CAN WE FACE A WIDESPREAD DROUGHT AGAIN WITHOUT FOOD IMPORTS ?*

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I recall hearing Dr. Rajendra Prasad for the first time in 1935 when as a school boy I attended a public meeting addressed by him during his tour to raise funds for helping the unfortunate victims of the Bihar earthquake of 1934. His name has since then been associated in my mind with the cause of fighting famine and distress arising from natural calamities. Bihar was one of the worst affected States during the widespread drought of 1965-66. This is why when I received the kind invitation of the Indian Society of Agricultural Statistics to deliver a lecture instituted in the memory of Dr. Rajendra Prasad, I chose the theme "Can we face a widespread drought again without food imports ?" Even at the outset, I must emphasise that my purpose in dealing with this topic is more in order to stimulate thought, research and appropriate action, rather than to offer any definite or simple solution to this vital question. I must also emphasise that the views I express are in the capacity of an agricultural scientist and are not made on behalf of any organisation.

Effect of the 1965-66 drought on food production

Addressing the Indian Society of Agricultural Statistics in 1967, Dr. S.R. Sen pointed out that during the first three Plan periods (1951-1966), there was a tendency for food production to show greater instability associated with an increase in the rate of its growth. Since this tendency is just the opposite of that witnessed in many of the developed nations, the reason obviously lies in the qualitative aspects of growth, namely, increased production arising from an extension in area rather than from an enhanced productivity per unit area. During the drought years of 1965-66, there was a 19 per cent

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drop in total food production, amounting to 17 million tonnes in quantitative terms. In spite of such a big drop, widespread famine was averted through a vigorous drive to mobilise food aid from many nations and more particularly through PL-480 food imports from the United States. During these two years the deficit from normal rainfall exceeded 50 per cent in many States. It has been postulated that a drought of this intensity and magnitude may occur only once in about 40 years. However, in relation to weather, statistics can only help to indicate trends from events which have already taken place and cannot help to foretell definitely what will happen.

Our food needs and global trends in agricultural production

In the 25th year after we became independent, we were justifiably happy that we need not beg other countries for our daily bread. Supposing a drought of the type of 1965-66 recurs in 1973-74, how shall we face it ? Will there be a drop again in food production of the order of 19 per cent and if so, what would be its impact in relation to the projected population size of 596 million and food needs of 129 million tonnes (Table 1 and 2) ? After taking into account the Government's buffer stock operations, we would still need from other countries about 15 million tonnes of food grains in case widespread drought again does the same damage to crop production as it did during 1965-66. Who will supply this 15 million tonnes ?

TABLE 1

Projection of population (million) and net domestic products (crores of rupees) [1967-68 prices=100]

	1967-68	*1973-74*
Net Domestic product at factor cost	282 0	384·7
Agricultural & allied services	149·7	190·0
Others	132·3	194·7
Net Domestic expenditure	314·5	425·4
Net domestic product at market prices	306·7	422·4
Net imports of goods and services	7·8	3·0
Population	514	596

Source : Fourth Five Year Plan 1969-74.

TABLE 2

Required production of selected important items and projected imports and exports

Item		*Unit*	*(Actual)* *1967-68*	*(Projected)* *1973-74*
Food grains		million tonnes	95·6	129·0
Cotton		million bales	6	8
Oilseeds		million tonnes	8·2	10·5
Sugar		thousand tonnes	2248	4700
HYV area covered		million hectares	8·5	24·5
Consumption fertilizers	N	thousand tonnes	1400	3700
	P	,, ,,	400	1800
	K	,, ,,	180	1100
Plant Protection (area covered)		million hectares	54	80
Imports				
Fertilizers and their raw material		crores of rupees	212	360
Food grains		,, ,, ,,	518	nil
Total Imports		,, ,, ,,	2059	2030
Exports				
Agricultural and allied products		,, ,, ,,	445	667
Cotton Textiles and jute manufactures		,, ,, ,,	294	336
Total Exports		,, ,, ,,	1199	1340

Sources : Fourth Five Year Plan 1969-74.
Actual Data for 1968-69.

