Productivity of Crops in Indian Agriculture

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In view of the important role that agro-climatic factors play in agricultural production, growth in agriculture turns to be a more complex process than that in industry. In a vast country like India, physical conditions of agricultural production differ widely from region to region and hence types of crop grown, resources used and response of output to inputs differ widely. These, associated with the differences in the resource endowments and the level of technology lead to regional differences in agricultural growth. Keeping aside these differences, the slow growth in production has been the crux of the problem of Indian agriculture. The main reason behind slow growth in agricultural output has been low response of output to inputs. Hence, breaking the low yield barrier of crops became the major problem of Indian agriculture, particularly after fifties when the scope for bringing more land under cultivation got severely reduced. A number of yield-increasing measures have, therefore, been initiated since early sixties, the most salient among them being the High Yielding Varieties Programe (HYVP). In view of land being the most scarce and the most important factor of production in Indian agriculture, these measures were mainly directed to raise the productivity of land. It would, therefore, be important to examine the impact of these measures on the productivity of land under different crops. Apart from this, this paper would specifically concentrate on examining the factors underlying the widely different performance of rice and wheat crops by using data of early sixties and early seventies. An attempt would also be made to probe into the prospects of growth of these two crops. The reason why special attention is being paid to rice and wheat crops is that they are the most important crops in Indian agriculture and jointly occupy about 35 percent of the total cropped area. Further, a major dent on the food problem of the country could only be made when there is a breakthrough in the productivity of rice which occupies about 23 percent of the total cropped area of the country.

In this paper, agricultural productivity has been defined in terms of yield per hectare of land. The reasons for measuring productivity in terms

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of land input are as follows : (i) data on productivity of land are easily available, (ii) land is the most scarce factor of production in Indian agriculture and there has been emphasis on maximising its production, and (iii) productivity of land could be easily compared over a period of time. This is, however, not to suggest that agricultural productivity should only be measured in terms of land input. In fact, it is quite important to know the productivity of all the inputs individually and in combination by constructing a combined input index. In view of the time and resource constraints, it was, however, not possible to attempt either of these. Apart from these, available secondary data, do not permit such analysis easily. Therefore, productivity of crops is measured in terms of land input only.

Rate of Growth of Output and Productivity

The compound rates of growth of output and productivity of land of important crops for two periods of time, 1949-50 to 1959-60 and 1960-61 to 1974-75, are presented in Table 1. This division of the whole period into two, though arbitrary, has been done with a view to knowing the effects of productivity-increasing measures, initiated during the latter period, on the growth of output and the productivity of crops.

It is clear from the table that excepting wheat and bajra crops, rates of growth of production of all the crops declined substantially during the latter period as compared to the earlier period. The rates of growth of productivity of most of the crops also declined considerably during the latter period as compared to the earlier one. The growth rate of productivity of total foodgrains remained constant during the whole period whereas there was a small increase in the case of total non-foodgrains.

Wheat is the only crop where output and productivity grew at a substantially faster rate since 1960 as compared to the decade preceding it, the rate of growth of productivity being 0.9 percent per annum during the earlier period and 4.3 percent per annum during the later period. On the other hand, in the case of rice, the most important crop in Indian agriculture, the rate of growth of productivity declined from 2.2 percent per annum during fifties to 0.8 percent per annum during the period after 1960. It is rather unfortunate that there has been absolute decline

Table 1 : Compound Rates of Growth of Output and Productivity : All India

(Percent)

Crops	1949-50 to 1959-60		1960-61 to 1974-75	
	Output	Productivity	Output	Productivity
Rice	3.2	2.2	1.5	0.8
Jowar	2.8	1.6	−0.7	0.3
Bajra	2.6	0.7	2.7	2.2
Maize	4.3	1.3	2.7	0.1
Ragi	4.5	3.6	0.3	0.7
Wheat	4.5	0.9	7.8	4.3
Barley	0.7	0.1	0.1	1.4
Gram	5.8	2.1	−2.3	−0,01
Pulses	3.1	0.1	−1.2	−0.2
Foodgrains	3.3	1.4	2.1	1.4
Groundnut	4.7	0.1	0.4	0.2
Oilseeds	3.4	0.7	1.4	0.7
Cotton	4.0	0 8	1.2	1.6
Jute	2.7	−0.1	− 0.6	0.4
Fibres	4.6	0.6	0.5	1.2
Sugarcane	4.0	1.0	1.9	1.0
Non-foodgrains	3,4	0.4	1.8	0,8
All crops	3.3	1.3	2.0	1.2

Source : (1) C. H. Hanumantha Rao, *Technological Change and Distribution of Gains in Indian Agriculture*, The Macmillan Company of India. Ltd, 1975. p. 2 (Table 1) (for the growth rate during 1949-50 to 1959-60)

(2) Direcrorate of Economics and Statistics, Ministry of Agriculture and Irrigation, *Estimates of Area and Production of Principal Crops in India, 1974-75*, p. 147 (for the growth rates during 1960-61 to 1974-75).

in the level of output and productivity of pulses after 1960. It is to be noted that the share of productivity in the growth of output increased during the later period for most of the crops. This implies that the share of area in the growth of output has declined.

Productivity Increase in Wheat and Rice

Having examined the rates of growth of productivity of important crops in Indian agriculture, we propose to examine the increase in productivity of rice crop by crop season and of wheat crop between early sixties and early seventies for the country as a whole and the prospects for the growth in their productivity. The reason for examining the increase in the productivity of rice crop in different seasons is to know whether rice crop performed equally badly in all the seasons. The average yield of rice and wheat at two points of time, along with the increase in their yield, are presented in Table 2. As noted earlier, the increase in the productivity of wheat has been much faster than that of total rice. But the faster increase in the productivity of wheat has been associated with its low level of yield at the base period. So far as the increase in the productivity of rice in different crop seasons is concerned, it has been fairly fast in the case of summer rice, about 38 percent during a decade, but extremely slow in the case of winter rice; whereas, it is very modest in the case of autumn rice. The fast rate of increase in the productivity of summer rice has been associated with a quite high yield at the base period, much higher than that of wheat.

Table 2 : Average Yield of Autumn, Winter and Summer Rice and Wheat during 1962-63 to 1964-65 and 1972-73 to 1974-75 : All India

(In kgs. per hectare)

	1962-63 to 1964-65	*1972-73 to 1974-75*	*Percentage Increase*
Autumn Rice	933·7	1022 8	9·5
Winter Rice	1062·2	1089·0	2·5
Summer Rice	1310·7	1814 0	38·4
Total Rice	1014·7	1094·5	8·0
Wheat	811·8	1259·9	55·2

Source : Directorate of Economics and Statistics, Ministry of Agriculture and Irrigation, *Estimates of Area and Production of Principal Crops in India : 1974-75.*

Apart from other things, the greater increase in the productivity of summer rice could be due to higher extent of adoption of high-yielding varieties. The HYV rice perform better in summer than in other two seasons because of greater intensity of sunlight and lesser chances of damage from pests and diseases to which these varieties are more prone.

In spite of substantial increase in the productivity of summer rice, its impact on the productivity of total rice could not be felt because of its small share in area and output of total rice crop. The slow growth in the productivity of total rice crop could be attributed to the slow growth of productivity of winter and autumn rice crops which together occupy more than 95 percent of the total area under rice (Table 3).

Table 3 : Percentage Share of Autumn, Winter and Summer Rice in Area and Production of Total Rice during 1962-63 to 1964-65, and 1972-73 to 1974-75 : All India

	Area		*Production*	
	1962-63 to 1964-65	*1972-73 to 1974-75*	*1962-63 to 1964-65*	*1972-73 to 1974-75*
Autumn Rice	40.8	43.8	37.5	40.9
Winter Rice	57.4	51.5	60.1	51.2
Summer Rice	1.8	4.7	2.4	7.9
Total Rice	100.0	100.0	100.0	100.0

Source : Estimates of Area and Production of Principal Crops in India, op. cit.

It is clear from Table 3, that the differential increase in the productivity of rice in different seasons has led to a considerable change in the relative share of area and production of rice in three seasons within a period of about 10 years. In spith of substantial increase in the share of summer rice, its share in the total rice still remains to be less than 5 percent in area and less than 8 percent in output. The availability of irrigation facilities and its competition with other crops for water could be one of the main limiting factors on the expansion of cultivation of rice in summer season.

It is hoped that with increasing irrigation facilities, the expansion of area under summer rice would be faster.

It is worth noting that the decline in the area and the output shares of winter rice has been quite significant during the decade. This could have been due to its very slow increase in yield. The main challenge facing the rice crop lies with the improvement in the productivity of winter and autumn rice which respectively accounted for about 52 percent and 44 percent of the total rice area, and about 51 percent and 41 percent of the total rice output in early seventies. It seems that high-yielding varieties could not make any dent in the case of winter rice and showed only a minor success in the case of autumn rice. Unless high-yielding varieties that could suit to winter and autumn seasons are developed in India, there is little hope of making a worthwhile success in increasing productivity of rice crop in general.

It is well known by now that high-yielding varieties of wheat have been much more successful than those of rice. Apart from other technical reasons, the cultivation practices of HYV wheat have been quite similar to those followed for the traditional varieties of wheat, whereas in the case of HYV rice, they are quite different.

It would, however, be worth examining as to what extent the cultivation of HYV rice and wheat could be extended. One of the oft-repeated conditions for the adoption of high-yielding varieties is availability of irrigation water. Assuming that high-yielding varieties of rice and wheat are generally cultivated under irrigated conditions, the scope for extending their cultivation could be guessed from the irrigated area under each of the crops. The relevant data presented in Table 4 indicate that the scope for extending area under HYV wheat appears to be quite limited as about 95 percent of the irrigated area under wheat is already occupied by HYV. On the other hand, the scope for bringing more area under HYV rice appears to be substantial since these varieties occupy only 57 percent of the irrigated area under rice. Asuming that the productivity of HYV rice is higher than that of their traditional counterparts, there seems to be substantial scope for raising the productivity of rice crop by bringing more land under HYV rice. In case there is technological breakthrough in rice crop, the possibility of increasing its productivity would still be higher.

Table 4 : Cropped Area, Irrigated Area and Area Under High-Yielding Varieties of Rice and Wheat in 1972-73 : All India

(Million hectares)

Crops	*Cropped area*	*Irrigated Area*	*Area under HYV*	*Percentage of croped area irrigated*	*Percentage of HYV area to irrigated area*
Rice	36.69	14.46	8.17	39.4	56.5
Wheat	19.46	10.75	10.25	55.2	95.3

Source : (1) *Estimates of Area and Production of Principal Crops in India,* op.cit.

(2) Fertilizer Association of India, *Fertilizer Statistics,* 1974-75, (for data on HYV area).

Factors Responsible for Difference in Productivity of Rice and Wheat

The extent of difference in the productivity of rice and wheat among the states and the factors responsible for this are examined in this section. The per hectare yields of these crops have been related to the extent of adoption of HYV and the extent of irrigated area under the crop. For some of the states, yields of HYV, irrigated and unirrigated rice and wheat is also presented.

The data on per hectare yield at two points of time, i. e., early sixties and early seventies, percentage increase in the yield during the period, percentage area irrigated, percentage area under HYV and percentage share of states in the total area of wheat and rice are presented in Tables 5 and 6. It is clear from Table 5 that per hectare yield of rice at two points of time as well as the percentage increase in the yield differ widely among the states. The per hectare yield of rice was the lowest in Madhya Pradesh, closely followed by Uttar Pradesh, and the highest in Tamil Nadu in early sixties. In early seventies also, Madhya Pradesh retained its position, with absolute decline in its yield, of having the lowest yield, but the position of highest yield went to Punjab, Tamil Nadu being pushed down to second position.

It is notworthy that the level of yield, the increase in the yield over time, and the percentage of area under HYV rice are positively correlated with the percentage of irrigated area under rice among the states. Thus, the difference in the percentage of rice area irrigated is the main factor responsible for the difference in the production performance of rice crop among the states. It is understandable in view of the fact that irrigation facilities not only provide insurance against irregular rainfall and give opportunity for the cultivation of rice crop beyond the rainy season, but also, help in the intensive use of inputs and the adoption of new inputs like HYV seeds and fertilisers which are pre-requisite for the faster growth of productivity. In view of better control of water under irrigated conditions, it becomes much easier to adopt HYV rice under irrigation, as plants of these varieties are short stemmed and get submerged under water if there is no proper water control. It is, therefore, not unexpected that the extent of rice area under HYV and the level of yield per hectare are related to the extent of rice area irrigated. The proportion of irrigated area to total area under rice is relatively much low, less than one-third, in those states that have shown either poor or negative increase in productivity. The absolute decline in the yield of rice in some of the states could be due to the adverse weather conditions that some of them faced during early seventies. It is, however, doubtful whether these states could have performed much better in view of their low proportion of rice area irrigated.

It is a matter of great concern that the performance of rice crop has been extremely poor in most of the major rice growing states The increase in the productivity of rice during the last one decade has been only 0·6 percent in Bihar, 1·2 percent in West Bengal and 7·1 percent in Uttar Pradesh, whereas there has been an absolute decline to the extent of 11 percent in Orissa and 6.3 percent in Madhya Pradesh. Incidentally, each of these states account for more than 12 percent of the rice area of the country, but the percentage of irrigated area under rice is quite low, less than one-third, in all of them. Andhra Pradesh and Tamil Nadu are the only two major rice growing states, accounting for about 8 percent and 7.5 percent of the country's rice area, that have shown an increase of about 20 percent and 30 percent, respectively in the yield of rice during the decade. On the other hand, the increase in per hectare productivity of rice has been very fast, (more than 60 percent) during the decade, in Haryana, Jammu & Kashmir and Punjab, but

Table 5 : State-wise Yield, Area Irrigated and Area under HYV of Rice

State	*Average Yield per Hectare (in Kgs)*			*Percentage of irrigated area to total area under rice 1972-73*	*Percentage of area under HYV to total area under rice 1973-74*	*Percentage share of States in the total area under rice 1971-72 to 1973-74*
	1962-63 to 1964-65	*1972-73 to 1974-75*	*Percentage increase*			
Andhra Pradesh	1309	1576	20 4	94.0	53.3	8.2
Assam	945	1004	6.2	33.8	13.5	5.4
Bihar	866	871	0.6	33 4	11.6	13.6
Gujarat	848	651	−23.2	32.3	19 7	1.2
Haryana	994	1625	63.5	90.4	42.8	0.8
Himachal Pradesh	869	1058	21.7	55.1	56.8	0.2
Jammu & Kashmir	1038	1785	71.9	92.6	67.5	0.6
Karnataka	1439	1756	22.0	64.1	24.3	2.9
Kerala	1388	1509	8.7	58.4	31.4	2.3
Madhya Pradesh	715	670	−6.3	14.6	17.6	12.1
Maharashtra	1049	946	−9.8	25.9	28.9	3.5
Orissa	950	847	−10.9	24.6	7.6	12.3
Punjab	1238	2124	71.6	91.8	79.2	1.3
Rajasthan	976	748	−23.4	32.4	18.9	0.3
Tamil Nadu	1508	1965	30 3	92.3	79 3	7.4
Uttar Pradesh	744	797	7.1	19.2	21.9	12.1
West Bengal	1136	1150	1.2	28.7	15.1	13.5
All India	1013	1094	8.0	39.2	25.4	100.0

These figures have been worked out on the assumption that the share of Punjab and Haryana in the combined area and output of rice of these two States remained the same during 1962-63 to 1964-65 and 1979-73 to 1974-75.

Source : (1) *Estimates of Area and Production of Principal Crops in India.*

(2) *Fertiliser Statistics* (for area under HYV)

(3) Ministry of Agriculture and Irrigation, *Indian Agriculture in Brief*, Fourteenth Edition (for share o f States in area)

these states taken together account for less than 3 percent of the rice area of the country and hence could not make any impact on the growth of productivity of rice for the country as a whole. It is thus clear that the main malady of rice crop with its low yield equilibrium lies in major rice growing states. This could be remedied mainly by creating additional irrigational facilities which, apart from increasing productivity of land on its own, would also help in the adoption of new technology of rice crop.

In the case of wheat also, the level of yields per hectare and the increase in it during the reference period differ widely among the states (Table 6). But the increase in the productivity of wheat is positive in all the states and significantiy high in most of them. It is important to note that unlike rice, both the level of yield and the increase in it during the reference period is fairly high in most of the major wheat growing states which individually account for 6 percent and 31 percent of the wheat area of the country, the increase in productivity during the reference period being between 24 percent in Madhya Pradesh and 90 percent in Bihar. The relatively poor performance of wheat in Madhya Pradesh could possibly be attributed to its relatively lower proportion of wheat area under irrigation. In some of the states where wheat is not an important crop, the increase in its productivity has been very fast, but from a low yield at the base period.

The level of per hectare yield and the extent of adoption of high-yielding varieties seem to be correlated with the percentage of wheat area irrigated in the states. But unlike rice, the increase in productivity of wheat has also been quite high even in those states where the percentage of irrigated area under the crop is low.

In most of the major wheat growing states, the percentage of irrigated area to total wheat area is quite high, generally more than 48 percent. Because of this, rate of adoption of high-yielding varieties of wheat is also high in these states. Apart from the high rate of adoption, the better adaptability of HYV wheat *vis-a-vis* HYV rice has also influenced productivity of wheat substantially. Thus, the higher proportion of area irrigated and the higher rate of adoption of HYV associated with their (HYV) higher yield potential in the case ot wheat *vis-a-vis* rice have been responsible for significantly higher production performance of the former than the latter crop.

Table 6 : Statewise Yield, Area Irrigated and Area Under HYV of Wheat

State	Average Yield per Hectare (in kgs)			Percentage of irrigated area to total area under wheat 1972-73	Percentage of area under HYV to total area under wheat 1973-74	Percentage share of States in the total area under wheat 1971-72 to 1973-74
	1962-63 to 1964-65	1972-73 to 1974-75	Percentage increases			
Andhra Pradesh	241	619	156.8	55.0	89.3@	0.1
Assam	823	1333	62.0	—	64.7@	0.3
Bihar	671	1275	90.0	48.4	65.4	9.5
Gujarat	864	1684	94.9	64.0	60.4	2.5
Haryana	1017*	1680	65.2	33.5	86.4	6.3
Himachal Pradesh	725	1043	43.9	18.9	66.1	1.6
Jammu & Kashmir	569	926	62.9	21.2	58.8	1.0
Karnataka	313	572	82.7	6.9	17.3	1.7
Madhya Pradesh	622	769	23.6	21.0	19.3	17.9
Maharashtra	451	608	34.8	34.9	40.8	4.6
Orissa	508	1465	188.4	68.6	88.5	0.2
Punjab	1373*	2269	65 3	88.4	84.3	12.4
Rajasthan	859	1194	39.0	73.3	40.0	8.0
Uttar Pradesh	842	1126	33.9	69.3	55.9	31.6
West Bengal	631	1924	204.9	40.5	90.1	1.9
All India	812	1260	55.2	57.6	58.7	100.0

@Pertain to 1970-71

* These figures have been worked out on the assumption that the share of Punjab and Haryana in the combined area and output of wheat of these two States remained the same during 1962-63 to 1964-65 and 1972-73 to 1974-75.

Source : Same as for Table 5.

Having examined the difference in the growth of productivity of rice and wheat crops in different states and its relation with the extent of irrigation and the rate of adoption of HYV, it would be appropriate to know the extent to which high-yielding varieties and irrigation influence the yield of these two crops. The data on per hectare yield of HYV, irrigated and unirrigated rice and wheat are presented in Tables 7 and 8. These data have been taken from the "Estimates of Area and Production of Principal Crops in India" and are based on 'Consolidated Results of Crop Estimation Surveys on Principal Crops'. These data are, however, not available for all the states and for all India. Further, they are, not available separately for HYV and local varieties cultivated under irrigated and unirrigated conditions. Thus, the data on HYV presented in the tables represent their (HYV) yield under both irrigated and unirrigated conditions, as these varieties are grown under both the situations, though at present they are mainly confined to the former. Similarly, the yield of irrigated and unirrigated crops would be having the impact of HYV on it depending upon the extent of their (HYV) cultivation under irrigated and unirrigated conditions. It was, however, not possible to work out separately the yield of HYV and local varieties for irrigated and unirrigated conditions, since data required for such calculations are not available. In the absence of adequate data for making such calculations, one could have made an attempt by generating data on certain assumptions. It could have been assumed that HYV are grown only under irrigation and hence area under HYV of a crop could have been multiplied by their per hectare yield to obtain total output of HYV of the crop. Similarly, total output of the irrigated crop could have been obtained by multiplying its area by its per hectare yield. The output so obtained for HYV of the crop should be deducted from that for the irrigated crop and the balance be divided by the difference between the area under irrigated crop and HYV of the crop to obtain the per hectare yield of irrigated local varieties. This could not be attempted because it was noted that in some of the states, area under HYV wheat was higher than the area under wheat irrigated, indicating that HYV wheat has also been cultivated on unirrigated land. The data on the area under irrigated HYV and unirrigated HYV are not available, though for a few states, per hectare yield of HYV unirrigated was reported for both rice and wheat. Thus the assumption that all the area under HYV rice and wheat is irrigated is untenable and hence per hectare yield of HYV and local varieties in relation to their irrigation status could not be worked out. In view of these considerations, our inferences on yield rates of HYV and local varieties would be based on the available data as presented in the tables.

While comparing the yield of HYV, irrigated and unirrigated, rice and wheat, it has been kept in view that a major part of the area under HYV rice and wheat are irrigated, and hence yield of HYV have been compared with that of irrigated crop. Similarly, the yield of irrigated crop has been compared with that of unirrigated crop. But we are aware of the fact that the whole comparison is extremely rough, as the productivity of HYV overlaps the productivity of irrigated and unirrigated crops. It needs to be mentioned that in spite of the limitations mentioned above, a few crude inferences from the data of the tables would not be totally out of order.

The data presented in Table 7 reveal that in most of the states, the per hectare yield of HYV rice is considerably higher, to the extent of between 300 kgs. and 700 kgs., than that for irrigated rice (which also includes the influence of HYV). Assuming that HYV rice is cultivated only under irrigated condition and if per hectare yield of irrigated local rice is worked out, the difference between the yield of HYV rice and that of irrigated local varieties of rice would still be higher. It is noteworthy that the difference between per hectare yield of HYV and irrigated rice is substantially high, to the extent of about 600 kgs, in some of the major rice growing states like Andhra Pradesh, Bihar and Orissa. There seems to be enough scope for extending cultivation of HYV in these states as only less than one-third of the irrigated area under rice is occupied by HYV in Bihar and Orissa, wheras it is less than 60 percent in Andhra Pradesh (vide Table 5). The same is the case with most of the other states also. We are aware of the fact that all the irrigated area under rice may not be brought under HYV, particularly in major rice growing states, because of technical reasons, including the poor adaptability of these varieties to the rice growing conditions of these states. Only in the case of Madhya Pradesh, yield of unirrigated HYV rice is reported and that is considerably higher than that of unirrigated rice in the state. Thus, at the present level of adoption, extension of area under HYV rice seems to hold a good promise for increasing productivity of rice crop in India, provided that the technical problems coming in the way of adoption are solved.

It is also clear from Table 7 that per hectare yield of irrrigated rice is substantially higher than that of unirrigated rice in most of the states, the

Table 7 : State-wise Yield of HYV Rice, Irrigated Rice and Unirrigated Rice : 1969-70 to 1973-74.

(kgs. per hectare)

State	*HYV Rice*	*Irrigated Rice*	*Unirrigated Rice*
Andhra Pradesh	2049	1464	735
Bihar	1536	969	620
Gujarat	1752	1710	1095
Haryana	2366	1657	1244
Himachal Pradesh	1392	1136	995
Jammu and Kashmir	2664	2307	1114
Karnataka	2479	1918	1265
Kerala	1942	1478	1411
Madhya Pradesh	1125 1082 (UI)	1124	747
Maharashtra	1900	1035	907
Orissa	1603	965	728
Punjab	2272	1951	1226
Tamil Nadu	2235	1953	1039

UI = Unirrigated

Source : Estimates of Area and Production of Principal Crops in India, 1973-74 and 1974-75, op. cit.

Note : These yields are simple averages of five years for most of the States. In some cases, yield data for all the five years were not available and hence less than five years averages have been presented.

difference between the two mostly ranging between 300 kgs. and 900 kgs. This implies at its face value that the creation of additional irrigation facilities would increase the yield of rice substantially, both by increasing yield of local varieties of rice as well as by helping adoption of HYV rice.

A perusal of Table 8 indicates that the difference between per hectare yield of HYV and irrigated wheat is much less than that observed in the case of rice, being less than 300 kgs. in most of the states. This is mainly because of the fact that in most of the major wheat growing states, 80 to 90 percent of the irrigated area under wheat is already allocated to its high-yielding varieties whereas in some other states, area under HYV wheat is considerably higher than that under irrigated wheat (vide Table 6). However, productivity of HYV wheat is a little lower than the irrigated wheat in the states of Himachal Pradesh and Uttar Pradesh. This could possibly be due to the fact that a substantial proportion of HYV area in these states is unirrigated (particularly in Tarai region of Uttar Pradesh and in most parts of Himachal Pradesh), whose yield may be substantially lower than that of irrigated wheat. The data for Bihar and Madhya Pradesh indicate that the yield of unirrigated HYV wheat is considerably higher than that of unirrigated wheat. Thus, HYV wheat seem to perform fairly better than local varieties of wheat even without irrigation. A comparison between the yield of irrigated and unirrigated wheat indicates that the yield of irrigated wheat is considerably higher, ranging between 300 kgs. and 1250 kgs. per hectare, than that of unirrigated wheat in all the states. Thus, there seems to be enough scope for increasing productivity of wheat by bringing more of its area under irrigation, although 50 to 90 percent of the area under wheat is already irrigated in most of the states.

Table 8 : State-wise Yield of HYV Wheat, Irrigated Wheat and Unirrigated Wheat : 1969-70 to 1973-74

(kgs. per hectare)

State	*HYV Wheat*	*Irrigated Wheat*	*Unirrigated Wheat*
Bihar	1348 (I) 1071 (UI)	1081	744
Gujarat	2009	1791	594
Harayana	2168	1974	1234
Himachal Pradesh	1324	1369	999
Jammu and Kashmir	1466	1283	612
Karnataka	1784	648	252
Madhya Pradesh	1826 (I) 967 (UI)	1296	644
Maharashtra	923	830	322
Punjab	2408	2364	1112
Rajasthan	1586	1332	704
Uttar Pradesh	1260	1339	805

I = Irrigated UI = Unirrigated

Source : Estimates of Area and Production of Principal Crops in India, 1973-74 and 1974-75 op. cit

Note : These yields are simple averages of five years for most of the states. In some cases, yield data for all the five years were not available and hence less than five years averages have been presented.

