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IDENTIFICATION OF BARLEY STRAINS WITH IMPROVED AMINO ACID BALANCE

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SUMMARY

Four barley strains viz. 1098-2, 1098-7, 1098-9 and 733-6, obtained from the progeny of the crosses, Jyoti × Hiproly and Vijay × Hiproly which showed an increase in the grain protein content and an improvement in amino acid balance, were identified.

INTRODUCTION

During the last few years, genotypes have been isolated in maize (MERTZ et al., 1964; NELSON et al., 1965), rice (JULIANO et al., 1968), wheat (JOHNSON et al., 1969), barley (HAGBERG & KARLSSON; MUNCK et al., 1970) and sorghum (SINGH & AXTELL, 1973) which hold great promise as sources of genetic variability to improve the nutritional quality of conventional high yielding varieties.

In barley, a high protein, high lysine genotype viz. Hiproly has been isolated from the World Collection of Barley Germplasm and characterized (MUNCK et al., 1970). However, it has poor plant type, is late maturing and gives a poor yield under Indian conditions. Hence, a breeding programme was initiated with a view to incorporate the high lysine, high protein trait of Hiproly into some of the high yielding commercial varieties of barley.

The present communication reports the isolation of some strains which combine a yield comparable to those of the high yielding parents with an improved amino acid balance and a high protein percentage of the grains.

MATERIALS AND METHODS

The high yielding varieties, Jyoti and Vijay were crossed separately with Hiproly. A large number of F_2 plants were grown in the experimental fields of IARI, New Delhi in the spring of 1971–72. NPK fertilizers (30:20:20 kg/ha) were applied to the soil in all the cases. From the population grown, F_2 plants were selected on the basis of maturity, head type (six rowed), fullness of grains, better tillering and straw strength. Late, two rowed plants with shrivelled grains were rejected. Part of the grains from single plants was used for chemical analyses and part for further advancement of families.

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Of the seven hundred plants selected, those with grains showing high dye binding capacity (DBC) and high crude protein content were isolated and grown as F_3 lines at Wellington in the autumn of 1972. Further screening was done on the basis of desirable agronomic characteristics. The selected lines were bulked and grown as F_4 lines at IARI in the following spring and screened on the basis of plant type, grain characteristics, better tillering, straw strength and chemical analysis.

Finally, the bulk samples of the lines 1098–2, 1098–7 and 1098–9 from the cross Jyoti × Hiproly, and 733–6 from the cross Vijay × Hiproly were selected for their total amino acid spectra. These four lines were advanced by one generation at Wellington in the autumn of 1973 and grown as F_6 lines in the following spring at IARI, New Delhi. Representative samples from the F_6 progeny of the selected strains were again analysed.

Data on yield and other agronomic characters of F_6 families of the selected strains and parents, which were grown alongside, were collected and are given in Table 1. Chemical anlyses were done on representative samples of the grains ground to a 60 mesh size in a Wiley Mill. Nitrogen was determined by using a Technicon Autoanalyser for mass screening of the strains. Repeat analyses for nitrogen content of the grains of the selected strains were carried out by the micro-Kjeldahl method (AOAC, 1965). The protein content was computed by using the multiplication factor 6.25.

DBC of the samples was determined by a slight modification of the method of UDY (1954 and 1956) and MOSSBERG (1969). Five hundred milligrams of the ground samples were taken in plastic bottles and 25 ml of the dye solution (suitably diluted) were added to each and immediately mixed. The bottles were then placed in a horizontal position in a mechanical shaker for two hours. Subsequently, the bottles were allowed to stand for such time as to allow the suspended particles to settle and the dye supernatant was filtered. The filtrate was diluted × 200 and the optical density (O.D.) was read at 470 nm on a Spectronic 20 colorimeter. The O.D. of the dye bound by the protein was calculated by substraction from the O.D. of the untreated dye.