The production trends in traditionally food surplus countries must be understood in relation to the fact that every nation tries to adjust its production policies in such a way that the output matches the needs of (*a*) the domestic market, (*b*) export possibilities and (*c*) aid commitments. The trend to strictly limit production to immediate needs will grow rapidly in the developed nations from this year, since the forthcoming U.N. Conference on Environment is bound to underline the points made in recent publications such as that of the Massachusetts Institute of Technology Team on the limits to growth. Using the System Dynamics approach*, the authors of this book have pointed out that each doubling of yield from the land will be more expensive than the last one, a phenomenon referred to by them as the law of increasing costs. For example, assessing the cost of past agricultural gains, they point out that to achieve a 34 per cent increase in world food production from 1951 to 1966, agriculturists increased yearly expenditures on tractors by 63 per cent, annual investment in nitrate fertilizers by 146 per cent and annual use of pesticides by 300 per cent. The next 34 per cent increase will obviously require even greater inputs of capital and resources, if the same pathway of advance is followed. Based on a global computer model involving the five basic factors which determine growth, namely, population increase, agricultural production, non-renewable resource depletion, industrial output and pollution generation, the MIT team concludes that the earth's interlocking resources probably cannot support present rates of economic and population growth much beyond the year 2100, if that long, even with advanced technology. I am emphasising this point only to stress that the demand for "zero growth rates" will grow in the highly developed nations as a counter to the complex problems of degradation of the environment, loss of faith in institutions, uncontrolled urban spread, insecurity of employment, alienation of youth, rejection of traditional values and inflation and other monetary and economic disruptions. We may have to therefore largely depend on our own food production capacity if the 1965-66 weather descends on us again. How shall we feed one-fifth of humanity in a year of widespread drought? In order to deal with this question, I would like to start with Dr. S.R. Sen's analysis of the extent of instability in our production.

Instability in food output

The periodicity of droughts in our country during this century has varied from region to region, the worst affected areas being Rajasthan, Gujarat, Uttar Pradesh and parts of the Deccan. Dr. S.R. Sen visualised that drought in high production areas like Bihar, Orissa, Madhya Pradesh, Western Uttar Pradesh, Coastal Andhra Pradesh or Tamil Nadu would have a much greater effect on total

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**The Limits To Growth*, Potomac Associates, Universe Books, New York, 1972.

TABLE 3

Distribution of cropped area and food production over regions of instability

Category	*Per cent contribution to cropped area*	*Per cent contribution to food production (1961-64)*	*Average yield (kg/ha)*	*Recommended measures*
A Stable and High yield	31	37	810	Maximise yield per unit area with intensive water use and management as in IADP and HYVP.
B_1 Less stable and Medium yield	27	28	700	Protective irrigation.
B_2 Unstable and Medium yield	15	14	630	Safe fertiliser dose and economic water use. Drought resistant and stable-yielding varieties.
C Unstable and Low yield	27	21	545	(a) Dry farming practices as moisture and soil conservation. (b) Optimum and stable economic returns per unit of water. (c) Change in cropping other than varietal pattern.

Source : S.R. Sen (1967). Growth and Instability in Indian Agriculture. Technical Address at the 20th Annual Meeting of Indian Soc. Agril. Statistics, Waltair. *Ind. J. Agri. Stat.*, *19* : 1-30.

TABLE 4

Regions of instability and predominant soil types for some principal crops of India

Rice		*Wheat*		*Sorghum*		*Bajra*	
A	*B*	*A*	*B*	*A*	*B*	*A*	*B*
Bihar and adjacent Bengal	Alluvial, Red and Yellow	Bihar	Alluvial	Mysore	Light red, Black	—	—
M.P.	Red & Yellow Partly Red & Black	M.P.	Medium to Deep Black	M.P.	Light red (K) Black (R)	Tamil Nadu	Light (K) Heavy (R)
Maharashtra	Medium black	Maharashtra	Medium Black	Maharashtra	Black	Maharashtra	Shallow Black and Brown
A.P.	Alluvial, Light Red	—	—	A.P.	Light red Heavy Black	A.P.	Red and Light
U.P.	Terai, Alluvial	U.P.	Alluvial	—	—	U.P.	Alluvial
		Rajasthan	Red & Yellow	Rajasthan	Red, Sandy	Rajasthan	Red & Yellow
		Punjab & Haryana	Alluvial	Gujarat	Black	Punjab & Haryana	Light, Alluvial

K=Kharif R=Rabi

A=Region of Instability B=Predominant Soil Type

Source : Annual Progress Reports of All India Coordinated Project on Agronomic Experiments and Simple Fertiliser Trials for 1969-71, and Annual Progress Reports of Coordinated Scheme for Investigations on Correlation of soil tests with crop responses for 1969-71.

production than a similar drought in Rajasthan, Gujarat or the Rayalaseema areas of Andhra Pradesh. A detailed analysis of the production data during the period 1965-67 confirms Dr. Sen's conjecture. Classifying the country into four major categories with reference to instability in production, Dr. Sen suggested specific steps to reduce the instability in each category (Table 3). He urged greater attention to the category "B" area where instability and production are both high. A major component of the fall in food production during 1965-66 and 1966-67 was the drop in rice output by 5·3 and 6·8 million tonnes respectively. The drop occurred during both the *kharif* and *rabi* seasons. The soil types of the areas of instability were terai, laterite, red and medium black soils in the case of rice and light and alluvial soils in the case of other crops during the *kharif* season. The instability occurred in all soil types during the *rabi* season (Table 4). The areas where the maximum reduction in food production took place are Bihar (67%), Madhya Pradesh (50%), Uttar Pradesh (40%), Maharashtra (39%), Orissa (27%) and Andhra Pradesh (25%). The States in which the reduction in yield per hectare was great were Gujarat, Madhya Pradesh, Maharashtra, Uttar Pradesh, Mysore and Orissa in 1956-66 and West Bengal and Uttar Pradesh in 1966-67. Both the autumn and winter crops suffered in Andhra Pradesh, a major rice producing area.