Conclusion

In spite of growing concern for increasing productivity of land, the rate of growth in its productivity has not only been slow but has also shown a substantial decline in the case of most of the crops during the period after 1960 as compared to the decade preceding it. Wheat is the only major crop which has shown a faster rate of growth, more than 4 percent per annum, in its productivity since earliy sixties. On the other hand, the rate of growth in productivity of rice declined from 2.2 percent per annum during fifties to 0.8 percent per annum during the period following 1960. In view of the importance of rice and wheat crops in Indian agriculture, an in-depth analysis was carried out for these two crops. Apart from examining season-wise increase in prodvctivity of rice for the country, the increase in productivity of rice and wheat in different states was related to the percentage of irrigated area and that of HYV area to the total area under each crop. The state-wise use of fertilisers to these crops,could, however, not be related to the increase in the productivity because data on the use of fert!lisers are not available for individual crops. It has, however,been assumed that use of fertilisers to these crops would probably go with the extent of area under HYV and irrigation. It is expected that, in due course, the intensity of fertiliser use per hactare of land would increase many fold for these crops, for which there is considerable scope at present. This would contribute to growth in productivity in a significant manner.

This paper provides an interesting insight into the reasons for contrasting performance of rice and wheat crops in India. The two factors that seem to make the major difference in the production performance of rice and wheat are the extent of adoption of HYV and the proportion of area under irrigation. The considerably-higher rate of growth in productivity of wheat for the country as a whole, is associated with relatively higher proportion of wheat area under HYV and irrigation—about 58 percent in both the cases. On the other hand, poor rate of growth in the productivity of rice is associated with relatively much lower extent of adoption of HYV and lower extent of irrigation, the percentage of rice area under HYV being only 25 percent and that under irrigation about 40 percent, for the country as a whole. Apart from this, it is a well known fact that the adaptability of HYV is much higher in the case of wheat than that of rice.

The enquiry into the yield perfomance of rice crop reveals that the increase in its productivity is not poor in all the crop seasons. In fact, it has been quite fast in the case of summer rice, but its impact on the productivity of total rice could not be felt because its share in the total rice area is much small, less than 5 percent. Though the importance of summer rice would increase in future with the increase in the irrigation facilities, it would be a folly to assume that it would make much dent on the productivity and the production of total rice crop. The possibility of increasing area under summer rice would be considerably reduced after a point because of constraints of irrigation water and its competition with other crops for land and water. In view of rice being the most inefficient user of water, it would be wrong from the social point of view to increase area under summer rice in case other crops could be grown successfully on the same land. Thus the low yield problem of rice should be solved by taking measures to increase productivity of autumn and winter rice crops, which together account for more than 95 percent of the total rice area. This would depend upon the increase in the extent of irrgation and of adoption of HYV during these two seasons apart from evolving HYV rice that could suit well to the agro-climatic conditions of major rice growina states.

It is a matter of great concern that the increase in the productivity of rice has been extremely slow (in some cases negative) in most of the major rice growing states of the country. In these states, the extent of irrigated area under rice is less than one-third and that under HYV is less than one-fourth. Thus, in most of the major rice growing states, rice is mainly cultivated under rainfed conditions, which, in turn, leads to poor adoption of HYV. Apart from this, the low extent of adoption of HYV in most of the major rice growing states is also due to the poor adaptability of these varieties to the agro-climatic conditions of these states, particularly in rainy season, when rice crop is mainly cultivated, as these varieties need more precise and scientific water management which is not possible in rainy season owing to irregular and heavy rainfall leading to water shortage and deep flooding of fields. But, in view ot the high correlation between extent of irrigation and extent of adoption of HYV, the considerably higher productivity of HYV than the local varieties, and considerably higher yield of irrigated as compared to unirrigated rice, it could be inferred that the productivity of rice in major rice growing states could be increased considerably by creating additional irrigation facilities, which apart from adding to yield on its own, would also broaden the horizon for the adoption of HYV rice. This is quite clear from the performance of rice in some of the minor rice growing states like Haryana, Jammu and Kashmir, and Punjab, where increase in the productivity of rice has been quite fast, more than 60 percent between early sixties and early seventies, because the extent of irrigated area under rice is more than 90 percent in these states and hence proportion of rice area under HYV is between 43 percent and 80 percent. Though relatively drier climate of these states could have been helpful in the adoption of HYV, the fact that rice is mainly cultivated under irrigated condition in these states cannot be overlooked from the point of view of the higher level of yield and the higher increase in the productivity of rice. In view of these considerations, there seems to be two options for the faster increase in the productivity of rice viz., (1) to increase the proportion of irrigated area under rice in major rice growing states, which would lead to an increase in the extent of adoption of HYV and in the consumption of fertiliser, and (2) to evolve new high-yielding varieties that could be successfully adopted to the agro-climatic conditions of major rice growing states and could withstand higher doses of fertiliser even if there would not be much increase in the extent of irrigation.

Unlike rice, the increase in the productivity of wheat has been substantially high in the major wheat growing states of the country, which has been associated with relatively higher extent of adoption of HYV and irrigation. The conditions of adoption of HYV are very much satisfied in the wheat growing states, since these varieties suit very well to the agro-climatic conditions of these states, and perform significantly better than the traditional varieties of wheat. But the extent of adoption of HYV wheat has almost reached saturation point in these states as more than 80 percent of their irrigated area under wheat is already allocated to HYV. Therefore, the further extension of HYV area would depend upon the extent of increase in irrigation facilities. In view of these considerations, it may be inferred that unless the extent of irrigation under wheat is increased and the quality of seeds of HYV is improved and fertiliser consumption is augmented, the rate of increase in the productivity of wheat would probably decelerate. Thus, in order to maintain the tempo of growth in the productivity of wheat, not only the proportion of area under irrigation and that under HYV be increased, but also there should be continuing improvement in the quality of seeds of HYV wheat and in the consumption of fertiliser. □

Factor Share in Output Growth in Indian Agriculture: A Production Function Approach

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Since independence, the country has passed through nearly a quarter century of planned development. Undoubtedly, India has achieved significant progress in many fields during the successive Five-Year plans. These plans have become an instrument to achieve a rapid and balanced growth within the framework of well-defined national priorities.

A development plan is essentially an instrument for making a critical appraisal of resources of the nation which should be allocated according to the needs of the society over a time horizon for which coefficients could be generated with certainty.

Within the agricultural sector, allocation or plan outlays between factors of production is necessary. Almost all new farm technologies increase output to resources employed. And it is necessary that priorities in allocation of resources among factors of production be based on the relative factor share in output.

The results of this study on production patterns, factor share, growth rates of inputs and output in the agricultural sector form an important input for developing strategies for economic development of agriculture within the framework of perspective planning. This paper is an attempt to achieve this objective.

The growth rate analysis and factor share study have been done at all-India level for two time periods representing the pre-green revolution period and the post-green revolution period. This is because the technological and structural breakthrough in Indian agriculture during the latter half of nineteen sixties has resulted in discriminating effects on factor shares in farm output. It is also hypothesised that the green

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revolution can result in disparate growth rates among different factors of production.

Methodology

Production function depicts the technology employed in the production activity in terms of two major characteristics : (i) input substitution to produce a given level of output and (ii) the relationship between output and given quantities of inputs. The second characteristic deals witht he efficiency of technology and the degree of internal economies of scale. The efficiency of a technology determines the output that results from associated input flows. In contrast, the degree of internal economies of scale refers to the proportionate increase in output that results from a given proportionate increase in all input quantities.

A change in the state of technology is represented by a shift in production function, i.e., by a change in one or more parameters of the production function.

We start with a general production function in which Y is the output and x_1, x_2, ...x_n, are n different inputs :

$$Y = f\ (x_1, x_2, \ldots, x_n) + e \qquad \ldots\ldots (1)$$

where the e' s are stochastic residual terms with standard least squares properties.

A technological change such as green revolution should shift the production function upward. The assumption that the intercept term as well as the input coefficients (slope as well as elasticity) will shift as a result of this technological change, was incorporated by introducing dummy variable D with the values zero and one to represent the pre-green revolution period (1960-61 to 1964-65) and the post-green revolution period (1967-68 to 1972-73) respectively[1]. With the incorporation of dummy variables, the functional relationship takes the form :

$$Y = f\ (x_1, x_2, \ldots\ldots, x_n, D, Dx_1, \ldots, Dx_n) + e \qquad \ldots\ldots (2)$$

1. Two unsual drought years, 1965-66 and 1966-67 were excluded.

Factor Share in Farm Output : If output Y (in value terms) is a function of the factors x_1, x_2, ...x_n and is homogeneous of degree m in these variables, then according to Euler's theorem[2]

$$my = x_1 \frac{dy}{dx_1} + \dots + x_n \frac{dy}{dx_n} \qquad \dots(3)$$

This gives

$$Y = \sum_{i=1}^{n} \frac{x_i}{m} \frac{dy}{dx_i} \qquad \dots(4)$$

To incorporate efficiency of technology, let the production function be of the following type :

$$Y_j = a_{oj}\, e^{r_j t}\, x_j^{\,bjl} + \dots x_{jn}^{\,bjn} \qquad \dots(5)$$

where j=1, for the pre-green revolution period

j=2, for the post-green revolution period

For a particular year t, the term $a_{oj}\, e^{r_j t}$ (which represents the efficiency of technology) can be treated as a constant and the functional relationship is homogeneous of degree

$$\sum_{i=I}^{n} b_{ji}$$

The factor share in the j-th time period is then given by

$$Y_j = \sum_{i=1}^{n} \frac{x_{ji}}{\sum_{i=1}^{n} b_{ji}} \frac{dy_j}{dx_{ji}}, \quad j=1, 2 \qquad \dots(6)$$

Equation (6) can also be used for studying the shift in the factor share over the two time periods.

2 Assumption of linearity is only a particular case of the general theorem

Growth rates of factors and their share in output growth : In the functional relationship (5), all the variables Y_j, X_{ji}, X_{jn} (j=1, 2) are functions of the time variable t. Total differentiation of Y_j with respect to time t gives :

$$\dot{Y}_j = \sum_{i=1}^{n} b_{ji} \dot{x}_{ji} + \dot{Q}_j + r_j \qquad \ldots\ldots(7)$$

where $\dot{Y}_j = \frac{1}{Y_j}\frac{dy_j}{dt}$ and $\dot{x}_{ji} = \frac{1}{x_{ji}}\frac{dx_{ji}}{dt}$. $\dot{Q}_j$ represents the effects of qualitative changes in the factors of production and r_j (the coefficient of the time variable, t) is the growth rate of the efficiency of technology. Let R^2 be the coefficient of the growth rate $\dot{Y}_j$ that is explained by the factors included in the functional relationship. Then the components that contribute to growth rate Y_j can be written as :

	Due to	*Share*
1.	Efficiency of technology	$R^2 \times r_j$
2.	Factor share (Quantitative changes)	$b_{ji} \dot{x}_{ji} (R^2)$, i=1, 2,....n.
3.	Qualitative changes in the factors of production	$\left[Y_j - \sum_{i=1}^{n} b_{jj} \dot{x}_{ji} - r_j \right] (R^2)$
4.	Omitted variables	$\dot{Y}_j (1 - R^2)$
5.	Total	Y

Here $b_{ji} = \frac{dy_i}{dx_{ji}} \frac{x_{ji}}{Y_j}$

Relative contribution of the qualitative and quantitative changes in inputs :

Let $\overline{Y}$ and $\overline{x}_{ji}$ (i=1, 2.. .. , n and j=1, 2) denote the average levels of output and inputs. Then $Y_j = a_j x_{ji}^{b_{ji}} \ldots x_{jn}^{-b_{jn}}$, j=1, 2 and $a_j = a_o e^{r_j t}$

$$\bar{Y}_2 - \bar{Y}_1 = a_2 \bar{x}_{21}^{b21} \cdots \bar{x}_{2n}^{b2n} - a_1 \bar{x}_{11}^{b11} \; \bar{x}_{12}^{b12} \cdots \bar{x}_{ln}^{bln}$$

$$= \left[a_2 \bar{x}_{11}^{b21} \cdots \bar{x}_{ln}^{b2n} - a_1 \bar{x}_{11}^{b11} \; \bar{x}_{12}^{b12} \cdots \bar{x}_{ln}^{bln} \right]$$

$$+ \left[a_2 \bar{x}_{21}^{b21} \cdots \bar{x}_{2n}^{b2n} - a_2 \bar{x}_{11}^{b21} \cdots \bar{x}_{ln}^{b2n} \right] \quad \ldots (8)$$

$$= \text{Qualitative effects} + \text{Quantitative effects}$$

Data : The following variables were included in the production function analysis ;

Sr. No.	*Variable*	*Unit of measurement*	*Symbol*
1.	Agricultural production	Rs. in iakkhs	Y or X_1
2.	Net sown area	Thousand hectares	X_2
3.	Proportion of irrigation area	Proportion	X_3
4.	Tractors	Number	X_4
5.	Bullock labour	Number in thousands	X_5
6.	Human labour (M.A.L.)	Number	X_6
7.	Fertiliser value at constant 1972-73 prices	Rs. in lakhs	X_7
8.	Rainfall	(cms)	X_8
9.	Time variable		t

The dependent variable Y or X_1 in the production function analysis is the agricultural output in value terms. The value of agricultural output (crop production) at constant (1961-62) and current prices for 16 states (excludiug the newly formed states of Meghalaya and Nagaland) over the time period from 1960-61 to 1972-73 were taken from the unpublished data of National Accounts Statistics in the National Income unit of Central Statistcal Organisation of India.

The agricultural output value was considered in absolute terms. This step was necessary to account for inter-state variation. Whereas year-to-year variation is maintained in the use of index numbers, the inter-state variation is lost because of the difference in the base for each state.

The data for the input variable of net sown area (x_2) and proportion of irrigated area (x_3) were taken from Statistical Abstracts of India. Fertiliser data were collected from Fertilizers Statistics in India and N, P and K were pooled by using constant prices as weights.

Human labour (x_6) includes the population of male cultivators + male agricultural labourers + 0.67 (female agricultural labourers). The census for 1961 and 1971 were used to estimate the human labour for the remaining years by working out the compound growth rates. Female cultivators were not included because of the change in the definitions and concepts used in 1961 census and 1971 census.

The cattle used for draught formed the bullock labour (x_5) These figures were taken from the Livestock Census data for 1961 and 1966 and from the Agricultural Census in India for 1972. The data on the number of tractors (x_4) was also used from the same source. For the remaining years, the estimates for x_5 and x_4 were worked out using Statistical Abstracts.

The data used in the analysis related to the time period 1960-61 to 1964-65 representing the pre-green revolution period and 1967-68 to 1972-73 representing the post-green revolution period. Two years, i.e , 1965-66 and 1966-67 being the abnormal years, these were deleted for the purpose of analysis. The cross section of 16 states and 11 (5+6) years gave 176 (80+96) observations in all.

Results and Discussion

Averages and Growth Rates : The means and coefficients of variation (C. V.) for all the eight variables under consideration over the two time periods are given in Table 1. The mean values for all variables except draught bovines (X_5) and rainfall (X_8) were higher in the second period. Average value of agricultural production at constant 1960-61 prices increased from Rs. 43351.89 in period I to Rs. 53956.27 lakhs in period II. Among the factors of production the shift in the number of tractors and the fertiliser value was quite marked.

Table 1 : Means, Standard Deviations and Coefficients of Variation

Variable	Period I (n_1=80)			Period II (n_2=96)			Overall (n_3=176)		
	Mean	S. d.	C. V. p.c.	Mean	S. d	C. V. p.c.	Mean	S. d.	C. V. p.c.
X_1 : Output Value at Constant Prices (in Rs. million)	4335.189	2512.803	57.96	5395.627	3242.917	60.10	4757.604	2867.390	60.27
X_2 : Net Sown Area (Thousand Hectares)	7940.04	5463.01	68.60	8412.92	5898.42	70.11	8128.41	5633.12	69.30
X_3 : Proportion of Irrigated Area	0.21	0.12	56.97	0.25	0.16	64.35	0.22	0.14	6120
X_4 : Number of Tractors	2031.41	2422.81	119.22	9544.45	14214.51	148.93	5924.15	9853.05	196.11
X_5 : Draught Bovines (Thousand Number)	4999.82	3514.85	70.30	4969 33	3759.16	75.65	4987.68	3606.43	72.31
X_6 : Number of Male Agricultural Workers	5,223,500	3,840,282	73.52	6,052,661	4,441,169	73.38	5,553,788	4,101,405	73.85
X_7 : Fertiliser Value at 1972-73 Prices (in Rs. Million)	51.424	64.204	124.85	323.118	303.218	93.05	159.51	237.990	149.07
X_8 : Rainfall (mms)	332.86	170.74	51.30	314.49	163.09	51.86	325.54	167.64	51.50

The coefficients of variation were low as expected for such variables as the number of male agricultural workers (X_6), draught bovines (X_5) rainfall (X_8) and the net sown area (X_2) conventional inputs. On the other hand, for fertiliser value (X_7) and the number of tractors (X_4), a high variability is indicated, mainly on account of substantial increase in their magnitudes. The coefficient of variation is a measure of instability in the data, but as far as the variables under discussion are concerned, this coefficient gives some indication of the increasing trend of the values of the variables over time. The coefficient with value 196.11 for the tractor population and 149.07 for the fertillser use depicts the growth in these variables over the study period.

The coefficient of variation was rather low for the agricultural output value (at constant 1960-61 prices). Further analysis showed that even the compound growth rate[3] of the output value at 1960-61 prices was very small, i. e., only 0.6 percent per annum during period I and 1.80 percent per annum during period II. This would lead us to believe that there was something wrong with the specification of this variable. In fact, output value at constant prices gives real value only if the prices of all commodities vary in the same proportion. But if we study the relative changes in prices of the various agricultural commodities over time, we find wide inter-commodity variability in these prices. The constant prices approach, therefore, ignores the relative change in commodity prices which affect the cropping pattern and ultimately the output value. To overcome this difficulty, the agricultural output value determined at current prices[4] was deflated by the Wholesale Price Index Numbers of Agricultural Commodities.[5] The resultant figures which also represent the output value in real terms gave slightly better results in terms of growth rates. And this represented the dependant variable in the sub-

3. These growth rates have been obtained by fitting the relationship $Y=AB^t$ (where Y=output value, and $B=1+\frac{r}{100}$) and $r=(B-1)\times 100$ is the growth rate, t=time variable.

4. Agricultural crop output values at current prices were collected from the unpublished records of State-wise time-series data compiled by the National Income Unit of the Central Statistical Organisation, Government of India, New Delhi.

5. The compound growth rate of Y can also be determined from the expression $Y=\frac{X}{P}\times 100$ where X is the output value at current prices, Y is the output value in real term. Here $Y=\frac{1}{Y}\frac{dy}{dt}=X-P$, compound growth rate of Y. P denotes the Whole Sale Price Index Numbers of Agricultural Commodities.

sequent analysis. The linear[6] and compound growth rates are presented in Table 2. Linear growth rates show the average annual increase in absolute terms whereas the compound growth rates give the increase in relative terms only. Both these growth rates served different purpose and have different interpretation. A compound growth rate may be low due to higher base. So this alone gives incomplete picture of the growth pattern between two time periods. The results need to be supported by the linear growth rates.

Table 2: Linear and Compound Growth Rates

Variable	Unit	Period I		Period II	
		Linear $\left(\frac{dx}{dt}\right)$	Compound $\left(\frac{1}{x}\frac{dx}{dt}\times 100\right)$	Linear $\left(\frac{dx}{dt}\right)$	Compound $\left(\frac{1}{x}\frac{dx}{dt}\times 100\right)$
X_1 or Y : Output Value at Constant Prices	Rs. Million	82.802	1.91	96 152	2.00
X_2 : Net Sown Area	Thousand Hectares	174.68	2 20	227.15	2.70
X_3 : Proportion of Irrigated Area	Proportion	0.01	6.54	0.0045	1.81
X_4 : Number of Tractors	Number	634.41	31 23	1490.84	15.62
X_5 : Number of Draught Bovines	Thousand Numbers	319.49	6.39	− 8.45	− 0.17
X_6 : Number of Male Agricultural Workers	Number of persons	294.08	5.63	140.42	2.32
X_7 : Fertiliser Value at Constant 1972-73 Prices	Rs. Million	23.141	45.00	54.833	16.97
X_8 : Rainfall	Millimeters	−0.0144	−0.0270	−0.27	−0.27
9. Index Number of Whole Sale Prices of Agricultural Commodities			8.44		3.25
10. Output Value at Variable Prices	Rs. Million		10.35		5.25
11. Output Value at 1960-61 Prices	Rs. Million		−0.61		1.80

6. These are the derived linear growth rates given by $\frac{dy}{dt} = Y\bar{Y}$ where Y is replaced by its mean value.

For the pre-green revolution period, the agricultural output value increased at the compound growth rate of 1.91 percent per annum and the average annual increase worked out to be Rs. 82.802 million. These growth rates were lower than those of the post-green revolution period, when the compound growth rate was 2.00 percent per annum and linear growth rate was Rs. 95.152 million per annum.

Despite the technological changes characterised mainly by the use of High Yielding Varieties of seeds in the case of wheat, bajra, rice, maize and jowar after the mid-sixties, the growth rate of the agricultural commodities, as a whole, has not experienced much acceleration.

The growth rate of net sown area increased from 2.20 percent in period I to 2.70 in period II. However, the green revolution resulted in the fall of growth rates for male agricultural workers from 5.63 percent to 2.32 percent and for draught bovines from 6.39 percent to —0.17 percent per annum. The fertiliser consumption increased at a growth rate of 16.97 percent in period II and 45.00 percent in period I. This, however, does not imply that the fertiliser consumption was lowered in the second period. In fact, average annual increase in the consumption of fertiliser use was Rs. 23.14 million in period I but Rs. 54.83 million in period II. All that happened was that fertiliser consumption level being very low in the beginning of the period 1960-61 to 1964-65, the compound growth rate was higher in period I.

Contrary to the expectations, the growth rate of the proportion of irrigated area declined during the second period. Again, tractor population increased from period I to period II but the compound growth rate declined from 31.23 percent to 15.62 percent. Average annual increase in the tractor population worked out to be 634 tractors in period I and 1491 in period II.

Functional Analysis : The preceding section describes the growth of agricultural output and of the specified inputs. The importance and impact of these variables varied from time to time and it was, therefore, necessary to examine the change in the contribution of various factors from the pre-green revolution period (represented by the years 1960-61 to 1964-65, Dummy variable D=0) and the post-green revolution period (1967-68 to 1972-73, D=1).

In this analysis, slope dummies were introduced to examine the period—specific changes in the effects of individual variables. A time variable t, was also used explicitly in the model to account for trend component. Both linear and log-linear models were used.

Owing to the multicollinearity problem, all the factors and their slope dummies could not be included in the production function. It will be seen that bullock labour represented by the number of draught bovines (X_5) being mostly tied up with the human labour (represented by the number of male agricultural workers, (X_6), it gave a high correlation of 0.9436 with human labour. The inclusion of both these variables in the production function resulted in large sampling variances of the estimates of coefficients, thus making them non-significant. The step-wise residual analysis was used to overcome the problem of multicollinearity. First four steps of this method selected the variables X_6, X_3, X_2, and X_7. These four variables explained about 87 percent of the variation in Y. The same technique was used for the selection of coefficient dummies.

Log-linear form turned out to be better fit in this case. The results of the subsequent sections are, therefore, based on the CD Model in which the elasticity of substitution is unity.

The estimated structural equation gave the following results :

$$\log Y = \underset{(0.0241)}{0.009913} + \underset{(0.0582)}{0.28151^{**}} \log X_2 + \underset{(0.0398)}{0.1401^{**}} \log X_3 + \underset{(0.0628)}{0.4635^{**}}$$

$$\log X_6 + \underset{(0.0046)}{0.0696} \log X_7 - \underset{(0.0057)}{0.0040} D \log X_6 +$$

$$+ \underset{(0.0314)}{0.0928} D \log X_7 + \underset{(0.0031)}{0.0028} t \log 10^e \qquad \ldots\ldots(9)$$

$P^2 = 0.8998^{**}$, $\qquad \bar{R}^2 = 0.8957$

$\rho = 0.00033$ (N. S)

$\bar{R}^2$ = Autocorrelation Coefficient.

$= 1 - \frac{(1-R^2)(N-1)}{N-K-1}$ where N is the number of independent variables.

Figure in parentheses denote standard errors.

Durbin—Watson 'd'=2.0

N=176

Here Y=Agricultural output value at constant prices (Rs. lakhs).

X_2=Net sown area (thousand hectares)

X_3=Proportion of irrigated area to net sown area.

X_6=Human labour (Number of persons)

X_7=Fertiliser value (Rs. lakhs)

t=Time variable

D= Dummy variable which takes the value zero for period I and unity for period II.

The Durbin-Watson test revealed the absence of serial dependence of residuals. Fairly high R^2 value suggested reasonably good fit. Ninety percent of the variation in log Y was explained by the independent variables included in the functional relationship.

The coefficients of slope dummies for X_2 and X_3, though positive in signs, were not significant in the trial functions, and were, therefore, deleted from the final function. This would suggest that the impact of net sown area and the proportion of irrigated area did not change overtime and, therefore, the elasticity coefficients of 0.2815 for the net sown area and 0.1401 for the proportion of irrigated area remained the same over the two periods. It may be further noted that these elasticities were significantly different from zero, which means that these factors were important for expanding output, although their impact did not change from the first period to the second period.

The elasticities for human labour and fertiliser value were positive and significant in the first period. The impact of these variables has undergone a significant change from the first period to the second period. The elasticity for human labour (X_6) declined to 0.4595 in the second period but it was still positive. Fertilisers gave positive shift of 0.0928 (significant) in the elasticity coefficient.

Sum of the elasictities was 0.9547 in period I and 1.0435 in period II indicating constant returns to scale in both the time periods.

Factor Share in Output : Since the functional relationship given above is homogeneous of degree one at a point of time, the factor shares of output values are proportional to the factor elasticities. Relative shares of output accruing to various factors were worked out and the results are presented in Table 3.

Table 3 : Factor Share in Output

	Period I		*Period II*	
	Elasticity	*Factor Share (Rs. Million)*	*Elasticity*	*Factor Share (Rs. Million)*
X_2: Net Sown Area	0.2815	1278.447 (25.40)	0.2815	1283.602 (24 98)
X_3: Proportion of Irrigated area	0.1401	809.380 (18.67)	0.1401	638 946 (13.43)
X_6: Human Labour	0.4635	2104.734 (48.55)	0.4595	3094.773 (46.03)
X_7: Fertilizer Value	0.0696	316.035 (7.20)	0.1624	740.283 (15.56)
Total	0.9547	4335.189 (100.00)	1.0435	5395 627 (100.00)

Figures in parentheses denote the percentage share.

