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Pattern of growth and technological impact on oilseeds production in Uttar Pradesh

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ABSTRACT

In the present paper, an attempt has been made to find the growth rates and the impact of Technology Mission on oilseed crops in Uttar Pradesh. The time-series data on area, production and productivity of oilseeds crop in Uttar Pradesh pertaining to the period 1970-71 to 2005-06 were used for the investigation of trend and growth of oilseeds and also impact of technological changes on oilseeds production in the state of Uttar Pradesh. The relevant statistical tools & technique like regression analysis etc. have been used for the purpose of investigation. The production gains in oilseeds were largely due to the expansion in area during the first period (before the launch of technological mission) rather than in productivity. The observed absence of growth in productivity was a result of adequate technological progress and/or poor adoption of yield enhancing technologies. In addition, the favourable price situation created through the Technological Mission on oilseeds resulted in expansion of marginal areas, thereby, causing a decline in average yields developing location specific technologies that enhance oilseeds productivity.

***Key words*:** Growth rate, TMO (Technology Mission on Oilseeds), trend

Uttar Pradesh is one of the front runners that benefited from the new agricultural technologies. Because of its rich resource endowments, it took lead in adoption of the yield increasing technologies. It may be major role of technology has shown in production of oilseeds increased from 3.62 lakh tonnes in 1970-71 to 7.89 lakh tonnes in 2005-06. The State also made greater progress in productivity of oilseeds crops like rapeseed-mustard and groundnut.

Such a growth in production was associated with substantial increase in the use of inputs. Uttar Pradesh is one of the States where average per hectare fertilizer consumption is 15.22q ha^{-1}. Yet, the performance in terms of productivity was not as impressive. Evidences show a plateau in crop yield levels even in well-endowed regions. Such a slow down or stagnation in yield levels can be attributed, among other things, to unavailability of new technologies, resources degradation associated with input intensification and low efficiencies in resource use. These concerns bring forth the need for government intervention in terms of policies for technology generation and transfer and market mechanisms. This paper is an attempt to examine the past trends in production of oilseeds in Uttar Pradesh and to examine the impact of technological change on productivity.

MATERIAL AND METHODS

Effect of change in acreage and productivity on differential production of oilseed crops

An attempt has been made to the study the effect of change in acreage and productivity of oilseed crops on the differential production between two points of time.

Let Y, A and P be the production, acreage and productivity of a particular oilseed crop/ total oilseeds at a given point of time. The Y can be expressed as

$Y = P. A$

Let ΔY, ΔA, ΔP be change in production, acreage and productivity of the crop after a specific period of time. So, we have

$Y+ \Delta Y = (A+ \Delta A) (P+ \Delta P)$

$Y +\Delta Y = AP + \Delta A P + \Delta P A + \Delta P\Delta A$

Therefore, we have

$\Delta Y = \Delta A P +\Delta P A+ \Delta P\Delta A$

Thus, the total differential production is composed of three components:

$P \Delta A$: Effect of change in acreage of the crop
$A \Delta P$: Effect of change in productivity the crop
$\Delta P\Delta A$: Interaction effect due to change in acreage and productivity of the crop

The period 1970-71 to 2005-06 has been divided into two parts *viz*., (1) before launching of Technology Mission on Oilseed (1970-71 to 1985-86) and (2) after launching of Technology Mission on Oilseed (1986-87 to 2005-06). The contribution of change in acreage, productivity and their interaction to the total differential production of the crops has been worked out for each period separately and also for overall period.

Estimation of growth rates

The most commonly used statistical procedure of computing trend and growth rates in agriculture has been to postulate some hypothetical trend equations and to select one of them on some statistical criterion and estimate the growth parameter in the equations by ordinary least square or some other methods. The procedure of estimating growth rates involves three important issues: (i) Choice of trend equation, (ii)

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Avoidance of volatile fluctuations in data, and (iii) Estimation of sub-periods growth rates.

