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Nutritional Criteria in Plant Breeding: Technical Problems and Constraints in relation to Sri Lanka's Plant Breeding Programme

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There is a considerable body of literature that has concerned itself with a critique of the products of plant breeding and has sought to redirect research from simple yield objectives to wider and broader considerations such as yield stability, drought resistance and broad spectrum pest and disease resistance. There appears however to have been little explicit discussion by plant breeders themselves on the use of criteria in determining priorities and in particular on the importance of technical constraints in determining and influencing the shape and objectives of research programmes. This paper is about the use of nutritional criteria in plant breeding and discusses the technical problems that plant breeders have faced in their research programmes; however it also questions the relevance of the plant breeders' approach to nutritional problems by an examination of nutritional status and the plant breeding programme in Sri Lanka.

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A. Breeding policy and criteria

It is accepted that plant breeding is but only one component of the activities of an agricultural department. However it is an activity that has dominated approaches towards raising crop yields as a result of a history of notable achievements and through a belief that improvements in agricultural productivity, however defined, are directly amenable to technical manipulation. Thus it has been argued that problems of low yields and disease sensitivity could be solved with the production of new varieties which had higher yield potential and greater disease resistance. Through breeding, yield potential of Sri Lankan rice varieties has risen from 2.4 t/ha for the traditional varieties in the 1950s to nearly 7.8 t/ha for the modern (BG) varieties. Yet the national average yields have only risen from 1.7 to 2.9 t/ha during the same time span and a historical view of Sri Lankan agricultural research policy is as much about the absence of an approach towards the farming system as a whole, as about the undoubted success of the plant breeder.

Plant breeding clearly works and the perception that biological constraints and a strategy of breeding for their removal, has had much to do with the dramatic increases in crop production that have been observed in many national agricultural programmes. Associated problems with the new crop varieties of pest and disease attack have resulted in increasingly sophisticated breeding programmes that have attempted to match these. Indeed the problems of non-adoption of some of the earlier new varieties alerted breeders to the wider questions of the acceptability and quality aspects of their new grains.

Yet it could be argued, that the very success of the plant breeder has given them an undue dominance in decision on criteria and policy of research, and perspectives of what the solutions could be. This is not to deny the emerging and emergent role of economists and sociologists who have viewed agricultural productivity constraints in a different way and to whom the plant breeders have had to pay increasing attention. But considering nutritional aspects, it is evident that agricultural research programmes generally and plant breeders specifically have approached the problem very much from the

basis of the individual crop rather than from that of a farming system with dietary considerations in mind. Indeed recognition that raising yields, in itself has beneficial nutritional consequences through raising the total food supply, has rarely been explicitly discussed. Ryan et al (1974)[1] offer one of the few discussions of the importance of yield vis à vis quality aspects of a species. But as will be discussed later, yield increases in Sri Lanka rice production have been of major nutritional significance.

However to be fair to the plant breeders, breeding higher yielding varieties was a response to general statements of calorie deficiency. The emergence in the 1960s of concerns for protein deficiency and the relative needs of protein to calories provoked research into looking for improved levels of protein in cereals, with improved quality. The changing ground of what that protein deficiency actually was and what the relative protein/carbohydrate ratios should be, certainly left plant breeders in confusion as to what breeding criteria they should be aiming for. Thus one breeder was moved to comment,[2] 'the confused shift of opinion as to needs and priorities in human nutrition is a problem which complicates decision making processes relating to recommendations for improvement in the nutritive content of plant foods'. The emergent picture that safe level estimates for protein/energy intakes are well within protein values of existing staples[3] makes it clear now that there is little justification for continued and intensive programmes for improvement of protein levels within individual species.

Nevertheless over the last decade or so plant breeders have spent considerable time and effort in examining various strategies for raising protein levels in individual species. In doing so, they have faced considerable technical problems and the fact that very few new high protein level varieties have been produced, is evidence of that.

The technology of breeding

To date, major objectives of plant breeders have been yield improvement, breeding for pest and disease resistance and only to a lesser extent quality factors. Other aspects such as drought resistance and salinity resistance have also featured far less prominently. This

order of priorities is a reflection of not only the ranking of perceived constraints to agricultural productivity, whether done explicitly or not, but also has much to do with the relative technical ease of being able to deal with the problem.