A close examination of the regions and soil types given in Table 4 reveals that instability in production occurred in the alluvial and red soils of Bihar, Madhya Pradesh and Andhra Pradesh in the case of rice, alluvial, black and red soils of Bihar, Madhya Pradesh, Punjab and Maharashtra in wheat, black and red soils of Madhya Pradesh, Maharashtra and Andhra Pradesh in *jowar*, and black, red and alluvial soils of Andhra Pradesh, Uttar Pradesh, Punjab and Maharashtra in *bajra*. The reduction observed during different seasons is indicated in Table 5. While rice production was affected in many States, little or no reduction occurred in the production of millets and pulses.

The relationship between the deviation in rainfall and the fall in output of rice is indicated in Table 6. In Andhra Pradesh the reduction in production during 1965-66 was greater than what would be expected on the basis of the rainfall received. Other factors like pests and diseases may be involved. In general in this State the spread of high yielding varieties of rice has been rather slow until recently (Table 6).

TABLE 5

Percentage reduction in yield per hectare as compared to 1961-62 and the crop seasons where it occurs for some important crops

State	Year	For some important crops									
		Rice				*Bajra*	*Jowar*			*Wheat*	*Pulses*
		Reduction %	*Kharif*	*Rabi*	*Summer*	*Reduction per cent (kharif)*	*Reduction percent*	*Kharif*	*Rabi*	*Reduction per cent (Rabi)*	*Reduction per cent (kharif)*
Andhra Pradesh	1965-66	5·2	yes	yes	yes	17·3	23·6	yes	yes	not grown	14·3
Bihar	1965-66	6·1	nil	yes	nil	not grown	not grown			5·4	nil
Gujarat	1965-66	46·3	yes	nil	nil	nil	nil			nil	nil
Madhya Pradesh	1965-66	51·4	yes	nil	nil	nil	nil			19·3	11·3
Maharashtra	1965-66	39·1	yes	nil	nil	18·0	19·9	yes	yes	27·9	9·7
Mysore	1965-66	15·6	yes	yes	yes	nil	nil			15·0	5·3
Orissa	1965-66	15·6	yes	yes	nil	not grown	not grown			not grown	22·9
U.P.	1965-66	30·5	yes	yes	nil	nil	nil			10·0	nil
	1966-67	43·4	nil	yes	nil	nil	nil			4·9	29·2
W. Bengal	1965-66	3·1	yes	yes	nil	not grown	not grown			not grown	nil
	1966-67	4·4	nil	yes	nil	not grown	not grown			not grown	nil
Assam	1966-67	5·4	nil	yes	nil	not grown	not grown			N.A.	N.A.
Tamil Nadu	1965-66	5·6	yes	yes	nil	6·0	13·7	yes	yes	not grown	8·1

Source: Compiled from 'Annual Estimates of Production in Different Crops' by Directorate of Economics and Statistics, Ministry of Agriculture, Government of India, 1961-1970.

N.A.: Not available.

TABLE 6

Changes in Rice Production in Areas of Maximum Reduction during Drought (1965-67)

State	*Periodicity of severe drought*	*Per cent reduction in total production over 1964-65*		*Per cent reduction in yield (kg/ha) over 1961-62*		*Per cent Maximum deviation from normal rainfall or S.W. monsoon*		*Per cent area under H.Y.V. 1969-70*
	Once in	*1965-66*	*1966-67*	*1965-66*	*1966-67*	*1965-66*	*1966-67*	
Andhra Pradesh	3-5 years	25	*	5·2	*	−10	−5	7·6
Bihar	5 years	13	67	6·1	56·5	−31	−38	10·1
Madhya Pradesh	5 years	50	5	51·4	43·0	−46	−31	3·4
Maharashtra	4-5 years	50	33	39·1	30·9	−32	−13	8·7
Orissa	5 years	27	16	15·6	5·0	−35	−31	3·8
U.P.	3-4 years	33	40	30·5	43·4	−41	−41	22·8

*No reduction or marginal increase.

Source: (a) S.R. Sen (1967); Growth and Instability in Indian Agriculture. Technical Address at the 20th Annual Meeting of Indian Society of Agricultural Statistics, Waltair. *Ind. J. Ag. Stat.* 19 : 1-30.

(b) Annual Reports of IADP and High Yielding Varieties Program : 1967-1971.