Acid hydrolyses were performed on the ground grain samples for estimation of their amino acid composition as described earlier (CHATTERJEE et al., 1974). The chemical score of the grain protein was calculated as percentage of whole egg protein taken as a standard (BLOCK & MITCHELL, 1946).

Table 1. Summary of the ancillary characters of the selected and parent barley strains.

Barley strain	Days to 75% heading	Days to 75% maturity	1000 grain wt. (g)	Grain type	Yield per plant (g)
1098-2 (Jyoti × Hiproly)	79	125	36	hulled	11.2
1098-7 (Jyoti × Hiproly)	79	125	39	hulled	15.2
1098-9 (Jyoti × Hiproly)	80	124	38	hulled	14.7
733-6 (Vijay × Hiproly)	82	125	40	hulled	15.4
Jyoti	83	121	38	hulled	11.7
Vijay	83	116	39	hulled	12.0
Hiproly	95	139	26	hull-less	–*

* Yield data could not be computed due to late maturity of the grains and high incidence of aphids.

RESULTS AND DISCUSSION

The correlation coefficient (r) obtained between DBC and crude protein (Kjeldahl N $\times$ 6.25) was 0.637*** and the regression coefficient (b) 0.017. The high protein, high DBC deviates, 1098–2, 1098–7, 1098–9 and 733–6 were selected for further study

It is evident from Table 1 that the selected strains combine early maturity and well-filled grains, besides having yields comparable to, or even more than the high yielding parents, Jyoti and Vijay. There was a considerable improvement over the yield, plant type and grain type of Hiproly.

The protein content in the grains of the selected strains was more than that in the grains of the high yielding parents (Table 2).

The progenies of the cross between Jyoti and Hiproly showed an overall increase in the essential amino acid content in their grain protein over that of Jyoti (Table 2). Only arginine showed a slight decrease. Leucine content increased in the strain 1098–2 but decreased in the strains 1098–7 and 1098–9. However, the slight decrease in the leucine/isoleucine ratio in the grain protein of all the three strains is a favourable indication (COPALAN, 1969).

The sulphur containing amino acid, methionine showed a slight decrease. Cystine, however, increased in 1098–9 but showed no change in 1098–2 and 1098–7. Since the content of sulphur bearing amino acids in barley grains is relatively good, the slight decrease in the content of these amino acids in the grain protein did not adversely affect the protein quality.

The non-essential amino acid, proline, decreased significantly in all three strains. Tyrosine content increased in the strain 1098–2 but decreased in the strain 1098–7. There was no significant change in the tyrosine content in the strain 1098–9. The content of glycine, an amino acid whose importance has been stressed in the feeding of chicks (HEGSTED et al., 1941), was increased.

The progeny of the cross between Vijay and Hiproly viz. 733–6 showed an increase in the content of all the essential amino acids in its grain protein over their content in the grain protein of Vijay. The non-essential amino acids, cystine and tyrosine showed a slight decrease (Table 2).

A comparison of the content of essential amino acids in the grain protein of the newly developed strains to that of the commercial barleys, which represent the available variability in the commercial cultivars, brings about some interesting differences (Table 3). Threonine, isoleucine and lysine, considered as the most limiting amino acids, showed a marked increase in the newly developed strains. Methionine showed a slight increase in the strains 1098–2 and 1098–9 but a decrease in the strain 733–6. Although the content of arginine had decreased in the strains 1098–2 and 1098–9, it had considerably increased in the strain 733–6.

The favourable increase in the content of the essential amino acids in the grain protein of the newly developed strains was reflected by an increase in the chemical score of their grain protein (Table 2). In view of the significant positive correlation between the chemical score and the biological value of a protein (BLOCK & MITCHELL, 1946), an improvement in protein quality is envisaged.

Table 2. Amino acid content (g/16 g N), protein percentage and chemical score of the grains of barley strains.