Plant breeders work by using the variation of characteristics (either natural or more recently, induced) within a population of a plant species, and by a variety of techniques combining, by various types of crossing patterns, desirable or superior forms of a particular character into one variety. In the first instance, identification of such variation is essential and programmes have to be set up to collect, screen and evaluate varieties for their characteristics.

The relative ease with which a breeding programme can be carried out depends initially on the floral characteristics of the species. Thus maize, by virtue of the fact that the male and female flower are carried separately on the same plant and are of a size that can be handled, has been a species that has been highly amenable to hybrid breeding. On the other hand, legumes pose awkward problems in their reproductive biology: the flowers are small and difficult to handle; there are complicated incompatibility systems which determine whether or not pollen from another source can pollinate the flower; the flowering period stretches over a long period of time (indeterminate) unlike the cereals in which the flowering on a single plant is synchronised or determinate; and finally, many of the legumes flowers abort after fertilisation. Such problems do not make legumes easy species to handle genetically.

Plant breeding depends on an understanding of the genetic base of the character under examination. Many vegetative characteristics such as pest and disease resistance, whose expression show little response to environmental conditions, can be easily transferred and incorporated into different varieties. There are other characteristics though, whose expression is very influenced by environmental factors. A case in point is protein content, the level of which within a variety of a species shows a marked response to the availability of nutrients, particularly nitrogen. Protein content also shows poor inheritance from one generation to the next; high protein content is somewhat recessive to low protein content (which is more dominant) and therefore

less liable to be expressed; in addition the endosperm tissues of the grain are triploid rather than the normal diploid of the remainder of the plant, and this makes the inheritance of protein even more complicated.

A third set of problems that the plant breeders have to contend with relates to the nature of the character that they are trying to select for. Yield as a character is determined by many physiological functions within the plant and its genetic base is quite complex; yet it has the advantage of being a character that has explicit morphological expression. A high yielding variety can be identified simply by going into the field and weighing its yield. But the usual breeders expression of 'breeding for yield' disguises the reality of how they actually do it. Such a statement implies that they carefully put together aspects and attributes from different varieties into a particular configuration that will predictably produce a high yielding variety. This though is very far from the case and what has happened almost without exception is that higher yielding varieties have been selected by empirical selection, from the progeny of crosses using parents of desirable traits. Even the production of the short strawed high yielding varieties of wheat and rice have been a result of simply selecting for biomass production. The understanding that the improved yield came as a result of improved partition from the vegetative to the reproductive organs of the plant and that this made the varieties more responsive to applied levels of nitrogen, was an understanding that came afterwards. Experiments and breeding programmes that have been set up specifically to separate biomass production and improve partition are scarce. Over time however plant breeders by observation have been able to break down those morphological features that contribute to yield and the understanding that yield capacity could be formulated as a product of a number of characters [4] (yield capacity for rice = number of panicles per m^2 of land x number of spikelets per panicle x number of grains per spikelet x potential size of grain) has assisted plant breeders in their selection of yield to a certain extent but in practice, negative correlations between the various components, has not made it an excessively fruitful approach; it still does not provide a detailed physiological picture

that can be seen to be expressed in yield. The understanding of the finer details of plant physiology and the pathways of yield metabolism are coming slowly but it is still a long way from the position whereby plant breeders will be selecting for particular enhanced biochemical pathways as their strategy for yield improvement. It has been fortunate that it has been possible to breed relatively easily for higher yielding varieties on the basis of really very little understanding of how the plants works.

Pest and disease resistance are other characteristics that also have morphological expression in that they can be selected for in the field. Their genetic basis is fairly well understood; the physiological understanding though of what processes go to confer resistance are much less clear.

There are a whole number of plant characters that cannot be selected in the field or do not have direct morphological expression and most of the nutritional and quality factors come within this group. Selection for protein quantity therefore is dependent upon the use of analytical techniques for assay and effective analytical methods for selection of raised protein levels and increased quantities of individual amino acids, and these have only been available during the last decade or so. Such techniques are becoming increasingly sophisticated in pursuit of accuracy and precision and as a result more time consuming and expensive, none of these features being likely to endear themselves to plant breeders or those who allocate research funds. The added complexity of the physiological interaction and interplay between plant processes concerned with yield formation and those with quality have made nutritive characteristics difficult for plant breeders to handle.