The popular forms of trend equation for growth estimation are linear, parabolic, exponential, log-quadratic, higher degree polynomial etc. But each of these trend equations imposes certain restriction upon the character of the growth process. For example, linear trend implies constant absolute growth rate. Exponential or log-linear implies constant growth rate. Although parabolic and log-quadratic trends are more flexible than linear and exponential in that they permit non-zero second derivative with respect to time (implying acceleration or deceleration in the growth process), they nevertheless impose restriction that the second order derivative are constant. One way to allow a non-constant second derivative is to add a cubic term of time in the trend equation but this process is unending. Further by doing so, the very objective of growth measurement would either be defeated (having more than one turning point in the growth curve of polynomial of degree three or more) or be unnecessarily laborious. Like log-quadratic trend curves are also open to the criticisms regarding the behavior of the acceleration/deceleration in the growth process.

The growth rate in area, production and yield of oilseeds crop have been worked out by fitting the following three different functions:

1. Simple linear function: $Y_t = a + bt$
2. Semi-log function: $\log Y_t = a + bt$
3. Compound growth rate function: $Y_t = a (1+r)^t$

where,

Y_t: Time series data on area/production/yield of oilseed crop at time t, a & b are parameters of the function to be estimated.

t: Time index (t= 1,2,…..n)

r: Average compound growth rate per annum.

In time series data of different crops in agriculture has affected the short term fluctuations. It is obvious that the moving average is commonly used with time series data to smooth out short-term fluctuations and highlight longer-term trends.

However, before the fitting of above functions, the time series data on area and production were treated by moving-average method. The three yearly moving average has been used for the smoothing the data.

After fitting the first linear trend function by least-square method, we get the estimate of b denoted by $\hat{b}$ (say). Then, annual linear growth rate is computed as follows

$$r = \frac{\hat{b}}{\overline{Y}} \times 100$$

where, $\overline{Y}$ is arithmetic mean of Y_t.

Second, semi log function was fitted by least square method and estimate of b as $\hat{b}$ was obtained. The annual growth rate is then computed as

$$r = \hat{b} \times 100$$

To obtain annual compound growth rate, the third function was first linearised by taking natural log on both side, i.e. $\log Y_t = \log a + t \log (1+r)$

or $Y_t^* = a^* + bt$

where, $Y_t^* = \log Y_t$, $a^* = \log a$ and $b = \log (1+r)$

The above linearised function was fitted by least square method and estimate of b as $\hat{b}$ was obtained.

The annual compound growth rate is then computed as r = (antilog of $\hat{b}$ -1) x 100

All growth rates are expressed in percentage. The best fitted function was judged on the basis of R^2 (coefficient of determination) and root mean square error (RMSE) both.

Impact of technological change

In order to examine the impact of technological change on production the following equation was estimated: $Y = aX^{\beta}e^{\lambda t}$

In logarithmic form, it becomes $\ln Y = \ln a + \beta \ln X + \lambda t$

where,

Y = production of crop (tonne)

X = Area under the crop (hectare)

t = Time in years (1, 2, 3…)

Ln a = intercept

β and λ are the regression coefficients associated with area and time, respectively. A positive value for λ indicates a technological progress and a negative value indicates a technological regress. The significance of regression coefficients and goodness of fit were tested by t test and F test, respectively.

The study made use of time series data on area, production and yield of the oilseeds crop for the period 1970-71 to 2005-06 obtained from Krishi Bhawan, Lucknow, Uttar Pradesh to achieve the first two objectives. The analysis was done for two time periods i.e. 1970-71 to 1985-86 and 1986-87 to 2005-06 (before and after launch of Technology Mission on Oilseeds) in order to see whether there is any change because of the impact of economic reforms that were given impetus.

RESULTS AND DISCUSSION

Cropping pattern

The decadal cropping pattern since 1970-71 onwards has been worked out and presented in Table 1. It is obvious from the table that technological changes in crop production particularly in rice, wheat and oilseeds have marginalized the production of other cereal crops and pulse crops as well. Area under total cereals have slightly decreased over last 35 years and presently it constitutes about 67% of the gross cropped area as compared to that of about 68 percent

in 1970-71. This decrease in area under total cereals can evidently be attributed to decrease in area under maize and barley, which together is now about 4.15% as against about 12.21% in 1970-71.

