NEW CHALLENGES BEFORE THE INDIAN AGRICULTURE

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I deem it a privilege to be asked to deliver the Dr. Panse Memorial lecture this year to the Indian Society of Agricultural Statistics. I had the pleasure of knowning Dr. Panse for many decades, in fact we were at college together in Bombay, and I had conceived feelings of both affection and respect for him. He was a scientist of great integrity, utterly fearless in the pursuit of truth, and willing to stand up for his findings even if they did not fit in with official thinking. At the same time he was modest, kind to younger people and was a well-loved figure in the world of agricultural statistics. I offer his memory my humble tribute of admiration and trust that his life and work would set an example to other scientists in his field.

The advent of the new technology with its high yielding and fertiliser responsive varieties in the mid-sixties gave a new glow of optimism to the outlook for Indian agriculture and with the record yield of 95 million tons of foodgrains that the country produced in 1967-68, the Government of India actually brought out a stamp in commemoration of the successful introduction of the green revolution in India. The euphoria continued for a few years, culminating in the next record yield of 108 million tons in 1970-71, the stoppage of imports in 1971, the building up of a substantial volume of buffer stocks by indigenous procurement and whispered hopes of India soon being able to turn into an exporter of foodgrains. The next year saw a marginal decline in output ; but the year that followed, namely 1972-73, was a drought year reviving ancient memories of the fickleness of Indian agriculture, and brought the output of foodgrains down to 95 million tons or the level with which we had begun the era of the green revolution with in 1967-68. The scramble for imports began again and the emphasis turned into disillusion, if not despair, cynical remarks were made about the so-called green revolution and the nation was once again seized of what seemed to be its intractable food problem. But nature smiled again, giving the country a good agricultural year in 1973-74 and official expectations placed the output of foodgrains at 114 million tons. From later information

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available about the state of the rabi crop and the possible reduction in moisture for the summer crop, it now appears that the output for 1973-74 would be more in the region of 108 million tons or about the same level as has been reached three years earlier in 1970-71. The increase in output between the first and final years of the Fourth Five Year Plan is thus no more than about 8 to 9 million tons or an average of less than 1.8 per cent a year, while the difference in output between the second year of the Fourth Plan—a good year—and the final year of the Fourth Plan—also a good year—is practically nil ; and this is in spite of the green revolution which has continued throughout the period with its expansion of the area under H.Y.V. and increase in the volume of fertiliser input.

It is now a well-known fact that the green revolution strategy was mainly concentrated on foodgrains, resulting in what Dr. Dharm Narain has termed "this near-paralysis in this output of cash crops" in his technical address two years ago to the silver jubilee session of the very organisation I am now addressing.

The contrast between the performance of foodgrains (the subject of the green revolution) and that of cash crops (which had not been brought under the green revolution) is clearly revealed when we look at their repective total outputs during these two five year periods. Relevant figures are given below :

TABLE 1

Commodity	*Unit*	*5-years ending 1964-65*	*5-years ending 1972-73*	*%-difference of col. 4 from col. 3*
Cereals	Million tonnes	356·4	447·8	+25·6
Sugarcane	—do—	54·0	63·8	+18·1
Oilseeds	—do—	37·4	39·2	+ 4·8
Cotton	Million bales of 180 kgs each	26·3	26·0	— 1·1
Jute	—do—	28·1	24·1	—14·2

The green revolution, however, was not directed at commercial crops but on foodgrains ; and its success must be judged by its impact on this part of agricultural output. We may therefore compare the output for the five years of the green revolution (1968-69 to 1972-73) with that of the five years preceding the green revolution (1960-61 to 1964-65) to assess the effect of the new technology on the performance

of the cereals to which it has been applied. Relevant figures are given below :

TABLE 2

(Figures in million tonnes)

Crop	*1960-61 to 1964-65*	*1968-69 to 1972-73*	*Difference between col. 2 & 3*	*% of the difference to col. 2*
Rice	179·8	199·1	+19·3	+10·8
Jowar	46·5	41·8	— 4·7	—10·1
Bajra	19·3	26·3	+ 7·0	+36·3
Maize	22·2	30·1	+ 7·9	+35·6
Wheat	56·0	114·0	+58·0	+103·6
TOTAL	323·8	411·3	+87·5	+27·1

The average annual rate of increase comes to 5·4 per cent which is substantially higher than the compound rate of growth of foodgrains as a whole during either of the two decades of the fifties or sixties or of the two decades combined. Wheat of course is the dominant partner in this achievement while maize and bajra have done reasonably well as compared to their previous performance. It is rice, the principal cereal in India, which has not shown progress, while jowar has actually recorded a decline in absolute terms. While bajra and maize have shown a high rate of growth during the five year period as a whole as compared to the earlier five year period, the fluctuations in their annual output seems to have increased during the later period.

The non-HYV foodgrains consists of ragi, barley, minar millets and pulses and accounted for about 17 per cent of the peak output in 1970-71. In their case, output during the green revolution period actually fell by 1.4 million tonnes as compared to their output in the pre-green revolution period—from 91.1 to 90.5 million tonnes—thus indicating the effect of the non-application of the new technology to these crops.

To sum up, there can be no doubt about the effectiveness of the new technology in raising the output of foodgrains, though this was confined only to the HYV cereal and among them mainly to wheat, maize and bajra, while rice output rose less than in the pre-green revolution period and jowar actually declined. While wheat had an unbroken record of a steady rise except for 1972-73, maize and bajra fluctuated substantially up and down even excluding 1972-73 when they fell along with wheat and rice. The obvious explanation for the differing behaviour of the five cereals was the effectiveness of HYV reinforced by irrigation and controlled water supply in the case of wheat, effectiveness of HYV diluted by the absence of irrigation in the case of maize and bajra, the non-effectiveness of HYV reinforced by lack of control of water supply in spite of irrigation in the case of rice,

and the ineffectiveness of HYV reinforced by absence of irrigation in the case of jowar. It must be added that as regards wheat, substantial increase in the area under cultivation was an important cause of its phenomenal growth in output during this period. In the case of the non-HYV cereals and pulses, the lack of progress in output, almost approximating to stagnation, was due both to the absence of the new technology and of irrigation in regard to these crops.