Breeding for nutritional and quality factors

Grain or yield quality is a composite term that includes such features as total protein quantity, protein quality (relative proportions of various amino acids) which is not an objective definition but is defined in terms of use, oil content (for oil seed crops), the presence or absence of toxic factors, milling and processing characteristics and the organoleptic properties such as palatability and taste. It is

not proposed to discuss quality aspects of non-food crop products such as the fibre content of jute, cotton and sizal or the sugar content of sugar plants although it is perhaps worth pointing out that because of the industrial values of such products, the quality aspects of such crops are well understood biochemically.

(i) protein quantity and quality in grain crops

It has been known for a long time that the protein content of grain legumes and cereals are markedly different and that both within and between species for both legumes and cereals there is considerable variability, which potentially can be exploited by the plant breeder. In terms of allocation of resources and priorities, breeding programmes for cereals have until very recently been selectively favoured over those for legumes on the grounds that cereals were grown on a greater area and were more important in the diet of the population. It has been stated [5] that cereals contribute about 70% and legumes only 20% of the supply of plant protein in the world and that rice is the main source of dietary protein and provides nearly 70% of the total calories in Asian countries. On that justification protein quality and quantity in cereals has been a major concern although it is questionable whether simple percentages are a justifiable criterion.

On the basis of publications and achievements, protein quality has featured far more than quantity, and this reflects the relative technical ease of achieving the two objectives. The breeding of high lysine level mutants in maize (opaque-2 and floury 2) in barley (hiproly, RØ mutant and in wheat (cl 13449) [6] were in their time held as major advances. Retrospectively though the defective nature of these mutants, particularly in relation to reduced yield potential, has muted the original claims for progress, and generally the negative correlation between protein quantity, quality and yield has been a major problem. The plant physiologist and breeder have been forced therefore into developing a greater understanding of how protein is formed and accumulated in the developing grain and of what the nature is of the various protein fractions to be found in the grain. [7] Knowledge that, for example, the increased lysine content of the maize mutants was due to the alteration of the relative proportions of the protein fractions

in the grain (a reduction in the prolamin fraction) lead to an appreciation of the need for more than an a priori selection for the level of a particular amino acid.

The technical difficulties involved in studying cereal proteins centres firstly on the absence of screening methods, since these proteins lack enzyme activity, and secondly on the complete lack of detail on the biochemical and control mechanisms concerned with protein formation and deposition. Further the lack of agreement in the reported amino acid ecomposition values for varieties, for example of legume species [8], is due much to the lack of standardisation of techniques, varying methods of analysis and also the source of the material in the first place.

There is little prospect or point in increasing the lysine content of rice which has one of the more nutritious protein contents in terms of amino acid balance, but for cereals, a relatively low protein content of 7.5-9%. And as has been found for most other cereals in screening for variability in protein content, environmental factors contribute much of the variability in levels and the use of such variability, combined with breeding technqiues designed to concentrate genetic factors for high protein content, has not produced successful varieties.

Recent work [9] has begun to look at the question of distribution of protein in the grain as concentration of protein occurs in the outer layers which are often lost with milling. The hope is to find varieties in which there is a more even concentration of protein throughout the grain which is therefore less susceptible to milling losses. However for IRRI, [10] improved protein content cannot be justified as a research priority because of the inherent difficulties of breeding for the trait but more importantly because of the urgency of other critical problems such as pest resistance and tolerance to various environmental conditions.

The problem of strong interaction between genotype and environment and separating out their relative contribution to variability in protein content, has proved a major stumbling block for breeders trying to raise protein levels in legumes or improve the methionine and cystine content, low levels of which are characteristic of legumes species. It is

difficult to find in the literature clear reasons as to why breeding higher protein levels for legumes (which average from 20 - 45%) is more desirable say, than going for higher overall yields which are notoriously low in legume species, not least because most legumes feature strongly in the farming systems of many marginal environments. Indeed breeding objectives concerned with restructuring the plant - less bushy habit, determinate flowering habit etc. could do far more to raise total protein production per unit area, than trying to improve translocation of biologically fixed nitrogen to the grain, given the value of the nitrogen rich residues and fixed nitrogen to the fertility of the agricultural system as a whole.

However breeders are continuing to look for strategies for improving the protein quality of grain crops;[7] improving total crude protein content, breeding nitrogen responsive varieties, changing the relative proportions of the protein fractions in the grain, using variation in seed morphology, and selecting for increased levels of free amino acids are all strategies that have a scientific base. Even the production of unconventional species of which triticale is an example, is a considered possibility although it is difficult to see why such a conventional species as the oat, which not only has a good amino acid balance but also a high protein level of 15% for cereals, has been so neglected.

