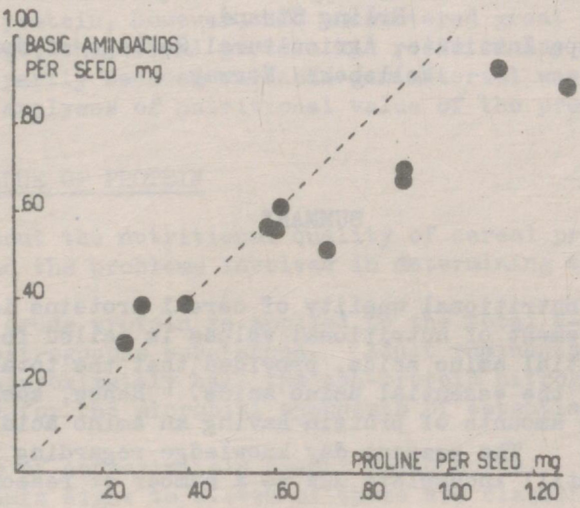
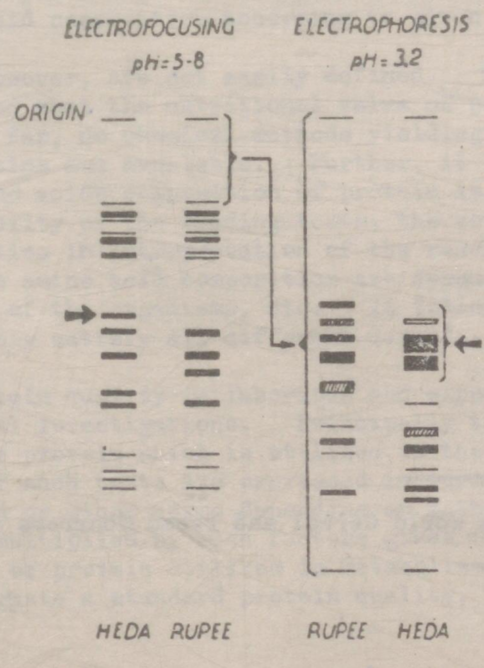


FIG.8 - Electrofocusing and electrophoretic patterns of Malteria Heda and Rupee barleys. Arrows indicate the genetically studied proteins.



BREEDING FOR IMPROVED NUTRITIONAL VALUE OF CEREAL PROTEINS 1/

by

Erling Strand
Farm Crops Institute, Agricultural College of Norway,
Vollebekk, Norway

SUMMARY

The importance of the nutritional quality of cereal proteins is now fully recognized. Precise and accurate measurement of nutritional values is called for, expressed in terms of minimum quantities of essential amino acids, provided that the total nitrogen supply is sufficient for synthesis of the essential amino acids. Hence, such varieties should be bred which contain adequate amounts of protein having an amino acid composition according to the given specification. The present day knowledge regarding the ideal amino acids composition of protein is still incomplete due to a number of reasons, including lack of suitable technology.

This paper discusses in detail the protein status of cereals as well as the different methods used for determining the nutritional quality of cereal proteins. The discovery of the high lysine mutants Opaque-2 in maize opened a new era towards improving the nutritional value of protein. Through extensive research which followed, it was possible to isolate types of rice, wheat and barley having richer lysine content. It is hoped that in the very near future it will be possible to develop such cereals for commercial plantation which will have improved nutritional value of their proteins.

1/ Paper presented at the 5th World Cereal and Bread Congress in Dresden, 24-29 May 1970.

INTRODUCTION

Success in plant breeding depends on two main categories of factors. One is the presence of adequate variation in the plant material. The other is the availability of methods for mass determinations of the desirable characters. In most cases the plant material is considered most important and is of most concern to the plant breeder, the recording of the characters to be improved being more or less a straight-forward procedure of simple tests or routine mass analyses. Breeding of cereal species for improved nutritional value of the protein, however, has encountered great problems of both kinds. Until five or six years ago, the cereal protein had resisted any attempts made to improve its nutritional quality, partly because suitable gene material was not known, and partly because methods for mass analyses of nutritional value of the protein were not available.

CONCEPT OF NUTRITIONAL VALUE OF PROTEIN

First a few words about the nutritional quality of cereal proteins today, the breeding aims for improving it, and the problems involved in determining the character.

The term protein or crude protein is applied to the total N-content which is bound in protein and non-protein nitrogenous substances. Adult ruminants can utilize all the protein and in addition approximately half the non-protein nitrogenous substances, which serve as nitrogen sources for the microbial synthesis of essential amino acids in rumen.