It can be seen that the highest contribution to the dependent variable was made by human labour, followed by net sown area in both the periods. The share due to fertilisers, however, increased from 7.29 percent in period I to 15.56 in period II.

The results show that there is a decline in the relative share of output accruing to land but the absolute share has, nevertheless, risen from 12784.47 to 12836.02 (Lakhs of rupees) owing to the increased demand for land consequent to the increased profitability of investment in modern inputs complementary to it. Land-augmenting technological change, however, should result in a decline in the relative as well as absolute share of land in output.

Labour-substituting technological change or farm mechanisation, other things remaining equal, have resulted in the reduction of the share of labour in absolute as well as relative farm. Labour share declined from 48.55 percent to 46.03 percent and the absolute share decreased from 2104.734 to 2094,773 in million rupees.

Factor Shares in Output Growth : Making use of the production function estimated above and the expression (7) the relative share of quantitative changes in each factor, and qualitative changes of all factors pooled, in the growth of output were derived for the two time periods and the results are presented in Table 4. Quantitative changes in fertilizer and human labour had highest shares in the growth rate of agricultural output in both time periods. Next in importance was irrigated area in period I, but the net sown area in period II.

Table 4 : Factor Share in Output Growth (Within Periods)

Due to	*Relative Share (in percentage)*	
	Period I	*Period II*
Quantitative changes in X_2	19.48	12 98
X_3	28.83	4.33
X_6	82.10	18.20
X_7	98.54	47.05
Total	224.94	82,56
Qualitative changes in X_2, X_3, X_6, X_7	—139.5	7.37
Efficiency of Technology	0.09	0.05
Omitted Variables	10.02	10.02
Total	100.00	100.00

Qualitative changes in the inputs discussed above had negative share in the growth rate of output in the first period, but the introduction of the High Yielding Varieties in the second period led to a positive share of 7.37 percent. The omitted variables accounted for 10 percent of the output growth rate in both the periods.

Irrigation is, no doubt, an important factor of production as indicated by the significance of the elasticity coefficient, but the results show that its growth rate contributed very little to the growth rate of agricultural output in the second period. It is because the proportion of irrigated area has not grown much over the study period, whereas the change has come up in terms of the intensity of irrigation which again is reflected through the share of qualitative changes.

An attempt was also made to work out the effects of qualitative and quantitative changes in inputs on the change in output between the two periods. Output increased from 4335.189 in period I to 5395.627 (in million rupees) in period II. The results showed that 45.40 percent of this increase in output was due to the qualitative effects of variables whereas 54.60 percent was due to the quantitative changes in variables. Earlier results regarding quantitative and qualitative changes and their share in the output growth should not to be confused with these results because the earlier results revealed the changes and shares within the two time periods whereas the present discussion deals with the impact of qualitative and quantitative changes between the periods.

Qualitative changes may be entirely attributed to the investment in agricultural research and development in India. However, the quantitative changes are partly due to this research variables and partly due to the general increasing trend in the use of these variables which will be present even when no research investments are made. Since the trend term is already incorporated in the production function to capture the effects of the general trend in the input variables as well as the efficiency of technology, the estimated output change can be corrected for the trend component and the resultant output change can be entirely attributed to research and development expenditure. □

Plant Breeding for a Changing Agriculture

H. K. Jain*

Concept of Harvest Index

The need for improving the plant type arises from the fact that many of our crop plants continue to retain several semi-wild characteristics such as an indeterminate and spreading growth habit, late maturity and poor harvest index. Harvest index measures the proportion of the grains or the economic yield relative to the total dry matter production. Thus, harvest index can be estimated as follows :

$$\text{Harvest Index} = \frac{\text{Grain yield or economic yield}}{\text{Total plant weight or biological yield}} \times 100$$

The term harvest index has been coined by the Australian crop physiologist Donald (1962) based on the ideas of Nichiporovich (1934) and Archibold (1945). Harvest index can be estimated on a single plant basis as well as on a unit area basis. It follows from this ratio that grains yield is the product of biological yield and harvest index. It also follows that the high-yielding varieties are those which show a high level of dry matter production combined with a high harvest index. It has not been possible, in most cases, to quantify an improved plant type but it seems clear that a high harvest index constitutes one of the important components of such a type.

Another important characteristic of an improved plant type is relative insensitivity to photo-periodic conditions. This makes it possible to extend the cultivation of a variety both in space and in time. We, in India, are particularly anxious to develop photo-and thermo-insensitive varieties because one of our major strategies for increasing agricultural production is multiple cropping. Short duration varieties whose sowing dates can be adjusted lend themselves well to such cropping systems. The concept of improved plant type has paid especially rich dividends in the case of wheat and rice, and it is now being extended to other crops like the grain legumes.

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Harvest Index in Wheat

The contribution made in recent years by the dwarf varieties of wheat developed by Borlaug (1968) and also by Vogel and his colleagues (1955) is well recognised. Thus, the introduction and development of these varieties in India during the last 9 years has helped to increase production of wheat from nearly 12 million tonnes to more than 26 million tonnes.

Recently, Jain and Kulshreshtha (1976) made an analysis of the characters contributing to high grain yields in bread wheat. Their observations on the yield and some of its components in different groups of tall and dwarf varieties are summarised in Table 1. The D_1, D_2, D_3 groups of varieties show a decreasing order of column length.

Table 1 : Observations on yield and other characters*

Varieties	*Mean plot yield*		*Harvest index*	*No of effective tillers (per M^2)*	*Yield per hectare*	
	Economic (kg)	*Biological (kg)*			*Economic (kg)*	*Biological (kg)*
Tall						
240-1	2.58	8.57	30.10	418	5297	17597
280-1	2.03	6.87	30.24	284	4168	14106
306-1	2.08	7.22	28.85	391	4271	14325
HD 2021	2,48	8.35	30.45	354	5092	17145
NP 824	2,47	8.40	29.59	391	5071	17248
D_1						
220-1	2.35	7.60	30.86	489	4825	15605
234-1	3.13	8.60	36.54	463	6427	17659
239-1	2.87	8.37	34.38	493	5893	17186
255-2	3.12	8.00	39.03	499	6406	16427
Sonalika	3.12	8.82	35.37	476	6405	18073
D_2						
153-1	3.31	8.37	39.57	505	6782	17186
195-1	2,72	7.80	34.96	491	5573	16016
201	3,38	8.80	38.40	453	6940	18069
217-1	2.33	7.52	31.06	472	4784	15441
Sharbati Sonara	3.06	7.85	38.97	447	6270	16085
D_3						
4-2	2.85	6.97	40.98	488	5852	14312
29-1	3.12	7.40	40.69	514	6406	15195
77-1	3.02	6.90	41.31	488	6201	14168
108-1	2.91	7.35	38.63	584	5975	15092
Moti	3,25	8,05	40.48	600	6659	16495

*Adapted from Jain and Kulshreshtha 1976.

It was observed that the tall varieties differ from the three groups of dwarf varieties primarily in respect of their harvest index and number of effective tillers. The harvest index was found to show a continued increase with reduction in plant height. A correlation analysis showed that a strong positive correlation exists between grain yields and harvest index, while no such correlation is observed between biological yield and the grain yield. The higher harvest index of the dwarf varieties was contributed by their greater number of effective tillers, the two characters being positively correlated. It was concluded that the dwarf varieties owe their higher grain yields not only to their resistance to lodging under conditions of high fertility, but also to a more efficient partitioning of the dry matter in them. The *Norin* dwarfing genes, it became clear, contribute to the physiological efficiency of the plant by diverting more of the dry matter to the production of grains.

Jain and Kulshreshtha proposed that further advances in the yields of bread wheat must come from increased dry matter production. They were of the view that in an ideal set of varieties both harvest index and biological yield should show a significant positive correlation with the grain yield. Fortunately, in the case of bread wheat, it should be possible to increase dry matter production while maintaining the harvest index at a high level. This conclusion is based on the finding that no negative correlation exists in this plant between biological yield and harvest index.

Harvest Index in Maize

Jain and his colleagues (1976) have attempted a similar analysis of yield in the case of the maize plant. The situation here was found to be very different. In the case of the high-yielding hybrids and synthetic strains of maize, it was found to be very different. In the case of the high yielding hybrids and synthetic strains of maize, it was found that the character which shows the largest correlation with grain yield is not the harvest index but the biological yield. In other words, the maize plant is not as efficient as bread wheat in the partitioning of dry matter for higher grain production.

It was concluded that further improvement in the yields of maize should come from selection for a higher harvest index, keeping the dry matter production at a high level. This, however, may present considerable difficulty. In maize, unlike wheat, a negative correlation was observed between harvest index and the biological yield so that the one parameter cannot be increased without decreasing the other. However, there are no fundamental reasons to believe that this negative correlation cannot be broken. Extensive hybridisation programmes should lead to the identification of genetic backgrounds in which this negative correlation is greatly weakened. Already there is evidence that the temperate varieties of maize are far more efficient in the partitioning of their dry matter than the tropical varieties. The harvest index in the former is much higher. On the other hand, the tropical types show a higher level of dry matter production. We, thus, do have the kind of genetic stocks needed to synthesize the optimum combination of high harvest index and dry matter production. The relatively low harvest index of the tropical maize plant appears to be a function of its limited sink capacity. Unlike wheat, the maize plant fails to produce tillers and although the plant is large in size, it produces in most cases only a single cob.

Harvest Index in Rice

While no data are available to establish that the new, dwarf, high-yielding rice cultivators, e. g. *Jamuna, Improved Sabarmati, Pusa 2-21* etc., possess a higher harvest index, their growth habit and yield characteristics are indicative of it.

Harvest index in Grain legumes

The need for improving the plant type in grain legumes can be more readily understood. These crops have been grown for centuries under stress conditions with the result that they have been selected for those characteristics which are of adaptive values under such conditions. For example, many of the pulse crops show a profuse vegetative growth. Perhaps the best example of this is provided by pigeon pea (*Cajanus cajan*). Pigeon pea is the second most important pulse crop in India and most of the traditional varieties show extensive vegetative growth with dry matter yields of the order of 20 tons or more per hectare.

In terms of dry matter production, pigeon pea thus compares favourably with the best of the spring wheat varieties. Table 2 shows the dry matter production, grain yields and harvest index of some of the commonly-grown pigeon pea and chick pea varieties in India together with those of wheat. It is clear that the main reason for the lower grain yields of the two pulse crops is their lower harvest index and not their photosynthetic efficiency which appears to be quite high. Based on considerations of this nature plant breeders in India in recent years have tried to develop pigeon pea varieties which are more compact, show reduced vegetative growth, respond to increased plant populations and have a higher harvest index. As a result of this work, it has been possible to develop a number

Table 2 : Yield (Quintals/hectare) and Harvest index in wheat, pigeon pea and chick pea varieties of comparable maturity duration.*

Crop	*Wheat*	*Biological yield (harvested dry) matters)*	*Harvest index*	*Economic yield (grain yield)*
Wheat	Kalyansona	162.58	36.19	58.86
	p4-2	142 82	40.98	55.12
Pigeon pea	Pusa Ageti	102.20	16.40	16.77
	P2-31	121.07	8.70	10.55
Chick pea	Pusa 53	99.72	20.00	19.34
	C-35	121.66	30.00	36.66

*Based on Jain, 1975.

of improved varieties whose per day productivity is relatively high (Jeswani, 1970; Ramanujam, S. and Sharma A. K, 1971; Swaminathan and Jain, 1973; Jain, 1975). Some of these new pigeon pea varieties allow a plant population of nearly 100,000 per hectare to be raised in contrast to 45,000 plants of the older varieties.

Heterosis and Higher Harvest Index in Cotton

Some of the world's highest yielding varieties of upland cotton have been developed in the USSR. The soviet breeders at the Tashkent Cotton Research Institute have developed new plant types in cotton which show little or no branching and allow plant populations of 200,000 plants or more to be raised per hectare. This work has inspired cotton breeders all over the world to select similar plant types having a high harvest index. Another approach which has been successfully adopted for the improvement of the upland cotton in India in recent years has been the development of F_1 hybrids. The hybrid-4 strain of *Gossypium hirsutum* developed by Patel and his associates (Patel, 1973) has been reported to give a record yield of nearly 40-50 quintals of seed cotton per hectare and it already covers thousands of hectares in the western part of the country. One of the remarkable features of hybrid-4 cotton is its very high harvest index. Although, the plant shows an indeterminate growth habit, it continues to produce balls with a great profusion throughout the flowering season. The exploitation of heterosis in cotton has shown that improvement in plant type and a high harvest index need not always be associated with photo-insensitivity.

Breeding of high-yielding varieties for an intensive kind of agriculture is a relatively recent development in Indian agriculture. The work was started about 15 years ago with the development of high-yielding hybrids of maize, sorghum and pearl millet. In more recent years, significant advances have been made in developing dwarf varieties of wheat and rice which show excellent response to conditions of high fertility and give very high yields. Encouraged by the success achieved in these crops, the Indian plant breeders are engaged at present in the preocess of diversification of the high yielding varieties development programme including the oilseeds, industrial and other crops. From a purely scientific standpoint there appears to be no reason why high-yielding varieties similar to those in wheat and rice cannot be produced in all these different groups of crop plants. □

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Systems Application in Agricultural Research Direction

J. B. Dent*

Systems analysis or systems research, as it more properly should be, represents an approach to solving complex problems. The basic hypothesis is that the system—whether it is defined as the physiological system of a plant, or the agricultural sector of an economy—cannot properly be understood by isolated study of the bits (or components) that make up the system. This is because the inter-relationships between the components of a system are so important—always the whole system is more complex and more comprehensive than the sum of the individual components. This is the simple common-sense basis for Systems Research which the author believes is obvious and about which there can be little disagreement.

Most of the important characteristics of agricultural and biological systems are associated with their dynamics : their constant change under the influence of climate, general environment, man's interference (management) and natural processes of development and change. *Systems research has built up a series of techniques aimed to study such dynamics* in the belief that closer understanding leads to better management and control and more possibilities for development. The most fundamental technique is that of model building. A model which mimics the behaviour of the defined system is constructed so that the system can be studied vicariously and more readily. Because of the important dynamics to be represented (and because of the uncertainties associated with agricultural and biological systems) such models will normally be of a variety known as simulation models.

Some of the reasons for creating such a model and setting it out as a computer programme are :

1. to objectively assess and assimilate the available data on the system platform for assembly of information.

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2. to assist in the better understanding of the functioning of the system.

3. to assist in the management or development of the system.

But such detailed models have also proved useful in research direction.

Applied Research

When our concern is the direction of applied research, the systems to which the research is pertinent will usually be at farm, (typical) region or command area level. The model will attempt to represent that system bringing all relevant data together, for example, on:

1. technological data for crop and animal science.
2. the area of the region and the number of different farming areas (defined by soil type and climate) and the number of farms in each of these areas.
3. the attitude of farmers in these areas to the adoption of new technology and their overall objectives.
4. the present level of farming skills.
5. the availability of credit and the attitude to borrowing.

The creation of the model forces a quantitative evaluation of our knowledge about the components of the system and in so doing locates areas where there is lack of understanding and hence where research is needed.

But more than this, once the model has been completed, it permits a detailed exploration of the system *via* the model—by Sensitivity Analysis. This permits the location of areas of the system to which the important parameters of performance are sensitive; these may be, for example :

1. agricultural output from the defined system.
2. income levels for various farming groups.
3. level of employment in the various areas of the region.

By implication, such sensitive areas should be the ones which are well understood and, therefore, represent areas where more research would be helpful. Obviously such areas can be ranked in order of sensitivity giving a first listing of research priorities. The operation is summarised in Fig. 1.

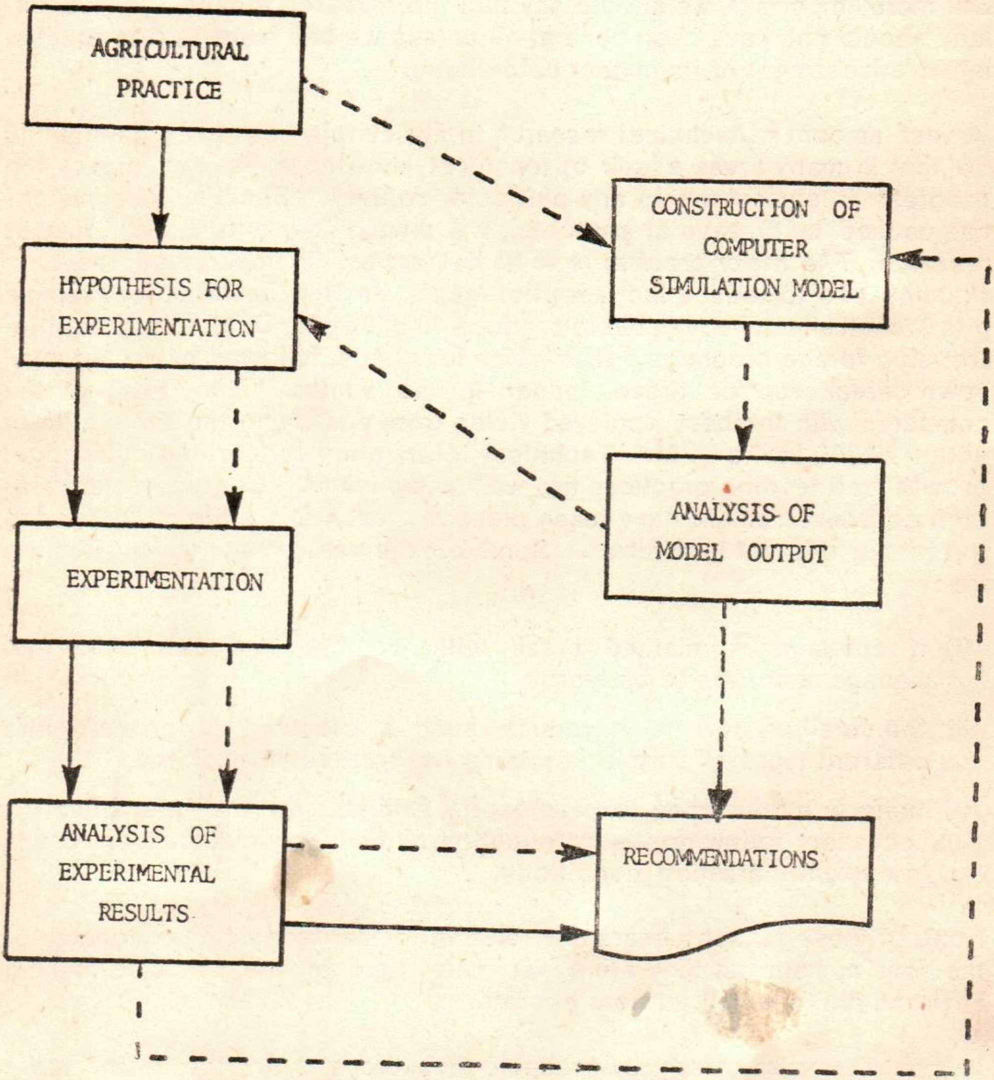

Fig. 1 : Conceptual View of Alternative Research and Extension Approaches

It will be observed that once an acceptable model has been established it is a perfect vehicle with which to explore the likely impact of any new technology on that particular system's performance parameters.

But more important, we should say that the research for the new technology should not have been done at all unless we had made a firm quantitative assessment of its impact beforehand.

A vast amount of technical research in agriculture has been completed so that in many areas a lack of technical knowledge is not preventing progress in agriculture in any particular country. Specific circumstances caused by disease or pest, etc., will always demand urgent further research. *The major problem* is to assist farmers to understand research findings and to reduce the 'adoption-gap'. In New Zealand, for example it is technically quite feasible to produce 40,000 kg/ha D. M. from a double-cropping forage programme with maize for silage, followed by an autumn-sown cereal crop for green fodder in the winter. This total output compares with the best achieved yields from pasture in the same area of about 12,000 kg/ha D. M. Technical information concerning cultivation, growth and feeding practices are well established. Considerable research and development have taken place to reach this state of knowledge but farmer interest is minimal. Some of the reasons for this situation are :

(i) it represents a marked break with tradition and new skills and management have to be learnt,

(ii) the detail of how to introduce such a cropping programme into different types of farming systems has not been explored,

(iii) there is a reluctance to make capital available for the intensification necessary following the introduction of the high-yielding forage crops in current marketing conditions.

None of these reasons bears any relation to the technical adequacy of the development but they are a very real part of the decision-making environment in which farmers operate.

In most countries, presently-available technology is, in the main, more than adequate to service the farming industry for some years into the future. It is now important to concentrate on how this information gets through to the farming community and what will aid and what will be the result of its introduction into farming systems. There is likely to be a strong case in many situations for a redeployment of finance from applied research and development in agricultural to research and practice in extension. Indeed, in many countries this redeployment has already begun.

Such arguments throw even more responsibility on the applied research worker, and particularly on those directing this research, to ensure that effective programmes are developed—programmes which are pertinent to the felt problems of the farming community. Technical researchers must increasingly be prepared to have their findings assessed in their socio-economic environment.

This same environment must assist in the development of the technical programme of work and the only feasible way in which this can be objectively achieved is through linking of systems approach with technical research.

In the above context, it may be worthwhile here to refer to a recent quotation by an Australian Professor :

> "If we are producing a great deal of unusable research it means we are choosing the wrong problems. If we are producing a great deal of usable but unused research, this means we are researching beyond the absorptive capacity of the industry."

Fundamental Research

The author is a firm believer in the need for fundamental research and its underpinning of the applied research and development process. However, he also believes that a similar concept to that expounded for applied research can apply to fundamental research.

Of course, the system defined in this situation will be at a different level of aggregation: it will be set at biological, physiological, biochemical, etc., levels. The model of such systems will also be of a different form, being mechanistic in nature so that the detailed theoretical concepts and basic data can be used directly in its construction. But we will still be attempting to represent the essential dynamics of these systems, their rates of change and the factors influencing the rates of change.

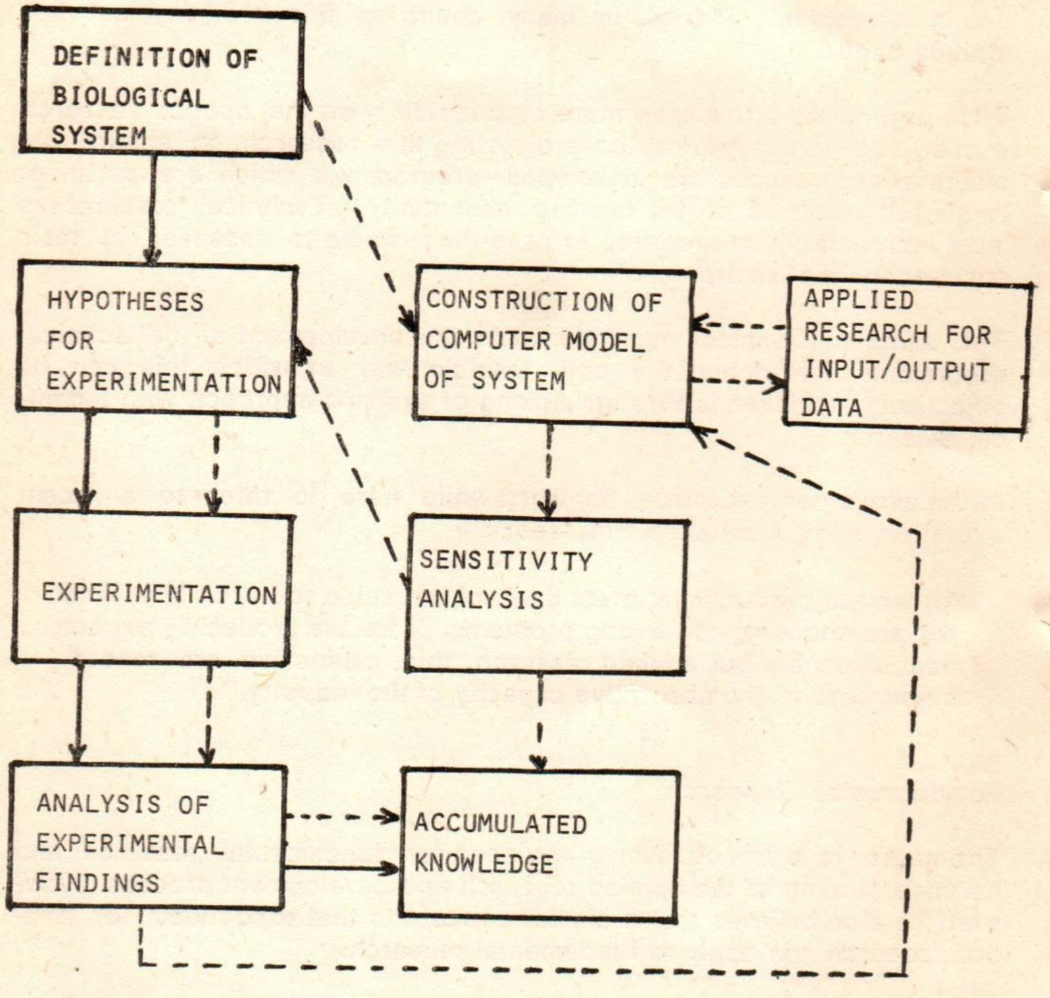

Fig. 2 : Conceptual View of the Role of Systems Modelling in Fundamental and Applied Research in Agriculture.

Recent evidence strongly suggests that guidance of fundamental research in this way is effective in directing programmes to areas of specific data deficiency or in opening up entirely new research directions stemming from a more complete understanding of the whole biological system.

A few examples will help:

1. Perhaps one of the most important areas restricting the understanding and development of ruminant production systems is that of feed intake. The concepts are still not finalised but the modelling work of Mertens (1973) on the kinetics of cell wall digestion opened up the field of research and directed research into the essential areas of rates of food passage and food particle size as important determinants of food intake.

2. The modelling work of Bywater (1976) has shown that our knowledge of endogenous glucose synthesis during early lactation (when the animal is using feed reserves to supplement ingested food) is totally deficient. This period of lactation is, of course, crucial to efficient milk production and yet it transpires that the basic nutritional components are not even conceptualised.

Part of the immense pay-off from this detailed biological modeling is that once fully validated, the model can itself be used as an experimental medium to create some input/output data—data commonly associated with applied research.

Througout the world a great deal of cost and effort is spent on applied research (perhaps, as suggested earlier, too much). For much of the crop and livestook work, experimental diffculties in generating meaningful data and interpreting them for farming practice are conveniently suppressed.

Some of the problems are:

(a) the variation of results from field experimentation between seasons and between regions.

(b) the time required to complete a trial.

(c) the cost in conducting such trials.

(d) the interseasonal interactions.

(e) the deficiencies of measuring techniques.

(f) the inability to handle enough treatments with appropriate control.

