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Basic factors underlying the scientific strategy

The favourable features of India's agricultural situation are: (a) the availability of abundant sunlight and the prevalence of favourable temperature for crop growth throughout the year in ^{most} all areas, ~~except~~ the high altitude regions of the Himalayas, ^{thereby making} which permit multiple cropping, ^{feasible} (b) the small size of an average farm holding and the large number of farm workers available, which render labour-intensive farming practices possible, and (c) the availability of large tapped and untapped water resources. Recent scientific research has aimed at exploiting these advantageous features through the genetic destruction of the yield barriers in the major cereals and millets and the development of the agronomic practices essential to enable the plant to reveal its yield potential. ^{As a result,} ~~Thus,~~ during 1964-67, the dwarf wheats Lerma Rojo and Sonora 64 introduced from Mexico, ^{the high-yielding wheat strains,} ~~at~~ Kalyam Sona, Safed Lerma, Sonalika, Chotti Lerma and Sharbati Sonora selected or developed locally, the rice strains Taichung Native 1, IR-8, Tainam 3, Taichung 65 and ADT-27, the Towar hybrids CSH.1 and CSH.2 the bajra hybrids H.B.1 and H.B.2 and the maize composites Jawahar, ^{K. in} Sona, Ambar, Vikram

and Vijay ~~have~~ as well as several maize hybrids have been introduced into cultivation by our agricultural scientists

Multiple cropping techniques employing a relay sequence were developed for enabling a farmer with a holding of about 2 hectares to grow 4 crops a year and earn a net ^{annual} income of over Rs 10000/- per hectare. (Continue in the same para material from p. 3.)

Special agronomic ^{methods} techniques have been x devised, such as sprinkling farm yard manure in fields sown with wheat in the month of January, which help in raising the soil temperature and increasing the speed of germination and growth of seedlings. Further, sowing in ^{the} North-South direction ^{has been shown to help} helps in capturing as much sunlight as possible by the green leaves and fosters ^{thereby} better ^{and quicker} growth. It has also been found that an important cause of lodging even in dwarf wheat varieties is the poor anchorage of plants in the soil, due to the poor soil structure arising from numerous ploughings. In light and alluvial soils, the number of ploughings should be reduced in irrigated areas and this can be safely done if weeds are controlled through proper weedicides. Simple practices of this kind make a large difference in the return a farmer gets from his investment on inputs.

Motivation for change

catalysts of transformation in
When those of us who have been privileged outlook

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to work in the field of agricultural research embarked on the relentless pursuit of higher yields in crop plants about 6 years ago, we had hoped that the high yielding varieties of wheat and other crops would help not only in increasing the yield of these crops, but would also act as catalysts in bringing about a total transformation in the outlook and agronomic methodology of our rural community. Where sights are limited, action is equally circumscribed and cynicism is the only reaction which new ideas receive. Mahatma Gandhi referred to this situation over 30 years ago, when he addressed volunteers who were to go to villages for rural uplift work and I quote 'The fact is the villagers have lost all hope.

The suspect that every stranger's hand is at their throats and that he goes to them only to exploit them. The divorce between intellect and labour has ^aparalysed their thinking capacity. The worker should enter villages full of love and ~~has~~ hope, feeling sure that where men and women labour unintelligently and remain unemployed half the year round, he working all the year round and combining labour with intelligence cannot fail to win the confidence of the villagers'. The new varieties and the new agronomy currently available both for irrigated and barani areas, have provided extension workers with excellent opportunities for winning the confidence of the farmers quickly and for providing them with the motivation needed for change. This is in fact what has happened in several parts of our country during the last two years. What is equally significant is that the recent research findings have stimulated educated urban classes to return to the villages and take to farming. Agriculture has acquired a new status, and the sociological and psychological base necessary for building a new agriculture in our country has been truly laid.

Farmers ~~to~~ with small holdings feel that a new life of hope and happiness has become open to them.

~~Multiple cropping techniques employing a relay sequence have been developed which enable the cultivation of 4 crops in a year, like wheat, Moong, Maize and potato or Mustard and can give a net profit of over 10000/- per hectare.~~

How to increase the yield in barani or unirrigated areas

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The rapid spread of high yielding varieties in irrigated areas has widened the gap in the income potential of irrigated and unirrigated lands. Research aiming at increasing the yield and income of farmers in unirrigated and low rainfall areas has indicated that the following practices would help in improving yields and stabilising production in such areas:

- a) Deep ploughing helps to conserve moisture and enables taking two crops in a year.