Proteins are made up of approximately twenty amino acids. For man, monogastric animals, and young ruminants eight to eleven of these are classified as essential, i.e. they must be present in the diet. The eight amino acids valine, methionine, leucine, isoleucine, threonine, phenylalanine, tryptophan and lysine are true essentials, while arginine and histidine are essential for youngsters only, and the glycine for birds. Cysteine can to some extent spare the requirement for methionine, and tyrosine for phenylalanine.

Because of these facts the study of protein quality, in the nutritive sense of the word, is of particular importance for these categories of living organisms. The importance of the protein quality calls for precise and accurate measurement of its nutritional value, which for this purpose on principle may be expressed in terms of minimum quantities of essential amino acids, provided that the total nitrogen supply is sufficient for synthesis of the non-essential amino acids. In order to meet these requirements of nutritional quality of cereal proteins, the varieties bred should contain adequate amounts of protein having an amino acid composition according to given specifications.

These specifications, however, are not easily defined. There are several reasons for this. It may first be stated that the nutritional value of proteins has to be determined by feeding tests, because so far, no chemical methods yielding satisfactory results as to these properties of the proteins are available. Further, it is a fact that our knowledge with regard to the ideal amino acids composition of protein is still incomplete. The main reason for this is the complexity of the feeding tests, the variation due to methods and techniques, and the difficulties in interpretation of the results. Finally, the optimum amount of amino acids and the amino acid composition are dependent upon the species, age and the physiological stages of the organisms, etc. It follows that no single specified quality of protein can possibly satisfy all different demands.

The feeding test of protein quality is laborious and expensive and is therefore applied mostly in more special investigations. Principally the feeding test should measure the part of the crude protein which is utilized in the metabolism of the production in question. The results of such tests are expressed in terms of BV = Biological Value, NPU = Net Protein Utilization or other terms depending on methods, technique applied, etc. The amount of total protein multiplied by such factors gives the amount of reference protein, which is the amount of protein utilized in metabolism. The term reference protein also is used to designate a standard protein quality, for example whole egg protein, etc.

A single feeding test, in spite of its obvious qualities, gives no information on the reasons why the nutritional value of a protein may be low. Supplementary amino acid analyses may give information on this point. Plant breeding involves the selection and testing of a very high number of entries for a number of characters. The feeding test, therefore, is not a feasible method for protein quality evaluation in this kind of work. As far as the nutritional properties of the protein are concerned, the testing of this character, for the reason just mentioned, has to be done by use of chemical methods suitable for routine mass analyses.

PLANT BREEDERS' METHODS FOR DETERMINATION OF NUTRITIONAL VALUE OF PROTEIN

In plant breeding of cereals three categories of chemical methods are used for the evaluation of the nutritional value of protein: (1) methods for determination of total protein content, i.e. Kjeldahl or others, (2) complete amino acid analyses, and (3) simple and inexpensive methods by which only one or a group of amino acids are determined, i.e. tryptophan, lysine, basic amino acids, etc.

The analysis of total protein is standard procedure. The complete amino acid analysis gives fairly reliable figures for the amino acid composition of the proteins. However, for a number of important amino acids the total amount cannot be utilized in the organisms. This is especially true of lysine, and to some extent also of methionine and cystine, all of which are more or less termolabile in food or feedstuff proteins. The availability of these and other amino acids may also vary because of enzyme inhibitors, differences in digestibility, etc. Only in the case of lysine a chemical method is at hand by which the available part of the amino acid can be determined. For plant material rich in carbohydrates, however, the method does not appear to be suitable.

Of the simple high capacity chemical methods the tryptophan method (Spies and Chambers 1967, CIMMYT report 1969) the lysine methods (McDonald et al 1969, Villegas 1970) and the DBC method (Mossberg 1969) are very useful tools in plant breeding. By the tryptophan method the amount of the amino acid can be determined on a single seed basis without damaging the seeds. By the DBC method, the sum of basic amino acids, of which lysine is the most important, is determined. Bioassy tests for lysine etc., are also being used to some extent. In spite of the uncertainties connected with the amino acid analyses as test methods for the nutritional value of protein, these are at present the most feasible.

As a standard or check protein, with reference to amino acid composition, whole egg protein was chosen. The amino acid compositions of other proteins are put in relation to this standard. Among others, mostly two terms are used in this connection. The 'Chemical Score' by Mitchell and Block (1946) based on the amount of the essential amino acid in greatest deficit compared to the standard protein. Oser (1959) proposed the EAAI index which is the geometric mean of the ratios of each of ten essential amino acids in the actual protein to the corresponding standard. Both indexes may be used for the estimation of the nutritional value of cereal protein. There is not time, however, to discuss the qualities and merits of these and other indexes in more detail.