The author is of the opinion that the potential in this direction is great and in due course should make significant differences to the total approach to applied research (as well as fundamental research). This belief may seem optimistic; but consider, for example, the situation presently existing in milk production. Even the first question, when we look for reliable feed input/milk output data—that of how much of different feed types the cow will actually consume if offered them. This would be an enormously costly and time-consuming applied experimental programme, which is why it has never been attempted.

Consider the present need to evaluate the use of crop byproducts in ruminant production throughout the world. Applied research programmes in such areas as the possible use of new forage crops and the exploration of conservation method are beyond present research capability—not in regard to technical competence (at least not totally) but in relation to the time and resources required.

While the wide use of appropriately-structured biological systems models nurtured on guided fundamental research to generate input/output data for farm system planning may be a little way in the future, it should be understood that progress towards appropriate models is progressing in a number of disciplinary areas. The potential should be in *influencing decisions made now* about research resource deployment.

Finally, it should be emphasised that the process of system integration with applied and fundamental research is now a process which takes research away from the traditional scientist. Rather, it gives more weight to his arm and at the same time extends his involvement in the socio-economic-political field in as objective a way as possible. □

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Impact of Fertilisers on Agricultural Production and Productivity

S. Seetharaman*

Production of foodgrains (cereals and pulses) in India which was around 52 million tonnes in 1951-52 reached an impressive level of 121 million tonnes in 1975-76. Even in respect of cereals alone, the growth is no less striking—from 44 million tonnes in 1951-52 to nearly 108 million tonnes in 1975-76.

Admittedly, several factors contributed to this tremendous increase in foodgrain production. Increase in irrigation facilities through major and minor irrigation projects and better exploitation of water resources; increase in gross cropped area made possible by increased irrigation facilities and multiple cropping; adoption of improved agro-techniques in dry land areas; large-scale cultivation of fertiliser-responsive high-yielding varieties of crops which were introduced in 1966-67 and increase in fertiliser consumption have all contributed to this happy situation, to mention only a few.

It would not, however, be quite correct to consider these factors in isolation for the purpose of studying their relative impact on agricultural production as these are very closely interlinked. For example, whether in the absence of increase in irrigation facilities and large scale cultivation of high-yielding varieties, fertiliser consumption would have reached the present levels is a moot point. Suffice it to say, that even with adequate irrigation facilities and use of improved varieties of seed, the present level of agricultural production would not have been possible but for increased use of plant foods in the form of manures and fertilisers.

It is well recognised that amongst the various inputs in agriculture, fertiliser plays a key role. It makes a direct addition to the fertility of the soil and is capable of application under proper guidance to almost any soil or crop. Further, the use of fertiliser is the signal for improvements in all the various aspects of crop husbandry. Fertiliser being the most costly input, a farmer using it would naturally try to use the

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best available seed, as well as pesticides to protect his crop, so as to get the most out of his investment in fertiliser. Fertiliser use can thus trigger a chain reaction transforming agriculture into a modern, commercial high-yield agriculture.

Historical Perspective

Even though fertilisers were being applied on a limited scale from the early years of this century to plantation crops like tea and coffee and to sugarcane, particularly in the south, little progress was made in their use on food crops till the 1950's. Even in the case of those crops which received fertilisers, the accent was mainly on fertiliser nitrogen. It was only from the early 1950's, i. e., the dawn of the development era that fertiliser application to food and commercial crops came to be recognised and increasingly adopted as an essential agricultural practice in India.

It may be recalled that during the first two Five-Year Plans, comparatively little attention was paid to the agricultural sector and it was only with the launching of the Third plan, that concerted effort was made to improve this sector. It would, therefore, be appropriate to trace the developments in agricultural production *vis-a-vis* fertiliser consumption from 1960-61, representing the last year of the second Five-Year Plan, up to the present.

Fertiliser Use : 1960-61 to 1975-76

In Table 1 is presented the year-wise cereal grain production during the period 1960-61 to 1975-76. It may be seen that cereal production has increased by over 50 percent during the last 16 years.

Any study of the impact of fertiliser use on agricultural production presents considerable difficulties because of absence of reliable data on the quantity of fertiliser used for individual crops. Only very broad indications are available According to a study carried out in 1970-71 by the NCAER, of the total fertilisers consumed, nearly 70 percent is accounted for by foodgrain crops (cereals and pulses) and the remaining 30 percent by cash crops. Again, the same study had indicated that negligible quantities of fertilisers were being used on pulse crops.

This is due to the fact that pulses are grown mostly in dryland areas and normally, therefore, do not receive much fertilisers. While in individual states or districts, fertiliser use pattern have undergone some changes during the last five years, it is reasonable to assume that on an all-India basis the situation would have remained unchanged in this respect.

Table 1 : Cereal grain production and fertiliser consumption during 1960-61 to 1975-76

(In million tonnes)

Year	*Cereal production*	*Fertiliser consumption ($N+P_2O_5+K_2O$) on cereals**
1960-61	69.3	0.168
1961-62	70.9	0.237
1962-63	68.6	0.317
1963-64	70.6	0.381
1964-65	76.9	0.541
1965-66	62.4	0.549
1966-67	65.9	0.770
1967-68	82.9	1.180
1968-69	83 6	1.233
1969-70	87.8	1.887
1970-71	96.6	1.579
1971-72	94.1	1.859
1972-73	87.1	1.938
1973-74	94.7	1.987
1974-75	89.8	1.801
1975-76	107.7	1.928

*Seventy percent of the total fertilisers is assumed to have been consumed on cereal crops in all the years.

The quantity of fertilisers consumed in case of cereal foodgrains worked out on the above basis is also presented in Table 1. The data indicate that there was an impressive 11-fold increase in fertiliser consumption during the last one and a half decades. This represents compound annual growth rate of about 17.7% which is impressive by any standard, notwithstanding the low base level in 1960-61.

Even though the growth rates of fertiliser consumption and foodgrain production are quantitatively different, an attempt has been made to study the relationship between fertiliser consumption and production of cereal foodgrains in the time series of 16 years. A significant correlation ($r^2=+0.79$) has emeraged which indicated a very close association between these two variables. It can, therefore, be safely argued that to enable the country to produce more foodgrains, increasing consumption of fertilisers is essential.

As regards agricultural productivity represented by yields per hectare, the impact of fertilisers is more difficult to assess in the absence of cropwise consumption data. However, a reference to Table 2 would clearly indicate that greater the fertiliser consumption per unit area, higher are the yield levels.

Table 2: Fertiliser consumption per hectare and productivity (yield per hectare) of Wheat and Rice in selected states

	Fertiliser consumption per hectare ($N+P_2O_5+K_2O$)		*Yield per hectare*	
	1974-75	*1975-76*	*1974-75*	*1975-76*
WHEAT				
Punjab	42.9	49.9	2,360	2,375
Uttar Pradesh	17.8	21.1	1,174	1,333
Bihar	11.3	12.0	1,353	1,265
Madhya Pradesh	4.7	5.4	844	846
RICE				
Tamil Nadu	31.8	37.1	1,855	2,182
Andhra Pradesh	24.9	29.0	1,604	1,657
Kerala	22.4	21.0	1,513	1,543
West Bengal	17.7	18.3	1,207	1,253

This conclusion is of great importance. Scope for extending the area under cultivation is limited in India due to alternative and competing demands on land use. Our growing needs of agricultural produce has to be met from the limited area already under cultivation, maybe with only marginal additions. This can only be achieved by increasing yields per unit of cropped area. We have to extend further the concept of intensive cultivation involving the adoption of modern technology in which fertiliser use plays a major role. We have to use larger quantities of balanced fertilisers to meet our future targets of agricultural production.

Fertiliser Consumption Projections

The Fertiliser Association of India prepared in 1976, projections of the likely fertiliser consumption levels up to 1983-84. The quadratic equation levels on time series 1961-62 to 1975-76 appeared to provide the closest fit, provided the abnormal consumption years in the series were ignored. For the purpose of this exercise, the consumption years ignored were 1972-73, 1973-74 and 1974-75 for N and 1974-75 and 1975-76 for both P_2O_5 and K_2O.

The quadratic projections that emerged from the exercise are given in Table 3.

Table 3: FAI Consumption Estimates 1976-77 to 1983-84

Year	*N*	*P_2O_5*	*K_2O*	*Total*
1976-77	2,466	679	400	3,545
1977-78	2,826	740	448	4,014
1978-79	3,214	801	498	4,513
1979-80	3,630	865	550	5,045
1980-81	4,074	929	605	5,608
1981-82	4,545	995	663	6,203
1982-83	5,044	1,063	724	6,831
1983-84	5,572	1,132	787	7,491

The National Commission on Agriculture has estimated that even at the 'low level' of demand, foodgrain requirements by 1985 would be about 150 million tonnes. This, in the Commission's view, would necessitate fertiliser consumption of the order of 7 million tonnes. On the other hand, if the Planning Commission's estimates of 163 million tonnes by 1985 are accepted, again according to the National Commission, fertiliser consumption would have to be stepped up to 9 million tonnes. These figures are indicative of the importance of stepping up fertiliser consumption in the next few years. If past trends are any guide, the demand projections given in Table 3 should not sound unduly optimistic and there is every hope that our foodgrain targets would be fulfilled. □

Post-Harvest Operations

B. R. Birewar*

While the quantitative increase in foodgrain production has been attained through improved pre-harvest agricultural techniques, there is also a need of equal importance to preserve the quality and quantity of the foodgrains produced and to avoid the losses during post-harvest operations which are estimated to be of the order of nearly 10 percent. The total production of foodgrains was estimated as 114.00 million tonnes in the year 1974-75. The post-harvest problems like threshing, transport and handling, storage, processing and marketing have tremendously increased in the country.

It is revealed from previous studies that 30-40 percent of the grain produced in the country is handled by the government agencies and traders while 60 to 70 percent of the grain is retained by the farmers in rural areas. But due emphasis was not given during the earlier period to improving the storage facilities at farmer level. The prevention of waste and loss of foodgrains at post-harvest is best achieved in the process of threshing, drying, storage, milling and handling and transportation.

Productivity in Grain Handling, Transportation, Storage and Distribution

Handling : The grain is usually stored either in bags or bulk. In a large quantity grain-storage installation, in order to improve the efficiency in operation, adequate mechanical grain handling facility is needed to be provided. Although suitable mechanical grain handling facility provided in a bulk storage installation adds nearly 40% to the initial cost yet it reduces the operational cost and at the same time improves the efficiency. From the studies conducted in loading and unloading operations of hexagonal brick masonry bins in Punjab through suitable grain handling equipment against manual operations, it is observed that the cost of operation has been reduced by 60 to 70 percent. In general, mechanical method of handling of grain has also other advantages, like (i) it

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saves time and labour, and (ii) spillage losses of grain in handling is comparatively reduced.

The handling of bulk grain in rice mills involves the movement of large quantities of materials in both the horizontal and vertical directions. The performance of a processing plant is measurably effected by the efficiency of the movements of materials from one unit of operation to another. The conveying equipment must be selected and sized to meet the requirements of each particular operation. A conveyor is a mechanism that moves material from one location to another in a continuous manner. Bulk grain handling system utilises one or more of the following types of conveying equipments : (i) screw conveyor, (ii) chain conveyor (iii) belt conveyor, (iv) bucket elevator, (v) pneumatic conveyor, (vi) gravity conveyor, and (vii) grain thrower.

When the grain is handled in bags, the provisions of c.c. ramps, brick masonry, raised platform and bag stackers would facilitate loading and unloading operation in the godown.

Transportation : The farmers usually transport the grain either in bulk or in bags. For long distance the grain is usually transported in bags either by rail wagons or road trucks. During transportation, there is a considerable loss of grain ranging up to 1%. There is an acute need in the country to provide adequate transportation system so as to avoid loss and damage to the foodgrain during transportation.

The improved method of tranportation of grain in bulk by road transport includes the use of road trucks with hydraulic tipping mechanism and truck or tractor mounted bulk grain hoppers. In the first case the truck has the rectangular container at the rear to carry nearly 10 tonnes grain and has the hydraulic machanism for tipping the loaded container to facilitate quick discharge of the grain. In the second case, a portable type steel container called hopper is mounted either on truck or tractor *trailer*. The hoppers are of different capacities and are provided with sloping floors and sliding type discharging outlets. There are a number of designs available with different capacities and grain discharging facilities.

The most common means of transportation of grain to long distances is by rail wagon. At the present, the grain is usually transported in bags by rail wagons. There are some improved designs of wagons used for transportation of grain in bulk. Such rail wagons are air-tight as well as moisture-proof and can preserve the quality of the grain during the period of transportation. Some of the designs of rail wagons are self emptying type with hoppers provided at the bottom for quick discharge of the grain. In another design, the door is provided at the rear end of the wagon. In this case the grain is allowed to be discharged from the rear end by tipping the rail wagon with heavy hydraulic ram, In certain designs, the doors are provided on both sides of the wagon. In such cases the grain is required to be discharged from the side by means of power shovels, mobile chain conveyor, etc.

Storage : A storage structure is a container constructed in such a manner as to prevent the entry of elements detrimental to the grain and to prevent the exit of elements beneficial to the storage of grain. Suitable design of storage structure is the important consideration to reduce grain storage losses during the period of storage.

While considering a facility for storage of grain at community or trader level, the basic decision that is needed to be taken is whether the grain is required to be stored in bulk or bags. This decision is dependent upon three basic considerations, namely the type of grain, the likely period of storage and whether the facility is meant exclusively for grain or for grain and other commodities as well.

Foodgrains stored in bags are relatively more susceptible to damage even with all the precautions taken. Under suitable dry climatic condition the grain can be held in bags in satisfactory condition, for maximum period up to two years, while the grain can be held in bulk practically without any damage for a period up to 5 years. The storage in bags is more flexible and requires lower capital cost than bulk storage. In bag storage structures, the utilisation of capacity is to the extent of 55 to 60 percent while in bulk storage it is 90 to 95 percent. The other relative merits of bulk storage are : (i) low running cost, (ii) rapid handling, (iii) low labour requirement, (iv) low losses through spillage, birds and rodents, (v) efficient and effective fumigation operation, (vi) less land area requirement, (vii) complete control on aeration, (viii) possible to store the grain for longer period, (ix) possible to mechanise the operations, and (x) possible to store moist grain.

Bulk handling and storage installations are not economically sound unless the storage capacity is about 1000 tonnes. The entire storage system may be designed in such a way that the cost of operation of the unit should be as low as possible.

The basic requirements of bag storage stuctures are : (i) maximum storage at the least cost; (ii) proper ventilation; (iii) high plinth for protection from sub-soil moisture and rodents; (iv) possibility to seal the godown for fumigation purposes; (v) floor which is capable of withstanding heavy loads, water proof, also facilitate sweeping and is free from pillars to facilitate stacking and fumigation; (vi) provision of platforms for the facility of loading and unloading of trucks or rail wagons, (vii) protected from birds, rodents, rats, and termite, (viii) proper sealing at the door openings and ventilators to prevent entry of rain water into the structure, and (ix) walls have a smooth finish without cracks and the sharp angles in the construction are avoided.

The basic requirements for bulk grain storage are : (i) moisture content of grain should be within the safe storage limit, (ii) temperature of the grain should be maintained as low as possible, (iii) grain should be cleaned and graded, (iv) grain should be free from infestsation, (v) a forced ventilation system must be introduced in the silo design, (vi) structures must be weather proof, constructed on firm water-impermeable foundations, and oriented advantageously with respect to solar radiation, and (vii) mechanical conveying system must be provided.

Generally, the farmers use low-cost, locally-available material for the construction of rural storage structures of different types, shapes and dimensions. A survey of the existing farm and rural storage structures revealed that the grain losses take place due to lack of application of scientific method of storage and use of improved storage structures. The Indian Grain Storage Institute, Hapur, has developed various designs of rural and urban types of bins using different materials and techniques for storage of different commodities of foodgrains like wheat, maize, paddy, pulses and seed grains.

In a hermetically-sealed, air-tight storage structure, moulds do not develop on damp grain and the grain remains mould-free. Similarly, insects get killed due to low oxygen concentration developed.

Milled rice deteriorates very rapidly under the normal method of storage. For its long period storage without losing its quality, rice is required to be stored at low temperature, preferably at 15° C. Under such method of storage (i) more than 80 percent germination can be maintained, (ii) damage due to insects and micro-organisms is reduced, (iii) fumigation operation is avoided, and (iv) quality of rice including taste is maintained for a long period.

Adequate storage facility is needed to be provided to maintain the viability of seed grain. The germination loss of seed grain is governed by the following factors : (i) weathering in the field, (ii) mechanical injury during harvesting and cleaning, (iii) heat damage during drying, (iv) fumigation, (v) seed treatment, and (vi) rodents, insects and moulds.

The selection of the kind of storage facility needed to be provided is influenced by the following :

1. Amount of seed to be stored.
2. Temperature and relative humidity of the area.
3. Kind of package or container to be used for the seed.
4. Period of seed storage.
5. Economic factors relating to the cost of construction.

Marketing : The conventional practice has been to carry the grain to bh sold to either the commission agent, the trader or miller who has been the hereditary buyer of the grain. This practice still continues in many areas where markets have not been regulated. In areas where the markets are regulated, it is obligatory that the produce is required to be sold by open auction under the supervision of market committee. In the market area, the grain is taken to the commission agent called *Kacha Adatia*. The agent provides the necessary facility for cleaning the grain and to secure a better price. Cleaning continues to be done manually and is generally not able to remove all foreign matter. Weighment is usually done of bags as facilities for bulk weighment do not exist in the markets. Apart from the use of hand-operated machines, power-operated machines are also used.

In the context of increased production and quick clearing of market products, bulk storage of grain and mechanisation of cleaning, weighing, bagging, stitching, handling and transportation operations have been considered to be necessary.

Grading becomes necessary where under-sized or over-sized grain has to be separated from the main grain. This is particularly effective where the market grain is required to be separated from the seed grain and similarly different varieties of grain are required to be separated from the mixture. Normally paddy is not graded prior to milling, but under certain circumstances the grading of paddy is desirable or even necessary. Grading has several advantages : (1) Immature grains are separated, (2) A more precise adjustment of the huller is possible, which minimises breakings, and (3) Independent milling of graded lots is possible. Grading of milled rice refers to the separation of brokens from the head rice. Grading is done by any one or a combination of different techniques, like shape separation, gravity separation, reflection separation, floatation separation, centrifugal force, magnetic force and elasticity.

The quality of the grain is determined by examining a small representative sample of the lot. For quality inspection it is essential that the sample be : (1) large enough to permit the required tests to be performed and (2) properly identified. The important factors determining quality are variety, moisture, dockage, milling yield, condition of grain and purity.

Rice, Wheat and Maize Mill Management

Milling is the trade name used for reduction of grains into flour or meal or any other consumable form for human beings or animals. In rice milling the term is used for removing husk or bran, retaining the grain shape. The objective in 'flour milling' is the preparation of a flour with nil or negligible bran content without emphasis on grain shape. The milling processes for three cereal crops namely rice, wheat and maize are indicated as below :

Rice Milling : Rice is the main cereal crop of India having the largest acreage under it. Paddy is milled to remove husk, bran, germ and the aleurone layer. Approximate recoveries of the various products are 20 percent husk, 6 to 8 percent bran, 2 percent germ and 70 to 72 percent milled rice. Rice is still traditionally processed by huller type rice mills.

The main disadvantage of the traditional Mills is the low yield of rice varying from 65 to 69 percent. Due to higher rice milling yield and better quality products, the modern rice milling technique is being adapted by the rice millers.

The modern rice mill includes the facility for (i) cleaning, (ii) shelling, (iii) husk removal, (iv) paddy separation, (v) whitening or polishing, (vi) removal of adhering bran and cooling, (vii) glazing, (viii) grading, and (ix) automatic weighing, bagging and conveying. In addition to the modern milling equipments it also includes the other facilities for mechanical drying of paddy, modern storage of paddy and rice and improved parboiling unit.

Necessary effort is being made in the country to improve the traditional milling technology, but the actual application and introduction of the modern mills have been rather slow. The main reason may be high capital and operational cost of the mill. Some of the following important problems need attention for wider application of rice milling technology :

1. To make available equipments and components at reasonably lower cost.
2. Adopting partial modernisation by introducing only roller type shellers.
3. Development and popularisation of low capacity mini-mill to replace the huller mills.
4. Economical and effective facility for drying and storage.
5. Reduction of processing cost in the production of parboiled rice. The reason for high processing cost is the use of expensive fuel in the drying process. Utilisation of cheap fuel like coal and solar energy should be exploited to reduce the cost of drying.

The parboiling process, developed by tradition in India and improved by various researchers, provides a unique tool for improving not only the milling quality but also other qualities of paddy. Parboiling of paddy requires three steps: soaking, steaming and drying. In the soaking, the void spaces in the husk and rice kernel are filled with water and the starch granules absorb water and swell which causes an increase in the volume of paddy. During steaming, soaked paddy is exposed to steam heat for a given duration and the starch present in the rice kernel is gelatinised.

Subsequently, the paddy is dried to 16 percent moisture content, which imparts the hardness that the grains require for milling. In general, the parboiling process has the following advantages : (iv) shelling is easier; (ii) extra strength acquired by the rice kernel helps to reduce the brokens; (iii) it retains more proteins, vitamins and minerals; (iv) it is more resistant to insect infestation during storage; (v) it withstands over-cooking; (vi) the loss of solids during cooking is less, and (vii) the bran contains more oil. It has the following disadvantages : (i) it takes more time to cook; (ii) it requires adequate facility for drying to reduce moisture from 45-50 percent to 14-16 percent; (iii) shelled rice is more difficult to polish; (iv) it may choke the polisher because of higher oil content of the bran; and (v) the parboiling process needs extra investment of capital.

The Government of India constituted a committee in the year 1966 to study and evaluate the overall performance of modern rice mills set up in the country and also to compare the relative performance of these mills with those traditional sheller and huller mills. The above study made by the committee revealed the following :

1. Average increase of rice outturn was found to be 2.5 percent over sheller type unit and 6.6 percent over huller units.

   In case of parboiled paddy the corresponding increase of rice yield was found to be 0.8 percent over the sheller mills and 1.6 percent over the huller units.

2. The average increase in head rice yield for raw paddy was found to be 6.1 percent over sheller mills and 15.1 percent over huller mills. For parboiled paddy, the corresponding increase was found to be 1.3 percent over sheller mills and 4.1 percent over huller mills.

Apart from giving significantly higher outturn of total edible rice and head rice, the modern rice mills yielded rice of superior quality with less broken and negligible quantity of foreign matter.

Wheat Milling : Wheat consists of seed coat (bran), embryo or germ and endosperm in the proportion of 12 percent, 3 percent and 85 percent respectively. Wheat milling is the physical process in the roller flour milling industry for producing *atta, maida, rawa*, *suji* in a most hygienic manner. The aim of modern wheat milling system is to obtain maximum white flour from endosperm without contaminating the flour with bran or germ. In most of the wheat milling operation the white flour is obtained to the extent of 70 percent while the remaining 30 percent includes germ and bran as by-products of milling.

Wheat milling process consists of four main steps, :(i) cleaning, (ii) conditioning, (iii) milling into flour and by-products, and (iv) storage of finished products. The wheat is cleaned to remove the impurities like sticks, stones, chaff and dust. It is further cleaned to remove bits of metallic objects by means of magnetic separator. The wheat is cleaned and washed thoroughly before milling. Conditioning refers to the addition of water to the bran and endosperm. This considerably improves the milling efficiency. In the milling operation the grain is broken open, milled to desired size and then the endosperm or white flour is separated from the bran. The flour and the mill feed (bran, germ and shorts) are bagged in water-tight bags and stored in cold dry condition in flat godowns.

The roller flour milling industry is essentially a *maida* industry. It needs modernisation in equipment and the latest techniques are required to be introduced. The industry needs different types of wheat for different types of flour. It has a great future for its expansion in the country.

Maize Milling : The milling of maize for producing flour or *suji* has not yet been widely practised in India. The technology developed in other countries may have to be suitably adopted for producing the type of products required for Indian condition. Like wheat, corn consists of bran, germ, endosperm in the proportion of 6%, 12% and 82% respectively. The flour prepared from maize generally takes a much longer time to soften during cooking than the wheat flour and rice. If the size of its particle is, however, reduced to finer grind, its cooking quality can be brought to the same level as that of wheat or rice. Corn is milled by two methods : dry milling, and wet milling. Dry corn milling is, in general, like wheat flour milling. In this system, operations like cleaning, degerming, conditioning, grinding, sifting, purifying, aspirating and bagging are required to be done. The wet milling method includes the facility for : (i) cleaning, (ii) steeping or soaking in warm water, (iii) degerming or breaking of germ, (iv) germ separation, (v) separation of hulls and fibre from starch and gluten, and (vi) gluten starch separation.

Agricultural By-Product Utilisation

Most of the agricultural commodities have got to be processed in one form or the other before consumption. In the processing industries almost all types of agricultural commodities provide substantial quantities of residues, wastes and by-products. These by-products have been utilised successfully by many advanced countries and adds considerably to the economic operations of the processing units. With the modern technology the residues and wastes of one industry have become useful by-product to start another industry. Cotton seed, a by-product of cotton ginning/textile industry commonly used for feeding of cattle is now being utilised for the production of edible oil, protein and cellulose/rayon. Similarly, rice bran which is commonly used as a poultry feed or otherwise wasted is being now used for oil extraction also. The utilisation aspect of commonly available by-products obtained from different industries are discussed below :

By-products of Rice Milling Industry : Rice bran is the most valuable by-product. The bran is the coating removed from brown rice during milling. It is highly nutritious, containing protein, minerals and vitamins. It is being used as a feed for poultry and livestock. Rice bran contains oil which can be utilised for industrial and edible purposes.

Rice husk is available to the extent of about 20 to 25 per cent. There is a problem of disposal of the husk. Considerable studies for its utilisation and conversion into useful products have been conducted by different organisations in India. Different ways of utilisation of husk are : (i) fuels, (ii) board and paper manufacture, (iii) agricultural purposes such as fertiliser and compost, animal feed, litter, nesting and bedding, (iv) cleaning, scouring and abrasives, (v) insulating, packaging and building materials, and (vi) sodium silicate, activated carbon and other chemicals.

By-products of Cotton Textile Industry ; India is a very important cotton producing country in the world. Nearly 20 lakh tonnes of cotton seed are produced every year as a by-product from cotton ginneries, etc. Nearly 5 to 6 lakh tonnes of cotton seed are being used for processing, while the remaining major quantity is being used as a cattle feed. The cotton seed can be utilised for manufacture of edible protein, refined oil and other products like lint for cellulose and rayon industry. There is a scope for increasing the number of cotton seed processing plants in the country.