Scenario of total oilseeds over last 35 years has slightly changed. The area under oilseed has increased to 3.25% in 2005-06 from 2.97% in 1970-71. Among the oilseed crops, drastic reduction in the area has been found under groundnut (1.47 to 0.42%), linseed (0.29 to 0.14%) while area under rapeseed-mustard has steadily increased (0.91% to 2.22%) over last 35 years. This increase in total oilseeds is found due to increase in area under rapeseed-mustard. Til has also experienced upward trend and has registered steady growth from 0.30% to 0.40% during last 35 years. However area under groundnut and linseed declined over the same period.

Two cash crops viz. potato and sugarcane have also showed increasing trends in its area since 1970-71 onwards. The potato registered a continuous growth in its area (from 0.70 to 1.76%), and same case is with sugarcane (from 5.80 to 8.52%) over last 35 years.

Table 1: Cropping pattern (in % of gross cropped area)

Sl. No.	Crop	1970-71	1980-81	1990-91	2000-01	2005-06
1.	**Total Cereals**	**67.8**	**71.66**	**67.05**	**69.62**	**66.82**
(i)	Rice	19.04	21.53	22.04	23.34	22.05
(ii)	Wheat	25.45	33.01	33.63	36.51	36.21
(iii)	Maize	6.50	4.98	4.3	3.64	3.30
(iv)	Barley	5.71	3.17	1.67	1.13	0.85
(v)	Other	11.10	8.97	5.41	4.99	4.42
2.	**Total Pulses**	**15.85**	**11.64**	**11.93**	**10.64**	**10.87**
(i)	Arhar	2.51	2.13	1.84	1.61	1.51
(ii)	Pea	3.12	0.91	1.38	1.32	1.63
(iii)	Lentil	0.72	1.12	2.12	1.32	2.40
(iv)	Gram	8.75	6.09	5	3.29	2.92
(v)	Other	0.75	1.39	1.59	3.10	2.40
3.	**Total Oilseeds**	**2.97**	**2.90**	**4.01**	**3.40**	**3.25**
(i)	Mustard & rapeseed	0.91	1.66	2.72	2.2	2.22
(ii)	Groundnut	1.47	0.78	0.60	0.46	0.42
(iii)	Linseed	0.29	0.26	0.37	0.22	0.14
(iv)	Til	0.30	0.19	0.31	0.43	0.40
(v)	Other	0.00	0.01	0.01	0.10	0.06
4.	Potato	0.70	1.08	1.35	1.56	1.76
5.	Sugarcane	5.80	5.50	7.28	7.66	8.52
6.	**Others**	**6.88**	**7.22**	**8.38**	**7.13**	**8.79**
Gross cropped area (ha)		**21729890**	**23207144**	**24573897**	**25304147**	**25303147**

It can be visualized from the table that most of the area under total oilseeds has shifted to wheat, rapeseed mustard and potato as these are competing crops to pulse crops. The most significant result is found in other crops which has registered about 28.70% increase in its area during the period under study. This is probably because of diversification in agriculture in recent years and farmers have shifted the area towards more remunerative crops like vegetable, medicinal and aromatic plants, and fruit crops.

Effect of change in acreage and productivity and their interaction on differential production of oilseed crops

As it is obvious that production of a crop is the product of its acreage shown and its productivity. Any change in its acreage or productivity or simultaneous changes in both would result change in production. In order to study the effect of these changes on differential production of different oilseed crops and total oilseeds, the differential production during first and second period has been decomposed into three components viz. (i) effect due to changes in acreage, (ii) effect due to changes in productivity and (iii) interaction effect due to simultaneous changing in acreage and productivity, using the methodology described in Section-II. [Pal and Sirohi, 1988]

Groundnut

An overall situation of groundnut has not been satisfactory as negative differential production of it has been recorded during both the periods. However, a positive share of 51% to it has been provided by upward change in its productivity during first period but drastic decline in its area has contributed

negatively by -117 percent, which has resulted negative differential production. During the second period, the declines of its area as well as productivity both have negatively contributed to the negative differential production, by 54 percent each.