The fact that both the optimum and the actual nutritional value of cereal proteins are imprecisely and incompletely defined, and the existing discrepancies between the total amount of amino acids and the amount utilized in organisms, should not, however, lead to the conclusion that improvement of the nutritional value of cereal proteins at the present time is not possible or feasible. In cultivars of cereal species there is a very wide and well recognized gap between the optimum and actual nutritional value of the cereal proteins. The uncertainties due to less efficient analytical techniques have a bearing only on the exact width of the gap. It is agreed that the gap is wide enough for many years of plant improvement. There is also no doubt about the character of the gap, and the remedies for closing it. It is further to be expected that as time and the breeding work proceed, narrowing the gap between optimal and actual quality, the development of simple chemical methods for the purpose will keep up with the increasing demand for a more precise evaluation of the nutritional value of cereal proteins.

THE PROTEIN STATUS OF CEREALS

The major part of cereal kernels consists of carbohydrates. The protein content of commercially grown varieties varies from less then 10 to 18-20 percent, and in special investigations protein contents outside these limits are reported.

The protein of cereals can be split into the fractions albumine, globuline, prolamin and glutelin based on their solubility in water, weak salt solutions, alcohol and alkaline solutions respectively. These protein fractions are chemically heterogenous. This is especially the case for prolamin and glutelin. From a plant breeding point of view, these protein fractions are of interest because their content of essential amino acids differs very much. The two main protein fractions, prolamin and glutelin, which in highest concentrations are found in the central parts of the kernels, are low both in lysine and other essential amino acids, while the proteins of the outer layers - and especially the germ - are rich in lysine approaching the egg protein in this respect.

The nutritional value of cereal proteins on a whole kernel basis generally is low. The reason for this is the low content of lysine followed by methionine and threonine in decreasing order of deficiency. Calculated according to Mitchell-Block based on the limiting amino acid, the chemical score is approximately 60-55 percent while the EAAI index indicates values of 55-60 percent, with, however, great variations. The protein fractions prolamin and glutelin have the lowest chemical score, approximately 45 percent. Since these fractions constitute the major part of the cereal proteins and in milled flour are still more dominating, the improvement of the nutritional value of prolamin and glutelin is of greatest importance.

The amount of protein and the nutritional value of the protein of cereals on a whole kernel basis may be greatly influenced by growing techniques, environmental conditions, etc., especially nitrogen fertilization. By using modern milling techniques, it is further possible by application of the air separation technique to obtain wheat flour fractions containing protein over the range of 2 to 25 percent (Reiz 1964). A similar fractioning also is possible as to the content of vitamins, minerals, fat etc. (Bradley 1963). The original composition of the wheat kernels, therefore, may seem to be of less importance. The nutritional value of wheat flour protein, however, is difficult to improve by milling techniques because of the low content of essential amino acids in the central parts of the kernels which have the best physical properties for bread making. In any case, grain of high quality for the production in question, yield better results. Furthermore, in the parts of the world where advanced milling techniques are not available, the basic quality of the crop cannot be overestimated.

An increase in the protein content of wheat and barley through heavy nitrogen application exert a strong influence on the amino acid composition of the protein. The most significant effect is that the percentage of lysine, the amount of which is insufficient, seems to be reduced. Larsen (1967) found that the percentage of lysine, and to some extent also the percentage of arginine, in wheat protein was lowered when the amount of nitrogen fertilizer was increased. In percentage of dry matter the lysine content increased somewhat at the lower nitrogen fertilization, later it decreased. Pence et al (1950) found that the amino acid composition in the different protein fractions was fairly constant in varieties of widely different protein content.

In 286 wheat samples investigated by Lawrence et al (1958), the variation in lysine content of protein was from 2.46 to 3.84 percent, which is a difference of 56 percent. Lindner (1964) reported lysine contents of 2.88 to 3.50 percent in Hungarian wheats. In another investigation of five varieties the same author found only small differences in amino acid composition. Michael (1963) found no significant differences in the amino acid composition of the prolamin (protein) fraction in barley varieties with high or low total protein. The differences in biological value of the protein, which in spite of this are recorded, seem to be caused by the variation in the amount of the main protein fractions, which again are influenced by variety differences and by environmental factors during growth and ripening, i.e. temperature, moisture, fertilization, etc.

Investigations by Finney (1963) showed no connection between protein content and amino acid composition on the one hand, and physical properties of the protein, i.e. water absorption, elasticity, etc., on the other.

Munck (1962) found that the gain in weight of mice in barley feeding experiments was more dependent on variety than the content of protein of the varieties tested. Possible effects of reduced lysine percentage of the protein due to heavier nitrogen fertilization on the gain in weight per gram of protein were not observed in the range of 7.5 to 11.4 percent protein in barley. In other Swedish experiments (Sanne 1967) where five barley varieties were grown in two years, no significant varietal differences as to a gain in weight, protein deposition or content of available energy were observed. In the same experiments no connections between percent protein in grain and the gain in weight were found. There were, however, significant varietal differences in feed intake by the animals. This indicates differences in taste and palatability which may be of importance. Grain high in protein due to heavy nitrogen fertilization or site of growing gave a higher gain in weight; the utilization of protein and energy, however, was reduced.