One further point is perhaps worth stressing; assessment of protein quality has largely been carried out using experimental animals under laboratory conditions. Wide variation in results have been reported using such tests for biological values from identical material and the applicability of using such figures as an assessment of the biological value of the protein to human beings, must be questioned.

(ii) toxic factors

A large number of toxic factors have been identified, particularly in grain legumes seed.[11] The significance of many of these to human nutrition is uncertain since many of the substances identified, for obvious reasons, have been assayed on experimental animals, and there is considerable evidence that normal cooking practices effectively

inactivate toxic substances such as protease inhibitors, haemaglutinins and cyanogenic glycosides. However toxicity due favism caused by eating the broad bean (Vicia faba) and lathyrism and Lathryus species is clearly a problem. For favism, which can cause hemolytic anemia, it has not been possible to reproduce the disease in experimental animals which has meant that the causative substance has not been identified. For lathryism on the other hand the causative substance has been identified and it should be possible to breed for varieties in which it is absent or low in concentration. Flatulence, which is not really a form of toxicity but more a discomfort and occurs when legumes are a large proportion within a diet, remains something of a mystery as the causative factors are not fully characterised. Without such identification, it has not been possible to breed flatulence free varieties. The selection for low levels of toxic vactors has also been carried out in other groups of food crops, such as in cassava (cyanogenic glycosides) and in oil seed rape (erucic acid).[12]

(iii) processing factors

Processing factors cover a wide range of physical attributes concerned with post harvest handling of the grain, from dehulling and milling to use in cooking or processing. Often such factors are chemically well understood and have been genetically selected for as, for example, high gluten, this being desirable for a bread making wheat, and similarly low dormancy low nitrogen content barley with a high extract of soluble and fermentable oligosaccharides being the ideal quality grain for beer making.[13] The recovery of complete rice grains from milling or the head rice recovery percentage is associated with the hardness of the grain and the absence of chalky spot;[14] however no genetic information is available on the inheritance of hardness factors. For rice that is precooked or parboiled prior to dehulling, there is almost no information on what are desirable parboiling characteristics or what their genetic base is. It should be remembered however that cultivation and harvest conditions are the ultimate determinant of the condition of the grain and much can be done in terms of quality with improved handling both before, at and after harvest.

(iv) organoleptic properties

Properties of grain quality that fall into this grouping are those that are associated with consumer acceptance of the grain: factors such as grain size, shape and appearance, cooking and eating qualities, aroma and pigmentation factors, are all influential in determining whether a particular grain is acceptable to the consumer. The usual approach of plant breeders to such characteristics has not been to mount a breeding programme to ensure that the desirable features are incorporated in the final product but simply to test the progeny of the breeding programme concerned with yield levels or pest resistance, on tasting panels to ensure consumer acceptability. This approach is a reflection of not only the relative order of research priorities and the difficulty of breeding for yield, disease resistance and grain appearance all at the same time, but also the lack of understanding, both biochemically and genetically of how, for example, aroma, is determined.[14]

In the rice breeding programmes it is well understood now that the relative concentration of anylose and amylopection, two kinds of starch in the rice grain, are influential in determining cooking characteristics such as the volume of expansion of the grain, water absorption capacity and the resistance of the grain to disintegration.[14] The appreciation of regional variations in consumer preferences or acceptance and the importance of these in influencing adoption and consumption of new varieties, has meant that rice breeders and biochemists have had to examine organoleptic properties in detail and develop screening techniques for them. Twenty years ago such aspects of grain quality were almost completely neglected; now they have achieved far greater prominence in the order of priorities of the rice breeder. They are unlikely to dominate such objectives as yield potential and pest and disease resistance but they may well become the most crucial aspects of grain quality to be considered.