By-products of Groundnut Oil Industry : Groundnut has been considered to be one of the important oil seeds and is cultivated over 6.5 million hectares in the country. Traditionally, groundnut is processed for oil. The cake is the major by-product, used mainly as cattle feed. With the introduction of solvent extraction industry, the groundnut cake has been processed for the extraction of oil which is usually left in the ordinary processing techniques. Studies conducted in India have revealed the benefit of using groundnut cake for production of edibie protein for human consumption. There is a great need in the country to develop this processing industry so as to enable better utilisation of such protein rich material.

The other important by-product which at present is being wasted in the groundnut is husk. Nearly 30 percent of the entire groundnut processed turn out to be waste material. The studies conducted show that the husk can be utilised for manufacture of board as required in the building industry. No concrete step has been taken to set up any plant in India.

By-product of Sugar Industry : Since there is no alternative source for exploitation of bagasse produced in the sugar industry it is mostly used as a fuel for boilers. According to studies conducted in the country and elsewhere, this waste product can be utilised for manufacture of paper and there is a scope for its partial or total utilisation for manufacturing of paper in paper industry.

By-products of Maize Milling Industry : Maize is being used for the manufacture of starch and glucose to a limited extent. By adapting improved techniques of milling of maize into maize flour, considerable quantity of maize germ will be available as a by-product. This will allow exploitation for oil as well as provide good quality protein for animal feed, etc.

Besides the by-products of cereals and oil seeds discussed earlier, there are waste and by-products from tea, tobacco, coffee, fruit, vegetable and cashewnut industries.

Productivity in Fruit and Vegetable Preservation

Fruit and vegetable preservation industry plays an important role in our national economy. The increased use of processed foods not only makes nutritious diet available at all times, but also helps in releasing the pressure of consumption on cereals and other foodgrains which are in deficit. In 1964, the industry manufactured products valued at about Rs. 110 million and utilised 50,000 tonnes of fresh fruits and vegetables. There is a definite demand from other countries for Indian processed fruits and vegetables, particularly mango products. One of the main difficulties in the way of the growth of the fruit and vegetable preservation industry has been the inadequacy of knowledge of modern methods and techniques of preservation. To overcome this difficulty, the CFTRI, Mysore, has been undertaking intensive studies and research on various aspects of preservation methods.

India produces practically all kinds of fruits and vegetables, temperate and tropical, in abundance. However, all these are not suitable for canning and processing. The fruits which are suitable for processing and canning include mangoes, bananas, pineapples, grapes, litchies, citrus fruits, apples etc. The vegetables include potatoes, tomatoes, french beans, cole crops, etc. About 18 million tonnes of these fruits and vegetables are grown annually in the country. Nearly 15-20 percent go waste on account of improper picking, handling, packing, transportation, etc.

The Fruit Products Order 1955 extends to the whole of the country except the state of Jammu and Kashmir. Under this order, it is obligatory for the manufacturer of fruit and vegetable products to obtain a licence for the manufacture of these for sale. The order lays down minimum standards in respect of the quality of the products, hygienic and sanitary conditions of the factory, its surroundings and personnel and machinery and equipment.

The fruit and vegetable products industries depend, in most cases, upon the control or proper utilisation of micro-organisms. In the canning of foods, micro-organisms capable of causing spoilages are destroyed by heat, and their entrance to the food is prevented by the use of hermetically sealed containers. Properly dried fruits and vegetables do not spoil because they do not contain sufficient moisture to support the growth of micro organisms. In the manufacture of wine and vinegar, the growth of micro-organisms is encouraged. Molasses, waste fruit juices, potato mash and other sugary materials are fermented by yeast.

Before dealing with various processes involved in the canning of fruits and vegetables on a commercial scale, it is necessary to consider certain important factors such as investment, site, building, water supply, staff, labour, equipment, etc., which are essential for the successful running of a large scale cannery.

For canning, fruits and vegetables should be absolutely fresh. The fruit should be ripe, but firm and evenly matured. It should be free from insect damage and malformation. Over-ripe fruit is generally infected with micro-organisms. The vegetables should be tender, except that tomatoes should be firm, fully ripe and of deep red colour.

The fruits and vegetables selected for canning pass through several processes before they are turned out as finished products. The processes include (i) sorting and grading, (ii) washing, (iii) peeling and blanching (iv) can filling and (v) processing. Both tin and glass containers are employed in the canning industry although tin containers are more common in use on account of the following reasons : these are fabricated readily and are strong enough to withstand processing ; they are light in weight, easy to handle and fairly cheap; they can be handled on high-speed machines.

The most important function of storage is to provide a suitable environment for maintaining the quality, appearance and sale value of the fruits and vegetables. A storage environment of cool temperature, high humidity and moderate air circulation will, in most instances, keep the products in a healthy and useful state. The spoilage of fruits and vegetables that used to take place in storage are of two kinds : spoilage by micro-organisms, and spoilage due to physical or chemical changes. A store must be well insulated and equipped with either machanical refrigeration or an air-cooling system to keep the storage temperature at the desired level. An air-cooled storage utilises naturally cold air through a ventilation system to maintain a suitable storage temperature. A mechanically-refrigerated cold storage can continuously provide suitable storage conditions for fruits and vegetables and it is preferred whenever economically feasible. For the best results all fruit crops should be stored only in a mechanially-refrigerated cold storage. In order to maintain high quality in stored fruits and vegetables skilled management has been considered to be equally important. Storage management involves the following factors :

1. *Sanitation :* Adequate sanitation is needed to be maintained throughout the period of storage.

2. *Quality of the product :* Only sound material of the proper maturity and free from insect damage, dirt and disease should be stored.

3. *Stacking arrangements :* The stacking arrangement should be such as will permit air circulation for cooling and the removal of respiration heat.

4. *Temperature control :* A desired temperature throughout the period of storage is needed to be maintained.

5. *Humidity control :* A desired level of humidity is needed to be maintained. □

Modernising Rice Mills for Increasing Productivity

M. Kuppuswamy*

One area of high importance in post-harvest operations that contributes significantly to increased productivity is in relation to the modernisation of rice mill machinery and techniques. An attempt is made here to consider the type and extent of rice mill modernisation as well as the volume of benefit that could flow to the rice industry as a result of modernising rice processing operations.

Perspective of Rice Mills in india

In India, we produce over 60 million tonnes of paddy, the bulk of which is handled in a somewhat primitive manner. The storage, milling, handling, etc. of paddy and rice were, until racently, by and large, without much scientific or technological basis. Significant losses were detected in the milling of rice in huller machinery. A large number of huller type rice mills exist in the remote villages and are engaged in custom milling for the local clientele. The sheller mills also admit of several improvements for reducing rice losses and improving the quality of rice bran. For proper preservation of paddy and rice, the grain should be dried down to a certain moisture level. This, in many cases, is not being done in view of the prevailing weather conditions. However, scientific investigations have revealed the possibility of improving drying, milling and storage operations. The parboiling of paddy, use of bran obtained from rice mills for extraction of edible-quality oil are other areas in which the application of modren teachnology could pay rich dividends by way of increased productivity.

Modernisation of Rice Mills

Government of India, more than ten years ago, launched a pilot project on rice mill modernisation, utilising some imported machinery and

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organising model rice mill complex including storage and drying, parboiling, cleaning, milling, etc. These pilot units were subsequently evaluated and their benefits clearly established. Cosequently, the Rice Mill Licensing Act and Rules were suitably amended for saving losses during the post-harvest operations of paddy and rice.

It was brought out from several surveys that hullers cause maximum damage and losses to the extent of 8 to 10% of the quantity hulled. Shellers also can be made to yield 3 to 4% more than what they are giving at present. It has been made compulsory for all rice mills to use paddy cleaners, rubber roll/centrifugal dehuskers and paddy separators as essential components for modernisation. The issue of licences is dependent on a phased programme of modernisation. This step was considered necessary since even in the case of parboiled rice, there could be substantial improvements in output if modern rice mills are employed for processing parboiled paddy. The parboiling operation itself admits of several improvements, such as for eliminating foul orders, eliminating leaching losses, etc. Steps have been taken to improve the technology and the equipment as well as operating processes. Though modernisation of parboiling has not yet been made obligatory under the rules, certain incentives are being announced with a view to inducing rice millers to take to modern parboiling systems in a big way. It has also been ensured that there is adequate manufacturing capacity within the country for the production of all the necessary rice mills, mechanical driers, cleaners, parboiling machinery, etc.

Productivity Measures

When we consider the total quantity of paddy produced in the country each year and the certain possibility of saving about 3% of this quantity through better practices, the importance of increasing productivity through rice mill modernisation can be easily gauged. More than 60 manufacturers are now turning out modern rice mill machinery components. Research and development programmes have brought about reduction in parboiling cost through use of paddy husk as fuel. Development of mechanical driers operated through paddy husk furnaces, development of new and simplified techniques of parboiling, etc. have also been taken on hand. Training programmes for the required technical personnel for operating rice mills, management, quality control, etc., have also been started by the Government at various centres. A Rice Process Engineering Centre at I. I. T., Kharagpur, was started by the Department of Food, Government of India, some years ago. There are also Regional Field Extension Centres started by the Government of India in Andhra Pradesh, Uttar Pradesh and Tamil Nadu to cater to the day-to-day technical needs of the rice millers. These Field Extension Centres would plan detailed programmes of rice mills modernisation in different regions, organise seminars and demonstration workshops, indentify potential plans for by-product utilisation, cost reduction, quality improvement, etc.

Increased Productivity

Application of modern technology to rice processing can lead to substantial increase in productivity and also the possibility of producing substantial quantity of rice bran oil—rice bran which amounts to about 4% by weight of rice contains nearly 20% by weight of oil in it. By suitable treatment to bran, it has been found possible to produce rice bran oil with low content of free fatty acid which could be used in Vanaspati for edible purposes. Thus, we see that modernisation of rice mills goes to increase national productivity in a significant manner by augmenting rice availability—by making available better quality of rice with less brokens, free from impurity, and giving rise to a new source of edible oil. □

Impact of Farm Mechanisation on Agricultural Productivity

A. C. Pandya*

The present population of India is about 600 million people. It is estimated that the population will be 900 million by 2000 AD. Present requirement of foodgrains is taken as 120 million tonnes. Total food-grain reguirement by 2000 AD would be about 220 million tonnes and fibre requirement will be about 20 million bales. The country could achieve this target only by bringing more area of land under irrigation and by intensive cultivation.

Productivity in agriculture means how for every unit of input, maximum output can be achieved — for every kilogram of improved varieties of seeds sown, for every litre of irrigation water used, for every kilogram of fertiliser applied, for every litre of herbicide and insecticide applied, unit of power employed for farm operations, etc. Maximising productivity means maximum output per unit of input. One may also measure the output per unit area per person working on the farm. Concept of productivity in agriculture is both qualitative and quantitative. Therefore, increase in productivity also may imply that the quality of agricultural produce be improved.

Efforts to increase agricultural productivity should mean that we should improve quality and quantity of inputs, utilise better techniques of applying inputs, so that we get maximum outturn of superior quality. In the last 30 years of our Independence, total production has increased by about 100 percent though agricultural productivity remains comparatively low, and, by one estimate, productivity has only increased by about 30 percent.

Planning for Future

Remarkable increase in the production of foodgrains, particularly wheat, has taken place during the last few years beacause of the introduction of better plant types, larger use of fertilisers, irrigation water and diversion

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of land from other crops. There is a further scope of introducing better plant types for most of the major crops which would substantially increase production. However, for the purpose of planning for the future, the basic limiting factors in agricultural production, namely land and water, became very important.

Any future planning must take into consideration a progressive increase in the productivity of both land and water resources of the country. Experience in wide range of situations in the past and the present has shown that higher land and water productivity are directly related to greater energy inputs. This is primarily because intensive and precise crop husbandry, land grading, and multi-cropping—all power-consuming practices—are important components of modern agricultural technology to achieve higher levels of land and water productivity.

Harnessing Solar Energy and Bio-gas

If a substantial amount of additional power is to be made available for agricultural production and post-harvest operations, the question arises about its source. Because of low output and efficiency, manual power would not fill the gap to any noticeable extent even if a large number of additional agricultural workers become available. Human being is a good governor of power, but not an economic source of energy. The alternatives to be considered are animal power, mechanical or electrical power, nuclear energy, solar energy and bio-gas. With a cattle population of about 70 million already competing with human population for food, further increase in cattle population of the country is practically ruled out. This is borne out of the fact that the number of draft cattle has tended to remain stable for the last few years. The use of non-biological sources of power such as oil engines, steam and electricity in ever-increasing numbers in the agricultural sector, therefore, appears to be inevitable if the energy input for the increased production is to be made available. There is an urgent need for development of such energy resources as solar energy and bio-gas for agricultural use.

Multiple Cropping

Large-scale introduction of short-duration and high-yield varieties of crops can create enough scope to employ the additional agricultural population in the next three decades. The potential double-cropped area should be at least as much even if the areas of high rainfall are distributed over large part of the year and the likely advancement in moisture conservation techniques in the rainfed areas are not taken into consideration. With only 20 million hectares under double cropping there is a potential for bringing at least 60 million hectares more under intensive crop production with average cropping intensity of 200 percent. It is reported that if a single-cropped area is turned into double-cropped area (for which more energy and better machines would, in general, be essential), the labour requirement per annum goes up by 50 to 100 percent. Information is available where high levels of energy inputs have been combined with high levels of agricultural employment to give high land productivity. The Table given below speaks volumes to show the effect on agricultural production and labour employment by the introduction of mechanical energy input :

Effect of tractor power on farm production and labour employment

Country	*Agr. workers per 100 ha. (available)*	*Agr. output per ha. (available)*	*Tractors Per 1000 ha.*	
			large	*small*
Japan	250.0	961	1.55	233
UAR	16.67	643	4,28	NA
Taiwan	166.7	477	0.36	NA
Philippines	83.3	139	0.66	NA
India	83.3	91	0.21	NA

Preparation of Seed-beds

Essence of sound agricultural practices is timeliness of operation in a right fashion. It is estimated that on 30 percent of land in India seed-bed is not properly prepared for sowing seeds, resulting in poor yields. Research studies in Punjab have shown that a farmer uses more than 100 bullock-pair-hours, to prepare a seed-bed and sow wheat in a hectare of land. In other words, a farmer cannot expect to take a good crop of wheat over more than 1.6 hectares if his source of farm power is a pair of bullocks. Large-scale use of mechanical power seems to be necessary for practising intensive cultivation. There is a direct relation between the energy available for agricultural production and yields per hectare. One study indicates that for achieving a target on average of 2 tonnes per hectare of foodgrains, the power input should be 0.75 horsepower per hectare. This figure does not take into consideration power required for irrigation. The above yardstick seems to be reasonable for planning of farm power in India.

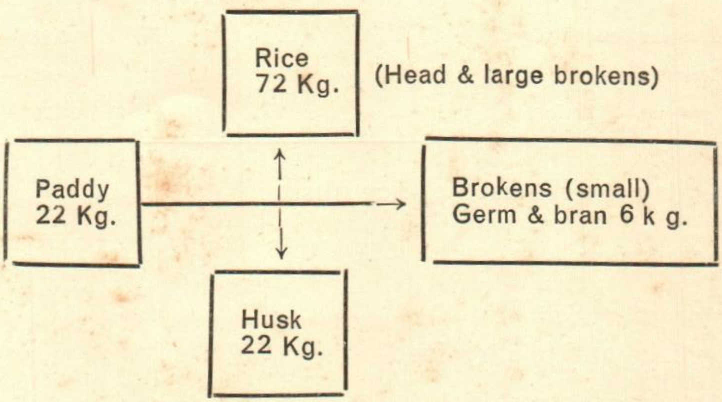
Farm Mechanisation vis-a-vis Agricultural Productivity

The main objective of farm mechanisation is to increase agricultural productivity. Specifically in India, the objective is to increase productivity per unit of water available for agriculture, as this is the most scarce resource. The second important objective is to increase production per unit of land. These objectives are quite different from the objectives of some countries of the world where the need is to increase productivity per man. Therefore, the major investments in tools and equipments in India will be for those that are small in size and are labour-intensive and are mainly directed to water management and tillage of land. □

Present Status of Rice By-product Utilisation

T. P. Ojha.* R. C. Maheshwari & B. D. Shukla*****

Among the foodgrains including cereals, oil seeds and pulses, there is hardly any one which is consumed as a whole grain in its original form. All these grains are subjected to a series of processing operations before they are fit to be consumed by human beings. During the processing operations such as dehusking, grinding, milling, sieving, grading, etc., the original grain changes its original shape and size, giving two or more products—the main product and the by-products. For example, paddy grain when subjected to the milling operations yields rice, brokens, germ, bran and husk. Similary the other cereals, pulses and oil seeds give main product and a few by-products. In the present state of economic conditions the world over, by-products are becoming more valuable than the main product. In this paper, attempt has been made to discuss the various applications of rice by-products in different parts of the world.



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Rice Husk

Rice husk continues to remain the largest by-product of rice. It is also identified as a non-intensively developed agricultural commodity existing on the earth. On a world-wide basis, over 60 million tonnes of husk has to be disposed off annually. So far, this is generally done in an unsophisticated manner. The composition of rice husk (Table 1) clearly indicates that it has a very high silica content as a result of which its suitability is limited to very few commercial uses in its original state. However, after being subjected to different heat treatments, the husk yields a few very useful secondary by-products such as silicon for solar cells, sintered glass materials and refractory bricks.

Table 1 : Approximate Composition of Rice Husk

Constituent	*Percent Range*
Moisture	9.80 — 11.00
Ash	15.68 — 18.24
Hal insoluable ash	14.50 — 17.50
Silica in ash	94.50 — 95.50
Crude Protein	2.94 — 3.62
Ether soluble extract	0.88 — 1.20
Crude cellulose	41.10 — 42.90
Non-nitrogenous extraction	24.70 — 27.90

The following are the uses of rice husk:

(A) Direct usage :

(i) Source of energy

(ii) Animal and poultry feed

(iii) An abrasive material

(iv) An absorbent

(v) Bedding material

(vi) As carriers

(vii) Incorporation into soil and usage as mulch

(viii) Building boards

(ix) as filler

(x) as insulating material.

(B) Indirect usage :

(i) in cement

(ii) rice husk char and ash in water purification

(iii) Activated carbon usage

(iv) Manufacture of sodium silicate

(v) in rubber compounds

(vi) in ceramics

(vii) as a raw material for furfural

(viii) in silicon carbide and silicon nitride manufacture

(ix) in silicon tetrachloride manufacture.

Husk Utilisation as Fuel

The, utilisation of rice husk is handicapped due to its abrasive character, poor nutritive value, high resistance to degradation, very low bulk density, and high ash content. The quality of husk (pure or mixed) obtained from a rice mill depends upon the type of mill. A modern rice mill of rubber rolls type yields pure husk, whereas a huller mill yields a mixture of husk and bran. By and large, the pure husk is used as a source of fuel for generating steam and basic material for manufacturing husk boards. The husk obtained from the huller mills is preferred for use as animal and poultry feed. The combustion of organic matter of the husk releases over 3000 Kcal/kg of heat energy.

Traditionally, in most of the rice mills where parboiling is not practised, disposing of husk is by burning. It is burnt either in heaps at or near the mill, or by selling them in small quantities in the locality. The movement of husk to a long distance from the mill is usually uneconomical because of high transportation cost.

At present, India produces about 13 million tonnes of rice husk as a by-product of rice. If the total quantity is utilised as a source of energy, it would yield nearly $39X10^6$ million Kilo calories. The calorific value of husk is approximately one-third that of diesel fuel. At the present market price of furnace oil (Rs. 1.50 per Kg.), the total quantity of husk produced in India would be worth Rs. 6500 million. However, half of the total quantity of husk produced in India is consumed as fuel in the rice milling complexes producing parboiled rice. In the early seventies, when the fuel became an expensive and scarce commodity, the use of agricultural wastes in general and that of rice husk in particular as fuel picked up considerably. During the same period, attempts were initiated to develop improved type of husk-fired furnaces in India. The successful designs developed at I. I. T, Kharagpur, are illustrated in figures 1 and 2.

The special features of these furnaces are as indicated below :

Furnace Specifications	*Grate type furnace*
Outside dimension	112 x 78 x (118 x 95) cm
Slope of inclination of grate	45°
Slope of arched roof	15°
Inclined stationary grate area	0.50 sq.m
Horizontal revolving grate	0.15 sq.m
Curtain wall height	60 cm
Feeding hopper capacity	02 cu.m
Combustion capacity	20 Kg./hr.
Blower capacity	85 cu.m. (3000 Cym)
Blower motor	3 h.p. 3 phase, 1440 rpm
	Cyclone type furnace
Cylindrical combustion chamber	87x58 cm
Ash trap chamber	87x58 cm
Total volume of furnace	0.386 m^3
Husk feed rate	20 Kg/hr
Blower capacity	6.93 cu. m/min
Blower motor	2 h.p. 3 phase 1440 rpm.

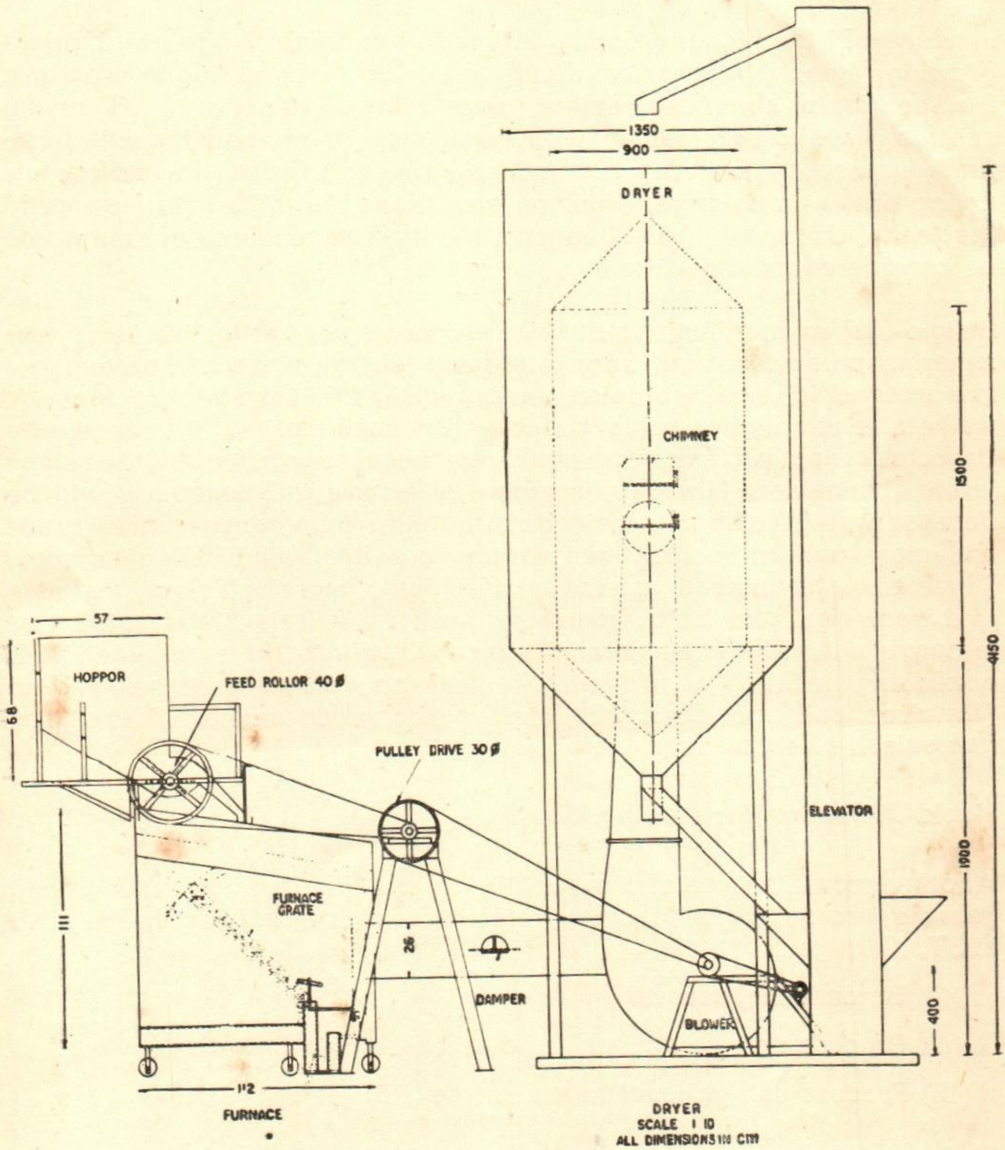

Fig. **Engineering Details of Husk-Fired Furnace Coupled with R. P. E. C. Dryer**

In view of the higher cropping intensities in different parts of the rice-growing regions, mechanical drying has to be resorted to, to overcome the vagaries of abnormal weather (heavy rains). Most of such drying centres have to be provided with mechanical dryers coupled with husk-fired furnaces. Even the rice mills have to resort to mechanical drying if the parboiling and milling operations are to be carried round the year. Under all these situations, the husk as a source of fuel would be considered most desirable.

Beagle [2] says, "This rice husk now appears very attractive as a raw material, particularly in a very integrated energy system, wherein the raw material is used to produce energy while the resultant residue is marketable at a higher value than the raw material. This concept is especially applicable to the rice husk because of the high residue levels obtainable. Howaver, in order to receive full benefits it will be necessary to develop new methods of burning to produce higher grade and more uniform residue than are now possible with existing methods. Therefore, a basic need exists for developing more efficient methods to extract maximum heat from rice husk in a saleable fashion that is consistent with the feasible utilisation of the residue. There is a continuing challenge to develop heat conversion processing units (furnaces, boilers and reactors) for the efficient conversion of rice husk into saleable heat and residue".

Husk Utilisation for Making Boards

Another promising use of rice husk is to manufacture insulation and particle boards. The following three processes have been investigated at IIT, Kharagpur.

(i) Binderless Process

(ii) Process using sodium silicate as binder

(iii) Process using phenol formaldehyde (PF) resin as binder

(i) Binderless Process :

This process involves a combined application of heat and compression on the mat of powdered (40-60 B.S. mesh size) rice husk. Boards of different densities ranging from 1200-1400 Kg/m^3, modulus of rupture (MOR)

125-207 Kg/cm², and water absorption capacity 5-10 percent (dry basis) were obtained with the planten temperature in the range of 160-165°C and press hold time of 12-15 minutes. The plywood lamination is essential for this type of boards for its smooth surface appearance.

(ii) Process Using Sodium Silicate as Binder :

The manufacturing conditions utilised for these boards were : planten temperature of 180°C and press hold time of 10 min. With 60 percent sodium silicate solution, the boards were prepared as per the requirement of Indian Standards Institution (ISI) Code 3478-1966. Since sodium silicate is soluble in water, the plywood lamination is essential on both the surfaces of the boards to make it moisture resistant.