Lawrence et al (1958), from his investigations arrived at the conclusion that the possibilities for improvement of the biological value of cereal proteins by increasing the content of lysine seems doubtful because the varieties high in protein had the lower content of lysine in their protein.

Miller (1950) found no significant differences between varieties as to the content of cystein, glutamin acid, lysine and methionine. Investigations in Australia (Simmonds 1962), England (Pace 1962) and Sweden (Sihlbom 1962) also found no varietal differences of a magnitude that could justify optimism regarding the possibilities of increasing the amount of limiting amino acids in wheat protein through breeding.

The investigations referred to in the preceding paragraphs are just a few examples chosen to illustrate the kind of results obtained from the earlier research work undertaken to improve the nutritional value of cereal proteins.

THE BREAKTHROUGH

During the years prior to 1964 a number of scientists, of whom some are referred to in the preceding chapter, devoted much time to investigating the amino acid composition of cereal proteins. The general conclusion of this work may be quoted from Lawrence et al (1958). These authors, based on their own investigations, expressed the opinion that the possibilities for improvement of the biological value of cereal proteins by increasing the lysine content seems doubtful, partly because of the small variation in lysine contents observed and partly because of the negative correlation between total protein and lysine content of the protein.

However, starting with the discovery of the high lysine mutants Opaque-2 in maize by Metz et al in 1964, a new area in the improvement of the nutritional value of protein in cereals was established. In 1965, and later, other lysine genes in maize were located. These genes are capable of increasing the lysine content of the maize protein by 65-70 percent above the level of ordinary maize. In the CIMMYT report 1967-68 it is stated that maize having at least 15 percent total protein with the Opaque-2 gene present would provide an adequate diet for children when supplemented with the necessary vitamins and minerals. Work is going on to incorporate these protein qualities into high-yielding commercial varieties of maize suitable for varying growing conditions. Success in this work will have to be classified as one of the greatest and most remarkable contributions by plant breeding to the welfare of mankind. The discovery of the lysine gene in maize was important not only because it made possible the improvement of the maize protein quality. It may be still more important because it indicated that lysine genes also might be found in other cereal species.

The extensive search which followed for similar plant types in other cereals has resulted in the location of types of rice, wheat and barley considerably richer in lysine than commercially grown cultivars of these species.

Johnson et al (1969) reported lysine contents of protein ranging from 1.77 to 4.15 percent among 4 100 wheat varieties tested. The value 4.15 percent approaches the level believed necessary for optimum balance of lysine with other essential amino acids. A weak negative correlation between percent lysine and total protein was observed in the material. The lysine content was also, to some extent, influenced by environmental factors. The authors concluded, however, that the data obtained provide the basis for very significant improvements of the nutritional value of wheat protein by breeding procedures. Work is undertaken to transfer the high lysine trait to commercial varieties of winter wheat.

Very recently Mattern et al (1969) reported that 7 000 varieties from the USDA World Wheat Collection were screened for their lysine and protein contents. A number of wheat varieties selected for high lysine content are being grown at widely separated sites in the USA to assess the stability of lysine content in different environments.

It also seems reasonable to believe that major genes, in addition to those already located, may exist in the remaining part of the World Collection not yet investigated. The first attempt made at the International Maize and Wheat Improvement Centre in Mexico to transfer the high protein and high lysine characters to Mexican semi-dwarf spring wheats are reported not to be very successful (CIMMYT report 1968-69). However, it is to be expected that the difficulties encountered very soon will be overcome by new breeding procedures as indicated by the team. Similar work is going on also at a number of other research centres in the world. Encouraging results are for example reported from India (Swaminathan et al, 1969) where the new variety Sharbati Sonora has significantly higher lysine content than other varieties.

The extensive search for high lysine varieties of barley carried out in the USA and Sweden has yielded excellent results. In 1967 and 1968 a total of 1 825 barley varieties were tested for protein and lysine contents at the Svalöf Station (Munck et al, 1969). The best variety selected, CI 3947 named Hiproly (<u>Hi</u>gh <u>pro</u>tein <u>ly</u>sine) had a very high protein content combined with a high lysine content. Under average growing conditions the figures were 16-17 percent and 4.1 percent respectively for these very valuable characters. The Hiproly, therefore, seems to have the qualities of the gene material required for a protein quality breeding programme.

Other cereals also have been subjected to screening for high protein and lysine contents. Swaminathan et al (1969) found the range of variability for protein and lysine contents in rice as extensive as in the case of wheat. A large collection of cultivated and wild rices is being screened for amino acid composition. The data obtained so far reveal that chances are good for significant improvements of the nutritional value of rice.