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- b) Spraying with urea helps to increase yield by over 25% in wheat. The scientists of I.A.R.I. have found that over 30% concentration of urea can be safely applied to wheat by breaking down the particle size of urea in a low volume sprayer. This has rendered aerial spraying of the urea possible in moisture-deficit areas and this can be ~~done~~^{provided} as a service by the Government.
- c) Under conditions of low moisture, tillering is very much reduced in wheat and barley. Hence, the yield has to come from the main tiller. I.A.R.I. Physiologists have shown that by increasing the number of grains per ear in the main stem it is possible increase the yield of wheat in barani areas. Hence a special variety of wheat with branched ears like Jowar is under development for barani areas. Also, hybrids between rye and wheat are under development which may also prove to be a boon to farmers in dry areas.

What next in wheat improvement

With the earlier tall varieties of wheat, about 30 to 40 quintals per hectare was the upper limit of the yield that could be easily obtained in irrigated areas. With the introduction of the dwarf varieties from Mexico by the I.A.R.I. in 1963, this upper limit was raised to 70 quintals per hectare. ~~The Mexican varieties~~

~~Lerma Rojo and Sonora 64 were approved for general cultivation in 1965. During 1967, Sonalika, Saphed Lerma and Chotti Lerma, selections made at the I.A.R.I. from breeding material received from Mexico as well as Kalyan Sona, a selection made jointly at I.A.R.I., Ludhiana and Pant Nagar were released. Another variety approved for general cultivation in 1967 was Sharbati Sonora, a strain developed by treating Sonora 64 with gamma radiation. Sharbati Sonora has yielded 34 quintals per hectare at Coimbatore in Madras State in 85 days. In North India, it yields 60 to 65 quintals per hectare in 120 ~~days~~ ^{to} 130 days. In addition to giving good yields, Sharbati Sonora has the highest protein content (16.5%) among the varieties so far developed and released in India. Its protein has a high lysine (an essential amino acid) content, and in feeding trials, mice fed with Sharbati Sonora put on 19% more weight as compared to those fed with other varieties.~~

~~The variety Kalyan Sona has the highest yield potential among those so far released. Its yield can go up to 80 quintals per hectare in favourable season, under good soil and water management ~~and~~ practices. The release in quick succession of several outstanding dwarf wheats has enabled us to have varietal diversity, which is essential to avoid severe disease epidemics. For obtaining still higher yields, the following attributes must be incorporated in a ^{wheat} variety.~~

The release of such high lysine cereals offers hope for fighting protein hunger successfully the danger of intellectual dwarfism facing our country as a result of the widespread protein hunger, particularly in the school children

- a) A shorter straw, the total height not exceeding about 50 cms so that there is no lodging even when rains and thunderstorms come in March and more nutrition is fed to the plant through the soil.
- b) A long ear with 100 grains per ear and a large number of synchronously developing tillers with stiff and erect leaves capable of an efficient interception of sunlight.
- c) A high degree of built-in resistance to diseases, particularly rusts.

In addition, the variety should have an excellent grain quality both from the nutritional and chappati-making standpoints.

The new varieties now in the assembly line at I.A.R.I. belong to the following categories:

a) Triple Dwarfs: These have 3 genes for dwarfing and will not lodge even under very adverse conditions. Triple dwarfs combining high yield, excellent grain quality and a high degree of resistance to rusts are now in the final stages of assessment *and multiplication*

b) Hybrids between Rye and Wheat: These have very long ears and may yield well both in irrigated and barani areas. In addition, Rye-Wheat (scientifically known as "Triticale") has nearly 20% protein and a high lysine content.

c. Hybrid wheat: As in maize, Jowar and bajra, research aiming to exploit the phenomenon of hybrid vigour is in progress in wheat. Such research was made possible by the discovery of male sterility in some wheat strains by Japanese workers.

d) Branched wheat: A mutation for branching was induced in the variety N.P. 797 by gamma ray treatment. ~~This~~ This has made the development of branched wheat varieties possible. Such varieties will have 3 to 4 times as many grains per ear as the varieties now grown and will greatly enhance the yield of wheat both in irrigated and dry areas. Branching is not known to occur in nature in bread wheats, but occurs in one species of the wheat family identified in Egyptian mummies ^{mummies} (Triticum turgidum var. mirabile).

Thus, in the immediate future, the prospects are bright for developing wheats which can yield about 100 quintals per hectare.

New prospects for increasing the yield of durum wheat and barley

Dwarf and high yielding varieties have been developed in durum (macroni)^a wheat, which is cultivated extensively in Madhya Pradesh and Mysore. In barley, the first upsable form of dwarfing gene (similar to the 'Norin' dwarfing gene in wheat) was discovered at the I.A.R.I. in varieties treated with chemical mutagens and this has rendered the development of dwarf and non-lodging barley varieties possible.