(iii) Process Using PF Resin as Binder :

The PF resin bonded boards out of rice husk were found most satisfactory in accordance with ISI, British Standards (B.S.) and American Society of Testing Materials (ASTM). These boards were prepared with planten temperature of 180°C, press hold time of 10 min. and planten pressure in the range of 1 to 4 Kg/cm², with the application of 8 percent PF resin. The production cost per square metre of rice husk board is estimated to be Rs. 15, while the market price for such type of boards varies from Rs. 28 to 42 per sq. m. An indigenous plant of 5 ton/day capacity will involve an expenditure of about Rs.1.5 million. The plant may be located in the rice-milling area so that transportation charges for rice husk are minimal.

Utilisation of Bran

Bran contains both valuable as well as undesirable compounds. Bran has oil, protein, calories, vitamins and essential minerals which are to be preserved. But bran also possesses enzymes, micro-organisms, insects, natural toxic constituents and harmful contamination which have to be either removed or their activity arrested. Utilisation of bran for food and feed is inhibited by the fast deterioration in its quality soon after its production at the mill. There is a long-felt need to develop equipment and technology to process raw bran into a product of good keeping quality. Quite a few stabiliser units have been designed and tested in the country. The fluid-bed stabiliser at IIT, Kharagpur, steam jacket stabiliser at C. F. T. R. I., Mysore, and screw type stabiliser at Jadavpur University have been tried. However, further developmental efforts are needed to fill the existing gaps in technology and equipment. At the meeting of Working Group of Rice Technologists held at Vienna in December 1976 under the auspices of FAO, two processes, i. e., dry heat and wet heat, were recommended for further exploration. The wet-heat method will be appropriate for those mills which already generate steam for parboiling and dry heat will be suitable for those mill units which process raw paddy only.

The energy of bran available for metabolism amounts to 2660 calories/kg. The protein content of bran is about 15-20 percent. 100g of bran provides the dietary protein necessary for a 1–5 years old child [1]. Rice bran is also an excellent source of the vitamins B and E. The chemical composition of brown rice, white rice and rice bran is listed in Table 2.

Table 2 : Chemical Composition of Brown Rice, White Rice and Rice Bran*

Constituent	*Brown Rice Percent*	*White Rice Wet basis*	*Rice Bran*
Moisture	13.30	13.90	11.46
Crude fat	2.20	0.77	20.00
Crude protein	8.80	7.72	15.08
Fibre	1.00	0.25	7.32
Ash	1.30	0.57	8.43
NFE	73.40	76.79	37.64

*Rice Bran Oil Technical Research Institute, Tokyo, Japan.

In addition, rice bran is a potential source of edible oil. 100 Kg bran yields 20 Kg edible oil. On the basis of 60 million tonnes of annual paddy production in India, and assuming an average of 3 percent bran on the basis of paddy and only 1/3rd of the total production being used for oil extraction, about 120,000 tonnes edible oil can be obtained. Considering the present market price of Rs. 6 per Kg., it will fetch Rs. 72 million for the rice milling industry. In other words, raw rice bran of

Rs. 90 per quintal will bring Rs. 120 worth of edible oil. The difference is a promising margin for processing the raw rice bran and extraction of edible grade oil thereof. The suchematic diagram for processing raw rice bran is illustrated in Fig. 3.

Rice bran oil with its high fatty acid content is suitable for soap manufacture only. It can also be used in detergents, emulsifiers, cosmetics plasticisers, etc. After refining, the edible grade bran oil can be used as salad oil and cooking oil. The deoiled rice bran is used as feed ingredient and as fertilisers. The feed value and preservation quality of deoiled bran is high as compared to crude bran. The fertiliser value of rice bran (Table 3) also goes up with the removal of wax and fat in deoiling process. In other countries, food uses of bran and high-protein, low-fibre bran flours are numerous, such as bread, pancakes, cookies, cakes, pies, extuded snacks and breakfast cereals.

Table 3 : Inorganic Value of Crude and Deoiled Rice Brans*

Constituent	*Raw Bran*	*Deoiled Bran*
Nitrogen	1.56	2.6
Phosphoric Acid	2.60	5.0
Potassium	0.80	1.8

Recommendations

It would be desirable to carry out a survey of the possible availability and usage of rice husk and bran in different parts of the country. Any other industry besides rice milling, should also be kept in view. The following few uses would be worth-while to be considered :

(i) In raw rice milling zone, heat energy can be used to produce steam for providing motive power either for rice mill or for other industry such as oil 'ghanis', dairy plants etc. Rice husk can also be used for drying high-moisture paddy harvested during rainy season or obtained as a consequence of early harvest.

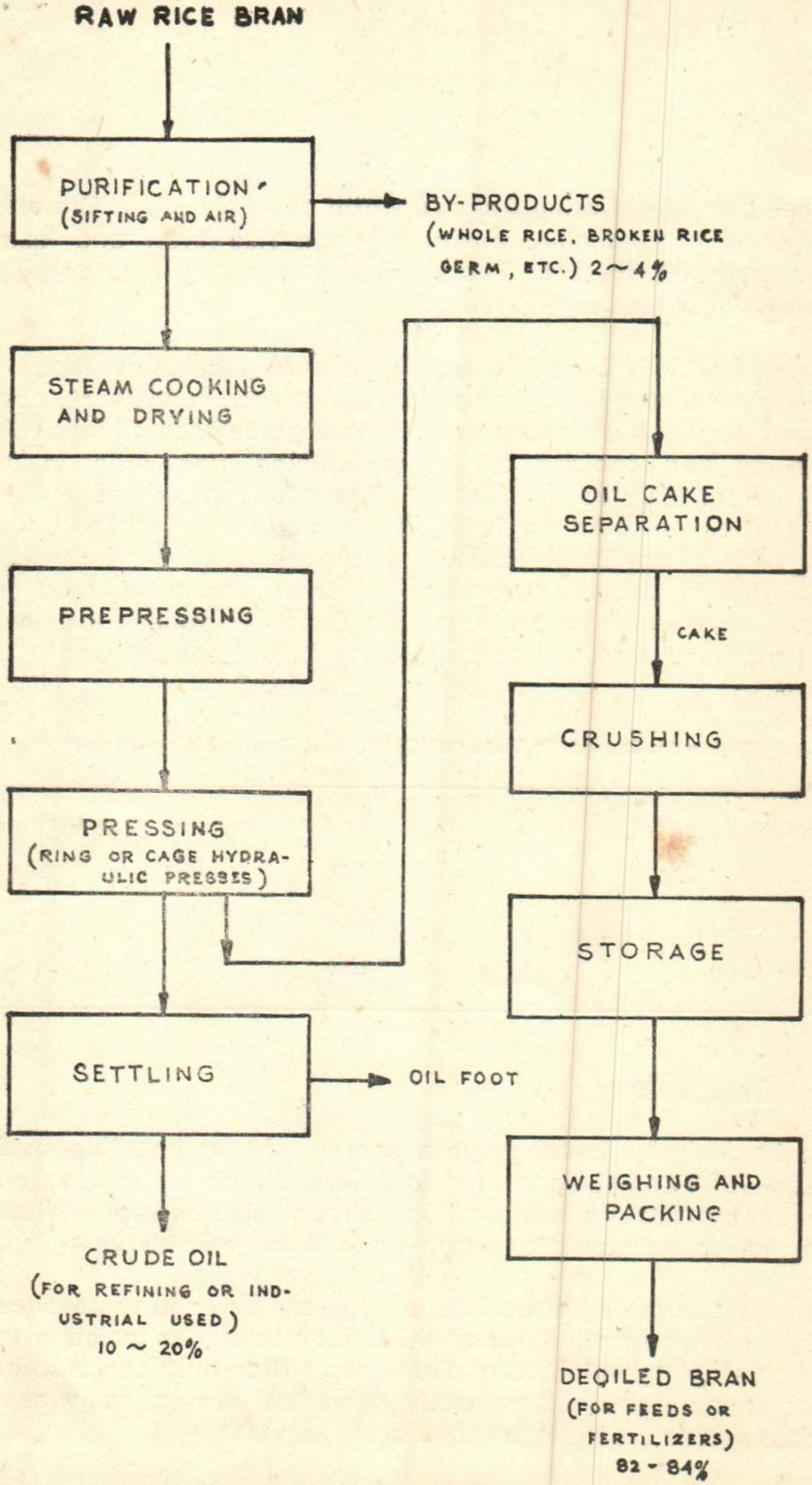

Fig. 3 : Schematic diagram of processing raw rice bran

(ii) In parboiling rice production zone, the heat energy can be utilised for hot water soaking, steaming, drying, power generation, etc.

(iii) As a source of kitchen fuel to be made available for the local population.

(iv) A rice-husk-board manufacturing plant should be located in the vicinity of modern rice mills and should be preceded by a market survey for boards.

(v) Emphasis should be laid on stabilising rice bran for the extraction of edible grade oil which has always been a scarce product. □

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Post-Harvest Operations : Need for Avoiding Wastes

S. H. Adhaoo*

It is only during recent years that the aspect of post-harvest operations has received sufficient attention of the agricultural scientists and engineers. It is a well-known fact that India is deficient in foodgrains (amounting to 10 percent of total production), whereas an equal amount of foodgrains is annually lost during post-harvest operations. Speaking in economic terms, it could be said that annually 10 percent, i.e., 11 million tonnes of foodgrains amounting to Rs. 16500 million are lost on account of losses during post-harvest operations However, this figure is considered rather conservative by many experts. According to them, if harvesting losses and losses at secondary processing and utilisation stages are added, the figure would be more than 10 percent. Table 1 gives an account of waste taking place during various stages of post-harvest operation.

Table 1 : Estimates of Losses of Foodgrains During Post-Harvest Handling, Processing and Storage

Annual average production (in thousand tonnes Av. of 1962-63, 63-64, 64-65)	*Total 28317.666 Estimated loss*	
Stages where the loss is caused	Total (Thousand tonnes)	Percentage
Threshing yard	1,317.708	1.68
Transport	117 478	0.15
Processing	748.913	0.92
STORAGE		
i) Rodents	1,957.949	2.50
ii) Birds	668.105	0.85
iii) Insects	1,992.166	2.55
iv) Moisture	534.114	0.68
Total	7,386.424	9.33%

Source: Bulletin of Grain Technology, Vol. XIII, April 1975 No. 2, p. 35

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Of the total agricultural produce, 70 percent is retained in the villages. Unfortunately, post-harvest techniques and storage conditions have not improved in these areas so far. The post-harvest operation begins right from the harvesting stage. It passes through different stages such as handling, transportation, marketing and distribution, till the foodgrains reach the consumers. It is essential, therefore, to introduce simple and yet scientific techniques such as improvement in the existing technology, introduction of technical know-how for every operation, etc., which can bring about changes effectively. This would effect saving in losses, thereby increasing productivity.

Comparative figures from different countries indicate that the foodgrain losses in the underdeveloped and developing countries are much higher than in developed countries (Table 2). The heavier losses are known to occur at the rural level in the tropical countries. It has been estimated that these could, in certain cases, be as high as 35 to 50 percent. In most of the agriculturally-advanced nations, post-harvest foodgrain

Table 2 : Weight loss by insects to stored products during storage in different countries

Country	*Commodity*	*Loss*	*Level of storage*	*Period of storage (Month)*
Ghana	Legumes	9.3	F.T.C.	12
Upper Volta	,,	50-100	F.T.C.	12
Nigeria	,,	10	T	6
South Africa	,,	50	F.T.C.	12
Tanzania	,,	50	F.T.C.	12
Japan	Rice	5	F.T.C.	12
India	Foodgrains	20.5	F.T.C.	12
	Foodgrains	5.0	F.	12
	Grains	4.0	C	3-4
	Wheat	8.3	C	12
U.S.A.	Maize	0.5	—	12
	Rice	1.5	—	12
	Sorghum	3.4	—	12
	Wheat	3.0	—	12
Thailand	Paddy	10	F	—

losses have been reduced to a great extent through application of Modern technology. However, the same may not be applicable to our conditions as such due to large variation in socio-economic conditions. For avoiding such losses, we shall haveto develop indigenous technology which would suit our conditions and is adapted by the farmers without much difficulty.

Important post-harvest operations such as harvesting, threshing, drying, transportations, storage, etc. need to be implemented more vigrously, because each grain saved is each grain produced. Each operation is dealt with in detail in the following section.

Harvesting

The resent research on harvesting of major food crops has advocated the practice of maturity-based harvesting to reduce the field and handling losses of crops and to improve quality of foodgrains. Besides these, there is a saving in time for farmers to cultivate the next crop. It helps in effective land utilisation in relay cropping pattern. Sickles are known to give lower harvesting losses than reapers, binders or combines. However, sickle harvesting is time-consuming and could be very expensive where labour cost is high.

Working prototypes of animal-drawn, power tiller and tractor-operated reapers have been developed and are now available in the market in our country.

Threshing

Farmers practising hand beating would find Japanese type pedal-operated thresher less tiring and more useful in doubling their capacity. Use of pedal thresher increases wheat threshing capacity 2 to 2½ times to that of ordinary bullock threshing Mechanical thresher of 2-3 h. p. is the rocommendation of XV I. R. A. E. Convention of Agricultural Engineers held at Pune on 10-12 February 1977. But, breakage in mechanical threshing needs improvement. A single cob shellar costing about Rs. 30 is found to give about 50 kg/2 man-hr. A hand maize sheller is found to give about 100 kg/2 man-hr.

Groundnut harvesting machines and decorticators have shown promising results in Tamil Nadu and Punjab. Mechanical threshing helps farmers to finish the threshing before rains, thus reducing the weather hazards, minimising floor losses due to birds, rodents, thefts, etc, and eliminating contamination.

Drying

Drying of the harvested crop is a necessary process to condition the grain for storage and milling. Sun-drying requires lower investment cost, higher labour employment and overall, low cost of operation. The main limitations are dependence of weather conditions, and requiring large floor area and labour. Drying on sand bed has shown to reduce the drying time. Use of PVC sheets have been experimented with encouraging results. Chillies drying on bed rocks of the river is a common sight in certain parts of Maharashtra.

During recent years, mechaninal drying of paddy has become popular in several parts of India. It is mostly adopted where large quantities are to be dried in relatively-short period of time. The common types of mechanical dryers which are used in India for drying foodgrains are batch or continuous flow dryers. The latter may be of non-mixing or mixing type. A batch dryer to be used (0.5 to 5 tonnes) by small and marginal farmers has been developed at I. I. T. Kharagpur. A batch type (deep-bed) dryers where paddy of 30-50 cm depth is dried by hot air are quite common in other countries. Capacities vary from 300 to 500 kg. The drying air temperature is usually around 40-60° C.

Solar energy and wind are available from nature free of cost. Under favourable conditions they meet the requirements satisfactorily. Improvements can be effected in sun-drying process by use of other moisture-resistant dunnage.

Transportation

At present, nearly 13 million bullock-carts are being used in India to carry the farm produce to the neighbouring market centres. This mode of transport is bound to play its role in the years to come. With this in view, considerable amount of research has taken place to improve the efficiency of the bullock-cart.

The foodgrains are usually filled in jute bags and then transported to their destinations, irrespective of whatever mode of transport it may be. For long distances, both trucks and rails are put to use. But in either case, considerable losses take place due to leakage or exposure to rains, etc. It is estimated that the losses on account of leakage vary from 1 to 2 percent. To add to these, absence of use of insecticides increase wastes substantially.

It isessential that scientific methods of transportation are more vigorously used. Bulk transport of foodgrains should be encouraged as it would eliminate the use of expensive jute bags resulting in increase in transport capacity by 25 percent. The sophisticated bulk transport trucks are provided with hydraulic tipping arrangement. Multipurpose nature of design of loading system would be useful for transporting grains one way and other commodities on return journey. Agencies involved in transportation should have coordinated schemes; otherwise, any missing link will bring the bulk handling system to a standstill.

Storage

Gunny bags are commonly used for small storage. About 300 million gunny bags are used in the country. These are vulnerable to attack by insects. Earthen pots are locally prepared and used for half to one quintal size storage. Bins constructed out of local materials like wood, bricks, mud, bamboo, straw platered with cowdung paste mixed with clay called *keedir, gumme, Puri, vodle ponaka, Gadhi, Galadi, Kothi, Pethi, Bukhari, Kup, Hamar, Morai* are used in different parts of the country. Metal bins are used to a limited extent. Underground structures namely, *Hageri, Vadevu, Pev, Khatti* are commonly used for bulk storage. These underground structures suffer from mould attack, bad smell and discolouration and chemical changes.

Many national and state level organisations are actively enagaged in improvement of rural storage structures and introducing them in the rural areas. Fumigation of storage grains although necessary is not widely adopted. This needs immediate attention with proper training.

Modification of Storage Environment : Herringten's thumb rule correlates the two important parameters, viz., temperature and moisture in storage. Either by reducing the storage temperature by 10 °F or moisture of the foodgrains by 1 percent, the storage life is doubled. Further, for safe storage, as far as possible, ths sum of temperature in °F and relative temperature in percent should not be more than 100. A grain temperature of 21.1°C (70° F) is considered as the danger line for insect multiplication above which the damage is expected. With a few exceptions temperatures above 35°C (95°F) are unfavourable for insect multiplication.

Improvements in Storage Structures : The airtight underground storage in Argentina and parts of Africa have given good results. Bulk storage has been considered preferable to bag storage by all workers. Sanitation has, undoubtedly, to be considered first, as this will enable us to have food that is pure, clean, wholesome and free from contaimination.

The development of dehydrated bins is an attempt to avoid adverse temperature changes in metal bins due to high thermal conductivity of the metal structures. The technique of placing 250 gauge polyethylene sheet and sealing it is essential in bag storage. Finally, the plastic envelope is made rodent proof by the application of rodent-repellent spray. Partial sterilisation with respect to insects and harmful moulds are also carried out in the ballon structures whenever needed. Besides improvement in the existing storage structures, a spectrum of new designs are available including aluminium and plywood bins which could be popularised wherever possible. Glass reinforced plastic is a very potential material. Concrete is a versatile material, capable of being moulded in any shape and is fire-proof. Rubberised cloth, P. V. C. coated nylon and 'Neoprene' coated fabrics are other promising materials.

Thus, with a healthy trend of becoming self-sufficient in foodgrains, provision of proper technology at every stage in the post-harvest operations will lead us to minimise losses, which is as good as increasing production of foodgrains. ◻

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Water Management for Small and Marginal Farms

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In India, nearly 51% of our agricultural holdings are operated by marginal farmers (less than 1 ha) and 19% by small farmers (1-2 ha). In some states consolidation of holdings has been done, resulting in creating awareness among the farmers to develop ground water resource for assured irrigation, but there is still lack of awareness about efficient conveyance and application of water in the field in terms of land preparation for efficient irrigation, timing and depth of application and method of application for uniform distribution. In the absence of consolidation of holdings, agricultural operation has become difficult.

A survey was conducted in tube-well command area of Nainital tarai during the year 1972-73 on 12 private farms, each consisting of 6 hectares. It revealed that the average conveyance loss was 12% and the irrigation efficiency was of the order of 50% in wheat, maize and sugarcane and only 30% in paddy, implying excess application of water in these crops. The survey thus indicated that there is large scope of improvement of the existing practices of irrigation for efficient use of available resources.

This paper deals with different aspects of irrigation suitable for adoption by small and marginal farmers in the country for more efficient use of water. Though, in general, the problems encountered by small and marginal farmers are similar in nature for some size of sources, there are some differences in respect of management and scheduling of irrigation water according to the type of source—a canal, a state tubewell or a private tubewell. It may, therefore, be desirable to discuss the management starting from the source itself.

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Table 1 : Flow from horizontal pipe by co-ordinate method (The co-ordinates X and Y are measured from the top of the inside of the pipe to a point on the top of the jets).

Sl. No.	*Y cm.*	*Size of pipe (nominal diameter)*				
		5 cm.	*7.5 cm*	*10 cm.*	*12.5 cm*	*15 cm.*
		Flow rate in litre per minute				
			X=0			
1	0.508	—	364.65	210.00	1386.0	—
2	1.016	—	292.95	769.50	1341.0	2331.0
3	1.524	82.35	279.00	724.5	1291.6	2214.0
4	2.032	75.15	262.8	675.0	1246.5	2115.0
5	2.54	61.65	238.95	625.5	1192.5	2007.0
6	3.556	2.7	132.25	517.5	1066.5	1791.0
7	4.572	—	108.5	405	922.5	1561.5
8	5.588	—	53.1	288	751.5	1527.5
9	6.604	—	—	184.5	571.5	1107
10	7.62	—	—	108	405	900
			X=15 cm			
1	0.6096	796.5	1395	2466	—	—
2	1.2192	567	1111.5	2079	3856.5	5008.5
3	1.8288	450	967.5	1818	3172.5	4261.5
4	2.4384	382.5	868.5	1597.5	2727	3798
5	3.048	337.5	787.5	1435.5	2443.5	3474
6	6.096	229.5	535.5	1030.5	1755	2623.5
7	9.144	180.0	423	846	1413	2142
8	12.192	157.5	355.5	679	1071	1737
9	15.24	155	282.5	522	675	1111.5
10	18.288	112.5	171	373.5	—	—
			X=30 cm			
1	2.4384	706.5	1435.5	2565	4563	—
3	3.7432	666	1372.5	2466	4383	5917.5
3	3.048	625.5	1314	2385	4162.5	5656.5
4	4.572	513	1111.5	1998	3433.5	4747.5
5	6.096	445.5	967.5	1777.5	2947.5	4180.5
6	7.62	391.5	868.5	1615.5	2623.5	3798
7	9.144	355.5	792	1494	2385	3474
8	10.668	328.5	724.5	1372.5	2200.5	3231
9	12.192	306	670.5	1291.5	2061	3028.5
10	15.716	283.5	630	1210.5	1917	2848.5
11	15.34	270	594	1152	1818	2686.5
12	16.764	258.5	587	1089	1734	2583
13	18.288	243	540	1048.5	1656	2466
14	19.812	234	513	1008	1597.5	2362.5

Reference : U. S. Soil Cons. Service, National Engg. Handbook, Section 15. Irrigation, Capt. 9, Measurement of Irrigation Water, 1962.

Measurement of Water

For proper estimation and efficient utilisation of irrigation water, it is necessary that at the entrance point in the command area the discharge at the source should be measured and proper records be made for volumetric utilisation of irrigation water. In the canal-irrigated areas, there has been an attempt in some states to provide gauged outlets, but in most of the states pipe outlets varying from 10 cm to 30 cm diameter are still in operation. These are poor and inefficient devices for measurement and delivery of irrigation water. Even when a steady water level is maintained throughout the length of the distributary, the supplies through the pipe outlets, except those having free overfalls, vary with the variations in water levels in the field channels. The water levels in these channels vary as to, whether they are irrigating higher or lower fields. Because of submerged flows in most of the outlets, there are great inaccuracies in estimation. In many cases because of silting or improper maintenance the pipe outlets remain defunct and the farmer has no alternative except cutting the canal near-by for irrigation. There is, therefore, a great necessity that suitable weir type outlets are provided and volumetric supply of irrigation water is initiated in areas where such practice does not exist. In case of state tubewells, V-Notch weir outlets are provided and it should not pose any difficulty in measurement of irrigation water. The volumetric system of measurement would be desirable in this case also for efficient utilisation of irrigation water. For the private tube-wells, either a standard V-Notch at the well outlet may be installed, or an economic masonry rectangular weir may be constructed. In case the farmer cannot afford any of these, the delivery pipe may be provided to have a horizontal jet of water. This would dig a stable hole which can be conveyed to a channel. The coordinates of the jet can be measured to give the discharge, using Table 1.

In the case of private tubewells mostly owned by small farmers, there are a number of stages at which improvements could be introduced at the source itself.

Development of Economic Resources

In the case of shallow tube-wells, wherever finance permits, properly slotted pipe and gravel-packed wells may be constructed. These tube-wells would be ideal though a little costlier. Economically viable tube-wells could as well be constructed out of closely-spaced iron rods, held in place by circular end rings. Over these rods, coir could be wound to decrease the size of openings. These strainers could be used as such in good gravel strata. In finer strata, it may be worth while to provide gravel packing around such strainers. For still smaller farmers of holdings of 2.5 ha, it has been estimated that a design capacity of 15-20 m^3/hr. may be needed. This quantity of water can be drawn through a 50 mm diameter pipe like an average stalk of a bamboo. A well point developed in this way would cost about Rs. 150 which would be cheap for small holdings. A large number of such wells each costing Rs. 800 per well are working in Bihar which may be standardised and used elsewhere under similar conditions of ground water. Even if its life is small, it will economically pay off for its run. In many cases attempt may be made of using the same pumping unit on a number of such pumping points turn by turn on a cooperative basis. This would provide independent wells for smaller holdings and in some cases provide more economical solution than channel lining in case of scattered holdings of a single individual. Generally, after construction of tube-wells by private contractors, development or testing is not done. Depending on the size of tubewell pipe, some commonly available cheap pump from the market is purchased. The development, if any, takes place by routine running of the pump by the owner. Similarly, the well characteristics should be tested before purchase of matching pump.

There is a great scope of educating or advising farmers regarding selection of site, spacing, depth, type of well and material of well for which consultancy services through government organisations or private bodies should be made available.

Pumping Units

A lot of difficulty and resulting inefficiency is observed in the process of installation of a surface centrifugal pump specially with respect to its distance from water table and its fluctuation with season. A surface centrifugal pump cannot lift water beyond a height of 6 m. Therefore, different platforms should be provided for installing a pump under such conditions either for a combined unit or with motor remaining overground and pump running by belt pulley changing, its height as desired. In conditions where there is difficulty and more finance could be available, a submersible pump could be installed. In some shallow wells, the pump is directly coupled with tubewell with a non-return valve fitted below the water table and pump fitted at the ground level. In such cases, it is desirable to have a pump up to a depth, a little below the water table for occasional repairs of non-return valve, otherwise the whole well has to be dug up to the non-return valve for repair.

Surveys carried out at different places indicate that a large number of pumps do not appropriately match the well requirements, giving rise to highly inefficient utilisation of the pump as well as the input energy, diesel or electricity. It should thus be required that a well must be developed and tested before a matching pump is installed at the source. This may be made a legal requirement for well drillers and pump dealers.

Similarly, this service may be provided by Minor Irrigation Department or other government agency. This would increase pump efficiency to 55 to 60% effecting a saving of power by 25 to 30%. Some work has been done at Pantnagar to collect and systematise head-discharge efficiency of different pumps available locally to assist the users and the dealers.

The motors of electric pumping units require appropriate precautions of installation. Non-functioning of one phase or low voltage supply may burn motors. In diesel pumping units, because of lack of lubrication oil and improper cooling, engines get siezed. Improper alignment of motor and pump, protection of each from rains also create problems. As per electricity safety code, 3 phase motors should be provided earthing arrangements. All these points call for appropriate safety devices for the equipment as well as the operators.