The Draft Fifth Plan envisages a target of 4·2 per cent compound growth in foodgrains. The following Table gives the relevant data on the compound growth during the second decade, the Fourth Plan targets and likely achievements and the Fifth Plan target, which will show the magnitude of the task that the Planners have set before Indian agriculture during the Fifth Plan period.

TABLE 3

Compound Growth Rate (per cent)

Crop	*1960-61—1971-72*	*IV Plan target*	*IV Plan achievement*	*V Plan target*
Rice	1·88	5·90	2·10	4·20
Jowar	—0·72	8·50	—0·60	3·00
Bajra	5·39	6·50	11·30	4·20
Maize	3·52	5·20	2·70	4·20
Wheat	8·76	5·90	10·00	4·50
Pulses	—0·48	3·70	2·00	4·00
TOTAL foodgrains*	2 64	5·60	3·10	4·20

*Likely achievement is 3·1 per cent against assumed base level of 1968-69 but is 3·9 per cent against actual level in 1968-69. This is on the assumption that output in 1973-74 would be about 114 million tonnes whereas it is more likely to be 108-110 million tonnes, which would bring down the growth rate achievement.

A relevant factor in the strategy for increasing agricultural production is the extent to which it is possible to have more than one crop on the same cultivated area. Contrary to popular impression, it is not only irrigated area that is capable of having more than one crop. India has a large area under double cropping which is not irrigated but only rain-fed, and this is, in fact, substantially larger than the irrigated area under double cropping. Thus in 1969-70, the latest year for which data is available, the total cultivated area sown more than once was 24.8 million hectares, of which rain-fed area sown more than once was as much as 17·9 million hectares or 72·3

per cent of the total double cropped area. Relevant figures are given below :

TABLE 4

Area sown more than once (in 000 hectares)

Year	*Irrigated area sown more than once*	*Rain-fed area sown more than once*	*Total cultivated area sown more than once*	*% of col. 3 to col. 4*
1950-51	1710	11437	13147	87·1
1955-56	2884	15271	18155	84·1
1960-61	3319	16254	19573	83·0
1965-66	4490	14634	19124	76·4
1967-68	5609	17715	22324	79·4
1969-70	6876	17924	24800	72·3

While the double cropped area under irrigation grew faster than that under rain-fed conditions and occupies an increasing portion of the total double cropped area, the bulk of the irrigated area still continues to be sown with only one crop. The following Table gives figures of the gross irrigated area, the net irrigated area, the irrigated area sown more than once and its proportion to the net irrigated area:

TABLE 5

Irrigated area (in 000 hectares)

Year	*Gross*	*Net*	*Sown more than once*	*Percentage of double cropped area to net irrigated area*
1950-51	22503	20853	1710	8·2
1955-56	25642	22758	2884	12·3
1960-61	27980	24661	3319	13·5
1965-66	31145	26665	4490	16·9
1967-68	33132	27523	5609	20·4
1969-70	37216	30340	6876	22·7

It is also interesting to note that there is a wide variation in the share occupied by irrigated area in the gross area sown more than once, as irrigated area is functionally more suited to multiple cropping than rain-fed areas. Relevant figures are given below :

TABLE 6

Area sown more than once (000 acres) 1967-68

State	*Area sown more than once*	*Irrigated area sown more than once*	*% of irrigated area sown more than once to total area sown more than once*
Punjab	3580	2795	78·0
Tamil Nadu	3029	2093	69·1
Andhra	3526	2182	61·8
Haryana	4043	1601	39·0
Karnataka	1063	339	31·9
Kerala	1554	373	24·0
Union territories	415	74	17·9
Jammu & Kashmir	324	57	17·6
Himachal Pradesh	870	151	17·3
Bihar	6575	1112	16·9
U.P.	12953	1717	13·3
Orissa	3600	405	11·3
Gujarat	1527	143	9·4
West Bengal	2679	52	1·9
Madhya Pradesh	4586	47	1·0
Maharashtra	2298	13	0·5
Rajasthan	3855	5	0·1
Assam	1270	nil	nil
All India	57634	13860	24·0

While irrigated area is functionally more suited to double cropping and irrigated area sown more than once is a higher

proportion of net irrigated area than that of rain-fed area sown more than once to total rain-fed area, it is surprising that it is so low and also how widely it varies between the irrigated area in the different States of the country. Relevant figures are given below ;

TABLE 7

Irrigated area sown more than once (in 000 hectares)

State	*Net irrigated area*	*Irrigated area sown more than once*	*% of irrigated area sown more than once tonet irrigated area*
Punjab	2333	1131	48·5
Tamil Nadu	2629	847	32·3
Andhra	3089	883	28·6
Haryana	1132	648	57·2
Karnataka	1082	137	12·6
Kerala	411	161	39·2
Union territories	140	30	21·4
Jammu & Kashmir	278	23	8·3
Himachal Pradesh	90	61	67·7
Bihar	2011	450	22·4
Orissa	977	164	16·8
U.P.	5657	695	12·2
Gujarat	1108	58	5·3
West Bengal	1478	21	1·4
Madhya Pradesh	1143	19	1·7
Maharashtra	1476	5	0·4
Rajasthan	1865	276	14·8
All India	27523	5609	20·4

Functional efficiency for sowing more than once on the same unit of land is determined partly by the extent to which the area sown more than once is irrigated and partly by the extent to which

the irrigated area is sown more than once. The following table presents this combination for the different states of the Union.

