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Working Paper

IMPACT OF CROPPING PATTERN
ON AGRICULTURAL PRODUCTION

By

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I. Introduction

Knowledge about the sources of growth of agricultural production and their relative importance in different regions characterized by different agroclimatic factors is desirable for effective agricultural planning at regional level. With this motivation this paper examines the effect of cropping pattern along with fertilizer and irrigation upon agricultural production.

There have been a few attempts in the past to examine the "Cropping pattern shift effect" upon growth in agricultural production over time. The decomposition of growth of agricultural output was attempted by B.S. Minhas and Vaidyanathan (1965) for period 1951-54 to 1958-61. They analysed the data on 28 major crops in 14 states and also the data on the same crops for 268 districts belonging to 13 states. The contribution of area, yield, cropping pattern and the interaction of the latter two factors to the increase in output was assessed by using an additive scheme of decomposition. Dharm Narain's (1976)

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work is an extension of the study of Minhas and Vaidyanathan. He decomposed the growth of productivity in agriculture into three factors, namely, changes in cropping pattern, locational shifts of area under individual crops and pure yield effect. His study concluded that the growth of productivity during the fifties was mainly due to the first two factors, that is, cropping pattern effect and locational shift effect. During the sixties the major factor influencing growth of productivity was pure yield effect, which was a result of technological change.

The above studies, however, do not examine the effect of cropping pattern, fertiliser and irrigation simultaneously upon agricultural production. This paper attempts to do so. The approach of this paper is to examine the effect of these factors upon agricultural output per hectare across 54 agroclimatic regions covering 16 major states for a pre-green revolution period from 1962 to 1965 and then for a post-green revolution period from 1970 to 1973.

The paper is divided into three sections. Section II describes the data and methodology used in this study. In Section III results and their implications are discussed.

II. Data and Methodology

In order to compute the agricultural output per hectare in different agro-climatic regions, the data on area and yield for different crops in all districts belonging to 16 major states are taken from the JNU-PPD study (1976). The crops and states covered in this paper are as follows :[1/]

Crops : Rice, Wheat, Jowar, Bajra, Maize, Ragi, Barley, Gram, Tur, Groundnut, Rapeseed and Mustard, Sesamum, Linseed, Castor Seed, Jute, Mesta, Cotton, Sugarcane and Tobacco.

States: Andhra Pradesh, Assam, Bihar, Gujarat, Haryana, Himachal Pradesh, Karnataka, Kerala, Maharashtra, Madhya Pradesh, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal.

The districtwise data are aggregated into the value of agricultural output per hectare in 54 agro-climatic regions by first adding the value of output of different crops in all districts in a region and then by dividing it by the total gross cropped area (the sum of area under different crops) in that region. The districts are aggregated by using the classification given in the Twenty Sixth Round of the National Sample Survey on Land Holdings (1972). The value of agricultural output is computed at the constant average all-India 1970-73 prices.

1/ Even though the data for Jammu and Kashmir are available in the JNU-PPD Study, it was not possible to figure out to which agro-climatic regions Jammu and Kashmir belong and hence that state is omitted.

These prices are taken from the JNU-PPD Study.

The cropping pattern index is computed by using the following formula :

$$CI_j = \frac{\sum_{i=1} (a_{ij} Y_i P_i)}{\sum_{i=1} a_{ij}} \quad \frac{\sum_{i=1} (A_i)}{\sum_{i=1} (A_i Y_i P_i)}$$

where

a_{ij} = area under the i^{th} crop in the j^{th} region,

Y_i = all-India average yield of the i^{th} crop,

P_i = all-India price of the i^{th} crop,

A_i = all-India area under the i^{th} crop, and

CI_j = Cropping pattern index for the j^{th} region.

This index is similar to the "Pure cropping pattern shift effect" defined in Dharm Narain's study. In his study Dharm Narain considers the base year yield and prices of different crops while in the above index all-India average yields and prices of different crops are used.

The fertilizer variable used in the paper is in terms of the sum of the kilograms of N, P and K per hectare. These data for 1962-65 are taken from the Ministry of Agriculture and Irrigation, and for 1970-73 are taken from the fertilizer statistics published by the Fertilizer Association of India.

Irrigation variable used in the paper is in terms of the percentage of gross irrigated area in total gross cropped area. These data for different districts for 1971 are taken from the statewise reports of the Agricultural Census while for 1962-63 they are taken from the Indian Agriculture Statistics. For 1962-63 these data however are not available for Assam, Kerala and Orissa.