In pearl millet (*Pennisetum typhoides*) a wide variation in protein and lysine contents is reported by the same authors. A world collection is under investigation for protein and lysine contents. Like the other cereals the possibilities for improving the nutritional value of pearl millet look promising.

In conclusion of this short review, it is to be expected that both the protein content and the nutritional value of the protein in commercially grown cereals in the next decade will be improved very significantly by means of plant breeding procedures.

REFERENCES

1. Block, R.J. and Mitchell, H.H. The correlation of the amino-acid composition with 1946 their nutritive value. Nutr. Abstr. and Rev. 16. p 249-278.

2. Bradley, W.B. Recent research on the nutritional quality of wheat products. 1963 Baker's Digest 37: 43-49.

3. Finney, K.F. et al. Soy-product variables affecting breadbaking. Cereal Sci. Today 1963 8: 166-168.

4. Hagberg, A. and Karlsson, K.E. Breeding for high protein content and quality in 1969 barley. IAEA, Vienna.

5. International Maize and Wheat Improvement Center (CIMMYT) Report. 1968-69

6. Isenback, K. and Hoffmann, W. Gerste. Handbuch der Pflanzenzüchtung BdII. 1950 Züchtung der Haubtgetreidearten, Berlin.

7. Johnson, V.A. et al. Breeding for high protein content and quality in wheat. 1969 New approaches to breeding for improved plant protein. IAEA, Vienna, pp 29-40.

8. Larsen, I. Kvaelstoftilförselens indflydelse på utbyttet og aminosyresammensaetningen 1967 og hvedekaerne. Ugeskr. f. agronomer 112: 203-206.

9. Lawrence, J.M. et al. Lysine content of wheat varieties, species and related genera. 1958 Cereal Chem. 35: 169-178.

10. Lindner, K. Aminosäurezusammensetzung und Nährwert der Weizeneiweissfraktionen. 1964 Qualitas plant et. met. veget. Haag 11: 31-38.

11. Massenback, H. Unterlagen für die Züchtung eiweissreicher Gersten. 1937

12. Mattern, P.J. et al. Improving lysine and protein content in wheat. Cereal Sci. 1969 Today 14. Suppl. pp 83-110.

13. McDonald, C.E. et al. Development and testing of methods to screen samples of ground 1969 whole wheat for potentially high lysine varieties. Cereal Sci. Today 14. Suppl. pp 83-110

14. Mertz, E.T. et al. Mutant gene that changes the protein composition and increases 1964 lysine content of maize endosperm. Science 145: 279-280.

15. Michael, G. Einfluss der Düngung auf Eiweissqualität und Eiweissfraktionen der 1963 Nährungspflanzen. Qual. Plant Mater. Veg. 10: 248-265.

16. Miller, B.S. et al. Amino acid content of various wheat varieties. I. Cysteine, 1950 lysine, methionine, and glutamic acid. Cereal Chem. 27: 96-106.

17. Mossberg, R. Evaluation of protein quality and quantity by dye-binding capacity: 1969 A tool in plant breeding. New approaches to breeding for improved plant protein. Int. Atomic Energi Agency, Vienna 1969: pp 151-160.

18. Munck, L. En analysmetod för bedömming av näringsvärdet hos fodersäd. Sv. Utsädesf. 1962 Tidskr. 72: 352-368.

19. Munck et al. Bättre näringsvärde hos spannmålsprotein. Sv. Utsädesforenings
1969 Tidsskr. 74: 196-205.

20. Nicolaysen, W. Hafer. Handbuch der Pflanzenzüchtung. Bd.II. Die Züchtung der
1950 Haubtgetreidearten Berlin.

21. Oser, B.L. In: Protein and amino acid nutrition. Academic Press, N.Y.
1959

22. Pence, J.W. et al. Characterization of wheat gluten. II. Amino acid composition.
1950 Cereal Chem. 27: 335-341.

23. Pace, J. Wheat proteins. Recent advances in Food Science 1: 212-225.
1962

24. Reitz, L.P. Wheat quality components responsive to genetic control. Qualitas
1964 plant et. met. veget. Haag 11: 1-16.

25. Sanne, O. Olika kornsorter och korn efter olika kvävegjödsling till kycklingar.
1967 Nordisk jordbruksforskning 49: 331.

26. Siglbom, E. Amino acid composition of Swedish wheat protein. Acta agr. Scand. 12:
1962 148-156.

27. Simmonds, D.H. Variation in amino acid composition of Australian wheats and flours.
1962 Cereal Chem. 39: 445-455.

28. Spies, J.R. and Chambers, D.C. Chemical determination of tryptophan. Analyt.
1967 Chem. 21: 1246-1266.

29. Swaminathan, M.S. et al. Genetic and agronomic enrichment of the quantity and
1969 quality of proteins in cereals and pulses. IAEA, Vienna. pp 71-86

30. Villegas, E. Personal communications.
1970

ABSTRACTS

International Wheat Genetic Symposium; Wheat Newsletter, Vol. XVI, 1969.