TABLE 8

Area sown more than once

State	*Area sown more than once (000 acres)*	*Percentage of area sown more than once to net cropped area*	*Percentage of irrigated area sown more than once to total area sown more than once*	*Percentage of irragate area sown more than once to net irrigated area*
Punjab	3580	26·6	78·0	48·5
Tamil Nadu	3029	16·8	69·1	32·3
Andhra	3526	11·2	61·8	28·6
Haryana	4043	31·8	39·0	57·2
Karnataka	1063	4·1	31·9	12·6
Kerala	1554	22·8	24·0	39·2
Union territories	415	19·4	17·9	21·4
Jammu & Kashmir	324	16·2	17·6	8·3
Himachal Pradesh	870	39·2	17·3	67·7
Bihar	6576	24·4	16·9	22·4
U.P.	12953	23·1	13·3	12·2
Orissa	3600	19·6	11·3	16·8
Gujarat	1527	5·9	9·4	5·3
West Bengal	2679	16·3	1·9	1·4
Madhya Pradesh	4586	9·4	1·0	1·7
Maharashtra	2298	4·8	0·5	0·4
Rajasthan	3855	9·4	0·1	14·8
Assam	1270	17·7	nil	nil
All India	57634	14·3	24·0	20·4

The data given in Table 8 for 1967-68 (the latest year for which this data is available) and since then there has been a big

expansion of irrigation and especially in terms of tubewells and energised minor irrigation with obvious consequences in enlarging the irrigated area under more than one crop and of irrigated area under more than one crop to the total sown area under more than one crop. With all that, Table 8 still presents a basic picture of the functional aspect of multi-cropping in Indian agriculture. While the all-India percentage of irrigated area sown more than once to the total area sown more than once is 24, only 5 States have a larger proportion of irrigated area under more than one crop, namely, Punjab, Tamil Nadu, Andhra Pradesh, Haryana and Karnataka but the total area sown more than once covered by them is only 15·2 million acres, of which irrigated area accounts for about 60 per cent. As against this, the five States of West Bengal, Madhya Pradesh, Maharashtra, Assam and Rajasthan have a negligible portion of irrigated area under the area sown more than once, even though they account for a total area sown more than once of 14·7 million acres. Taking the country as a whole, 76 percent of the area under more than one crop is without irrigation and therefore subject to climatic hazards, while the greater tragedy is that only 20·4 per cent of the irrigated area bears more than one crop, thus indicating that the vast bulk of irrigation in the country is either for the purpose of giving security to only one crop or that agronomic practices in the irrigated area have not sufficiently developed to go in for more than one crop. The truth probably consists of a mixture of both these explanations.

Since irrigation by itself does not secure the best results from the new technology unless it is accompanied by water control and scientific water management and as water control is easier with tube-wells and wells worked by energised pump-sets, it would be relevant to look at the progress of irrigation by sources. Relevant figures are given below :

TABLE 9

Net irrigated area by sources ('000 hectares)

	1950-51	*1969-70*	*Difference*
Government canals	7158	11272	+4124
Private canals	1137	984	— 153
Tanks	3613	4448	+ 853
Wells	5978	10446	+4468
Others	2967	2490	— 477
Total	20853	30340	+9487

To the extent that energised minor irrigation with its controlled water supply makes for more agricultural efficiency, it is only about one third of the irrigated area that can claim this distinction.

It is clear from what has been said above that the existing state of irrigation in the country is in drastic need of overhauling with a view to increasing the efficiency of its utilisation and giving the country not only a higher yield per acre of the irrigated crop but also of producing a much higher yield of grain output per hectare by promoting the sowing of two and more crops on the irrigated hectare. More attention also needs to be given to the problem of maximising output from the double crops sown on rainfed land, which occupies such a large proportion of the area sown more than once in the country. Apart from better maintenance which is required for both major and minor irrigation works, the major defect in some of our irrigation system is the non-availability of assured and regular water supplies to meet the changed requirements of present-day agriculture. Some of the other problems connected with improving the efficiency of our irrigation system are the construction of water courses and field channels, land levelling, land shaping and other on farm development works, construction of proper drainage systems that will prevent water logging, salinity and alkalinity drastically modifying the current practice of doing field to field agriculture and adopting the rostering system of irrigation.

Then of course there is the possibility of extending the area under irrigation. We have in fact been concentrating on this since the advent of planning and it has certainty helped in the increase which has taken place in our agricultural production. And there is still a long way to go before we fully realise the irrigation potential of the country. On present estimates, 107 million hectares of land can be ultimately irrigated both from surface and ground water sources, their contributions being 72 and 35 million hectares respectively. So far we have developed irrigation potential for 44.7 million hectares of which 28.7 million is from surface water and 16 million from ground water. The potential utilised, however, is only 42.9 million hectares. During the Fifth Plan, it is intended to add 12.2 million hectares to the irrigation potential of which 7.7 millions will be from surface water and 4.5 millions from ground water. That would still leave the country with a potential of about 50 million hectares for the sixth and subsequent plan periods. The estimated cost of exploiting this potential at Rs. 4,000 per hectare at current prices would work out at Rs. 20,000 crores; and the Irrigation Commission has concluded that it would be possible to get this done in about 30 years or before the end of this century. The question needs to be considered however whether it would not be possible to shorten this period in view of the imperative need for stepping up the rate of agricultural growth (of both foodgrains and cash crops) within a much shorter period of time than we have envisaged so far. The investment needed is well within our resources specially if we are prepared to take the necessary hard decisions and change priorities in our investment and current outlays and control our non-developmental expenditure. The question that really needs examination is from the point of view of technical feasibility, obtaining the construction material and equipment needed and the volume of energy required to lift the ground water and the skilled

man-power needed to undertake and complete the programme within a defined short period.