The methodology in this paper can be divided into two parts. First the effect of cropping pattern, fertilizer and irrigation upon the agricultural output per hectare is examined by way of visual comparison. Second the linear and double log functional forms are fitted for the pre- and post-green revolution periods separately by using the Ordinary Least Squares method and then significance of different variables is assessed. The regression analysis in the paper is illustrative in nature. It can be further modified by incorporating rainfall, size distribution of owned land etc. which affect agricultural productivity.[2/]

2/ In the FAO-IIMA study the agricultural production per hectare across 57 agro-climatic region is examined by considering size distribution of ownership of land alongwith fertilizer and irrigation. For the results of this analysis, see V.S. Vyas (1978).

III. Results

Tables 1 and 2 present regionwise agricultural production, fertilizer use, irrigated land and cropping pattern index for 1962-65 and 1970-73. Comparison between Northern Punjab and Coastal Northern Tamil Nadu for 1970-73 shows that even though the percent irrigated land was higher in the former region (73.62 percent) than in the latter region (61.66 percent), still the yield was higher in the latter region (Rs. 2030) than the former (Rs. 1067). At the sametime, however, the cropping pattern index was higher in Coastal Northern Tamil Nadu (126.4) than that in Northern Punjab (119.5). For the same regions although the fertilizer input is not positively correlated with yields, the cropping pattern index is positively correlated with yields. The fertilizer use was less in Coastal Northern Tamil Nadu than that in Northern Punjab. Thus the allocation of area is more towards high value crops in Coastal Northern Tamil Nadu which also has the highest agricultural output per hectare among all the regions.[3/]

The above finding, however, does not imply that the cropping pattern index and yields always move in the same direction. This will be evident after comparing all regions in Orissa with all regions in Punjab for both periods. In Orissa, although the

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3/ See Table 5 for the value per hectare of different crops in 1962-65 and 1970-73.

cropping pattern index is higher than that in Punjab, the yields are much low and so are the fertilizer use and irrigation too.

The above discussion implies that in order to examine the effect of fertilizer, irrigation and cropping pattern separately, it is necessary to do ceteris paribus analysis. Hence we propose to do the regression analysis. Here one might argue that cropping pattern depends upon irrigation and fertilizer, and hence it might create multi-collineanity among the independent variables. This, however, is not the case because the correlation coefficient between the cropping pattern index, and fertilizer and irrigation was never higher than 0.4 in two periods (Table 4). Thus the regions growing high value crops do not necessarily have high fertilizer use and more irrigation compared with other regions.

The coefficients of the estimated linear and double log functional forms are presented in Table 3. The estimated coefficients of all variables for both periods are positive and highly significant, and also R^2 is very high. Thus even though the visual inspection of Table 2 indicates that certain conflicting cases exist with respect to changes in yield and the cropping pattern effect, the regression results show that higher the cropping pattern index, the higher will be yields ceteris paribus.

This result is important in deciding how far high yielding foodgrain technology, along with fertilizer and irrigation, needs to be pushed in comparison with growing more of high value crops in order to increase agricultural productivity in different regions. It appears that marginal manipulations in the cropping pattern in a region can increase agricultural productivity significantly even if fertilizer and irrigation use remain unchanged.

Table 5 shows that during 1970-73 sugarcane, tobacco, jute, mesta, rice and groundnut were top six high value crops. Although these crops, wherever they can be grown, have a comparative advantage over other crops, farmers in a region might be growing foodgrains for home consumption purpose. In such cases policies can be formulated for encouraging these farmers to grow high value crops.[4/] A policy in this respect could be of providing adequate and assured supply of foodgrains for home consumption when those farmers shift to high value crops. The extension machinery can play a big role in tapping the comparative advantage of different regions.

4/ A similar suggestion for growing trees is given by Tirath R. Gupta (1979) for Western Rajasthan when he shows that the farmers in that region have a comparative advantage in growing trees as against continuing crop husbandry.

Table 1 : Regionwise Agricultural Production for 1962-65 and 1970-73

	State/Region	Yield is Rs. per Hectare	
		1962-65	1970-73
	(1)	(2)	(3)
1.	Andhra Pradesh		
	Coastal	1380.2	1475.9
	Inland Northern	744.5	652.8
	Inland Southern	1028.7	1192.2
2.	Assam		
	Plains	1152.5	1214.0
	Hills	1199.0	1503.1
3.	Bihar		
	Southern	892.2	865.6
	Northern	906.4	950.5
	Central	983.1	1135.5
4.	Gujarat		
	Eastern	1004.4	987.7
	Plains, Northern	891.4	1175.1
	Plains, Southern	956.9	1098.4
	Dry Areas	414.5	553.2
	Saurashtra	760.1	911.9
5.	Haryana		
	Eastern	905.0	1372.8
	Western	706.2	913.7
6.	Himachal Pradesh		
		745.9	931.1
7.	Karnataka		
	Coastal and Ghats	1515.8	1665.8
	Inland Eastern	1257.1	1582.3
	Inland Southern	1018.6	1412.3
	Inland Northern	539.1	719.5

Table - 1 (.. Contd ..)