B. Sri Lanka: nutritional criteria used in breeding

In considering the use and priority of nutritional criteria in Sri Lanka agricultural research programme, it is necessary to consider it within the context of the historical development of agricultural research and in the general setting of nutritional status within Sri Lanka

(1) the development of the agricultural research programme

Prior to independence in 1948, the interest of the British in the Sri Lankan economy centred on the plantation sector of tea, rubber and coconuts and the activity of the Agricultural Department reflected this. The food base of the rural community, largely rice, was almost completely neglected although some collection and improvement of pure line varieties of rice was carried out in the 1920s and in the last years of the colonial administration. The British policy was essentially that of importation of cheap wheat flour to meet the large shortfall in domestic grain production.[15] The second world war and the need for food rationing stimulated a belated interest in domestic food production. and as will be discussed later. laid the basis for a subsidy system which has been a crucial feature of Sri Lankan economic and political development since then and has had important implications for the general nutritional status within the country. Although immediately post war and during the early years of independence. the financial status of the country was healthy. foreign exchange crises and a growing population, focussed greater attention on domestic food production.

Thus in the early 1950s a major rice breeding programme was set up within the primary objective of raising the yield potential of rice varieties this being seen as the primary constraint to enhanced food production levels. Associated with this was the continuation of the British policy of colonization of the dry zone and the expansion of the cultivated area. The breeding programme centred on the selection of new hybrid varieties,[16] the opinion being that continued selection of pure line varieties afforded little prospect for substantial yield increases particularly since they were unresponsive to applied nitrogen. In breeding terms this hybrid rice programme has been remarkably successful with first the H varieties, particularly H4 and latterly the BG varieties. Average yields for rice in the thirty year period up to 1980 have risen from 1.7 t/ha to 2.9 t/ha; a combination of these new varieties, increased inputs of nitrogen fertiliser and disease control both by breeding and chemical means, and an expansion of the cultivated area,

has raised rice production levels such that the country has risen from [17] 55% to over 90% self sufficiency.

Other food crops such as pulses (green gram, black gram and cowpeas), finger millet, cassava and vegetables have received far less attention within the agricultural department although guaranteed price schemes and other government policies which have been attached to rice for many years, have over time been extended to cover many other crops to encourage production and thereby reduce imports. A notable example of this was when the Bankaranaike government in the 1970's banned imports of chillies, onions and other crops. Production of these rose rapidly, capitalizing on varieties bred nearly a decade earlier.

In recent years the overall focus of the agricultural programmes in plant improvement has shifted somewhat from rice although it still remains the dominant element and greater attention has been placed on legumes, root crops and the farming system as a whole. Thus production and productivity has now come to be viewed not simply in terms of the individual crop but more in terms of the cropping system as a whole.

One feature that is important to stress in Sri Lanka is the factor of ecological diversity. On the basis of rainfall, drought risk and soils Sri Lanka can be divided into [23] distinct agro-ecological zones. [18] These distinctions are meaningful in that the characteristics that a rice variety must have to grow in an upland area on soils where upwelling due to hyrdological conditions causes iron toxicity problems are very different from those on an ideal rice soil in the north west dry zone. The current principle Sri Lanka rice breeder [16] esimtates that he needs at least 30 different varieties of rice based on differences in duration and tolerance of different soil and water conditions to meet the needs of environmental variation. That in itself poses substantial demands on any plant breeding programme.

(ii) Nutritional status in Sri Lanka

There is no evidence that any Sri Lankan government has ever had an explicit nutrition policy, yet from the facts that the average number of calories available per day per person varies from between 1950-2250, [19] which is average for Asian standards and that over one third of both calories and protein consumed are imported, one might have thought that

nutrition levels would have been concern. However if one examines indicators of nutritional status and health, the evidence is that on balance the Sri Lankan nation in comparison with other Asian countries is remarkably well fed. The life expectancy at birth in Sri Lanka is at 65, ten years above the Asian average [19] and infant mortality is under 50 per 1000 births; in addition general health care provision is high. While it is true that malarial control in Sir Lanka has been important among general health activities, in itself it is not a sufficient explanation of the current health status. Nor can economic prosperity be advanced as an argument as in per capital terms, Sri Lanka remians one of the poor countries of the region and the world. What can be suggested though, is that the ration system started during the war and extended to a generalised rice subsidy scheme with a comprehensive public food distribution programme, has ensured that there has been a relatively egalitarian pattern of distribution and basic food supplies have been available to all. This is not to deny that there have been and still are communities of groups in which malnutrtion exists. Sectors of the urban poor, until recently estate workers in the plantation sector, and isolated communities for example in recently settled areas of the Mahaveli scheme, and in fishing communities on the east coast, illustrate this. But generally the majority of the population receives the average calories and portein intake as indicated by the fact that in 1973, [19] only 5% of the population consumed more than 2,200 calories and only 3% fewer than 1.700 calories.