There are many farmers using electric and diesel pumping units, but small farmers with holdings of less than 2—3 hectares may not be able to afford such pumping units. Improved indigenous water lifting devices should be provided to them. A guideline is provided in Table 2, for giving approximate idea regarding their adaptability. Some work has been done by Khepar, et al [2] to develop a bullock-drawn reciprocating pump which can be installed over a tube-well. Work is under way for developing bullock-drawn Egyptian Screw for low-lift high-discharge which may also be tried.

Table 2 : Adaptability and capacity of indigenous water lifts

S. No.	*Device*	*Power*	*Maximum lift (meter)*	*Average discharge (Litre/hr.)*
1.	Counterpoise lift	One man	3	2200
2.	Egyptian Screw	One man	1.0	16000
3.	Paddle wheel (2.4 m dia with 12 blades)	One man	1.0	18000
4.	Rope and bucket lift	Two pairs of bullocks and three men	3.0	9000
5.	Self employing bucket	One pair of bullock and one man	9	8000
6.	Chain pump	One pair of bullock and one man	6	30000
7.	Persian wheel	One pair of bullock and one man	10	10000
8.	Bullock-drawn Reciprocating pump	One pair of bullock and one man	6	25000
9.	Bullock-drawn Egyptian	One pair of bullock and one man	1.2	50000 (Expected discharge)

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For irrigation of paddy lands, low-lift and high-discharge pumps are needed. For such cases, efficient axial flow propeller may be used more economically. Existing pumps may be tested for adaptability or new pumps need be developed. Similarly, Ejecto pump with its ventruri fitted on delivery side also appears to be promising, but needs further investigation. Hills pose special problems. Probably, hydraulic ram-storage-sprinkler system could provide a good solution which needs some preliminary exploratory work.

Land Levelling

Perhaps, the greatest single operation that can substantially increase water distribution and application efficiency is land leveling. This can be done by large-scale heavy earth-moving equipments, tractor-drawn levellers or bullock-drawn levelling equipments or by heavy earth-moving machinery.

Heavy earth-moving machinery used for land levelling consists of bull-dozers, scrapers, road graders, land levellers and floats. Scrapers could be of various types such as towed type, self-propelled type and self-loading. Bulldozers are used for deeper cuts and short hauls such as in rough levelling or benching. Scrapers towed by crawlers are good for haulage of about 300 to 400 metres. Self-propelled scrapers are good for haulage of 700 to 800 metres, but require pusher dozers. Self-propelled scrapers with self-loading arrangement could be more economical. Probably, small scrapers of 2 to 3 cu. metres operated by 70 to 90 hp wheel tractor could also do quite a good production. Graders could be used independently for small cuts or for second stage land levelling after bulldozer or scraper has been used. For minor land levelling, tractor-drawn levellers along with harrows could also be used economically. Land-planer may be used for finishing after major land levelling has been done.

A number of economic combinations are possible for the equipment given above.

This scale of land levelling can be done by large organised efforts of government or command area authorities, who may treat all the land as an integrated unit and after surveying, planning, executing and levelling in an integrated way, provide conveyance system and field layout for proper distribution in the command area. This would enable the small farmers to benefit from a large organised effort of land development.

Levelling By Tractor Drawn Leveller

Tractors and indigenous land levellers have become quite common in areas where heavy earth-moving equipment is not present. Land levellers can neither take deeper cuts nor do large-scale clean transport of earth as done by scrapers. But they cut high spots and fill low spots during their travel. They can be more efficiently used if high spots are scraped by a harrow. If guidance and incentive is available, these simple tractor-drawn levellers could be hired and used for minor levelling and land improvement by small farmers.

Levelling by Bullock-Drawn Equipment

It is also possible to improve distribution of water by using indigenous levelling equipment and providing proper conveyance system and field layout. It will be helpful to have the area surveyed and topographic map made even for small holdings. The existing conveyance system should run on ridge line, otherwise, an ancillary conveyance system may be laid out for letting water into the field. Later, a buck scraper may be used for small-scale cutting or a levelling karah may be used for comparatively larger volume transport. For smaller holdings and smaller size bullocks as in hills, smaller buck scrapers and levelling karahas have been developed which may be used efficiently. Gradual shifting of earth may be done to provide one-sided slope for border irrigation in a phased way in two to three years, provided proper layout is made available to the cultivator.

If there is paddy-wheat rotation, lot of levelling and earth shifting can be done alongwith a leveller-cum-puddler during the preparation of field under wet land condition before transplanting.

Surface Irrigation System

This consists of appropriate sizes of fields keeping in view the discharge, topography, the infiltration rate and the crop. The different methods of surface irrigation and their adaptability for small farmers are discussed below. The different methods are :

(1) Graded Border
(3) Level Border (Basin)
(3) Contour Levees
(4) Contour Ditch
(5) Graded Furrow
(6) Contour Furrow
(7) Level Furrow
(8) Corrugation

Graded Border

The graded border requires land levelling and one-sided slope running in the direction of flow of water. In this method, water is kept flowing at the lowermost end till the water has percolated the root zone. All the water flowing out at this end goes as run off. To avoid waste of water a bund may be constructed at the lower end and the stream may be cut of around 75 to 80% of run, permitting the rest of the area to be covered by surface storage. A mathematical relation based on Israelsen's development has been suggested by Chauhan and Singh [3] determining length of the border. According to this criterion the water may be permitted to flow into the border till sufficient water has percolated to fill the root-zone depth. The length of advance predicted by Israelsen's relationship in non-dimensional form, given below may be taken as recommended length of the border.

$$\frac{a}{I_{av}\ X} = \frac{e^{d/c}}{e^{d/c}-1}$$

where q is the inflow discharge per unit width, I_{av} is average intake rate; X is length of advance in time t; d is depth of infiltration at upper end of the border and c is constant depth of surface storage. c can be estimated by empirical methods; I_{av} can be estimated by conventional methods and depth of water to be applied for saturating the root-zone depth can be found by standard methods. Therefore, for a given stream size available 'X' can be determined. This method of design has been found to provide fairly good distribution efficiency to the system. The brief table (table 3), presented below gives the values of length of border for practical use.

Table 3 : Length of ponded borders (metres) for depth of water application equal to 8 cm.

Inflow discharge (lit/sec./m).	Average Intake rate (cm/hr)						
	1.0	2.0	3.0	5.0	6.0	8.0	10.0
0.5	133	66	44	27	22	17	13
1.0		133	88	53	44	33	26
1.5			133	80	66	50	40
2.0				107	88	66	53
2.5				133	110	83	66
3.0					133	99	80
3.5						116	93
4.0						133	109
4.5							119
5.0							133

Thus wherever land levelling through organised or individual effort is possible, border irrigation may be recommended for efficient application.

Level Border or Basin Method

Level Border or basin method is based on rapid application of irrigation water to a level or nearly level area enclosed by dykes that retain water at a uniform depth until it has been taken into the soil. This is good for a medium to fine-textured soil for growing wide range of crops.

In India this is adopted because of a number of reasons such as low discharges, undulating topography and lack of know-how for a better system. There should be an attempt to encourage the practice of graded borders but, wherever, because of slope or discharge limitations, it is unavoidable to practise basin method, it is desirable to provide appropriate design criteria for this system as well.

Keeping this in view, work was done at Pantnagar [2] to develop relationship among different variables for basin method as :

$$\frac{A \quad I_c}{A \quad t_a} = 0.57 \times 10^{-2} \left[\frac{A^{1.25} \qquad g^{.5}}{Q} \right]^{0.33}$$

where A is the spread area in sq. metres in time t (minutes) for an inflow Q (cu. metre/hr) and I_c is cumulative infiltration for the period. From this relationship the parameter of interest such as 'A' can be estimated by knowing the other parameters for conditions similar to experimental conditions.

Contour Levee

Contour levee is similar to basin except that area is divided into contour levee and cross levee for complete flooding. This is specially suited to rice with areas having less than 0.5% slope and soils having infiltration rate of 1cm/hr or less. This needs land levelling or smoothening and a little more precise control of system. It may, therefore, be possible for adoption by small though educated farmers, provided the system is planned and demonstrated for precise control.

Contour Ditch

Contour ditch system is specially suited for highly-sloping lands. The ditches run approximately on contour from which the water is divorted by temporary dams. Water flows from one contour ditch to next and run off may be collected for reuse. The spacing may be suitably designed depending on topography. If proper field layout can be provided this might prove to be one of the most economical and reasonably efficient system for highly-sloping lands.

Similar to graded border, and level border, is contour ditch; in furrow-irrigated crops graded furrows, contour furrows and level furrows may be used. The only aspect to be kept in view is that the longer the furrows the more uniform is the distribution of irrigation water, the more labour economy can be effected and greater use can be made of improved bullock-driven implements.

Irrigation in Rice Cultivation

Rice cultivation under transplanted conditions require proper puddling of wet land so as to reduce the percolation losses and irrigation requirement during the growth period of the crop.

Field experiments [4] have shown that in clay-loam soil among tractor drawn puddling implements, rotary puddler gives much better performance in respect of reducing hydraulic conductivity of the puddled soil, percolation losses and irrigation requirement than paddy harrow, wet land leveller and double cage wheel. The grain yield per unit area was also highest in case of rotary puddler. Performance of paddy harrow was next in order.

It is suggested that rotary puddler may be used for wet land preparation for paddy transplantation. Bullock-drawn puddlers have also been developed, which should be preferred over the conventional method of puddling in case of bullock-farming.

Conveyance and Control of Water

The farm irrigation distribution system requires layout of conveyance channels with suitable control structures connecting the source of irrigation to different fields of the farm. The same is done through open channels or pipelines. The open channels may be constructed in natural base soil or they may be lined with materials harder, stabler and more impervious than the natural base soil. Lining in addition to preventing water seepage from the channel, also increases the channel's resistance to scour, resulting in increase in the maximum permissible velocity.

Considerable quantity of water is lost in unlined channels, mainly due to seepage. In medium soils such as in Nainital tarai region, on farms having an area of 6 hectares, the average conveyance losses in earthen channels are found to be of the order of 12%. On larger farms, the losses may be as high as 30%.

Channel Lining

The lining may be classified as follows :

(i) Lining with a layer of impervious soil;

(ii) Masonary lining;

(iii) Lining with a bituminous layer;

(iv) Concrete lining;

(v) Clay tile lining.

Lining Channels with Impervious Soils :

Soils that may be used as lining material are listed below in the order of their suitability :

(a) Sand with clay as binding material (50–70% sand, 30–40% clay, 0–10% silt),

(b) Gravel with binding clay (30–40% clay),

(c) Sand with high clay content (30–40% sand, 70–60% clay),

(d) Lean clay (30–50% clay, 60–40% silt, approx. 10% sand),

(e) Fat clay.

When the base soil is very permeable (small pebbles, coarse, poorly graded sand, cracked rocks etc.), the use of fat clay may give good results acting not as a lining but as a sealing material which fills the cracks and pore spaces in the base soil. The thickness of the lining varies according to the material from 5 to 15 cm after compression. When finished, it is covered with sand, straw or sawdust and then watered thoroughly for two weeks. Experiments to evolve a suitable lining for small channels conducted at I. R. I. Roorkee [5] have shown that Usar lining, Alkathene film lining, mud and *bhusa* plaster, stabilized soil lining (one part of cement mixed with 6 to 10 parts of earth) although effective in the initial period, the reduction in seepage losses continuously decrease with time and the lining thus deteriorates with time.

Masonry Lining

The masonry lining for water channels is done with or without connecting mortar. In the latter case, the lining does not provide any protection against seepage losses, and only increases the channel's resistance to scour. Masonry lining without connecting mortar is, therefore, not considered suitable for lining of irrigation channels. Brick lining and stone or *rora* (brickbats) lining are quite old and effective lining methods. First class bricks are laid in 1:4 cement mortar with 1:2 cement mortar pointing. *Rora* lining is done using first class brickbats laid in 1:4 cement mortar with surface plastered to a thickness of 1cm. Brick lining using various combinations of white lime, surkhi and sand mortar have also been tried to explore the possibility of replacing cement with white lime or *kankar* lime at I. R. I. Roorkee[5]. The performance of these methods in reducing seepage and their economics indicate that first class brickwork in white lime and surkhi (1:1) or first class brickwork in cement and sand mortar (1:4) are more suitable.

Lining with Bituminous Material

Various bituminous compounds have been tried for channel lining. The mixtures commonly used are (i) bitumen 80/100, and light creosote oil

(4 parts of bitumen mixed with one part of creosote oil), (ii) Janta Emulsion (a Shalimar tar product) and (iii) liquid Asphalt no. 2. A small percentage (5–6%) by weight of dry soil bituminous material is mixed with soil. The soil selected for the preparation of lining mixture should be sticky. To avoid cracking upon drying, the soil is thoroughly mixed with wheat straw or rice husk added at the rate of 3% of the weight of soil and the mixture is allowed to rot for a week or more in the presence of excess water. Addition of cow dung at the rate of 5% of the weight of the puddle helps in reducing cracking when dry. The bituminous mixture is added to the puddle one or two hours before the application of the plaster. The plaster is used on the sides and bottom of the channel after cleaning and compressing the surfaces. Initially the plaster is applied to a thickness of about 1 cm. A second coat 3mm thick is applied after 2-3 days.

The bituminous mixture lining could be used as a temporary arrangement for 2-3 years after which it does not remain effective. The major disadvantage with it is that it does not prevent weed growth and that it is easily damaged by walking on it.

Concrete Lining

Concrete lining is the strongest of all linings and gives long service with minimum repair and maintenance cost. There are three methods of concrete lining: (a) casting *in situ*, (b) lining with prefabricated channels and (c) spraying into the surface of the channel under pneumatic pressure. In the last method, the lining consists of cement-mortar (a mixture of sand and cement) without any coarse aggregate. The mortar is sprayed onto the soil surface under air pressure. It solidifies in place and usually forms a very strong lining. The thickness of the lining is kept around 3-4 cms. However, this method of lining is not very common in our conditions. Lining with prefabricated channels should be preferred over the channels constructed *in situ*, because proper curing of the channels in the field is not possible. This results in the development of hair cracks defeating the very purpose of lining. Lining with prefabricated channels is a convenient and effective method.

Techniques for the design and construction of manually made non-reinforced cement concrete (NRCC) pipes and semi-circular channels have been developed at Pantnagar [6,7]. The techniques are simple and economical and can be made use of by the farmers after short-term, training. The process needs fabrication of moulds made of mild steel a pulley block and a curing tank. Two concentric moulds are constructed with or without collars, depending on whether socketed or non-socketed pipes are needed. To construct 30.5cm pipe, the internal diameter of the outer mould is kept 38.0 cm and the outer diameter of the inner mould is kept as 30.5 cm. to keep a barrel thickness of 7.5 cm. The diameter of the collars is kept 44.5 cm. and 39.4 cm. The vertical length of the mould is kept as one metre. The outer mould is divided in two halves which can be separated from one another. For semi-circular channels two mild steel plates are provided in between these halves of the mould to split the pipe in two halves. The chain pulley block is fixed just above this set keeping the centre of the pulley in line with the axis of the moulds. The concrete mixture is filled in the annular space of the mould. The inner mould is pulled up slowly after 20-30 minutes with the help of chain pulley block. The pipe with outer mould is kept to dry for 24 to 36 hours and then cured for 14 days. An U-shaped mould can be used for the manufacture of NRCC trapezoidal channels. In this method a wooden form is used to cast the channel section.

Baked Clay Tile Lining

Semi-circular clay tiles moulded and burnt in kilns provide water-proof lining of irrigation channels. Michael, et al [8] developed techniques for making hand-moulded tile channels. The size of the hand-moulded tile is limited to 30cm. diameter and 37cm. length. The tiles are provided with a bell joint(collar) on one end for joining together. The hand moulded tile is air-dried in the shed for a few days. Colouring, if desired, is done by dipping the tile in a bath of red clay. The dried tile is baked in a kiln in the same way as roof tiles. During field layout of the tiles, the ends should be joined with cement mortar. Burnt clay pipe 15 cm to 20 cm. in diameter and 60. cm. long provided with collars are manufactured by Gandhi Smarak Nidhi at some places. They could also be used for underground conveyance of water.

Water Control Structures

Water control structures are necessary for efficient and easy irrigation operations. Adoption of such structures reduces water loss, in conveyance end junctions and it also reduces the labour required to irrigate. Michael, et al [8] have described the construction and operation of a number of water control structures. Some of these are, diversion boxes to distribute water to two or more ditches, checks to form an adjustable dam to control the water level in the ditch and turn out These may be made of masonry, wood or metal, depending upon availability of material and finance. Farmers need to be educated about the construction and use of such structures through short-term training and demonstration.

Recommendations

1. For proper management and distribution, measurement of irrigation water is necessary. This can be done economically by V-notch, rectangular weir or coordinate method.
2. There is a scope of development and improvement of water lifting devices for small farmers. Some of the existing water lifting devices like bullock-driven reciprocating pumps, Egyptian Screw or propeller pumps may be used at appropriate locations.
3. For better efficiency and saving of energy, centrifugal pumps and the drive should be selected for matching site conditions.
4. Shallow wells with bamboo strainer, m. s. rod strainers with or without coir depending upon strata could be installed on small farms.
5. Same pumping unit could be used on a number of pumping points, turn by turn, on a cooperative basis where such arrangements permit.
6. Consultancy service through government or private organisations may be established to educate or advise farmers regarding selection of site, design, construction and material to be used for wells. The same organisation could also advise farmers for selection of matching water lifts.
7. A well must be developed and tested before a matching pump is installed at the source. This may be made a legal requirement for well drillers and pump dealers.

8. Agency for land development through government or cooperatives in an integrated way should be established. This agency may own heavy earth-moving machines and perform land development work on suitable charges to be paid in instalments by the farmers.
9. Border method may be used wherever land levelling is possible to provide one-sided slope. Check basin on fine-textured flat land and contour irrigation on areas with irregular slope may be adopted.
10. Lining of channels is a MUST. Depending upon the available financial resources, underground pipeline system with outlets or lining with prefabricated channels should be done. Training of farmers or local masons on fabrication of moulds, construction of channels using these moulds and field layout of such pre-fabricated channels may be frequently arranged at regional level. The system of introducing cooperative society may be encouraged to take up fabrication of channels/contracts for layout. □

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Capital Productivity in Plantation Industry

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One of the measures to judge the performance of an industry is the return on funds invested in that industry. In other words, the rate of return indicates the productive use of capital, which is measured as :

$$\text{Return on Investment (R. O. I.)} = \frac{\text{Earnings}}{\text{Investment}}$$

The capital for investment purposes can be obtained from various sources such as risk capital and debt. In either case, the capital has different cost of funds. Earnings after payment of interest on debt funds are available for the risk capital and indicate the returns to owners for the risk undertaken by them. To maximise the return on owner's capital, it is also necessary to provide heavier doses of debts from cheaper sources of funds alongwith equity. Return on investment, an indicator of capital productivity, is influenced by (a) the margin on sales, and (b) the turnover of funds invested.

This relationship can be expressed as

R. O. I. = Margin on sales X Turnover of Investment

= Profit/Sales X Sales/Investment

= Profit/Investment

Thus the factors influencing capital productivity can be interpreted as :

(i) Sales and the cost of sales influencing margin on sales. Costs are incurred for payment to various factors of production, and their productivity, in turn, influences the return on funds invested.

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(ii) Interest and other fixed charges on loan funds, the financial costs, etc., depend upon capital mix and return on investment. In other words, return on investment is influenced by the financing policies of the management, to ascertain the extent of supplementing owners' funds by the debt.

(iii) Velocity of funds indicates the speed of turnover of funds invested into sales. This is also termed as the use of funds.

(iv) Another factor influencing productivity of capital is the growth of the industry which indicates the need for funds and the policy of the management to financing the growth. This covers the policy of distribution of profits into dividends or retention of profits for reinvestment purposes.

Objective and Coverage

The objective of this paper is to study the productivity of capital in plantation industry covering tea, coffee and rubber for a period of 14 years (1960—1974). Plantation industry is one of the oldest industries in India and contributes about Rs. 2754 million by way of foreign trade, accounting for about 9% of total export earnings. The present study is based on the data provided in Reserve Bank of India studies on Joint Stock Companies for medium and large public limited companies. In terms of paid-up capital, the study broadly represents 80% of the total industry. The RBI study is available in quinquennial series and the companies covered in each series need not necessarily be the same. It is assumed that the change in grouping of companies in the series does not influence the findings of this study.

Analysis

Return on investments as shown in (fig. 1) varies among plantation industries. It can be seen that tea industry has the lowest return on investment as compared to coffee and rubber plantations. It is also observed that this return in tea was lower than the average return for all industries. On the other hand, coffee and rubber plantations enjoyed higher returns and their average returns were higher than that of average for all industries. When compared to return on total funds, the return on owner's funds or ratio of profit to net-worth was low, particularly in tea and rubber plantations as compared to that of in all industries.

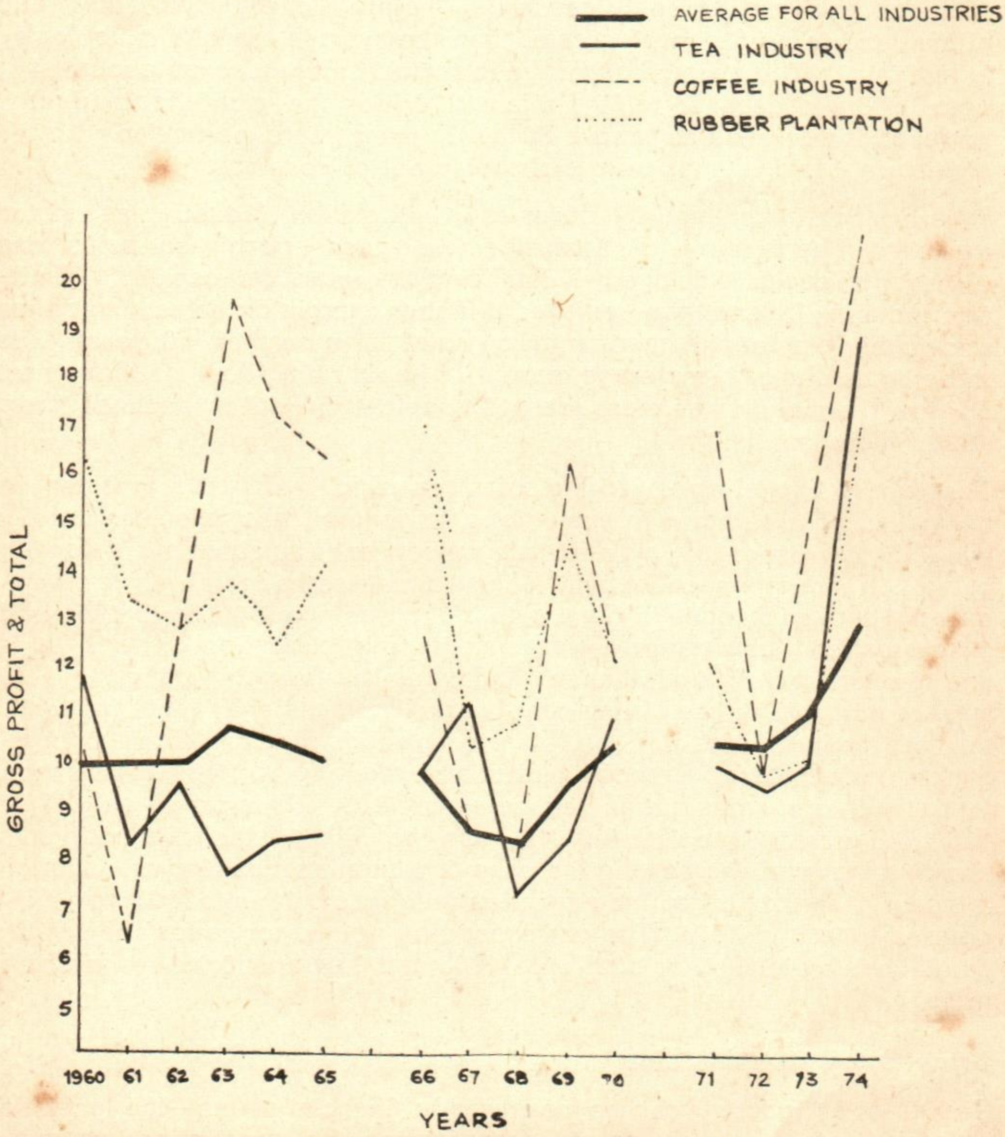

Fig.1 : Return on Investments

In contrast to the above analysis, the rate of dividend on equity in plantation industry was more than 10% for all years except for a few years of recession. Besides, the rate of dividend in plantations was higher than that of all industries, in general. The profit payout ratio (the ratio of dividend to profits) was greater than the average payout ratio for all industries. The average payout ratio for all industries was about 64% upto 1968 and declined to 52% after 1970; for the plantation industry, however, it was generally above 80%. In many years, particularly for tea plantation, the dividends were distributed out of reserves.

The variation in productivity of funds in plantation industry, as stated earlier, can be examined by analysing two ratios—margin on sales and turnover of capital employed—influencing the return on capital. Plantation industry, by and large, enjoyed a higher margin on sales. In coffee and rubber plantations, the margin on sales for a number of years was three times that of the average margin of about 10% for all industries. For tea, the margin was more than 10% upto 1964, but it declined from 1965 onwards.

Turnover of capital employed indicates the velocity of funds invested in business. The turnover in plantations, in general, has been below 0.6, while the corresponding ratio for all industries was about 1.0. Among plantation industries, coffee and rubber industries had relatively low turnover of funds, 0.5, while in tea plantation it was about 0.6 upto 1965 and 1.0 thereafter. Low return on investments, particularly on owner's funds and low turnover of funds depend mainly on the financing policy of the management. The use of low cost funds, like loans and debts influence the total cost of funds and the return on owner's funds. With the emergence of a number of financial institutions, the ratio of debt to owner's funds in all industries has increased since 1965. This ratio was 0.18 in 1960 and increased to 0.42 in 1974. On the other hand, this ratio has shown a marginal increase in the case of plantation industry, even though it is less than 0.1. In tea industry, this ratio was 0.01 upto 1965 and increased to 0.08 in 1974. The corresponding figures for coffee and rubber plantations were 0.04 for both upto 1965 and 0.01 and 0.08 respectively in 1974.

Growth and Its Financing

Growth of an industry can be measured in financial terms—the increase in total assets and fixed assets representing the production capacity.

The total assets in plantations industry increased from Rs. 1770 million in 1960 to Rs. 1960 million in 1974, indicating an annual growth rate of less than 6%. The corresponding figures for fixed assets were Rs. 590 million and Rs.1250 million respectively, indicating an annual growth rate of about 5%. These growth rates were far below the average growth rate of about 10% (except for the period of recession) for all industries. Among plantation industries, tea plantation has a relatively higher growth rate as compared to coffee and rubber. Tea industry has a fixed assets growth rate of about 5–6% per annum during the period under study, except during 1969-71; coffee industry had a growth rate below 4% per annum while in rubber plantation the growth rate increased from 2.5% in 1961 to about 5.6% in 1974.