Improvement in other Cereals and Millets

Until recently, plant breeding led to yield increases only in an arithmetic progression. An exception was hybrid maize whose cultivation in the United States revealed that when breeding interacts with agronomy, yields can increase in a geometric sequence. As a result of exploiting this concept of breeding plants which will respond to efficient soil and water management practices, we are now poised for a major yield explosion not only in wheat but also in rice, jowar, bajra and maize. Many varieties possessing the type of morphological architecture and developmental rhythm favourable for the efficient utilization of sunlight, water and fertilizer are now available in these crops. In maize and Jowar, in addition to hybrids, varieties which can give over 6 tonnes per hectare are available. With such varieties the farmers can keep their own seeds, unlike in the case of hybrids, where they have to buy the seeds each year. Since adequate quantities of seeds of high yielding varieties ^{will} ~~would~~ be available hereafter, it should be feasible ~~from the next crop year~~ to produce ^{soon} about 20 million tonnes of wheat and 50 million tonnes of rice, provided the requisite quantities of fertilizers are available. *and the interest in these crops among farmers is sustained*

Future of wheat and Rice Production

The future of wheat and rice production would however depend not merely on the availability of inputs but also on how remunerative the cultivation of these crops would be. The experience of all developed nations including the USSR indicates

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that the edifice of scientific agriculture can be built only on the foundation of remunerative pricing and efficient marketing. This is particularly true in our country since a majority of the farmers have small holdings and poor means. Trends in sugar production in recent years indicate the impact of income on the decision-making process of our farmers and consequently, on the area and attention paid to different crops. Violent fluctuations in price levels would create confusion in the farmers' minds and would cause undulations in the relative availability of different products from year to year. Now that the scientific base for a rapid advance in production has been firmly laid, urgent attention is needed to the question of stabilising the era of remunerative cultivation of food crops which has just begun. This has to be done both through scientific and extension work aiming to increase the efficiency of farming and through administrative action in the field of marketing. I feel that the time is ripe for the formation of a Rice Board and a Wheat Board which are charged with the responsibility of drawing up indicative plans for the production of these crops year to year, so as to ensure to the farmers the price levels regarded as desirable by the Government and the Prices Commission. Such Boards could get their plans for procurement and marketing implemented through the Food

Corporation of India. The Wheat Board of Canada took many years to evolve to its present state of utility and hence the constitution of the Indian Wheat and Rice Boards need not in any way be regarded as being meant for the immediate marketing, particularly export, of these grains. These Boards should only be conceived as instruments of achieving stability in production and income through helping to regulate production to local needs and possible export. Since exports can be more readily accomplished only by paying attention to quality, the Boards can study the quality requirements of grains in the importing countries. In the case of rice, India is in a unique position as regards export possibilities since being a centre of origin of rice we can grow both some of the finest varieties of rice in the world and at the same time japonica varieties having ^{the} sticky grains preferred in the countries like ~~in~~ Japan. The development of a dwarf Basmati strain of rice at the IARI has opened up great possibilities in increasing the production of Basmati rice.

~~In the case of wheat, the formation~~ ^{The formation} of a Wheat Board ^{could also} ~~would~~ help in introducing greater sophistication in matching varieties to purpose. We have varieties which are specifically suited for biscuit making, bread making, chapati preparation and the manufacture of macroni and allied products. For example, the variety Lerma Rojo gives better biscuits than any other wheat variety, while Sharbati Sonora ~~is~~ is excellent both for bread and chapati making. ~~At present no attention is being paid to selecting the variety most suited~~ ^{Since so far we have been} ^{for our wheat needs, the awareness of the importance of} ^{is being paid to} selecting the variety most suited

depending on imports a specific variety for a specific end-use has ~~not~~ naturally not developed.

Need for a strong research and training base

Another One of our most urgent needs is the availability of an efficient information transfer system. The number of scientists and extension workers with knowledge worthy of being extended is only a few; in contrast, the number of farmers to whom the knowledge has to be communicated is huge. Today, even progressive farmers do not realise that the efficiency of their farming is low, because of the high prices they get for seeds and grains. It is obvious that in the long run farmers should derive a good income by maximizing the return from their investment on inputs and not through prices which cripple the consumer. In dwarf wheat, for example, the timing of the first irrigation can make as much as 8 quintals per hectare difference in yield, given the same number of total irrigations and fertilizer dose (Table 1). The depth of transplanting and water management make a similar difference in rice. Hence, the sooner the qualitative aspects of input use are widely understood, the better it will be both for increasing production with existing input resources as well as for lowering the prices of grains. ~~Increasing the efficiency of farming should be one of our principal efforts in the coming years.~~