TABLE 7

Targets envisaged in Fourth Five Year Plan for high yeilding varieties and some agricultural development programmes

Crop	*HYVP (million hectares)*				*Programme*	*Additional target in IV Plan (million hectares)*
	End of III and Annnal Plan 1968-69	*Additional target IV Plan*	*Total*	*Coverage till 1970-71*		
Paddy	2·5	6·6	9·1	4·5	Multiple cropping	9·0
Wheat	4·6	4·0	8·6	6·1	Soil conservation	5·6
Maize	0·4	1·0	1·4	0·6	Land reclamation	1·0
Jowar	0·7	2·2	2·9	1·2	Major & medium irrigation	4·2
Bajra	0·7	1·8	2·5	1·4	New area	3·2
Total	8·9	15·6	24·5	13 8	Replacement of depreciated area	2·4
					Total	27·0

Source : Fourth Five Year Plan 1969-74, Planning Commission.

TABLE 8

Area, Production and Extra return under High Yielding Cereal Varieties duing 1970-71

Crop	*Area under HYV (million ha)*	*Percentage coverage by HYV*	*Increase in production in 1970-71 over package period*		*Grain Price (Rs./q)*	*Extra gross income expected over (Rs. in crores)*	*Extra cost involved (Rs. in crores)*	*Net increase in income over package period (Rs. in crores)*	*% contribution to net increase in income totalled for all crops*	*Net increase in income/ha in area under HYV (Rs.)*
			Expected	*Actual*						
Paddy	4·45	11·81	7·83	6·22	45	325·4	137·0	188·4	12·2	423
Wheat	6·07	36·53	14·39	12·00*	75	1079·2	151·9	927·3	61·2	1527
Maize	0·61	10·37	1·86	2·88	55	102·3	9·5	92·8	6·1	157
Jowar	1·22	6·53	3·20	0·54**	50	160 0	12·1	147·9	9·8	1217
Bajra	1·42	11·34	3·16	4·02	55	173·8	14·1	159·7	10·5	1127
Total	13·8	15·08	29·84			1840·7	324·6	1516·1	100·0	

* Loss due to lodging and heavy rains

** Reduction due to severe drought in Deccan.

Sources : Annual Progress Report of IADP and High Yielding Varieties Programe 1968-71.
Swaminathan, M.S., and Murty, B.R. (1972): Production trends in the sixties. (Unpublished).

Major developments since 1965-66

(a) Spread of High-Yielding Varieties

The targets and the achievements of the High-Yielding Varieties Programme (HYVP) initiated in 1965-66 are given in Table 7. Mention is also made in Table 7 of the other developmental projects initiated during the Fourth Plan. The expected and actual increase in production and the extra income derived from the high-yielding varieties are given in Table 8. The increase in production is more or less in accordance with the expectations, in spite of severe drought in South India and other natural calamities like flood and cyclone in Bihar, eastern India and coastal regions. The impact of HYVP in reducing instability during 1960-70 has been the greatest for wheat in both areas of high and low productivity. *In rice, the interaction between the levels of productivity and seasonal variation revealed that the stability in production is low even in areas of high yields and much lower in low yielding areas, thereby underlining the role played by other factors such as the incidence of pests and diseases in regulating rice output.* In rainfed crops like *jowar* and *bajra,* relative stability in yield level was achieved during 1960-70. The same is true for maize.

(b) Infra-structure development

The drought of 1965-67 stimulated widespread interest in the exploitation of ground water and in the introduction of more efficient equipment for drilling. During 1970-71, one lakh private tube wells, 1000 State tube wells and 1·7 lakh dug wells were developed and 2·65 lakhs electrical pump sets were installed. The benefits from major, medium and minor irrigation schemes have been steadily increasing (Table 9). There has also been greater attention to the qualitative aspects of water use and data are now available in crops like wheat and rice on the critical stages in the growth of the plant when water is needed most. Much work has also been done on the choice of crops to suit varying conditions of moisture availability and the concept of income per 1000 litres of water is slowly being introduced as a criterion in the development of cropping systems. Multiple cropping techniques are being developed for irrigated areas which would help to maximise the benefits from the available irrigation facilities. The surface water resources indicate a utilizable surplus of 32 million hectare metres of water, which could irrigate another 40 million hectares of land. The corresponding

TABLE 9

Benefits from major and medium irrigation schemes (million hectares)

Source	Ultimate Potential	1950-51		1960-61		1968-69		1973-74
		Potential	Utilization	Potential	Utilization	Potential	Utilization	Projected Potential
Surface Water	60	16·1	16·1	21·0	19·7	26·7	25·1	32·0
Major & medium	45	9·7	9·7	14·4	13·1	18·6	17·0	23·3
Minor	15	6·4	6·4	6·6	6·6	8·1	8·1	8·7
Ground water (minor)	22	6·5	6·5	8·2	8·2	10·9	10·9	13·5
Total	82	22·6	22·6	29·2	27·9	37·6	36·0	45·5

Percentage of irrigation potential utilized } to the end of 1968-69=43·9
to the end of 1973-74=53·4 (projected)

Source : Fourth Five Year Plan 1969-74.

development programmes for ground water resources under the Fourth Plan can help to irrigate an additional 12 million hectares by better water management, conveyance and distribution.*

Considerable progress has also been made since 1965-66 in improving the production and availability of fertilizers within the country. The targets for internal production during 1971-72 were 1·55 million tonnes of N, 0·45 million tonnes of P_2O_5 and 0.70 million tonnes of K_2O. There has been a steady improvement in the consumption of fertilizers, although the actual use is still far below the IV Plan target (Table 10). Slow but steady progress is also being made in the availability and use of pesticides.