Plans are getting underway for the Fourth International Wheat Genetics Symposium to be held in Columbia, Missouri, USA, in 1973. Dr. Gordon Kimber is the Organizing Secretary. Any questions or information desired concerning the next symposium should be directed to him. His address is: Department of Genetics, 206 Curtis Hall, University of Missouri, Columbia, Missouri 65201, USA.

* * *

DJELEPOV, Cyril P, Dobrudja Agricultural Research Institute, Gen. Toshevo; Induced Dwarf and Semi-Dwarf Mutants; Wheat Newsletter, Vol.XVI, 1969.

By means of X-ray treatment followed by ethylmethan sulphonate (EMS) treatment of winter wheat seeds of Bezostaya 1, Mironovska 808 and Apulicum 233 forms have been singled out, characterized by short stems and resistance to lodging. At present (M6) some stable lines have been found. The height of mutant plants from Bezostaya 1 vary from 53 to 19 cm compared to 77 cm for the original sort; mutants from Mirinovska 808 varied from 55 to 31 cm compared to 93 cm for the original sort; and mutants from Apulicum 233 varied from 81 to 53 cm compared to 90 cm for the original. Mutants having the shortest stem also possess a dense ear, while for the rest the ears approach the original forms.

Some mutants differed from the original sorts by other characters: a higher productivity potential - M 36/322 and M 51/112; better sprouting - M 3661; greater weight per thousand seeds - M 204/36; and higher sedimentation test for mutants M 20/127, M 50/112, M 169, M 98/21, M 197/322, M 190/256, M 295/206, M 204/36, M 161/322 and M 8/24.

Most of the mutants have smaller grain, i.e. a lower weight per thousand seeds, less sprouting and thence a lower absolute productivity compared to the original sorts.

The induced qualities referred to above, combined with a higher cold resistance, impart to these forms valuable quality to serve as original material while selecting short straw sorts.

* * *

GILL, B.S., and ANAND, S.C., Department of Plant Breeding, Punjab Agricultural University, Ludhiana; Three-gene dwarf wheats; Wheat Newsletter, Vol. XVI, 1969.

Extensive work is being carried out for the evolution of wheat strains possessing all the three dwarfing genes to avoid losses due to lodging. The problem of poor seed set has been largely overcome. The best triple dwarf cultivar yielded as high as 45 percent more than the check cultivar Kalyansona. The partial correlation studies indicated that kernel weight was the most important yield component contributing towards grain yield in the 3-gene dwarf strains. Some of the early cultivars which were shy in tillering possessed very bold grains and were among the highest yielders. Of the other two components, number of ears per plant is the next yield contributing factor whereas the number of grains per ear was found to be the least important.

* * *

QUINOÑES, Marco, MAYA, J.L., KLATT, A.R. and BORLAUG, Norman E, CIMMYT; Developments of the Spring Semi-dwarf Bread Wheat; Wheat Newsletter, Vol. XVI, 1969.

Mexican semi-dwarfs are currently being sown on ten times more area in foreign countries than is sown to wheat in Mexico, where they were developed. It is estimated that the CIMMYT-Mexican dwarf wheats and their derivatives were grown on 7 457 000 hectares in Asia and North Africa in 1968-69. In addition, a considerable but unknown area is sown with these wheats in East and South and North America. In the last two years these wheats and their new technology have been largely responsible for increasing total wheat production in Pakistan and India by 60 percent and 50 percent respectively compared to the previous all-time production high in the 1964-65 season. In 1969, this increased wheat production added $250 million and $625 million to the GNP of Pakistan and India respectively. However, even with this remarkable success many new problems either have appeared or will soon come into being because of the world-wide distribution of these wheats. To offset these dangers, the revitalized National Wheat Improvement Programmes in India, Pakistan and Turkey are now beginning to increase a number of semi-dwarf cultivars selected under their own conditions. This will lead to more diversification of the types of disease resistance within the next two years.

In many of the countries which are now more experienced in the growing of these cultivars under irrigation (Pakistan, India and Mexico), there is an ever-increasing demand from farmers for still shorter wheats (triple dwarfs), based on the hopes that this will push the yield potential higher. Several promising triple dwarfs have recently been isolated from the cross II-23584 - (Ciano x Sonora 64-Klein Rendidor) x 8156. Several of these lines appear to have a higher yield potential than Siete Cerros, Super X, MexiPak, Kalyansona, PV-18, or Indus, all of which were selected from II-8156. In the CIMMYT testing programme many of these double and new triple dwarf lines have shown good resistance to the prevalent races of stem, leaf and stripe rusts in Mexico. With additional testing in different environments, some of these lines may soon replace the prevalent cultivars in Mexico, India, Pakistan, and many Middle East countries.