Yet another factor which needs mentioning before we deal with the policy measures needed to meet the challenges to our agriculture, is the one which is most occupying the public minds in India today and that is the impact of the energy crisis. The energy crisis should not be treated as having only a short period character. In the short period it means paying much higher prices for the energy components that we have to import for producing our fertiliser supplies and for operating the traction requirements of our agriculture (I am leaving out of this discussion the impact of the crisis on our non-agricultural requirements and on the creature comforts of our elitist classes). It also involves scrambling for supplies in a seller's market, where some of the buyers have not only much larger resources than we have but also are prepared to use them solely for this purpose, as it involves not only their industrial future but also protecting even their existing production and standard of living. The crisis however has a long term aspect which we should not forget. Non-reproducible energy supplies based on crude oil and gas which have a limited life mean that sooner or later we would have to face the same crisis we are facing today and that too from a more vulnerable position as by that time we would have given more hostages to fortune by increasing our dependence on this convenient but disappearing source of energy and fertiliser output. The onset of the energy crisis should certainly lead to a new look being given to our strategy for increasing our agricultural production insofar as it is based on a massive increase in fertiliser inputs and a significant increase in mechanisation in our farming operations.

We can now proceed to the principal theme of the address, namely, new challenges to Indian agriculture. Perhaps the use of the phrase 'new' is not quite appropriate. Many of the challenges faced by our agriculture are not new ; but to the extent they are old, they have acquired a new intensity because of the growth of our population, the increase in demand following our economic development however inadequate its growth rate, the revolution of rising expectations, the helpless resort we have started to make of deficit financing with its spiralling increase in money demand for goods and services and finally the new programme we have undertaken of 'garibi hatao' that has taken a firm hold on the imagination and emotional fervour of the common man in India. And then of course there is the new fact of the energy crisis in both its short period aspect of balance of payments, procurements of supplies and erosion of self-reliance and in its long term aspect of building our agricultural castles on sand and on foreign and insecure sand at that. While there can be no two opinions on the need for bringing down the rate of our population growth and planners are perhaps justified in projecting a halving of this growth rate in about two decades, this is not going to afford any immediate relief to the urgency of bringing about a substantial increase in the growth rate of agricultural production in India in the immediate present and during the short period. In fact, the more

quickly we are able to do this, the better will be our ability to bring about a reduction in the birth rate by playing upon it the historically well-proved motivation of a decent standard of living. In my view, we need a growth rate of 4 per cent in our foodgrains and of 6 per cent in our cash crops for the remaining years of this century if we are to solve the economic and political problem that has now begun to threaten our social stability and pose law and order problems such as we have not faced for many decades in our country. This is the new challenge that confronts Indian agriculture today. What can we do to meet it ?

The bald fact with which we have to start our discussion is that we have no possibility of increasing more than marginally the land resources we have for increasing agricultural production. It is true that the net sown area in India has increased from 119 million hectares in 1950-51 to 141 million hectares in 1970-71 or by about 22 million hectares in a little more than two decades. But we also know that the rate of increase in net cropped area has been falling, the compound rate of growth being 0.61 per cent during 1960-61 to 1971-72 as compared to 1.90 per cent during the earlier decade. The possibility of any further increase of significance during the seventies is remote and it is likely to be nil long before we come anywhere near the end of this century. For increasing the supply of land therefore we have to rely on an increase in the gross cropped area and not on an increase in the net cropped area. This means using irrigation and the new agricultural technology to increase the effective supply of land. The same thing can be expressed differently by saying that we have now to rely on increasing agricultural productivity, or output per hectare, by irrigation, HYV and its associated inputs and by multi-cropping ; and this has to be done quickly. That is the gist of the challenge facing Indian agriculture.

I do not propose to deal with all the possible answers that can be made in this connection nor am I competent to do so. I would therefore confine myself to dealing with two or three key factors which need to be dealt with in facing these new challenges to Indian agriculture.

There is the basic problem of irrigation. While we seem to be fairly successful in extending the area under irrigation (the pace could be a little faster), we seem to have failed hopelessly in getting the maximum benefits out of the investment we have made in irrigation. I am not referring to financial returns to Government on its investment, which of course are quite unsatisfactory but to the failure to get irrigated land to make its maximum contribution to agricultural output. Theoretically, irrigation should make it possible to go in for multiple cropping or at least two crops a year ; and yet, as pointed out earlier, of the 30·3 million hectares under irrigation in 1969-70 (the latest year for which data is available), only 6·9 million hectares are sown more than once or only 22·8 per cent. In fact, the area sown more than once, which does not have the benefit of irrigation, was more than two and a half times larger and has

been showing a fairly steady growth over the last two decades. In his address to the silver jubilee session of this Conference Dr. Dharm Narain has visualised the possibility of each irrigated acre resulting in two cropped acres and the Planning Commission in their draft Fifth Year Plan has relied on irrigation as the remedy for increasing the effective supply of land to meet the problem of non-availability of fresh land for increasing the cultivated area. If we assume that it is legitimate to consider one unit of irrigated land as having the capacity to produce two units of land on a single crop basis, it means that we have today an unutilised capacity of from 75 to 80 per cent in the use of irrigated land*, an extent of under-utilisation that far surpasses the unutilised capacity in most public sector enterprises which is so much a matter of concern to Government and the Planning Commission. Considering that nearly 80 per cent of irrigated land is under food crops, it is a matter of serious concern that there should be such a large measure of unutilised capacity in this sector. It is high time that a thorough-going technical, economic and sociological analysis is made of this phenomenon and steps taken as early as possible to increase irrigation capacity utilisation at least to 80 per cent ; if not to 100 per cent. In fact, if we are to accept the research findings of agricultural scientists, it should now be possible to grow three and even four crops on one unit of irrigated land and scientific publications give rosy details of the possibility of raising 10 to 12 tonnes of grain per hectare and have spelt out alternative rotations of crops that should be followed for this purpose. If this is correct, then the irrigation capacity should be three times the one crop production, which means that the unutilised capacity which irrigated land in India now suffers from is even more in terms of output and contribution to the social product. For obvious reasons, I am not in a position to offer a competent analysis of this phenomenon or suggest remedies nor I must confess have I seen such a competent analysis and policy formulation even in the pages of the learned report of the Irrigation Commission. Within my limited knowledge and negligible experience of the subject, I would hazard the following tantative ideas as an explanation of this phenomenon :

1. Inadequate maintenance even in the case of major and medium irrigation systems, and poor maintenance in the case of minor irrigation works, especially of tanks and open wells.

