FACTORS CONTRIBUTING TO REGIONAL VARIATIONS IN PRODUCTIVITY AND ADOPTION OF HIGH YIELDING VARIETIES OF MAJOR CEREALS IN INDIA*

By

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The introduction of high yielding varieties of cereals during the mid-sixties ushered in an era of quicker agricultural development in the country. A steep rise of 25 per cent in the production of cereals from 76.9 million tonnes in 1964-65 to 96.6 million tonnes in 1970-71 was obtained in a short span of 5-6 years, mainly because of the higher productivity of these varieties with adequate doses of fertilizers and other improved practices. However, the new varieties were highly sensitive to appropriate agronomic and management practices as also susceptible to pest and disease attack. Their performance was, therefore, governed to a large extent by the local factors like soil, climate and management practices adopted leading to sharp variations between regions and even between districts in a region.

With the spread of new technology in larger areas, the variations in the level of inputs and practices adopted led to differential rate of growth of agricultural production in different regions and thus created wide regional imbalances even though the package of recommended practices was more or less the same.

To study these regional imbalances in agricultural production and investigate constraints and limiting factors, data from large scale survey of assessment of high yielding varieties programme conducted

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by the Indian Agricultural Statistics Research Institute in 88 districts covering 15 States during 1973-74 were utilised. For the purpose of the study, the results were pooled over districts within the same agro-climatic region formed on the basis of soil, moisture index and cropping pattern.**

METHODOLOGY

The design adopted for the survey was a stratified multistage random sampling with villages, cultivators, fields and plots of specified dimensions constituting the various stages of sampling units.

The estimate of average yield (variety-wise and pooled over the varieties) was obtained by the usual procedure. For estimation of area under HYV, since the variability in this character was observed to be rather high and also since it was correlated with total area under the crop, ratio method of estimation was used.

The district-wise estimates of yield were pooled taking area under HYV of the crop as weights. Other estimates of inputs were also suitably pooled over the districts in a region. Since, rice and wheat are the major cereals accounting for nearly 70 per cent of the cereal production in the country, the results pertaining to these two crops only have been presented and discussed in the paper.

RESULTS AND DISCUSSION

Rice. The results regarding yield, area under HYV, fertilizer use etc., for rice are given in Table 1. Large variations in the average yield of rice varying from 11.7 q/ha in Bilaspur (Madhya Pradesh) to 37 q/ha in southern Karnataka region were observed. Even in a traditional rice growing State like Andhra Pradesh, the yield varied from 31.4 q/ha in the lower Andhra Pradesh region to 24.2 q/ha in the upper Andhra Pradesh region. High variation in the yield from 14 to 26 q/ha was similarly observed between Bolangir and Ganjam districts in Orissa. However, in the other traditional rice growing States like Tamil Nadu, West Bengal and Uttar Pradesh, the yield variations between different regions were not so serious. The yield rate of 32.7 q/ha obtained in Punjab region was higher than that obtained in most of the regions in the traditional rice growing States.

Regarding the extent of adoption of HYV, the proportion of area under HYV to the total area under rice crop was the largest in Punjab (81%) followed by upper Andhra Pradesh (55%).

**Agro-climatic Regions in India by Dr. Rajendra Prasad, Professor of Agronomy, I.A.R.I. New Delhi.

TABLE 1

Area, yield, fertilizer use, irrigation, credit and agro-climatic factors for HYV of rice in different agro-climatic zones, 1973-74

Agro-climatic zone No.	*State*	*Districts covered*	*Moisture index*	*Broad soil type*	*Holdings irrigated (%)*	†*Estimated area under HYV (000 'ha)*	*Average yield (q/ha)*	‡*Average rates of application*			*Cultivators availing credit (%)*
								N	*P*	*K*	
1	2	3	4	5	6	7	8	9	10	11	12
1.	Andhra Pradesh	Anantapur, Chittoor	−20 to 60	Medium black, Deep black, Red and black	98	49.1 (39)	31.4	86 (97)	37 (56)	29 (46)	9
2.	,,	Karimnagar, Warangal, Nellore, Nizamabad	−20 to 60	Red, Medium black	96	109.8 (31)	26.9	65 (90)	28 (62)	17 (10)	36
3.	,,	Krishna, East Godavari, Guntur	−30 to 60	Deltair alluvium, Red	98	400.2 (55)	24.2	53 (99)	30 (84)	22 (30)	35
4.	Tamil Nadu	Coimbatore, Madurai, Tirunelveli	−20 to −40	Red, Red and black	100	70.3 (31)	27.0	113 (92)	39 (68)	39 (67)	18
5.	,,	Chingleput	−20 to −40	Red	100	16.3 (9)	23.9	53 (99)	41 (89)	38 (85)	11