TABLE 10

Progress of consumption of Chemical Fertilizers
(Nutrients in million tonnes)

Nutrient	*1968-69 Achievement*	*1971-72 Achievement*	*Fourth Plan target 1973-74*
Nitrogen	1·15	1·78	3·20
Phosphorus	0·39	0·64	1·40
Potassium	0·16	0·34	0·90

Source : Planning Commission.

(c) *Programme Development*

Significant advances have been made since the last drought period in developing programmes which will help to identify and spread improved production technology speedily. In the field of research, 71 All-India Coordinated Research Projects were initiated by the Indian Council of Agricultural Research with the objective of achieving rapid advances in improving biological productivity through a critical study of complex problems by a national grid of multi-disciplinary research teams. In addition to the HYVP which started bearing results from 1967-68, special schemes for small and marginal farmers and agricultural labour, pilot projects for dry land farming and multiple cropping and programmes for the development of selec-

* *Towards Self-Reliance In Agriculture,* Indian Agricultural Research Institute, New Delhi, 1972, p 82.

ted command areas have all been initiated during the IV Plan. These projects have provided considerable operational experience to our extension workers and administrators in the handling of developmental projects applicable to a wide spectrum of farming communities and cropping systems.

Differences in our technological capabilities between 1965-67 and 1972-74

Besides the advantages gained in infra-structure and programme development, the most significant factors which provide room for optimism that a drop in production of the magnitude witnessed during 1965-67 need not be permitted again even if the rainfall fails to the same or even greater extent, stem from recent scientific advances. I would like to indicate the more important among them from the point of view of facing drought.

(a) Development of relatively photo-insensitive crop varieties

The crop varieties used in traditional cropping systems are by and large season-bound or sensitive to factors like the number of hours of sunlight and temperature with regard to the initiation of flowering and fruiting. We now have varieties which are relatively insensitive to photoperiod in a wide range of crops like rice, wheat, maize, *bajra*, *jowar*, and several pulses and oilseeds. Among oilseeds, sunflower is a striking example of a crop which can be grown in different seasons. The yield of wheat can be quite high even in sowings done in January in Punjab, Haryana and Western Uttar Pradesh (Table 11). Hybrid maize gives better results in summer

TABLE 11

Effect of date of sowing on the yield of wheat varieties (North Western Plains Zone) (1970-1971)

Date of sowing	Yield (q/ha) of variety: *Kalyan Sona*	*Sonalika*	*Hira*
9th November	57·6	58·6	63·7
29th November	51 0	56·5	51·4
19th December	43·1	46·3	43·4
8th January	39·5	43·8	40·9

Source : Annual Progress Report of All India Wheat Coordinated Project 1970-71.

and *rabi* seasons than during the *kharif* season, when it used to be cultivated until the recent past (Table 12). Thus, there is now considerable scope for early or late sowing, sowing of crops in non-traditional seasons and sowing quick-yielding strains.

TABLE 12

Yield of maize hybrids in different sowing seasons
(Grain yield kg/ha at 15% moisture)

Location :		Hyderabad (Deccan)	
Name of Hybrid :			
Year	*Kharif*	*Rabi*	*Gain in Rabi as % of Kharif*
1965	5556 (4)*	6719 (8)	+20 9
1966	5796(10)	7046 (9)	+21·5
1968	6032(7)	9776 (3)	+62·1
Mean	5794	7847	+35·0
Location :		Pant Nagar	
Name of hybrid :		Ganga 5	
Year	*Kharif*	*Summer*†	Gain in *Summer* over *Kharif*
1968	5330 (2)	6974 (1)	+30 8
1969	5824 (11)	8451 (1)	+45·1
1970	4994 (5)	6725 (1)	+34·7
Mean	5382	7383	+37·0
Name of Hybrid :		Ganga 3	
1968	4656 (3)	7779 (1)	+67·0
1969	4905 (2)	8235 (1)	+67·9
1970	3286 (2)	7232 (1)	+120·1
Mean	4282	7748	+80·0

* Values in parentheses indicate the number of trials on which mean values are based.

†Sown in February.

Source : Annual Progress Report of All India Coordinated Maize Improvement Project : 1965-71.