2. Absence of drainage facilities which not only leads to waste of water and tends to reduce yield, but also causes permanent damage to land productivity by inducing water logging, salinity and alkalinity.

3. Almost complete absence of the supporting facilities that are needed to make optimum use of the water supplied through irrigation such as land levelling, land shaping,

* Part of this may be due to the nature of the irrigation that may not land itself to growing of two or more crops in a year *e.g.*, tanks, wells and non-perenonial canals.

land consolidation, rostering of water supply and efficient field channels.

4. Absence of appropriate agronomic practices, including suitable varieties of short maturing crops and appropriate rotations, lack of farmer education in optimising irrigation use, and inadequate and insufficiently trained extension services.

5. Tendency to treat irrigation use as a protective rather than as a production-increasing instrument and orientation of irrigation systems either to water only one crop or as an insurance for a one crop technology largely dependant on rain.

6. Over-estimation of the command areas and failure to make water use optimal in terms of its socio-economic returns in terms of maximum output.

7. Absence or inadequate knowledge of modern methods of water-management partly at least promoted by failure to supply facilities of water control along with water supply.

For remedying the situation, I would suggest :

A. Rehabilitation, renovation and modernisation of existing irrigation systems.

B. Proper maintenance of irrigation works and especially of minor irrigation works which seem to have a high casualty rate.

C. Reinforcement of canal irrigation by well-irrigation at suitable points.

D. Better extension services, suitably linked with research organisations and agricultural scientists, and specially linked with irrigation agriculture and multi-cropping farming practices.

E. Large scale rural public works aimed at land levelling and land shaping in irrigated areas where this does not exist at present.

F. Education in water management.

G. An all-India coordinated programme practised on farmers ; fields in irrigated areas for the purpose of promoting double cropping, multi-cropping and optimal use of water.

H. Command area projects for integrated rural development such as have been included in the draft Fifth Plan.

While all this is intended for improving capacity utilisation in the existing irrigated acreage, I presume that all care will be taken in the case of new irrigation projects, even before they are commissioned and during the period when they are reaching full use of the water potential created, to see that they aim at capacity utilisation in terms of producing a second and a third cropping acre for every irrigated acre.

The second problem I would like to deal with is the one which has now received an added emphasis from the recent energy crisis, namely, the use of chemical fertilisers which is such a basic ingredient of the new agricultural technology. The basic premise I want to start from is the imperative need for minimising our dependence on imports of fertilisers or of import-based domestic fertilisers not only on account of the foreign exchange commitments involved but also in view of the larger and more long period considerations implicit in dependence on non-renewable fossil fuels from abroad for meeting our fertiliser requirements. The basic economic principle I would enunciate in this connection is that we should aim at maximising the output per unit of fertiliser than at maximising the output per hectare of limited portions of the area under cultivation. This principle would have no validity if supplies of fertilisers were unlimited in which case it would obviously be more economic to aim at maximising the output per hectare even if it meant using fertiliser inputs at diminishing levels of marginal productivity. But if we have only a limited supply of fertilisers to apply, even though we have also only a limited supply of land, it would be more economic to maximise the output per unit of fertiliser. Yield response to fertiliser input is not of a linear variety but is subject to the law of diminishing returns in terms of physical quantities. Under the circumstances, it would be more appropriate to permit a larger number of holdings to get limited supplies of fertilisers for use on their individual holdings than permit market forces to enable the larger holdings with their larger resources to go in for larger inputs of fertilisers that would maximise their individual monetary returns but not add to the national output to the extent that smaller doses for more of the small holdings would result in. My view on this matter is strengthened by the finding contained in the first report of the newly created Department of Agricultural Research and Education (appropriately abbreviate as "DARE") that the adoption of the "Management Mini-kit Programme" adopted in 1973 under the All-India Coordinated Rice Improvement Project resulted in a return of 50 kg. grain for each kg. nitrogen applied at moderate level and with good management of non-cash inputs. The report adds, and I quote, "Good management of both cash and non-cash inputs resulted in a yield of 5,200 kg/ha which was 76 per cent of the yield obtained with *four times more* (italics mine) nitrogen applied and the same non-cash inputs." It also follows that better management is more likely with limited inputs of fertilisers than with the ability to get unlimited supplies and this would, in turn, lead to a larger return per unit of fertiliser used.