1	2	3	4	5	6	7	8	9	10	11	12
6.	Karnataka	Bellary, Mysore, Shimoga	0 to −60	Medium black, Deep black, Red & black, Red	96	77.3 (28)	37.0	104 (100)	45 (79)	43 (76)	31
7.	West Bengal (Ans)	Birbhum, Murshidabad, Midnapur	0 to −20	Red & yellow, Laterites and lateritic	70	50.2 (26)	20.2	48 (92)	21 (69)	37 (48)	14
8.	,,	24-Parganas	0 to 50	Coastal alluvium	97	2.6 (15)	20.0	81 (99)	36 (91)	31 (25)	**
9.	West Bengal (Aman)	Birbhum, Murshidabad, Midnapur	0 to −20	Red & yellow, Laterites and lateritic	82	196.5 (20)	20.0	42 (95)	25 (76)	41 (26)	14
10.	,,	24-Parganas	0 to 50	Coastal alluvium	30	13.9 (6)	22.3	92 (87)	47 (73)	44 (18)	3
11.	Orissa	Ganjam	−20 to −40	Red, Coastal alluvium	36	NA	26.1	56 (89)	35 (35)	* (5)	17
12.	,,	Bolangir	0 to −20	Red, Red and yellow	26	NA	13.7	82 (100)	74 (88)	* (15)	3
13.	Assam (Autumn)	Kamrup, Sibsagar	50 to>100	Alluvial, Laterites and lateritic	11	35.4 (17)	28.5	57 (57)	32 (46)	27 (44)	—
14.	Assam (Winter)	Kamrup, Sibsagar	50 to>100	Alluvial Laterites and lateritic	8	51.7 (13)	28.5	45 (37)	28 (32)	26 (29)	1

15.	Uttar Pradesh	Meerut Muzaffarnagar, Bulandshahr, Etawah, Kanpur, Saharanpur	−40 to −60	Alluvial	96	58.4 (20)	18.5	68 (76)	47 (28)	24 (12)	11
16.	,,	Basti, Bahraich, Deoria, Gonda, Gorakhpur, Moradabad	0 to −20	Alluvial	62	221.7 (17)	15.5	54 (88)	39 (33)	26 (27)	3
17.	,,	Rae Bareli, Faizabad	−20 to −40	Alluvial	74	97.8 (40)	18.0	61 (87)	46 (26)	48 (19)	5
18.	Punjab	Hoshiarpur, Kapurthala, Jullundur	−40 to −60	Alluvial	100	71.6@ (81)	32.7	79 (99)	34 (95)	37 (22)	38
19.	Haryana	Ambala	−20 to −40	Alluvial	86	19.8 (40)	25.8	69 (95)	48 (5)	* (*)	15
20.	Rajasthan	Kota	−40 to −60	Medium black	97	1.7 (21)	18.4	88 (98)	49 (84)	38 (24)	21
21.	Maharashtra	Nagpur	−20 to −40	Medium black	62	2.1 (5)	17.3	70 (100)	30 (98)	19 (53)	39
22.	Madhya Pradesh	Bilaspur	0 to −20	Red & yellow	35	109.8 (17)	11.7	64 (87)	42 (78)	20 (18)	48

NA—not available.

**Negligible

*Estimates not presented as based on very few observations.

@Refers to area reported to have been achieved under high yielding varieties.

†Figures within brackets in column 7 give estimated area under HYV as percentage of total area.

‡Figures within brackets under columns 9, 10 and 11 give the percentage area benefited.

The adoption of HYV in different regions, therefore, had no direct bearing with the yield rate since even in a State like Karnataka with the highest yield rate of HYV, less than 30 per cent of the area was cultivated with these varieties.

The important factors governing the extent of adoption of HYV are the local conditions including the climate, supplemental water supply and the agronomic and management practices. The variability in the yield would also be mainly governed by the levels of inputs. Thus, a study of these factors would to a large extent, explain the variations in both yield and extent of adoption of HYV in different regions.