This low growth rate in assets in plantation industries is commensurate with the low growth rate in sales representing the demand for the products. In other words, following the acceleration principle of investment that the investment is influenced by the increase in sales with time lag, the low growth rate in sales particularly for coffee industry (even negative growth in a few years) confirms the low growth rate of fixed assets. For all industries, the average growth in sales was about 10%. The following statement of sources and uses of funds shows the funds required for growth and how these funds were raised during the period under study.

Statement of Sources and Uses of Funds for the Period 1961-74

(Rs. Million)

Uses		Sources		
Fixed Assets	670.2	INTERNAL		
Investment & Other Uses	38.6	Reserves	312.1	
		Depreciation	351.3	
Inventories	482.3	Others	145.1	808.4
		EXTERNAL		
		Proceeds from Shares Issue	44.4	
		Banks & Fin. Inst.	109.9	
		Debt & Mortgage	89.0	243.0
		Reduction in Working Capital		139.7
	1191.1			1191.1

The analysis of this statement reveals the following :

i) About 56% of the total investment was made in fixed assets, of which plant and machinery accounted for about 20% of the total uses.

ii) Inventories accounted for about two-fifths of the total uses and investment in raw materials represented hardly 5% of the total inventory, while investment in finished goods and work–in–progress inventory represented 76% of the total inventory;

iii) Two–thirds of the total requirements of funds were met from internal sources of funds like depreciation, profit retention and others like tax provisions. Of the internal sources, depreciation and reserves accounted for 29% and 26% respectively of the total uses. As compared to internal sources, external sources accounted for only 20% of the total requirements. Proceeds from issue of shares accounted for only 3.5% while the corresponding figure for bank and other debts was 16.5%.

iv) Long term sources, that too internal sources, in plantation industry have been sufficient to finance fixed assets. It can also be concluded that due to greater availability of internal funds, the reliance on debt funds has not been high.

v) The margin on sales, which is a determinant of return on investment is influenced by the cost of product or the cost incurred on various factors of production The ratio of cost of goods sold to total sales has increased from about 0.85 in 1961 to 0.92 in 1973, resulting in higher cost of production and lower profit margin. Material and labour are the two main costs of production. There is a sharp and marked change in the share of labour as well as materials in total cost of production, since 1966. This may be due to the grouping of expenses in RBI studies in series of five years. For instance upto1965, proportion of material to total cost was below 30% but after 1965, it increased to about 51%. On the other hand, labour cost which was about 42% before 1965, decreased to 28% after 1965. Despits this change. observation of labour cost data, as a proportion to total cost, shows a reduction in the later years of each series. Managerial cost as a proportion of total costs shows a definite fall and it may be due to various statutory restrictions on managerial remuneration. Further, interest cost as a proportion of total cost, is a small figure and shows an upward trend.

Conclusion

The study shows that the productivity of funds invested, measured in terms of the return on investment and the return on owner's funds in plantation industry is relatively low as compared to that of average for all industries. This low rate of return may be due to low velocity of funds invested and distribution of higher proportion of profits as dividend. The low growth rate of sales (even negative growth rate in a few years) in plantation industry confirms a low growth rate of assets employed in the industry. The growth rate of assets in plantation industry has been about 5% per annum and they were financed mainly out of internal funds. The reliance on external funds was only one-fifth of the total requirements. Due to greater availability of internal funds, the reliance on debt or institutional loans has not been high.

Lastly, the decline in margin on sales over the period, particularly in tea, due to increase in costs of production has also affected capital productivity. □

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Book Reviews

Professional Management in India: Problems and Prospects

M. V. Pylee and K. Sankaranarayanan

Foundation for Management Education, pp. 466, Rs. 75.00

Reviewed by Prof. S. Neelamegham*

The book is a collection of thirty-nine articles which highlight various issues and problems confronting professional management in India. Part I which consists of fifteen papers deal with aspects concerning management development in Indian industries. Part II which consists of ten papers deal with public sector management. Finally, the fourteen papers which constitute part III discuss the major problems concerning trade unions, industrial relations and personnel management in the Indian context.

In the lead article under part I, M. V. Pylee critically examines the role that the family management has played in the industrial development of the country. He highlights both the strong points as well as the weaknesses of the family enterprises. Finally, he advocates that in the present context it is vital that the family management should revitalise itself through deliberate and systematic education and training in order to play its constructive role and also face the challenges of the future. This is further reiterated by K. Srinivasan in his article entitled "Management methods under change conditions." He emphasises that "as time goes on, there will be a considerable amount of interdependence between family and professional managers on the one hand and between the private and public sector on the other. Therefore, a group of people trained in a common understanding of problems will be essential for such cooperation. ....The executive of the future, irrespective of the source from which he originates should first of all be professionally competent and knowedgeable." T. Sukumaran Nair highlights the need for development of social skills and attitudes of Indian managers. He argues that in addition to emphasising knowledge and techniques, management education and training should aim at developing the total personality of the individual managers.

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With an investment of more than Rs. 7,000 crores and a turnover of nearly Rs. 12 billion, the public sector in India today occupies a commanding position in the economy. Of late, increasing attention and importance is given to their effective functioning. In this context, part II of the book presents many valuable insights into the working and management of our public sector undertakings. K. T. Chandy emphasises the need for the Government to lay down clearly the social objectives and obligations of the public sector undertakings. In the absence of such clarification it is very difficult to have proper appraisal of the performance of these undertakings. J. R. D. Tata makes a forceful plea for granting more freedom to public sector enterprises. He emphasises the need to define clearly the relationship between the public sector, Government and the Parliament. While discussing the importance of management development in public sector organisations, P. L. Tandon observes : "Public sector is very much a part of Government and integrally bound to administration : it cannot get away from it". However, it requires its own industrial and commercial industrial culture. For this, he emphasises the need to develop a new type of industrial executives with industrial skills, and trained in this culture to ensure effective performance.

Part III deals with diverse issues such as trade unions and productivity, inter-union rivalry, wage boards, joint consultation and other related issues in the field of personnel management and industrial relations.

Professional management has made rapid strides in India, especially during the last two decades. With the growing industrialisation, increasing role of the Government, expanding public sector, and the active role played by the professional bodies such as productivity councils and management asssociations, management movement in India is likely to gain further momentum in the coming years. In this context, M.V. Pylee and K. Sankaranarayanan have made a valuable contribution towards management development in India by making available to the practising managers as well as to the students and teachers of management, this anthology which highlights several issues and dimensions of the managerial function. □

The Spectrum of Industrial Relations: A Series of Talks

Bagaram Tulpule

Indian Institute of Personnel Managment, Durgapur Branch, 1975, pp. viii+70, Rs. 15.00.

Reviewed by M. J. Naik*

IIPM deserves praise for bringing out in a book form the lectures delivered to IIPM audience at Durgapur by Bagaram Tulpule who (as the chairman of IIPM Durgapur Branch in his Acknowledgement puts it) is a "rare mix" of the combined role of a Trade Unionist and a General Manager in the same person.

The talks cover a wide spectrum of subjects like Industrial Conflict, Industrial Relations, Collective Bargaining, Discipline and Human Relations.

Throughout the lectures one can feel what Tulpule himself observes (page 1), "an insight into the problems of industrial relations and of the conflict which these are often accompanied by" which is otherwise missing in both the management and the trade unions.

While talking of industrial conflicts he says (page 4), "the fact of strained industrial relations is a part of our lives, ... which we have come to accept as something inevitable in industrial situations". But he wants us to do something about it because of not only the loss caused on account of man-days lost in terms of the value added by labour, but more so because of the total loss caused by the "interdependence of the system and therefore, the multiplier effect" of any industrial conflict at any place. He compares the severity rate of other countries with India and points out as to where we stand. While on this subject he points out the difficulty in the introduction of change (in organisation, of methods, of technology) which, according to him, is the effect of poor industrial relations. He also enumerates the problem of social cost, of human frustration and their consequences on industrial society.

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On nature of industrial relations, he readily admits of the inherent conflict of interest between workers and employers or management. In pursuing this argument he talks of the needs of the workers and goes on to point out (page 9) that the worker wants these needs "to be satisfied primarily through his employment,......where he spends the major portion of his working life." He then goes on to discuss the conflict of interest of the needs of the worker and of the employer because the objectives for which an employer puts up the industry and the objective for which a worker comes to the industry "are different". As he succinctly puts it, (page 10) "They are not only different, but there is an element of conflict in them". Similarly, he talks of the conflict between the employer's concept of discipline and the worker's concept of his own dignity and his own recognition as an adult responsible human being; the conflict between the concept of "hire and fire" and the worker's need for security of employment. It is not merely a conflict of interest that matters, but a problem of industrial relations arises because "this freedom to go their own individual ways is not available to the parties" . "yet a relationship has to be continued, has to survive in spite of the conflict of interest". Tulpule, therefore calls the work place "a heavily charged field" because of the past history, economic disparity and difference in the roles and totally different norms for judging "equity".

On this firm premise he describes the historical background and the power conflict in what he calls (page 24) as the genesis which has given the trade unions the character of "movement of protest".

He further enumerates other factors which cause labour-management relationship to be charged or loaded. These factors, according to him are the "Roles Gap" in the sense of trade unions touching very few functions out of the management functions; the "Economic Gap" in terms of the wide gap between the economic status of the workers and management resulting in an "ideological gap"; environmental factors like the political philosophy of the rulers or social stratification. He thus concludes (page 29) the talk on Nature of Industrial Relations by repeating that these number of influences, number of pressures "create a situation of distrust and hostility", making it difficult to resolve the conflict under this situation. He, therefore, advises the parties to meet on a "neutral field" rather than try to operate in a charged field. He has, however, not elaborated where this neutral field can be found or what this neutral field is.

Perhaps he wants us to understand how to create this neutral field by trying to see the objectives which we should strive to attain. He himself puts to us a question whether the minimisation of industrial conflict is the overriding objective. But, he himself answers by stating that "minimisation of conflict is probably too limited an objective". According to him, therefore, "the objectives of industrial relations have also to be extended to the creation of climate of relations where this kind of human, social and psychological satisfaction will be possible." This he calls the creation of certain positive climate of relations. He, however, does not overlook the problem one has to face to achieve these objectives. He talks of the adverse images in the perception of the management and the unions of the other side which he says generally range from grey to black and they do not come within the area of grey to white. Yet, inspite of these, we have to carry on our search for solutions to the problems. The other and the most dominant problem is the issue of wages where the issue gets coloured with the rival sets of images. Tulpule then describes in detail how the resolution of this problem of wages is difficult because of the different yardsticks. On the issue of bonus, he points out how the trade unions tagged on to it the concept of deferred wage and candidly admits (page 35), "I must say I was a party in doing that". He thus suggests that in such situations where the assessment of merits of a case becomes extremely difficult, in essence it becomes a question of "adjustment of interests"—what he subsequently calls (page 37) as "the problem-centred attitude" essentially directed to finding a solution to the problem rather than to find "an absolute norm of equity or fairness or justice". In finding a solution, work stoppages either in the form of strikes or lockouts are, he admits, pressure processes on either side. But he asserts that, neither the mangement nor the unions can look upon industrial conflicts as the ultimate effort of one side to impose its will on the other for all time or finally to subdue the other side.

Tulpule, in his next talk, advises, as the title suggests, on the "Parity of Bargaining Strength" where no party should have predominant strength which it is difficult to use discretely and judiciously. Nor should there be an attitude of win or lose.

In his next talk on "Industrial Relations Policy", Tulpule talks on the positive role a representative union can play and then describes in detail about the problems in India in finding out representative character

Critical path Analysis: A Systems Approach

A. V Srinivasan

Affiliated East-West Press, pp. 128, Rs. 24.00

Reviewed By S. K. Kalra*

Systems principles for management are built around planning, organising, communication and control. Critical Path Analysis is the best example of management where systems principles are applied to the maximum possible extent. The author has driven home this point very well in the first chapter of his book.

Chapters 2 to 9 relate to the fundamentals of Network Analysis and have been presented in a style that it could be useful to both the student of business administration and the executive who wants to develop his knowledge of the managerial aspects of project execution. These chapters have been written in a simple, lucid and crisp style, that one can go through these in a shortest possible time and also have a good understanding of the subject. The whole subject of Critical Path Analysis has been dealt with in about 40 pages of the text. The case examples given in the chapters lend clarity to the understanding of network techniques.

In chapters 10 and 11, the author describes the use of the other related techniques like Line of Balance and Graphical Evaluation and Review Techniques. These two topics and their applications have been included in the book very appropriately. In chapter 12, the author discusses about the computerisation of Network, other related techniques of Network Analysis like Multi-projects Scheduling and various computer programmes for CPA on systems IBM 1401, IBM 360, ICL 1900, etc. In chapter 12, the author has also dealt with the organisational aspects of Project Management, the use of Master Network, the Zonal Network and detailed Network. The Six Indian case studies from the areas of marketing, construction, maintenance, research and development, education

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and military planning underline the vast scope for the application of Network Analysis.

The author has done a commendable job in dealing the subject in a precise and lucid manner within a span of 100 pages. A book on the subject by an Indian author and with Indian case studies, and at a modest price was definitely needed. The reviewer endorses the view of the author that this compact volume is invaluable to the executive who wishes to establish rapport with the technician and also is an ideal primer on network analysis for the student of business administration. □

Multi-National Firms

S. Shiva Ramu

Sultan Chand & Sons, Darya Ganj, Delhi, pp. 95, Rs. 30.00

Reviewed by O. P. Jain*

Multinational business has received a tremendous impetus after the Second World War, particularly during the fifties and sixties. Based on figures compiled by European Economic Community secretariat, there are approximately 10,000 multinationals in Europe, USA and elsewhere—4534 having a base in Europe and 2570 in the US, with 49,256 and 24,171 links, respectively. In 1970, the share of mulinationals was estimated at $450 billion, i. e., 15% of the total gross world product. Their growth rate has been faster than the growth rate of the world trade. These figures speak about the substantial role of multinationals in the world product and trade. A great future lies ahead of them : it is anticipated that by 1985 more than half of the gross world product will be produced by 200 giant multinationals.

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It has been argued recently that multinationals have, by and large, played an important role in the economic growth and welfare of the *host* countries, including both the developed and the developing countries. This observation does not, however, preclude somewhat bitter criticisms made by the nationalist elements in developing countries against the exploitative motivation and designs of multinationals in the developing countries. But doubts and scepticism are gradually dispelling and the non-political observers are inclined to view dispassionately the contributions made by multinationals in the past and their potential role in the future of such countries. Sufficient literature, both theoretical and empirical, has recently emerged on this subject, which tends to enlighten public opinion on the need for channelling multinationals in the desired directions of production and trade for mutual advantage of the parent and the host countries. There is a growing appreciation at national and international level of the value of code of conduct as a precaution against the exploitative tendencies of certain multinationals. The Indian experience shows that once the adequate policy safeguards are provided, multinationals can be harnessed to the advantage of both the developed and developing countries.

It is against such a perspective of the past, present and the future of multinationals that the book under review is to be welcomed by those interested in the subject. The author himself states in the preface : "for a proper perspective, it is necessary to understand the genesis of multinational firms and how they have been able to adapt themselves to the changing environments in the international politico-economic system". Equally important is to observe that a proper perspective of the contribution by multinationals needs to be built up for a proper understanding of the genesis and potentialities of such firms in relation to economic needs of developing countries. The book claims to meet the first need by confining its scope to the study of strategy of the multinational firms and the environment in which they operate. But it does not attempt to meet the second, though equally important, need.

The book is divided into five chapters with an Annexure illustrating the case of India in the field of industrial cooperation among developing countries.

In chapter I, there is an interesting account of traversing by a multinational firm through different phases of marketing—product-market, finance, and technical and managerial skills. Also, there are useful references of eminent authorities on different constituents/elements of business strategy including multiple goals, motivation for entry in foreign countries, techniques, and criteria of strategy planning. The same approach, dotted with authoritative opinions and quotations, graphical representations and numerical illustrations, is dominating the analysis of financial management in chapter II, product-market strategy in chapter III and management strategy in chapter IV.

The product-market combinations in the operational policies of these firms should help a reader understand the variety of their operations with distinct *features*, determined by different countries individually or in groups. Also, there are useful references to the different spin-outs and effects of multinational business on the parent companies and organisational structure. One may not be able to resist temptation to go through the diversity of motivation and operational problems faced by these firms under different politico-economic environments. The brief but pointed references in chapter V are likely to stimulate readers' interest in further probe into the subject. The factual analysis of Indian joint ventures made against a perspective of different forms of industrial cooperation among developing countries in the Annexure should help identify directions in which such a cooperation can be further developed for mutual benefit.

With its present coverage, the book should help promote understanding of certain basic concepts, key operational aspects of some business techniques and behaviour pattern of multinational firms in the world of today. It should creditably serve the purpose of a primer on the subject, guiding and goading an enlightened reader for authoritative references needed to undertake in-depth analysis of multinationalism. It may not, however, serve the purpose of a text book on the subject, intended to explain in detail the basic concepts, principles and practices of multinational business, because it assumes a sufficient amount cf prior understanding of the subject on the part of its readers.

However, the book invites little controversy in facts, analysis and conclusions, because it narrates different approaches and strategies with different consequences, not in application to a particular set of circumstances in a specific country or period of development of multinationals. The author could profitably attempt a critical appraisal of India's experience in respect of (i) operations of multinationals and (ii) economic cooperation among developing countries, against the background of basic concepts, motivations and strategies explained in the book.

Nevertheless, the limited scope and non-critical treatment of the subject do not detract from the value of the book as a useful addition to the literature on the subject. A busy business executive and economic policy maker can profit by what is analysed in this book for proper understanding and evaluation of the performance of one or more multinationals in his own country. □

Political Linkages and Rural Development

K. Seshadri

National Publishing House, New Delhi,1976, pp. 233, Rs. 35.00

Reviewed by S.D. Thapar*

It was not a day early that the Government of India felt concern for the rural poor in 1975. In a political set up like ours, the good intentions of policy makers often flounder on the rock of expediency of election gains of political leaders. The programmes of Community Development and of Panchayati Raj achieved but little for the very poor in villages because the interests of local elite were at cross purposes with them. And the role of elite to mobilise votes has been undisputed all this while. In the absence of consciousness on the part of high-caste party bosses and due to the lack of committed bureaucracy, the lot of backward class agricultural labourers and small and marginal farmers has improved only marginally since independence. K. Seshadri's book written in 1972 makes a graphic presentation of the then situation. Based on sample survey studies in two states and personal experience and understanding of the political system in the country, the author has reached conclusions which though not new are expressed daringly forthright.

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The value system of the new economic order economists is under revision. A distinction is made between 'growth' and 'development' and it is agreed that sheer concern about growth may not promote human happiness, development and social justice. The role of panchayati raj in the new economic order is great. Through it everyone in the village receives significance. He is a participant in development, rather than being only at the receiving end. How far panchayats have been able to achieve this objective in India is the subject of enquiry.

Since the author believes that the socio-economic objectives of panchayati raj get compounded with political linkages from the centre downward, he selected two distinct situations of Gujarat and Andhra Pradesh for his case studies. The study throws floodlight on the awareness of the population about socio-economic changes taking place or planned to take place in the country. Interviewing was done at various levels : the officials and the non-officials, the opinion leaders and the general public, the village elite and the depressed classes. A thorough research is made into the power structure at local level. The degree of independence with panchayat raj functionaries, and intervention and/or non-intervention in their work by higher-level political leaders and services is another aspect of the study. The opinions of the people about cooperatives made a subject of enquiry.

By broad conclusions, the local governments remain anachronistic institutions where the privileged sections continue to dominate. The cooperative movement has not touched the weaker sections and has become almost an instrument in the hands of the privileged rural elites for their own improvement. Respondents in Andhra Pradesh say that coopratives are a fraud. Ever since the inception of the community develeopment programme in the country, village officials are answerable to two types of high level bosses, the generalists and subject area specialists. To avoid conflicts, many of them followed the practice of inaction. The relationships of state-level political leadership with panchayati raj leaders makes another interesting study. They depend upon the local leaders for winning elections, as they have little contacts and/or following of their own. But having got elected, they vie with local leaders as regards powers to dispense favours among communities. By and large, a villager regards a panchayati leader more than a legislator.

Politicising of panchayati raj is a moot point. While it has vitiated the harmonious community life in villages, a well-knit political linkage assures solution of local problems by the higher echelon in political hierarchy. The author rightly believes that what matters ultimately is the character of people. The bane of the Indian polity has been double-thinking on the part of even the highest level leaders. There is a dual stream in India, one rhetorical and another practical. All caste affinities, econonic relationships are exploited during elections and at the same time lip sympathy is shown to a casteless society, socialism. Competitive politics should not mean caste-oriented politics. In the name of reality in politics, immorality cannot be condoned. If Gandhiji made any contribution to civilised politics it was to inform political actions. It is not old-fashioned, writes Seshadri, to re-emphasise morality. "A society that makes a mockery of morality cannot survive for long". □

The Poverty of Policy and Other Essays in Economic Policy and Administration

H. K. Paranjape

Somaiya Publications Pvt. Ltd., Bombay, pp. xvi+387, Rs. 85.00

Reviewed by V. S. Mahajan*

The book under review is a collection of articles that the author wrote over the last decade. It is divided into three parts and contains 29 articles. In "The Poverty of Economic Policy" which is the key article in Part 1, the author lays emphasis on the fact that the Indian economy had failed to follow a bold economic policy. The author recalls that while the Economic Programme Committee, under the Chairmanship of Pandit Nehru, had brought out a Report in 1948 outlining the future course of industrial development in this country and which was quite in tone with the assertions made by the congress before independence, this was opposed especially by the large business interests; and ultimately,

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the contents of 1949 Industrial Policy Resolution were much different from the earlier economic programme. Further, the author adds, "This actually became almost the norm about policy statements since then. To satisfy a radical conscience and also for electioneering purposes, bold objectives were stated, and these finally ended in resolving that we aim at socialism. All such statements were, however, qualified by various ifs and buts so as to leave considerable latitude for pursuing in practice something quite different. This also resulted in the tendency to work out large plans and programmes, but leaving their concertisation in detail only half complete", (p.10).

Regarding saving for investment the author poses a pertinent question—should saving for investment in the public sector for development of large capital assets in industry, power and transport and other public construction come from the public sector itself or from the private sector? If it were to come from the private sector, then more incentives would have to be provided to the large-scale private sector, which, in other words, would mean, encouraging vast inequalities in income distribution. And this, the author concludes, has actually happened in India. Even in its anxiety to solve the foreign exchange problem, the government has often encouraged unnecessary foreign collaborations and in this process large profits have been made by foreign capital. Such approach has also resulted in the emergence of a wrong system of priorities. For example, in the private sector a high weightage has been given to investment in less essential and luxury articles for it was found to be highly profitable and this has as well contributed more resources to the government in the shape of taxes. However, all this has resulted in vast inequality in income distribution and movement away from the path of socialism.

The author asserts that economics and politics can only be separated in theory and not in practice. India having accepted a political framework of parliamentary democracy, failed to provide a healthy system of financing such system. The result has been that for financing elections, which have gradually turned out to be extremely costly campaigns, political parties have been increasingly looking to the large corporate sector for financial support, and this was natural to lead to a large-scale economic concentration through favours shown to certain industrial groups (who had liberally financed elections) like the issuance of licences, allocation of scarce foreign exchange, etc. While the approach paper to the Fifth

Plan (1973) had articulated programmes for better income distribution, i.e., more in favour of the poor members and less in favour of rich and middle income groups, it would certainly be a difficult job to achieve it without first radically changing the process of production.

The author favours the adoption of a suitable income policy. He is of the opinion that the public ownership of means of production would help in such a task. This, of course, is a debatable issue. Further, a suitable income policy can only be ensured through evolving a suitable price policy as well. In India, prices being mainly dependent on the production of agricultural and consumer goods, the success of an income policy would depend on the maintenance of stable prices of these goods.

Issues like Joint Sector, Licensing Policy (1970), Social Control of Private Businesses, Industrial Policy and MRTP Act are dealt in Part II of the book. While the author provides here a brief introduction summarising the main issues involved in these fields, one finds that in the articles included there is considerable overlapping of material. For instance, while two chapters are devoted to the Joint Sector (and even here there is repetition), this issue also occupies considerable space elsewhere (e.g., in Social Control of the private sector). Perhaps, while writing a book of this nature overlapping of material is unavoidable, at the same time with suitable editing, this could have been considerably reduced.

Political and administrative problems in the implementation of Plans are discussed in Chapter 12. Here the author spells out the role of the Indian Government in industry, agriculture, economic overheads, social overheads, maintenance of international balance of payments, ensuring price stability and increase in financial resources. The Indian Government has to play a vital role in all these sectors. In fact, the very success of each Plan depends on the dynamism displayed by the Government while looking into different problems under each of these sectors. Because of India's size, population and regional problems, the success of each Plan would depend on the cooperation that the Centre gets from the State Governments, as well as on the approach that the Centre adopts to tackle the problem of individual state.

Most of the issues raised in the book are of topical interest and would be found of interest by students of Indian economy in particular and by all those who are keen to know the recent developments in this country. □

Management Information Systems

Edited by Dr. N. K. Kulshrestha

H. C. M State Insitute of Public Administration, Jaipur, 1977, pp. 94.

Reviewed by M. K. Bobde*

The book contains papers presented by senior managers and officers of public undertakings and also by the faculty of HCM State Institute of Public Administration, Jaipur, in a workshop. The major contribution is from Dr. N. K. Kulshrestha.

The author presents three papers, one giving the outline of MIS, second on Management Reporting and the third dealing with MIS for MBO. In management reporting, he has brought out a good point about the reporting, viz,, "after fact" and "before fact". He has also given a comprehensive list of report for Rajasthan State enterprises which many a state undertakings may find useful. In the third article, he has tried to link up MIS with MBO and has given a comprehensive check list for industrial diagnosis. At the end, he gives the list of information for goal-oriented appraisal of management efficiency for Rajasthan State Road Transport Corporation which the State Road Undertakings may find useful.

However, in such short papers, it cannot be expected from the author the finer points on how to arrive at a specific information/report need and to what use it can be put to. Rathore presents the need of MIS in the government departments and how it differs from those of business organisations. This is so because the objectives and activities of government differ from the business organisation. He also deals with the design consideration of MIS in very general terms. He elaborates on the need of codification and classification.

The three papers presented by M/s. Varshney, Chauhan and Saxena are very general and no attempt has been made to go into details of designing of MIS or decision. The book presents the advantages of MIS for private, public and government organisations. In view of shortage of literature on this subject in the country, this book is a commendable effort. □

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