Moreover, it is not quite correct to proceed on the assumption that, without fertiliser, HYV will not yield any additional output as compared to the traditional variety. I had gathered from knowledgeable persons that while HYV seeds are of course mainly distinguished from traditional varieties by their much higher response to fertilisers, they also had an inherent genetic capacity for giving higher yields than traditional varieties. I now find confirmation of this thesis in the report of DARE which, basing itself on a large number of experiments taken from the scheme on "Simple Fertilizer Trials on Cultivators' Fields" and pooled over the four years 1967-68 to 1970-71 came to the conclusion that average yields per hectare for HYV wheat and rice without fertilizer were higher than those of the traditional or tall varieties without fertilizer, the result of the trials over all regions showing a difference of 3·4 kg/ha in favour of HYV for wheat and of 4·2 in the case of kharif-irrigated rice. Details are given in the two Tables given below which are taken from the Report :

TABLE 10

Average Response (Kg/ha) for Wheat (1967-71)

Region/State	*Variety*	*No. of trials*	*Av. yield without fertilizer*	*Response to*	
				N 60	*N60 P30*
Northen (Delhi, Haryana, Punjab)	HYV	552	2454	769	1275
	TV	116	2054	572	878
Indo-Gangetic (Bihar, U.P., W. Bengal)	HYV	976	1809	810	1060
	TV	654	1574	540	743
Western (Gujarat, Maharashtra, Rajasthan)	HYV	458	1837	362	755
	TV	539	1647	334	581
Central (M.P.)	HYV	249	1514	857	1417
	TV	124	1312	734	1273
Over all the regions	HYV	2235	1988	695	1072
	TV	1433	1650	496	755

As a large area both under wheat and rice are still under traditional local varieties, a change over to HYV, even without using fertiliser, should yield a substantial addition to the national output of these grains. It would also be easier for the farmer with limited resources to adopt them, as he does not have to go in for the costly cash input that is involved in the use of chemical fertilisers. What is suggested is of course meant for the transitional period when fertiliser is in such short supply and also uncertain in the extent of procurement. When the fertiliser situation shows a significant improvement

TABLE 11

Average Response (Kg/ha) for Rice (1967-71)

Region/State	*Variety*	*No. of trials*	*Av. yield without fertiliser*	*Response to*	
				N 60	*N 60 P 30*
Southern (A. P., Mysore, Tamil Nadu)	HYV	502	3704	688	1277
	TV	459	3018	580	1066
North Eastern (Bihar, W. Bengal)	HYV	180	2646	856	1158
	TV	143	1795	768	1047
Central (M. P.)	HYV	119	2882	671	1227
	TV	168	2966	749	1327
Northern (Haryana, U. P.)	HYV	146	2419	775	957
	TV	91	2193	1005	1189
Over all the regions	HYV	947	2913	748	1155
	TV	861	2493	775	1157
Rabi Irrigated					
Southern (A. P., Mysore, T.N.)	HYV	416	3108	729	1249
	TV	281	2319	548	922
Eastern (Orissa)	HYV	210	3094	593	1282
	TV	—	—	—	—
Over all the regions	HYV	626	3101	661	1265
	TV	281	2319	548	922
Rabi Unirrigated					
Southern	HYV	308	3090	458	796
Kerala	TV	215	3375	297	738

Source : Simple Fertilizer Trials on Cultivators' Fields 1967-68 to 1970-71.
HYV=High-Yielding Varieties.
TV=Tall Varieties.

not only in terms of procurable supply but also in terms of national self-sufficiency on the basis of domestically available feedstock—as will be the case when the country goes in successfully for coal based fertiliser technology on a large scale—then it should be possible to make chemical fertilisers available to the entire area grown under HYV on the scale needed for increasing the output to the desired levels.

A third aspect of the new fertiliser strategy that could be adopted in the light of the energy crisis is to use organic manure, both farmyard manure and urban and rural compost. It is estimated that vast quantities of farm yard manure are available which could give an additional nutrient supply of 1·07, 0·5 and 0·8 million tonnes of N_1, P_2O_5 and K_2O per year. Another estimate places the results at almost double these figures. All this, of course, will mean a good deal of effort and organisation and will also have to be accompanied by providing rural areas with an alternative source of fuel. It will also take some time before sizeable quantities become available. Gobar gas plants, which are now coming into fashion once again because of the energy crisis, can also be a good instrument for making organic manures available to the cultivator. Compost from urban waste is also a useful source for supply of nutrients and even today about 4·5 million tonnes of urban compost containing 1·5 per cent N_1, 1 per cent P_2 O_5 and 1 per cent K_2O are being produced. It is possible to treble this quantity. It is also possible to obtain sizeable quantities of compost from forest litter and other waste material. What is needed is a country-wide and organised campaign for the use of farmyard manure, gobar gas manure, urban and rural compost and green manure. While all this will not result in any major reduction in the need for chemical fertilisers, it can make some difference, added to which is the additional quality it has of increasing the efficiency of the soil in absorbing chemical fertilisers and incidentally launching a mass participation movement for the improvement of agriculture. It is also possible to improve the fertiliser availability in the soil by suitable rotation and by the planting of leguminous crops and thus reduce the quantum of chemical fertilisers needed for plant growth. It is good that the Ministry has set up a programme for the development of organic manure during the Fifth Plan. It is necessary to see, however, that the programme is implemented and not dropped or diluted because it means a large effort for a comparatively small return and it is easier and less taxing on one's resources to take the line of least resistance and ask for more of chemical manure either by import or by domestic manufacture.

One final point I would like to add about the fertiliser strategy needed to answer the energy crisis is to go in a big way for the setting up of coal based fertiliser plants. Coal is the one fossil fuel we have in abundance and though its technology is still to be perfected and measures devised to bring down its cost, it is the only safe way in which the country can assure itself of stable and sufficient supplies of fertilisers over the long period. Fuel oil of course is an alternative to naptha and it is not only cheaper but also can be more easily diverted from its current alternative uses than perhaps naptha. But fuel oil is a petroleum product and depends upon the supply of crude which we do not produce in sufficient volume. It would be wiser therefore to go all out for the coal-based technology, as soon as our coal-based fertilizer factory at Talchar comes into commission and proves its effectiveness in using this feedstock for the production of fertilizer and we become familiar in actual fact with the problems involved in coal-based production of fertilizers. Meanwhile all the preliminary

work should be undertaken for a comprehensive programme of coal-based fertilizer factories including locational, transport, supply and other economic and technical aspects of such an extensive programme. And we should not be too much in a hurry to put many new projects on the basis of feedstock derived from the processing of crude oil.