In almost all the regions except in Assam, nitrogen was applied to more than 90 per cent of the area under HYV of rice. Use of phosphorus was also fairly common (above 80%) in upper Andhra Pradesh, northern Tamil Nadu, eastern Karnataka, West Bengal, Bolangir (Orissa), north Punjab, Kota (Rajasthan), Nagpur (Maharashtra) and Bilaspur (Madhya Pradesh). In the remaining regions phosphorus was applied to 50-70 per cent of the area under HYV except in Assam, Uttar Pradesh, Ganjam (Orissa) and Haryana where use of phosphorus was rather low. Application of potash was substantial in Tamil Nadu and Karnataka while in the remaining States, it was low. Thus, the area under HYV of rice benefited by the three major nutrients varied considerably in different regions.

The rate of application of the three nutrients showed that the doses of nitrogen were the highest in Tamil Nadu and Karnataka being more than 100 kg/ha followed by Andhra Pradesh, West Bengal, Punjab and Rajasthan (about 80 kg/ha). The rates of application of phosphorus and potash were however fairly uniform in different regions, varying generally between 30-50 kg P_2O_5 and 20-45 kg. K_2O per hectare. Thus the variability in the levels of application of both P & K was much less compared to that of nitrogen. This is possibly because relatively fewer cultivators adopted these nutrients but having decided to apply these nutrients, the cultivator normally applied adequate quantity to meet the crop needs of these nutrients. The contribution to the variability in the average yield from the use of fertilizer, therefore, comes not so much from the unbalanced use of NPK as from differential proportion of cultivators applying these nutrients.

The other sources of variability in the yield rate as well as the extent of adoption of HYV is the water availability and the nature of supply (whether assured or not). Taking into account the rainfall

and climate of a region, a composite moisture index was worked out as follows:

Moisture Index $= (P-PE)/PE \times 100$

where P is the annual precipitation and PE is the panevapo transpiration. The moisture index for different agro-climatic regions is also given in the table.

As expected, the moisture index was the highest in Assam followed by West Bengal and low in Andhra Pradesh, Karnataka, western Uttar Pradesh, Punjab and Rajasthan. Thus the moisture index does not appear to have a direct bearing on the yield or extent of cultivation of HYV possibly on account of supplementary irrigation facilities available in different regions. The most assured source of water supply was the well (including tube-well). The highest yield and adoption rate of HYV were obtained in Punjab, Haryana and Andhra Pradesh, where the moisture index was low but assured water supply was available through supplementary sources. The soil type was another factor which partly explained the variability between regions in Orissa and Tamil Nadu. The low yield in Maharashtra, Madhya Pradesh and eastern Uttar Pradesh are further explained by the low percentage of holdings having irrigation facilities.

One of the reasons for the imbalance in the use of inputs particularly fertilizers was the limited availability of cash resources with the farmers. A higher scale of adoption of HYV was observed in the relatively more affluent areas mainly because of the capacity of the farmers to purchase adequate quantities of crucial inputs like fertilizers and plant protection chemicals.

The highest percentage of farmers taking loan was 30-40 in Andhra Pradesh, Karnataka, Punjab, Maharashtra and Madhya Pradesh. The average amount borrowed was also generally higher in these States.

Wheat. The corresponding results for wheat crop are given in Table 2. The proportion of area under HYV was much larger in the traditional States like Punjab, Madhya Pradesh, Haryana and Uttar Pradesh. The only exception was West Bengal where more than 70 per cent of the area under wheat was grown with HYV and the yield rate was also fairly high being around 23 q/ha. This compares very favourably with the yield rates in the traditional wheat growing States. The yield rate in some of the regions of the traditional States like Haryana and parts of Uttar Pradesh was relatively poor (below 20 q/ha) even though the adoption of HYV was at a fairly large scale. One of the main reasons for lower yield in Punjab and Uttar Pradesh was the adverse climatic factors reported during the year 1973-74,

TABLE 2

Area, yield, fertilizer use, irrigation, credit and agro-climatic factors for HYV of wheat in different agro-climatic zones, 1973-74

Agro-climatic zone No.	*State*	*Districts covered*	*Moisture index*	*Broad soil type*	*Holdings irrigated (%)*	†*Estimated area under HYV (000 'ha)*	*Average yield (Q/ha)*	‡*Average rates of application (Kg/ha)*			*Cultivators availing credit (%)*
								N	*P*	*K*	
1	2	3	4	5	6	7	8	9	10	11	12
1.	Uttar Pradesh	Saharanpur, Meerut, Muzaffarnagar, Bulandshahr, Etawah, Kanpur	−40 to −60	Alluvial	99	799.7 (86)	16.1	68 (83)	46 (50)	40 (19)	10
2.	,,	Basti, Bahraich, Deoria, Gorakhpur, Gonda, Moradabad	0 to −20	Alluvial	88	779.5 (75)	19.0	46 (66)	32 (34)	22 (18)	5
3.	,,	Varanasi. Rae Bareli, Faizabad,	−20 to −40	Alluvial	93	194.3 (78)	21.5	64 (81)	46 (39)	38 (29)	9