Amino acid*	Strains selected												Parents used		
	1098–2			1098–7			1098–9			733–6					
	1973	1974	mean	1973	1974	mean	1973	1974	mean	1973	1974	mean	Jyoti	Vijay	Hiproly
Lysine	4.02	4.16	4.09	3.63	3.62	3.63	3.30	3.55	3.43	3.38	3.29	3.34	3.00	2.77	4.04
Histidine	2.48	2.27	2.37	3.00	2.51	2.76	2.78	2.08	2.43	2.50	2.42	2.46	2.34	2.19	2.75
Arginine	5.01	4.29	4.65	4.79	4.78	4.79	4.13	4.55	4.34	5.49	5.84	5.66	5.19	4.81	6.29
Aspartic acid	6.53	7.07	6.80	6.27	6.40	6.33	6.28	5.77	6.02	5.82	5.66	5.74	4.42	3.68	5.75
Threonine	2.89	2.93	2.91	2.75	2.84	2.79	2.71	2.66	2.68	2.87	2.80	2.84	2.67	1.89	2.47
Serine	4.26	4.32	4.29	4.03	4.64	4.34	4.34	3.71	4.02	4.26	4.14	4.20	3.19	3.19	4.16
Glutamic acid	26.12	20.83	23.48	21.67	20.45	21.06	20.75	19.25	20.00	25.42	25.73	25.57	20.67	15.73	20.18
Proline	9.24	10.19	9.31	9.31	9.15	9.23	8.22	8.31	8.26	9.57	9.62	9.60	11.48	8.36	8.91
Glycine	4.05	4.26	4.20	3.94	4.08	4.01	3.58	3.80	3.69	3.79	3.68	3.74	3.01	2.95	3.90
Alanine	5.21	5.06	5.13	4.61	4.58	4.60	4.34	4.33	4.34	4.11	4.20	4.16	4.38	3.68	5.47
Cystine	1.56	2.69	2.13	1.60	2.56	2.08	2.50	2.18	2.34	2.44	2.32	2.38	2.12	2.86	1.66
Valine	4.74	4.83	4.78	4.95	5.36	5.15	4.18	5.08	4.63	4.53	4.41	4.45	4.47	3.17	4.74
Methionine	1.56	1.87	1.72	1.35	1.70	1.53	1.65	1.73	1.69	1.43	1.42	1.43	1.74	1.33	2.35
Isoleucine	3.99	3.70	3.84	3.70	3.58	3.64	3.72	3.51	3.61	3.53	3.43	3.47	3.62	2.73	3.17
Leucine	7.20	6.84	7.02	6.79	6.29	6.54	6.41	6.14	6.28	6.80	6.62	6.71	6.73	5.69	6.71
Tyrosine	3.13	3.44	3.28	2.59	2.95	2.77	3.21	2.81	3.01	2.96	2.98	2.97	3.05	3.20	2.83
Phenylalanine	5.21	5.70	5.46	5.81	5.38	5.60	5.47	5.59	5.53	5.09	4.96	5.03	5.04	4.07	5.01
Protein (%) (N × 6.25)	17.69	15.74	16.71	17.26	15.11	16.18	19.80	15.28	17.54	15.44	16.48	15.96	13.75	9.62	20.21
Chemical score(%)			55			49			52			46	45	38	49

* Values are average of duplicate estimations and are expressed on moisture free basis.

Table 3. Percentage increase in the essential amino acids and chemical score of the grain protein of the selected barley strains over the average values obtained for commercial barley varieties.