The third factor I would like to mention in dealing with the new challenge to our agriculture is in respect of high yielding varieties with particular reference to commercial crops like fibres and oilseeds and food crops like rice, millets and pulses. We cannot hope to realise our targets of 4 per cent growth rate in foodgrains and 6 per cent growth rate in commercial crops unless we find answers to the problems that have been confronting our HYV programmes in respect of rice and the other cereals like maize, jowar and bajra and make a determined attempt to achieve a break-through in respect of finding appropriate HYV for our fibres and oilseeds. As it is not possible to devote any additional acreage of irrigated area exclusively to the eash crops and as our millets will still continue to be largely based on the dry areas, research work needs to be streamlined and intensified into dry farming technology and steps taken to convert the results into action programmes in the field. Dry farming technology does not yield either quick or spectacular dividends like modern but irrigation-based agricultural technology. We have to go in for modern technology also in respect of the commercial crops and of millets and pulses ; but this has largely to be based on dry farming areas and that is much more difficult than for example the way in which we achieved spectacular success in the case of irrigated wheat and will no doubt soon do so in the case of irrigated rice. At the same time a significant portion of the additions that will be made to our irrigated area will have to be set apart for the commercial crops. Irrigation and HYV technology is comparatively new for our commercial crops with the exception of cotton and it will need very competent and specially trained extension services to tackle it successfully, apart of course, from finding the necessary inputs for its operation. Pulses and oilseeds pose the real challenge for our agriculture and both science and administration have to make special efforts to meet this challenge.

Yet another challenge I would like to mention is in respect of the fluctuating character of India's agricultural income. While no crop can hope to escape from this handicap even if it is irrigated and based on genetic stability in yield, it is particularly significant in respect of maize, jowar, bajra, pulses, fibres and oilseeds. And the introduction of HYV, large cash inputs, and producing for the market all add to the risk element and make for larger amplitudes when the fluctuations make their inevitable appearance. And yet some countries with their Commodity Boards have been able to solve this problem by a centralised system of purchases, buffer stocks and stabilisation of incomes rather than just prices. In our country, coffee offers a standing example of the way in which the whole fortunes of an agricultural industry have been changed for the better by

an organised marketing arrangement. It is time that we gave thought to what we can do to bring a measure of stability and continuity in the incomes of our farming population. So far, the emphasis has all been on price support ; but this does not prevent fluctuation in agricultural incomes nor is it likely for political reasons to ensure, for the consumer and especially the poor consumer in both urban and rural areas, a share, in the gains from the new technology. While the consumer needs stability in the prices he pays for his basic consumption goods, especially foodgrain, what the farmer needs is stability in his income with a rising secular trend in line with the national growth in per capita income and after ensuring enough motivation for him to go on increasing his agricultural output and saving and investing to do so. I doubt very much whether this can be achieved by either the market mechanism of prices or a State-controlled system of purchase and selling prices based on changes in outputs, costs and pressures. What we need is an income policy for the producer and a price policy for the consumer. The incomes policy must allow for a steady secular increase, while the price policy must be directed towards a maximum possible stability in the prices of mass consumption goods, especially foodgrains. It is not easy to work an incomes policy even in a developed and on the whole a disciplined and discriminating country like the United Kingdom ; and it will be much more difficult to do so for a country like India with its many millions of producers and a weak administrative machinery for dealing with problems other than law and order. And yet there is no escaping the need for an incomes policy in India if we want social stability and a steady rise in production, savings and investment. In my view it is through an appropriate incomes policy that we can hope to reach a reasonable measure of price stability for the consumer and not the other way about. And for a country like India with the important place that foodgrains and food occupy in the people's budget and the vast number of persons whose income is derived solely by its sale and of other crops, it is essential that we should have an incomes policy for our farming population. What this policy should be and what would be its impact on price policy and how the two can be adjusted to each other in such a manner as to ensure a rising level of income for the farmer and stable prices of essential consumer goods for the consumer, especially the poorer consumer in both the urban and the rural areas, is a problem that can well command the attention of research workers in the social sciences More effectively, it can be an appropriate subject for enquiry and analysis by a high powered commission that only the Government can constitute. Whatever may happen to this suggestion, I have no doubt that a challenge that faces Indian agriculture, especially if it is to develop and grow, and we all continue to function in a democratic society, is the problem of fluctuating and uncertain incomes for the farmer and what to do about it. My strong feelings on this subject can be easily understood when you look at the table I compiled of the variations each year over the previous year in the output of the various foodgrain crops during the last 23 years (included as the only appendix to this paper) and got shocked by its implications on the year-to-year changes in agricultural income; especially of the small and medium farmers who

have no reserves and can build none either and the impact it must be having on their standard of living, their attitude to risk, their self-confidence, their desire to save and willingness to invest and altogether their entire social and cultural psychology.

I cannot leave this subject without referring to the most important challenge that faces Indian agriculture today; and that is the role of small and marginal farmer in its development and the share that he will get of the gains from such development. It is now well-known that the so-called green revolution which helped the country to raise its output of foodgrains has also been accompanied by a widening of the range of inequality in rural incomes, the loss of their status as tenants by a number of small cultivators, the marginalisation of small farmers and the emergence of social and economic tensions in the country-side. This whole subject with reference not only to India but to the whole of the developing world has recently been the subject of a global research study by the United Nations Research Institute for Social Development; and I have contributed a paper on 'Growth with Social Justice in Asian Agriculture' which will shortly be published by the Institute as one of their research monographs. It is a whole subject by itself and cannot be dealt with in a satisfactory manner as a part of this lecture. All that I can say is that the challenge which Indian agriculture faces is not only of production but also that of distribution; and in our anxiety to concentrate on production problems, we should not forget the human and social implications of agricultural development. Increase in inequalities within classes and between regions is no longer a matter for academic research. It has grave political and social consequences and may well come in the way, of the movement for increasing production if we do not take steps in time and bring about social justice alongside agricultural growth in the rural areas. The small and marginal farmers may not account for the bulk of agricultural production; but they do account for the bulk of the agricultural population. Our efforts at increasing agricultural output have to be accompanied by even stronger efforts to involve the participation of the small man in Indian agriculture and secure for him a significant improvement in his standard of living and a larger share in the gains from the new agricultural technology and the vast investments that Government is making for the improvement of Indian agriculture.