	(1)	(2)	(3)
8.	Kerala		
	Northern	1631.2	1751.9
	Southern	1601.0	1800.0
9.	Madhya Pradesh		
	Eastern	818.1	897.4
	Inland Eastern	519.3	592.5
	Inland Western	570.7	617.7
	Western	621.6	629.2
	Northern	626.6	674.3
10.	Maharashtra		
	Coastal	1370.3	1345.9
	Inland Western	109.4	632.3
	Inland Northern	655.2	497.2
	Inland Central	475.7	293.8
	Inland Eastern	511.2	399.7
	Eastern	706.1	657.6
11.	Orissa		
	Coastal	1169.0	1067.5
	Southern	1065.8	975.3
	Northern	1067.9	1011.9
12.	Punjab		
	Northern	1194.2	1793.7
	Southern	1124.1	1738.8
13.	Rajasthan		
	Western	159.2	225.7
	North Eastern	484.2	720.5
	Southern	746.7	775.1
	South Eastern	537.9	705.3

Table - 1 (.. Contd ..)

	(1)	(2)	(3)
14.	Tamil Nadu		
	Coastal Northern	1588.4	2030.2
	Coastal Southern	1488.4	1821.5
	Inland	1383.1	1564.0
15.	Uttar Pradesh		
	Himalayan	880.2	1034.7
	Western	1115.5	1344.9
	Central	897.2	1014.9
	Eastern	858.7	928.3
	Southern	596.9	721.9
16.	West Bengal		
	Himalayan	1264.9	1320.8
	Eastern Plains	1231.8	1371.0
	Central Plains	1532.5	1608.3
	West Plains	1314.2	1433.0

Table 2 : Regionwise Fertilizer Use, Irrigated Land and Cropping Pattern Index for 1962-65 and 1970-73.

State/Region	1962 - 65			1970 - 73		
	Fertilizer (Kg./ha.)	Percent Irrigated Land	Cropping Pattern Index	Fertilizer (Kg./ha.)	Percent Irrigated Land	Cropping Pattern Index
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1. Andhra Pradesh						
Coastal	13.52	38.05	130.4	34.92	43.00	126.8
Inland Northern	4.78	21.08	85.9	13.71	20.49	75.8
Inland Southern	3.78	24.29	103.6	12.03	24.19	99.2
2. Assam						
Plains	1.35	N.A.	147.5	2.96	8.64	139.0
Hills	0.91	N.A.	146.4	1.46	24.61	149.4
3. Bihar						
Southern	1.34	8.12	126.0	2.90	6.64	121.7
Northern	1.77	3.04	131.6	10.73	14.17	127.1
Central	4.15	19.71	120.2	13.66	55.29	121.9
4. Gujarat						
Eastern	3.70	3.70	99.7	19.03	3.26	92.8
Plains, Northern	3.88	11.56	95.8	19.24	15.64	86.3
Plains, Southern	4.08	2.75	106.2	19.69	5.90	99.2
Dry Areas	0.29	5.58	63.9	4.04	8.77	59.2
Saurashtra	3.97	7.26	100.1	23.81	11.51	89.2
5. Haryana						
Eastern	2.37	28.32	96.5	20.50	42.31	108.5
Western	1.28	30.71	67.3	12.67	51.85	74.5
6. Himachal Pradesh	3.43	15.42	86.5	6.70	15.78	98.1

Table - 2 (... Contd ...)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
7. Karnataka						
Coastal & Ghats	2.19	22.96	144.2	36.80	27.05	138.1
Inland Eastern	2.94	28.50	111.8	29.52	38.34	106.2
Inland Southern	9.12	16.56	96.0	25.40	19.64	94.2
Inland Northern	1.93	4.32	79.0	9.60	6.86	77.1
8. Kerala						
Northern	8.93	N.A.	138.3	27.21	14.46	132.6
Southern	15.06	N.A.	145.8	54.30	18.22	137.3
9. Madhya Pradesh						
Eastern	1.20	9.23	125.3	6.95	10.29	122.5
Inland Eastern	0.31	1.44	95.2	2.38	2.44	100.2
Inland Western	0.39	2.25	77.2	3.39	3.62	90.5
Western	0.88	4.04	81.3	7.77	5.87	77.8
Northern	0.41	10.35	71.7	6.91	16.72	81.4
10. Maharashtra						
Coastal	3.39	2.42	125.0	23.85	1.66	120.1
Inland Western	3.19	11.10	74.2	14.79	12.82	70.3
Inland Northern	4.01	5.75	75.6	13.45	10.81	72.8
Inland Central	0.57	4.09	74.7	6.77	2.91	66.5
Inland Eastern	2.17	1.65	79.0	10.27	2.05	74.4
Eastern	1.34	19.19	78.8	9.94	19.57	95.2
11. Orissa						
Coastal	2.05	N.A.	140.7	9.90	33.30	132.3
Southern	1.00	N.A.	135.8	1.05	2.36	124.5
Northern	0.85	N.A.	137.8	7.31	15.56	131.0
12. Punjab						
Northern	3.52	25.03	108.5	63.16	73.62	119.5
Southern	4.74	58.73	87.1	39.15	79.25	103.5