TABLE 13

Yield and Production per day of some high yielding varieties under Rainfed conditions

Crop/Variety		*Yield (kg/ha)*	*Duration (days)*	*Production per day per ha (kgs)*	*Grain yield in kgs* for each kg of N*
Wheat :	Kalyan Sona	3292	120	27	15 to 30
Bajra : (Severe moisture stress)	23A×J. 87	1133	82	14	40 to 120
	HB 3	3011	76	39	
	HB 4	2290	87	27	
	Local	641	85	8	
Jowar :	CSH-1	2698	105	26	60 to 120
	Local	1685	101 to 120	13 to 17	
Rice :	Jaya, Kaveri Krishna	3040	120 to 130	23 to 25	60 to 120
	Local	2332	120 to 130	18 to 19	
Castor :	Aruna	1500	140	11	
	H.C.6	450	240	2	

Sources : *Saxena, P.N. *et al.*, *Indian J. Agron*, 1970-71.
Annual Progress Reports of All India Coordinated Projects on Rice, Wheat, Bajra, Jowar 1966-1971.
A new Technology for Dryland Farming (1970). Publication by Indian Agricultural Research Institute, New Delhi.

(b) Development of crop varieties which do well under moisture stress

A very fortunate characteristic of hybrids of *jowar* and *bajra* is their ability not only to give high yields under good management but also much higher yields than the earlier strains under conditions of low moisture availability. Several high yielding varieties in some of the major cereals, millets and oilseeds do relatively well under rainfed conditions (Table 13). They are medium to short in duration, are capable of attractive yields per day and respond very favourably to nitrogen fertilization.

(c) Application of nutrients to irrigated and rainfed crops

There have been considerable advances in recent years in the technology of nutrient supply to both irrigated and rainfed crops. Deep placement and foliar feeding methods have yielded beneficial results in rainfed crops (Tables 14 and 15). In the case of upland rice, the application of 50 kg. N, 25 kg. P and 25 kg. K gave 50 to 100 per cent increase in yield when all the nitrogen was drilled at seeding in Uttar Pradesh. Madhya Pradesh and Orissa. The red and yellow soils of Orissa and Madhya Pradesh, the terai region of Uttar Pradesh, the laterite soils of west coast and the alluvial soils, in general, respond to the application of micro-nutrients like manganese, zinc and boron during the *kharif* season. Due to the limited availability and high cost of fertilizer, the efficiency of the application should be improved. For example, a linear programming study has revealed that considerable savings can be made through an appropriate choice of fertilizer combinations (Table 16).

TABLE 14

Yield (q/ha) of dryland rice and wheat by aerial application of urea solution

Treatment	*Rice*		*Wheat*
	Bilaspur (M.P.) 44 cuts	*Raipur (M.P.) 32 cuts*	*Kotah (Rajasthan) 24 cuts*
Unsprayed	20·7	20 4	5·9
Sprayed	23·3	23·7	7·7
Per cent increase	12·5	15·4	31·0

Rice— 17·8 kg urea or 8.0 kg N in 89 litres of solution per ha
Wheet— 17 kg urea or 7·6 kg N in 73 litres of solution per ha
Source ; Rajat De (1971), *Fertilizer News*, **16** ; 77-81.

TABLE 15

Grain yield (q/ha) of some crops under soil and foliar application of nitrogen

Wheat				*Rice*		*Hybrid Bajra*		*Mustard*	
Rainfed		*Irrigated*		*Method of Application (per/ha)*	*Yield*	*Method of Application (per/ha)*	*Yield*	*Method of Application (per/ha)*	*Yield*
Method of Application (per/ha)	*Yield*	*Method of Application (per/ha)*	*Yield*						
20 kg. N: Soil	23·7	24 kg. N: Soil	45·7	50 kg. N: 80% Basal +20% Top dressing	51·8	Foliar: 11·2 kg. N	8·2	Soil: 40 kg. N	11·1
$\frac{1}{2}$ S+$\frac{1}{2}$F	30·3	Foliar	48·2	80% Basal+ 20% Foliar	55·7	22·4 kg. N	10·3	60 kg. N	12·9
40 kg. N: Soil	31·3	36 kg. N: Soil	47·8	100 kg. N:80% Basal	55·6	Soil: 22·4 kg. N	8·2	40 kg. N:Soil+ 40 kg. N:Foliar	16·4
$\frac{1}{2}$ S+$\frac{1}{2}$ F	32·8	Foliar	60·8	80% Basal+20% Foliar	59·6	44·8 kg. N	10·3	60 kg. N: Soil+ 40 kg. N: Foliar	18·8
CD 5%=2·2				C.D. 5%=3·6				C.D. 5%=1·9	

Source : Rajat De (1971), *Fertilizer News, 16* : 72-81 & Shri Ram, *Khad News* (1971).