I must now conclude. Indian agriculture is facing new challenges today. They are new to some extent but largely they are old challenges made more challenging because of the intensity of the reaction they are now evoking and the threat they pose to the political and social stability of this country. Production must increase and that too at a much faster rate than that witnessed so far in Indian agricultural history; and this must include not only food crops but also the commercial crops. At the same time inequalities must diminish, the

small man must get larger and increasing opportunities for participating in and gaining from the development process, and social justice must concretely and visibly dominate the economic scene. What we need is a policy and programme for agricultural development that will have in-built into its growth with stability and social justice. This is the new challenge that faces Indian agriculture today; and on the success with which we meet it will depend the entire future of our country.

Fluctuation in Agricultural Output: Percentage Changes over the Previous Year

Year	*Rice*	*Jowar*	*Bajra*	*Maize*	*Ragi*	*Barley*	*Small millets*	*Wheat*	*Gram*	*Tur*	*Other pulses*	*Total foodgrains*
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
1950-51	—12·6	— 6·4	— 8·5	—15·5	— 7·5	+ 5·6	—23·2	+ 1·1	— 1·7	+69·2	—10·8	— 7·5
1951-52	+ 3·5	+10·6	— 9·6	+20·1	— 8·2	— 0·5	+ 9·4	— 4·3	— 7·2	+ 6·5	+ 5·3	+ 2·3
1952-53	+ 7·5	+21·1	+36·1	+38·2	+ 1·9	+23·7	+ 0·6	+21·3	+24·2	— 7·0	+ 2·4	+13·9
1953-54	+23·2	+ 9·8	+42·5	+ 5·9	+28·7	+ 0·8	+28·6	+ 6·9	+14·8	+ 9·5	+19·6	+17·9
1954-55	—10·6	+13·8	—22·6	— 2·1	—11·9	+ 1·0	+ 0 7	+12·8	+16·3	— 7 8	— 8·0	— 1·1
1955-56	+ 9·3	—26 9	— 2·6	—12·5	+11·7	— 5·5	—17·0	— 3·1	— 3·6	+ 8·3	+ 4 3	— 1·7
1956-57	+ 5·4	+ 9·1	—16·2	+18·3	— 2·9	+ 1·7	— 6·8	+ 7·3	+15·0	+ 6·9	—11·6	+ 4·6
1957-58	—12·1	+17·9	+20·6	+ 2·3	+ 0·2	—19·9	—10·2	—14·9	—21·5	—25·8	— 4·0	— 8.0
1958-59	+20·9	+ 4·6	+ 6·9	+ 9·9	+ 8·6	+17·5	+25·7	+24·5	+43·6	+18·8	+38·4	+19·9
1959-60	+ 2·7	— 5·0	— 9·7	+17·6	+ 1·8	+ 0·9	— 7·1	+ 3·7	—20·0	— 0·1	+ 1·3	— 0·6

1	2	3	4	5	6	7	8	9	10	11	12	13
1960-61	+ 9·2	+14·4	− 6·0	+ 0·2	− 7 5	+ 3·8	− 5·7	+ 6·5	+11·2	+21·5	− 2·1	+ 7·0
1961-62	+ 3·2	−18·2	+11·0	+ 5·7	+10·4	+11·7	+ 7·4	+ 9·8	− 7·4	−33·8	+ 4·9	+ 0·8
1962-63	− 6·9	+21·4	+ 8·6	+ 6·8	+ 0·5	−23·2	− 9·5	−10·7	− 7·3	+15·7	− 0·4	− 3·1
1963-64	+11·4	− 5·6	− 2·0	− 1·0	+ 1·0	−15·8	+ 9·0	− 8·6	−16·0	−12·8	− 8·6	+ 0·6
1964-65	+ 6·2	+ 5·3	+16·5	+ 2·3	−34·4	+23·7	− 2·9	+24·4	+28·3	+37·0	+13·3	+10·8
1965-66	−22·2	−21 7	−17·0	+ 3·4	+22·9	− 5·5	−20·8	−15·2	−26·9	− 8·3	−16 1	−19·0
1966-67	− 0·5	+21·7	+19·1	+ 1·5	+15·5	− 1·4	− 4·3	+ 9·6	−14·3	−34·8	− 9·8	+ 2·6
1967-68	+23·6	+ 8·9	+16·0	+28·1	−12·5	+49·2	+28·2	+45·2	+64·9	+54·1	+22·1	+28·0
1968-69	+ 5·7	− 2·4	−26·7	− 9·1	−28·5	−30·8	− 5·4	+12·8	−27·8	+ 4·3	− 2·2	− 1·1
1969-70	+ 1·7	− 0·8	+40·1	− 0·5	− 0·9	+11·6	− 4·0	+ 7·7	+28·7	+ 1·4	+ 0·2	+ 5·8
1970-71	+ 4·4	−16·6	+50·7	+31·9	nil	+ 2·5	+14·8	+18·6	− 6·3	+ 2·2	+10·1	+ 9·0
1971-72	+ 2·1	− 4·9	−37·4	−32·1	NA	− 7·2	−20·4	+10·9	− 1·8	−16·4	− 7·2	− 2·9
1972-73	−10·4	−16·9	−28·3	+21·6	−13·6	−11·5	NA	− 5·7	NA	NA	NA	− 9·5