In the 1968-69 season in Morocco, characterized by extremely heavy and protracted rain, Septoria leaf and glume blotch was very severe, seriously damaging some of the Mexican dwarf wheats as well as the native wheats. Especially severe damage occurred on Siete Cerros and Inia 66. However, under these epidemic conditions, Tobari 66, Norteño 67, and Penjamo 62 appeared to give a tolerant reaction. In addition, a number of breeding lines containing Tezanos Pinto Precoz and Andes in their pedigree gave varying degrees of tolerance to Septoria. Some lines from Brazil, Argentina, and Italy have also shown different levels of resistance. All the cultivars and lines showing tolerance or resistance are currently being utilized extensively in the Mexican crossing programme in order to incorporate Septoria resistance into promising lines. In Brazil, cultivars resistant to both Septoria and Fusarium are urgently needed. Several tall Argentine and Brazilian cultivars with this dual resistance are currently being crossed to Mexican dwarfs in order to incorporate their resistance into semi-dwarf wheats with higher yield potential.

In 1968-69, 800 experimental lines were evaluated in replicated yield trials in Ciano. From these trials the 53 most outstanding lines in regard to resistance to the rusts, resistance to lodging, resistance to shattering, yield potential, and certain quality characteristics were selected for further evaluation. These 53 lines have been included in the CIMMYT 1969 'A' Screening Nursery, which was distributed to collaborators in many other countries. In this group, there are also lines which are slightly taller than is desirable for irrigated conditions. However, some of these lines may be well adapted to rainfed conditions in Tunisia, Morocco, Turkey, Pakistan, India, and other countries. The most promising lines of this type come from the crosses Ciano "S" x Inia "S"2 (II-23959) and Tobari 66 x Ciano "S" (II-25000).

In the 1969-70 season at Ciano, 32 of the most outstanding lines are undergoing preliminary field multiplication for possible release as new cultivars either for Mexico or in other countries. Included in this group are several lines from II-23584, II-25000 and II-23959 crosses.

* * *

VARUGHESE, George and ESPIRICUETA, T., CIMMYT; The Development of Spring Dwarf Durums; Wheat Newsletter, Vol. XVI, 1969.

Durum wheats are extensively grown in the North African countries of Morocco, Algeria, Tunisia and Libya. Extensive areas are also planted to durums in Turkey, Syria and other

Near East countries. With the expansion of CIMMYT activities into the Near East and North Africa, high-yielding, light-insensitive, dwarf spring and semi-winter durums with more yield stability are urgently needed.

Norin dwarfing genes which revolutionized the spring wheat production were introduced into the durum wheats from Pitic 62 through a series of back-crossing to Tehuacan during the mid-sixties. In 1965 a derivative of this programme, Oviahic 65, was released. However, this dwarf durum lacks both yield stability and light insensitivity.

One of the major aspects of yield stability is a reasonable fertility in the spike under different environemental conditions. Norin 10 dwarfing genes are associated with a number of sterility factors. However, currently many of the Norin 10 bread wheat derivatives in the CIMMYT breeding programme do not exhibit this characteristic. It could be reasoned that there was a break in the linkage between the dwarfing genes and the sterility factors. Since the dwarf durums received their dwarfing genes from Pitic 62 which is a highly fertile cultivar, and since the durums exhibit the sterility under unfavourable conditions, it indicates that there is no actual separation of the dwarfing genes and the sterility factors. Hence, it is reasonable to argue that the stability in fertility is due to the selection of complementary factors which masks the effect of the sterility factors. This assumption of stability in fertility due to the selection of complementary genes is supported by two observations: (1) with the expansion of the genetic base we are getting highly fertile lines in the dwarf durums; (2) F_2 generation from the crosses of highly fertile x highly fertile of different origin segregates for fertile as well as semi-sterile types.

Yet another factor which influences the stability of yield is the sensitivity to the photoperiod. During the past few years a considerable amount of insensitivity has been incorporated into the CIMMYT dwarf durums mainly from Barrigon Yaqui and Zenati Bonteille.