There is an important and further consideration that might explain a certain paradox between the basic calorie and protein intakes and the indicators of nutritional status: conformity to the Asian pattern on the basis of per capita calories availability would lead to a life expectancy in Sri Lanka of 53 and not 65 although considerable caution should be used in drawing conclusions from per capita calorie availability. If one examines the composition of the diet, Sri Lanka is unusual in comparison with Asian standards in the importance that fruits (bananas, plantains, jak and mangoes), vegetables and fish play in the diet, meeting both calories, protein, vitamin and mineral needs. Only 63% of all calories in the Sri Lankan diet are estimated to come from starches, compared to the Asian average of 70%. It is against this background that the relevance of nutritional criteria in the Sri Lankan agricultural programme must be set.

(iii) nutritional criteria for agricultural research in Sri Lanka

From the above discussion it is clear that a priori there are no grounds for stating that nutritional criteria should in any way be a priority of the Sri Lankan agricultural research programme. The nutritional status of the population would not seem to justify it and questions of yield potential and pests and disease problems could justifiably be seen as the major biological constraints to higher productivity of crops. Which is not to say that clear decisions were made at any stage balancing yield, disease resistance and nutritional factors and their relative importance and ranking them on any form of criteria. The absence of any mention of nutrition or quality concerns in the Administration reports of the Directors of Agriculture [21] or in the Draft Agricultural Development plan 1971-1977, [22] would support the suggestion that quality considerations did not feature, at least in the scale of priorities.

Rice, by being the staple crop in terms of both consumption and area cultivated, but also for political and cultural reasons, has been the major crop researched and the production of the new hybrid varieties, of both the old improved H type and the new BG grouping, forced the question of quality to the attention of the rice breeders when the problems of non-adoption emerged, [23] which could be associated with consumer preference. For example it was found that the recent variety BG 90-1, although with high yield potential, has not found favour with the cultivator because of its poor storage characteristics, probably associated with a thin hull. [23] Routinely now progeny from crosses that show potential are evaluated for milling characteristics, appearance, physiochemical properties and palatability and surveys have been carried out to evaluate the consumer preferences. It should be noted though that the primary objectives of the rice breeding programme still remain yield, disease and pest characteristics although the availability of short-duration varieties and the possibilities of double cropping have enhanced total protein production, as has increased yields. Quality is not explicitly incorporated into breeding programmes - such aspects are merely used as a measure of acceptability of the new high yielding disease resistant variety. Concerns over protein quantity and quality have never featured in the breeding programme; the reasons for this are not clear but undoubtedly a major consideration has been not only the yield priorities but also the technical problems and technical facilities and resource endowment needed for protein quantity and quality

programmes.[16]

The attention now being focussed on grain legumes, as with rice, is centred on yield, disease and pest considerations as criteria for selection. No explicit reference has been made to the use of enhanced yield levels as a strategy for increasing the total quantity of protein available. However the aid funded programme of introduction of the soybean to Sri Lanka, where it is not an indigenous species, has been quite explicit in relation to the nutritive values of the soybean and products and this appears to have been an important reason for the initiation of the project. Similarly attention paid to promoting production of the winged bean which has had a long history of cultivation in Sri Lanka, has stressed its nutritional values. For the future, yield, disease and pest characteristics and growth in different environments, will remain priorities in the breeding programmes although consumer preferences are clearly considered important. Within the framework of the nutritional status of the country, these would seem to be justifiable priorities.

Conclusion

The argument of this paper has been that technical problems have frustrated attempts by plant breeders to improve the protein quantity and quality of crop species, although progress has been made in other areas of nutritional significance such as toxicity factors. It has also illustrated the importance of technical constraints in influencing and directing research in plant breeding programmes. However, as shown by the example of Sri Lanka, strategies for nutritional improvement encompass far more than simply concerns over protein profiles of individual crop species and it is clearly important that issues such as pricing policy, subsidies, distribution mechanisms and even such understandable topics as yield enhancement, should inform and direct more closely any nutritional programme within an Agricultural Department. Although protein quality and quantity is an aspect that may have relevance to animal nutrition, the clear statements now by nutritionists that protein values of crops are not below the safe level estimates for protein/energy intakes of humans [3] should refocus plant breeders' attention to carbohydrates and to the neglected area of improvement of oil content of food species. Unfortunately there seems to be little evidence that this is indeed happening.

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