4.	Punjab	Amritsar, Hoshiarpur, Kapurthala, Jullundur, Patiala	−40 to −60	Alluvial	100	568.4 (62)	23.3	94 (93)	43 (79)	25 (49)	39
5.	Punjab & Haryana	Bhatinda, Hissar	−60 to −80	Calcareous Sierozem	99	295.9 (74)	20.9	78 (92)	62 (38)	20 (1)	7
6.	Haryana	Ambala, Rohtak	−20 to −60	Alluvial	84	125.2 (62)	17.8	51 (92)	40 (4)	47 (4)	16
7.	Rajasthan	Kota, Chittorgarh	−40 to −60	Red and black, Medium black	87	85.6 (35)	19.9	73 (81)	48 (65)	37 (21)	17
8.	,,	Jaipur	−40 to −60	Alluvial	99	38.8 (46)	18.1	52 (90)	16 (28)	— (0)	4
9.	Madhya Pradesh	Mandsaur, Morena	−20 to −60	Red and black, Medium black	94	96.6 (75)	27.2	75 (94)	41 (92)	57 (11)	38
10.	Gujarat	Banaskantha	−60 to −80	Desert, Grey Brown	81	22.4 (39)	26.6	66 (83)	41 (16)	* (*)	0
11.	,,	Kaira	−40 to −60	Grey brown	99	52.4 (80)	26.6	48 (81)	47 (29)	— (0)	21
12.	,,	Rajkot	−60 to −80	Medium black	99	3.8 (92)	19.6	78 (99)	62 (82)	— (0)	26

1	2	3	4	5	6	7	8	9	10	11	12
13.	Maharashtra	Ahmednagar, Satara, Sangli, Sholapur, Osmanabad, Jalgaon	−40 to −60	Medium black	87	70.4 (12)	15.5	54 (82)	28 (57)	15 (42)	26
14.	,,	Aurangabad, Buldhana, Akola, Bhir, Parbhani	−40 to −60	Medium black	67	99.3 (37)	12.2	51 (65)	33 (55)	25 (34)	25
15.	,,	Amravati, Nanded	−20 to −40	Medium black	51	16.8 (26)	14.2	52 (87)	33 (74)	19 (63)	4
16.	,,	Wardha, Nagpur	N.A.	Medium black, Shallow black	51	38.6 (37)	13.0	69 (83)	30 (76)	19 (62)	7
17.	West Bengal	Murshidabad, Birbhum, Midnapur	0 to −20	Red & yellow, Laterites and lateritic	89	84.6 (69)	22.7	49 (92)	24 (74)	32 (54)	18
18.	,,	24-Parganas	0 to −50	Coastal alluvium	96	29.2 (71)	23.8	67 (97)	12 (57)	37 (68)	17
19.	Karnataka	Belgaum	0 to −20	Medium black	55	12.9 (26)	22.9	75 (71)	28 (52)	21 (48)	25

The extent of fertilizer use was almost similar to that of rice.

The percentage of holdings having irrigation facilities was fairly high (above 80%) in almost all the States except Maharashtra and Karnataka. The main source of irrigation was well. However, the moisture index was negative showing inadequate rainfall in almost all regions. Nevertheless, with assured supplemental irrigation available, the yield rate would perhaps not suffer much on this account.

About 40 per cent of the cultivators in Punjab and Madhya Pradesh availed of credit facilities, while in other States, this proportion was much smaller.

Conclusion

The regional imbalances were more pronounced in the case of rice compared to wheat mainly on account of lack of assured water supply and resource endowments of the farmers. The average yield was highly variable in the rice regions compared to wheat and the credit utilisation was also less for rice cultivators. The variability in the yield rate of HYV did not show much association with extent of adoption of HYV, the regions with higher yield rates of HYV showing low percentage of area under HYV and *vice versa* in a number of cases. Apparently, proper water management and supply of crucial inputs like fertilizer either by supply of credit or otherwise would narrow the gap considerably.