The negative differential production in groundnut has been obtained in both the periods due to largely decline in its area in most of the zones except in zones 6, 7 and 9 where in both the periods positive differential production has been obtained that is due to largely increase in its area and productivity both.

Table 2: Effect of change in acreage, productivity and their interaction on differential production of different of oilseeds crops along with total oilseeds of Uttar Pradesh

Zone	Period	Differential production (ΔY)	Acreage effect (PΔA)	Productivity effect (AΔP)	Interaction effect (ΔAΔP)
Groundnut	I	-121402.00	-142281.21	61561.85	-40682.64
		(-100.00)	(-117.20)	(50.71)	(-33.51)
	II	-26009.00	-13952.82	-13968.44	1912.26
		(-100.00)	(-53.65	(-53.71)	(7.36)
Linseed	I	16866.00	11759.49	2905.14	2201.37
		(100.00)	(69.72)	(17.22)	(13.06)
	II	-8961.00	-12700.48	8235.88	-4496.40
		(-100.00)	(-141.73)	(91.91)	(-50.18)
Rapeseed-Mustard	I	230451.00	221188.51	2878.91	6383.58
		(100.00)	(95.98)	(1.25)	(2.77)
	II	334418.00	67527.08	212353.56	54537.36
		(100.00)	(20.19)	(63.50)	(16.31)
Total oilseeds	I	119937.00	84679.10	28296.09	6961.81
		(100.00)	(70.60)	(23.59)	(5.81)
	II	331861.00	68789.71	223918.00	39153.29
		(100.00)	(20.73)	(67.47)	(11.80)

Linseed

In overall state, a positive differential production has been observed in case of linseed during the first period, where effect of change in its acreage, productivity and their interaction has contributed about 70, 17 and 13 percent to it, respectively. However, the linseed production has declined during second period and as a result negative differential production has been found. This phenomenon has been observed due to the effect of drastic decline in its area and its share has been about -142 percent, while the effect of positive change in the productivity has been about 92 percent to the negative production on differential.

The situation of linseed production in all the zones along with overall State has been worsened as it is obvious from preceding results. It has observed continuous downfall right from the 1970-71 onwards. The situation has little improved due to some increase in productivity but total differential production remained negative because of considerable reduction in acreage and its interaction, with change in productivity. Since there has been decreasing trend in the area of linseed, increase in its productivity levels seems to be the only remedy to even sustain the present level of linseed production in the State. There appears to be no scope for increase in the area under this crop in time to come. Therefore, efforts should be made to increase substantially the productivity of this crop to meet the requirement of continuously increasing population of the State.

Rapeseed-Mustard

Positive differential production has been witnessed in case of rapeseed-mustard during both the periods in the overall State. The effect of positive change in its acreage has contributed about 96 and 20 percent to it during the first and second periods, respectively, while upward change in its productivity has affected to its share by 1 and 63 percent, respectively. The interaction effect due to positive change in acreage and productivity simultaneously has been found more (16%) in second period as against that of (3%) in first period. It shows that it is the effect of positive change in productivity during the second period which has brought about positive differential production in the State.

The position of rapeseed-mustard production in all the zones along with overall State remained satisfactory. The positive differential production in rapeseed-mustard in both the periods has been observed in all the zones due to largely increase in its area and productivity both.

Total oilseeds

The situation of total oilseeds in the overall State has been satisfactory as positive differential

production of it has been recorded during the both periods. The effect of positive change in its acreage has contributed about 71 and 21 percent, respectively, while that of productivity by about 23 and 67 percent. The interaction effect due to positive change in acreage and productivity simultaneously has been found more (12%) in the second period as against that of (6%) in the first period.