We are now at the beginning of an era of what I have termed "Exploitive Agriculture", shifting from a state of "natural agriculture" where the cultivated plants largely depend for their survival and productivity upon natural factors supported by minimal assistance from man. My reason for coining this term is to stress the fact that land is a capital resource which we have to exploit in such a manner that there is not only no depreciation but a continuous appreciation in its production potential. "Commercial farming", the term commonly used to indicate ^{profitable} efficient farming does not stress the ^{vital} aspect of land use. Exploitive agriculture offers great possibilities if carried out in a scientific way but poses great dangers, if carried out only with an immediate profit or production motive. Intensive cultivation of land without conservation of soil fertility and soil structure would lead ultimately to the springing up of deserts. Irrigation without arrangements for drainage would result in soils getting alkaline or saline, as has already happened in large areas in the Punjab, Haryana, western Uttar Pradesh and Andhra Pradesh. Indiscriminate use of pesticides, fungicides and herbicides could cause adverse changes in biological balance as well as lead to an increased ~~xxx~~ incidence of cancer. Unscientific tapping of underground water could lead to the rapid exhaustion of this wonderful capital resource left to us

through ages of natural farming. The cultivation of one or two high yielding strains in large contiguous areas could lead to the incidence of severe disease epidemics similar to those *which caused* ~~responsible for~~ the Irish potato famine of 1845 and the Bengal rice famine of 1942. The adoption of exploitive agriculture on a large scale without coincidentally building up a proper scientific and training base to sustain it, may only give rise to unfulfilled expectations. *It is these*

The relative importance of diseases and pests will also change, as is happening already in wheat where for the first time insect pests are assuming menacing proportions

Every one knows that a scientific innovation alone is not enough to change agriculture.

To have an impact on production, the first requisite is appropriate and adequate administrative action to render the widespread adoption of ^{scientific} the innovations possible. India is sometimes cited abroad as one where research and ^{development} extension function without proper co-ordination and interaction. While there is basis for this comment, very few are aware that India today holds the world record for the speed with which a significant research finding has been applied in the field. During ^{with the kind help of the Rockefeller Foundation} rabi 1963-64, ^{this} IARI ^{the} Institute introduced wheat varieties containing the

Finally, on behalf of ~~the~~ I should express the deep gratitude of agricultural scientists to our political and administrative leaders who have taken

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[Handwritten signature]

'Norin' dwarfing genes from Mexico on the basis of my theoretical analysis that dwarf varieties are essential for ~~destroying~~ ^{the destruction of} the barriers to high yields in this crop. These were thoroughly tested all over the country during 1963-64 and 1964-65 and data adequate to taking ^{take} the decision of importing large quantities of seeds of two varieties were presented in June, 1965. 250 tonnes of seeds were imported in 1965 and 18,000 tonnes in 1966. As a result, we had nearly 400,000 hectares under dwarf wheats during the last winter season and we have nearly 200,000 hectares under them now. There is no parallel for such rapid spread of new varieties in the world and this great achievement has stimulated Turkey and Pakistan to take similar action this year.

(KTO)

If we continue with the same dynamism
~~of us~~ in the path of integrated
planning and action, ~~the~~ agriculture
will soon become our primary industry
and the source of great rural
prosperity and national happiness.

At this time of our record wheat
harvest, it is important that
we do not allow ~~our~~ the prevailing
climate of confidence to degenerate
into a climate of complacency.

~~and resurgence~~

Table 1. Effect of irrigations applied at
different stages of growth
to Sonora 64

Crown root	Stage of growth					Total No. of irrigations	Yield (Q/Ha)
	Late Tillering	Jointing	Boot	Flower ing	Dough		
1	1	0	0	1	1	4	52.3
1	1	0	1	1	1	4	44.0
0	1	0	1	1	0	4	45.2
0	1	0	1	1	0	3	42.3
0	1	0	1	1	0		

Yojana article

Legends to Figures

Fig. 1 A triple dwarf variety growing without any lodging (unlike the neighbouring variety) after the rains in the 3rd week of March

Fig. 2. A new wheat strain with a type of leaf habit which permits the maximum interception of sunlight.

Fig. 3. A crop of Sharbati Sonora ~~growing~~ grown at Coimbatore. This crop gave 3.4 tonnes per hectare in 85 days.

Fig 4. Loaf volume of breads prepared with the same quantity of flour of different wheat varieties

Fig. 5 A branched wheat under development (right) compared with the

a currently grown variety

Fig. 6 Rye-wheat, a new high
protein cereal for barane areas.