Essential amino acid[1]	Amino acid content (g/ 16g N) of six commercial varieties[2]		Percentage increase in the selected strains over the commercial barleys			
	mean	range	1098-2	1098-7	1098-9	733-6
Lysine	2.99	2.77–3.16	37	21	15	12
Histidine	2.18	1.96–2.34	9	27	12	13
Arginine	4.75	4.19–5.19	–	1	(–) 9	19
Threonine	2.10	1.89–2.67	39	33	28	35
Valine	3.75	3.17–4.47	27	37	23	19
Methionine	1.52	1.33–1.81	13	–	11	(–) 6
Isoleucine	2.97	2.69–3.62	29	23	22	17
Leucine	6.27	5.69–6.73	12	4	–	7
Phenylalanine	4.29	3.95–5.04	27	31	29	17
Total essential amino acids	30.82		20	18	12	15

[1] Tryptophan was not determined. However, barley grain protein has a tryptophan content of about 1.28 g/16 g N (EGGUM, 1968).

[2] Individual values of the commercial varieties have been reported earlier (CHATTERJEE et al., 1974).

In short, the isolated genotypes hold great promise as potential sources of increased supply of protein and essential amino acids, particularly in India, where barley is used as food, feed and fodder.

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REFERENCES

AOAC (Association of Official Agricultural Chemists), 1965. Official methods of analysis, 10th edition. Washington D.C.

BLOCK, R. J. & N. H. MITCHELL, 1946. The correlation of the amino acid composition of protein with their nutritive value. Nutr. Abstr. Rev. 16: 249–278.

CHATTERJEE, S. R., SANTOSH GASSI & Y. P. ABROL, 1974. Amino acid composition of barley varieties. J. Fd Sci. Technol. 11: 85–86.

EGGUM, B. O., 1968. Determination of tryptophan. Acta agric. scand. 18: 127–131.

GOPALAN, C., 1969. Studies on the pathogenesis of some nutritional deficiency states. Indian J. Med. Res. 57 (suppl.): 75–79.

HAGBERG, A. & K. E. KARLSSON, 1969. Breeding for high protein content and quality in barley. In: New approaches to breeding for improved plant protein. IAEA/FAO, Vienna, STI/PUB/212: 17–21.

HEGSTED, D. M., G. M. BRIGGS, C. A. ELVEHJEM & E. B. HART, 1941. The role of arginine and glycine in chick nutrition. J. biol. Chem. 140: 191–200.

JOHNSON, V. A., P. J. MATTERN, D. A. WHITED & J. W. SCHMIDT, 1969. Breeding for high protein content and quality in wheat. In: New approaches to breeding for improved plant protein. IAEA/FAO, Vienna, STI/PUB/212: 17–21.

JULIANO, B. O., C. C. IGNACIA, V. M. PANGANIBAN & C. M. PEREZ, 1968. Screening for high protein rice varieties. Cereal Sci. To-day 13: 3–5.

MERTZ, E. T., L. S. BATES & O. E. NELSON, 1964. Mutant gene that changes protein composition and increases lysine content in maize endosperm. Science 45: 279–280.

MOSSBERG, R., 1969. Evaluation of protein quality and quantity by dye binding capacity: a tool in plant breeding. In: New approaches to breeding for improved plant protein. IAEA/FAO, STI/PUB 212: 151–161.

MUNCK, L., K. E. KARLSSON & A. HAGBERG, 1970. Selection and characterization of a high protein, high lysine variety in the World Barley Collection. In: ROBERT A. NILAN (Ed.), Barley genetics, II. Pub. Washington State Univ. Press, Pullman, Washington, p. 544–558.

NELSON, O. E., E. T. MERTZ & L. S. BATES, 1965. Second mutant gene affecting the amino acid pattern of maize endosperm proteins. Science 150: 1469–1470.

SINGH, R. & T. D. AXTELL, 1974. Survey of World Sorghum Collection for opaque and sugary lines. In: Research progress report on inheritance and improvement of protein quality and content in *Sorghum bicolor* (L.). Agency for International Development. Department of State, Washington, D.C., p. 1–22.

UDY, D. C., 1954. Dye binding capacities of wheat flour protein fractions, Cereal Chem. 31: 389–395.

UDY, D. C., 1956. Estimation of protein in wheat and flour by ion binding. Cereal Chem. 33: 190–197.