Growth behaviour

Annual growth rates of area, production and yield of oilseeds crop have worked out using three functions, *viz.*, linear, semi-log and compound growth for two periods (before and after the launch of Technology Mission on Oilseeds) and also for the entire period under study. The results are presented and discussed as follows.

The annual growth rates of area, production and yield of oilseeds for two periods and for entire period have been computed and are presented in table-3 The values of R^2 (coefficient of determination) and Root Mean Square Error (RMSE) are also given in the Table. Semi-log function and compound growth function have provided consistent estimate of growth rates. Similar works have been done by Kaushik (1983), Kuchhyadiya *et. al.* (1999), Lal *et. al*. (1989), Mitra and Jena (1991), Singh and Sisodia (1989), Sarswat (1984), Tripathi and Gowda (1993).

Table 3: Annual growth rate (in %) of area, production and yield of oilseeds crop in Uttar Pradesh

Function	Period	A	P	Pvt.	R^2			RMSE		
					A	P	Pvt.	A	P	Pvt.
Linear	I	0.76	0.97	0.17	17.47	7.88	0.65	3468498281	4403914250	0.33153
	II	-0.23	0.78	1.23**	0.66	5.09	54.79	25675516790	22177410793	0.25443
	Overall	0.04**	2.54**	1.58**	32.26	58.80	76.68	18215529425	17294981815	0.37853
Semi-log	I	0.79	0.97	0.17	18.06	7.10	0.61	0.00622	0.02690	0.01124
	II	-0.21	1.07	1.28**	0.57	8.42	53.86	0.02742	0.04186	0.00476
	Overall	1.04**	2.68**	1.63**	35.07	63.25	73.99	0.02080	0.04290	0.00966
Compound	I	0.80	0.99	0.18	18.06	7.10	0.61	0.00622	0.02690	0.01124
	II	-0.21	1.07	1.29**	0.57	8.42	53.86	0.02742	0.04186	0.00476
	Overall	1.05**	2.72**	1.55**	35.07	63.25	73.99	0.02080	0.04290	0.00966

*Note: A= area, P= Production and Pvt. = Productivity ** Significant at P<0.01, * significant at P<0.05 and + significant at P<0.10*

Table 4: Analytical results of total oilseeds in Uttar Pradesh

Period	Parameters	Estimates	S.E.	t	F	R^2	RMSE	Chow's test
I (n= 16)	α	-11.7836*	4.7898	-2.460				
	β	1.8297**	0.3562	5.135	14.35**	68.83	0.028	
	λ	-0.0053	0.0098	-0.542				
II (n=20)	α	-2.6592	2.0902	-1.272				
	β	1.1638**	0.1515	7.679	32.70**	79.37	0.013	
	λ	0.0143**	0.0044	3.191				
Overall(n=36)	α	-5.3757*	2.0844	-2.579				
	β	1.3452**	0.1546	8.699	101.53**	86.02	0.022	
	λ	0.0135**	0.0028	4.766				

** Significant at P<0.01, * significant at P<0.05 and + significant at P<0.10

The area under oilseeds in the State has registered a positive growth rate of about 1.04 percent annually. The second period has registered a nominal downfall in the growth of area, i.e. by 0.21 percent per annum. On the other hand, area has increased as the rate of 0.79 percent annually during the first period.

An overall positive growth rate of production by about 2.68 percent has been observed. It was more (1.07%) in second as compared to that of about 0.97 percent in first period.

The productivity of total oilseeds has registered a positive growth rate of about 1.63 percent annually. This positive growth rate was more prominent (1.28%) during the second period as compared to that of about 0.17 percent during first period. Growth in productivity has realized some satisfaction level of its production in the State.

Technological change

The result of analysis of impact of technological change on production of oilseeds in Uttar Pradesh is presented in Table-4 and also worked out by Kuchhyadiya *et al.* (1999).

It is obvious from the table that the Chow's test did not reveal a structural difference in the production process of the total oil seeds between the two periods in the state.

It is the land which contributed significantly to the production of total oil seeds during both the periods and during the entire period. The coefficient of time trend (λ) has been found significant during the second period as well as in the entire period which