Table - 2 (.. Contd ..)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
13. Rajasthan						
Western	0.04	2.21	34.7	2.64	2.37	38.5
Northern Eastern	0.98	23.59	65.2	5.32	27.57	69.5
Southern	0.53	19.21	85.1	3.15	21.46	85.1
South Eastern	0.80	14.63	72.1	12.51	23.12	77.5
14. Tamil Nadu						
Coastal Northern	10.85	55.22	131.3	47.68	61.66	126.4
Coastal Southern	10.97	55.92	122.2	43.53	55.25	117.9
Inland	9.18	33.17	102.1	41.06	33.11	97.0
15. Uttar Pradesh						
Himalayan	1.32	11.52	113.4	16.43	21.68	118.2
Western	4.20	33.75	136.9	26.97	51.17	140.4
Central	2.53	18.41	118.8	15.36	27.86	121.6
Eastern	3.42	29.12	123.1	22.03	32.97	127.0
Southern	0.78	17.16	73.0	4,49	20.58	81.9
16. West Bengal						
Himalayan	1.24	13.92	152.8	1.73	8.29	140.1
Eastern Plains	1.73	16.45	140.7	11.79	40.56	131.2
Central Plains	9.77	28.43	145.9	38.18	4.03	135.1
West Plains	2.70	30.14	140.7	14.90	4.28	133.9

Percent irrigated land is equal to the percentage of gross irrigated area in total gross cropped area.

Table 3 : Yield Regressions for All India[1]

Functional Form	Explanatory Variable: Fertilizer[2]	Irrigation[3]	Cropping Pattern Index	Constant	R^2	F-Value
			1962-65[4]			
Linear	30.05* (3.73)	5.61* (3.28)	0.97* (10.38)	-120.12 (1.58)	0.87	91.8*
Double log	0.13* (4.86)	0.08* (3.18)	0.92* (10.01)	0.29 (0.49)	0.90	134.46*
			1970-73			
Linear	15.39* (7.26)	3.16** (1.98)	0.91* (8.76)	-175.78 (1.72)	0.84	89.52*
Double log	0.14* (4.02)	0.10* (2.86)	1.14* (10.34)	- 1.57** (2.13)	0.81	69.94*

1. Figures in paranthesis are t-Values.
2. Fertilizer is in Kilogram per hectare.
3. Irrigation is the percentage irrigated gross cropped area in total gross cropped area.
4. Total number of observations for 1962-65 and 1970-73 are respectively 47 and 54.

* Means significant at 1 per cent.

** Means significant at 5 per cent.

Table 4 : Correlation Coefficient Totalwise

	Fertilizer	Irrigation	Cropping Pattern	Yield
		1962-65		
Fertilizer	1.00	0.63	0.40	0.68
Irrigation	-	1.00	0.33	0.62
Cropping Pattern	-	-	1.00	0.83
Yield	-	-	-	1.00
		1970-73		
Fertilizer	1.00	0.59	0.32	0.76
Irrigation	-	1.00	0.25	0.57
Cropping Pattern	-	-	1.00	0.72
Yield	-	-	-	1.00

Table 5 : Value of Different Crops

Sl.No.	Crop	Price (Rs. per Kg.)	1962-65		1970-73	
			Yield (Kg./ha.)	Value (Rs.)	Yield (Kg./ha.)	Value (Rs.)
1	Rice	1.159	1015	1176.39	1106	1281.85
2	Wheat	0.813	811	659.34	1322	1074.79
3	Jowar	0.781	522	407.68	452	353.79
4	Bajra	0.682	365	248.93	472	321.90
5	Maize	0.649	996	646.40	1085	704.17
6	Ragi	0.717	803	575.75	865	620.21
7	Barley	0.665	824	547.96	1033	686.95
8	Gram	0.983	569	559.33	645	634.04
9	Tur	1.194	643	767.74	712	850.13
10	Groundnut	1.505	760	1143.80	734	1104.67
11	Rapeseed & Mustard	1.846	418	771.63	507	935.92
12	Sesamum	2.340	187	437.58	212	496.08
13	Linseed	1.679	227	381.13	260	436.54
14	Castor Seed	1.666	224	373.18	332	553.11
15	Sugarcane	1.034	4563	4718.14	4973	5142.08
16	Cotton	6.900	119	821.10	129	890.10
17	Jute	1.400	1237	1731.80	1227	1717.80
18	Mesta	1.900	751	1426.90	687	1305.30
19	Tobacco	5.153	845	4354.29	852	4390.36

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