TABLE 16

Least cost combination for cereal crops based on a fertiliser cost minimising model

Crop	*Recommended dose N:P:K(kg/ha)*	*Common Practice*							*Minimum cost combination*						
		N as ammonium sulphate (20·6% N) Rs. 54/qtl		*P as Super-phosphate (16% P) Rs. 40/qtl*		*K as Muriate of Potash (50% K) Rs. 55·40/qtl*		*Total cost*	*N as urea (46% N) Rs.95/qtl*		*P as diammonium phosphate (18%N, 46%P) Rs. 122/qtl*		*K as Muriate of Potash (50% K) Rs. 55·40/qtl*		*Total cost*
		Quantity reqd(qtl)	*Value (Rs)*	*Quantity reqd(qtl)*	*Value (Rs)*	*Quantity reqd(qtl)*	*Value (Rs)*		*Quantity reqd(qtl)*	*Value (Rs)*	*Quantity reqd(qtl)*	*Value (Rs)*	*Quantity reqd(qtl)*	*Value (Rs)*	
Wheat & maize	120:60:40	5·85	314·82	3·75	150·00	0·80	443·2	509·14	2·10	199·50	1·30	158·60	0·80	44·32	402
Paddy	100:60:30	4·35	261·90	3·75	150·00	0·60	33 24	445·14	1·66	157·70	1·30	158·60	0·60	33·24	349
Jowar & Bajra	100:40:20	4·85	261·90	2·50	100·00	0·40	22·16	384·06	1·83	173·85	0·87	106·14	0·40	22·16	302

Source : I.J. Singh & R.N. Pandey, *Farm Extension Digest*, 1971, *3*, 214-219.

(d) *Pest control and surveillance systems*

Valuable data have been gathered in recent years on efficient methods of pest control. The emphasis is on integrated pest control involving an appropriate admixture of genetic, chemical, agronomic and biological methods of control. Dramatic increases in yield are obtained when appropriate pest control methods are adopted (Tables 17 and 18). Disease and pest warning systems are also under development in wheat and rice. An efficient disease surveillance system is already in operation in wheat. The major difficulty in effective pest control has been the lack of cooperative effort on the part of the entire village community.

(e) *Multiple and relay cropping*

Thanks to the development of relatively photo-insensitive crop varieties, the cultivation of 3 or 4 crops during a year has become possible in irrigated areas. Considerable data on the most profitable multiple cropping systems are being gathered under the National Demonstration Programme and the All-India Coordinated Agronomic Experiments Project. Yields ranging from 10 to 15 tonnes per hectare per year have been reported in these experiments (Table 19). The development of high yielding varieties in tuber crops like potato and tapioca has added a further dimension to the yield possibilities. The general approach has been the standardisation of various alternative rotation patterns, all of which are scientifically sound from the viewpoint of maintaining the long term productivity of the soil but from which the farmer can choose according to his capacity to mobilise inputs, market conditions and seasonal behaviour.

Steps needed to capitalise our technological capability to face widespread drought

Let me now summarise the major differences between 1972-73 and 1965-66. Firstly, we now have a larger area with assured irrigation both by virtue of several major and minor irrigation works becoming operational and the increased exploitation of ground water resources. Secondly, we have more fertilizer, pesticides and storage space. Thirdly, we have non-season bound and quick-yielding varieties in the important cereals, millets, pulses and oilseeds and a better capability for rapid seed multiplication. Fourthly, we have better methods of moisture conservation, nutrient supply, pest control

TABLE 17

Effect of Plant Protection on the yield levels in some major crops averaged over several locations and three seasons

	Jowar (CSH-1)		*Bajra*†		*Maize*		*Mung (PS-7)*		*Gram*		*Mustard*	
	Treated	*Control*	*Treated*	*Control*	*Treated*	*Control*	*Treated*	*Control*	*Treated*	*Control*	*Treated*	*Control*
Yield (Q/ha)	35·7	15·5	12·5	8·3	53·3	40·7	8·7	0·4	17·2	12·3	5·6	1·4
	62·6*	14·6*										
	80·4	39·8**										
Chemical used	(*a*) Carbofuron 4 to 6 parts/100 parts of seed		Phorate or Disulphoton		Endosulphon, cytrolane or Carbofuron		Disyston 1·5 kg./ha.		Endosulphon 0·07%		Lindane 0·1% spray twice after flowering	
	(*b*) Endosulphon 4% granules (3 applications)											
Pest/Disease	Shootfly Stemborer and Midge		Shootfly		Stemborer		All borers and sucking insects		Pod borer		Aphids	

* Integrated pest control using phorate, lindane and carboryl for shootfly, borer and midge respectively.
** Irrigated trial at Delhi, Udaipur, Poona and Parbhani.
† Data at Coimbatore in 1970 under severe incidence.

Source : Annual Progress Reports of All Indian Coordinated Projects on Sorghum, Millets, Maize 1968-71.
Towards Self-Reliance in Agriculture (1972), IARI, New Delhi.