During the 1968-69 crop season, 42 advanced durum lines outyielded the bread wheat variety Inia 66. Of these, 14 yielded more than 8 tons/ha. The best crosses are listed in the table below :

Promising Dwarf Durum Lines, Ciano - 1968-69

Cultivar No.	Pedigree	Yield	
		Kg/ha.	% of Inia 66
V-03266	$(LD357_E Tc/D\#2\text{-}Tc^3)LK.$ II-21279-6M-2R-11M-OY.	8458	123
V-03254	$BY_E\text{-}Tc^5$ II-21276-3Y-6Y-1Y-OY	8338	121
V-03252	Anhinga "S" II-22234-9M-2Y-OY	8302	120
V-065	Brant "S" II-24102-4R-3M-1Y-OM	8297	120
V-03	$(TM_E\text{-}Tc^2/Z\text{-}BxW)\ (BY_E\text{-}Tc^2/$ $TAC_E\text{-}Tc^2)$ II-25609-6M-OY	8261	120
V-067	Crane "S" II-23055-45M-5Y-1M-1Y-OM	8063	117
	Inia 66	6867	100

Tc = Tehuacan 60 - a tall Mexican durum

Most of the available CIMMYT dwarf durums have excellent agronomic architecture. Many are light insensitive, have fair to good fertility, good seed characteristics and resist diseases prevalent in Mexico. However, almost all of them are backcross derivatives built upon a very narrow genetic base. Hence, attempts are being made to widen the genetic base while retaining the plant characteristics.

* * *

RAJARAM, S. and RODRIGUEZ, E., CIMMYT; Preliminary Survey of Genes for Resistance in CIMMYT Wheat; Wheat Newsletter, Vol. XVI, 1969.

Breeding experiences have shown that the continuous success of any wheat breeding programme would depend upon the proper utilization and incorporation of various sources of resistance genes. In most instances, the stem rust resistance of CIMMYT wheat cultivars has been due to the combination of major genes with those genes which operate at post-seedling stage, commonly known as adult plant resistance. Research is continuing for the location of new sources of major genes (vertical or specific type resistance) and also to uncover new types of adult plant resistance (horizontal or general type) and then to combine these resistance types by conventional breeding procedure.

Preliminary studies utilizing selected strains of stem rust having differences in pathogenicity genes, have indicated that the cultivars Tobari 66, Inia 67 and Sonora 64 carry the gene Sr11. In addition, Tobari 66 and Sonora 64 each carry at least one previously undescribed gene, which may possibly be different. The seedling resistance of Siete Cerros is due to the genes Sr6 and Sr11. Pathological evidence also suggests that Norteño 67 and Noroeste 66 carry identical genes for resistance, but these genes may be different from those genes already named and described.

Our studies regarding adult plant resistance suggest that there is good variability present in the CIMMYT wheat breeding materials. For example, Tobari 66, Bluebird #1, Bluebird #5 and Siete Cerros inoculated with stem rust race 151 (virulent on plants having genes Sr6, Sr11, Sr9b and Sr8 singly or in combination) produce a reaction of 30 MR, 10 MS, 5 R and 80 S respectively, in adult plant stage, although all these cultivars are susceptible to this race in the seedling stage. This indicates that there are real genetic differences in adult plant resistance in the CIMMYT wheats.

Most of the genes for leaf rust resistance in cultivars like Sonora 64 and Inia 67 have become ineffective because of the presence of virulent strains. Our studies suggest that the genes present in Tobari 66, Agatha and Preska are giving resistance to all the prevalent races in Mexico. Preliminary evidence also suggests that Tobari 66 has contributed greatly towards the resistance of advanced lines in the CIMMYT wheat programme.

* * *

ZILLINSKY, F.J. and LOPEZ, A., CIMMYT; Triticale Programme at CIMMYT; Wheat Newsletter, Vol. XVI, 1969.

The Triticale programme was started in Mexico five years ago. During this period the major improvements in the Triticales have been the incorporation of day-length insensitivity, disease resistance and dwarfing from bread wheats by crosses between hexaploid Triticales from the University of Manitoba and Mexican bread wheat cultivars. In 1968 several F_4 lines containing highly fertile plants were found among the segregating populations. These plants have subsequently been reselected and grown under different climatic conditions in Mexico and have continued to produce fertile plants for three generations. Crosses have been made to short, strong-strawed selections derived from the *T. aestivum* x Triticale crosses. These populations are still in the early segregating generations.

The performance of the more fertile Triticales under conditions outside of Mexico is influenced greatly by environment. Generally, they have performed poorly at latitudes above 30°. They apparently do not possess the wide adaptability of the Mexican bread wheats. It is hoped that broad adaptation can be bred into the Triticales by intercrossing the best plants from early generation populations selected at many different environments.

In July 1969 seed of the first International Triticale Yield Nursery (ITYN) was distributed to 30 experiment stations representing all the continents. In November 1969 seed from the best F_2 populations was sent out as F_3 Bulks to 25 stations on six continents. Seed for screening nurseries will be available after the 1969-70 crop is harvested at Ciudad Obregon, Sonora.

* * *

WI/B1257/2.71/E/1/600