TABLE 18

Effect of carbofuron seed treatment (4% a.i.) on the yield (q/ha.) of Sorghum (Kharif 1970)

Location	*Yield of grain (q/ha.)*		*Per cent increase over control*
	Untreated	*Treated*	
Delhi	36·5	54·6	49·6
Udaipur	8·8	44·1	401·3
Parbhani	15·7	34·9	122·3
Poona	12·3	36·4	195·9
Hyderabad	4·2	8·5	102·4
Average	15·5	35·7	130·3

Source : Annual Progress Report of All India Coordinated Sorghum Improvement Project 1970-71.
a.i.=Active Ingredient.

and cropping patterns for the dry land farming areas. Fifthly, multiple and relay cropping techniques capable of yielding more than 10 tonnes of food grains per hectare per year in the irrigated areas are now available. Lastly, we now possess considerably more operational experience in organising production and crop protection campaigns and in using the mass communication media, particularly the radio and National Demonstrations, in what I recently termed as "techniracy" (technical literacy) drives. The storage and warehousing facilities—including cold storage—are much better. All these developments have endowed us with the capacity to readjust our cropping programmes to suit emergency situations and to introduce "midseason corrections" in cropping systems in case of failure of monsoon. How can we take advantage of this power?

In my view, the first requisite is the organisation of a National Crop Planning Board charged with the responsibility of developing alternative cropping strategies for every part of the country on the basis of different weather models. The Board ought to have plans ready to meet crop failures arising from drought or floods, so as to

TABLE 19

Yields and total production of two and three crop annual sequence at various centres during 1970-71

State	*Centre Soil type*	*Crop sequence*			*Yield in kg/ha*			*Grain production per day kg/ha/day*
		Kharif	*Rabi*	*Summer*	*Kharif*	*Rabi*	*Summer*	
Andhra Pradesh	Tirupati, Red Sandy	Rice (IR-8)	Rice (IR-8)	Rice (Hamsa)	4438	6410	3090	42·9
	Maruteru, Medium Black	Rice (IR-8)	Rice (IR-8)	Mung (P. Baisakhi)	4666	5583	910	34·1
		Rice (Pankaj)	Rice (Padma)	Rice (Kaveri)	4693	3871	2689	35·8
Uttar Pradesh	Banaras, Alluvial	Rice	Wheat	Rice	3732	5042	4309	39·4
Mysore	Mangalore, Laterite	Rice (MTU-20)	Rice (Padma)	Rice (Padma)	2450	1770	4570	34·3
Tamil Nadu	Bhavanisagar, Red loam	Rice (ADT-27)	Rice (IR-8)	Rice (CO-29)	3643	3908	5106	35·6
Orissa	Bhubaneswar, Laterite	Rice (Padma)	Rice (T-141)	Rice (Padma)	2648	1970	3127	28·8
		Jute (JRO-212)	Rice (T-141)	Rice (Padma)	1738	2055	4485	33·7

Source : Annual Progress Reports of All India Coordinated Agronomic Experiments, 1969-71.

ensure that not only does total crop production remain fairly normal under such conditions but also that the farmer has reasonable income and employment. It would not be adequate if the Board just has paper plans but it should also make arrangements for implementing the drought-production strategies it develops. For example, we should not only have buffer stocks of grains but also buffer stocks of seeds of drought or flood-avoiding and photo-insensitive and quick yielding varieties of crops. Plans for optimal use of water, fertilizer and pesticides during drought years should be developed.

In normal seasons, the National Crop Planning Board can help in promoting rational land use policies and in linking production with marketing possibilities, so that prices can be maintained at a level which are reasonable to the consumer and remunerative to the producer. While planning at the national level is useful and necessary, the success of a plan would obviously depend upon execution at the field level. It should, therefore, be one of the essential tasks of the Board to generate an awareness of the dynamics and economics of cropping systems under diverse agro-ecological conditions at the block level.

Above all, we should realise that there are limits to growth in our country also, although we are just in the infancy of the scientific upgrading of our agricultural production potential. The National Crop Planning Board could also be the agency to ask and answer the following three questions suggested by the authors of "The Limits to Growth" before a new technology is introduced.

1. What will be the side-effects, both physical and social, if this development is introduced on a large scale ?

2. What social changes will be necessary before the new development can be implemented properly and how long will it take to achieve them ?

3. If the development is fully successful and removes some natural limit to growth, what limit will the growing system meet next ? Will society prefer its pressures to the ones this development is designed to remove ?

If we start thinking and acting on these lines, we may have every possibility of avoiding the environmental degradation of the developed nations on the one hand and the periodic recurrence of hunger from aberrant weather on the other. This will be an appropriate tribute that we can pay to the late Dr. Rajendra Prasad who did so much to fight hunger and misery among his countrymen.

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