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Research Journal of Agricultural Sciences
An International Journal

P- ISSN: 0976-1675
E- ISSN: 2249-4538

Volume: 12
Issue: 03

Res Jr of Agril Sci (2021) 12: 848–853

CARAS

Res. Jr. of Agril. Sci. (May-Jun 2021) 12(3): 848–853
www.rjas.org

Full Length Research Article

Mechanization and Modernization of Indian Agriculture: A Study with Reference to Rice Production in India

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Received: 04 Mar 2021 | Revised accepted: 12 May 2021 | Published online: 21 May 2021

A B S T R A C T

The state of Indian agriculture has improved considerably since the beginning of the Green Revolution in the mid-1960s. It has led to the wider use of modern agricultural machinery and equipment. Along with this the supply of various inputs for different agricultural processes has also seen a rising trend for the past decades. As a result, it has increased the production and productivity of agricultural crops to a great extent. This paper attempts to highlight the effect of modern machinery and the use of fertilizers on rice production. By using time series data, the impact of mechanization and use of fertilizers on the production of rice is measured with the help of a regression analysis. The result shows the key role played by farm mechanization and fertilizer consumption in determining the rice yield. The trend analysis captures the pattern of growth in rice production, tractor utilization and fertilizer consumption. Hence, it emphasizes the need of government intervention in ensuring a fair distribution of tractors and fertilizers among the farmers. It is important to address the accessibility issue of these modern agricultural machineries and fertilizers by the poor and marginal farmers. A proper policy framework and strategy for implementation from the government can help to address the issue. Besides, we emphasize the on the role of government initiatives in providing awareness of various dimensions of faster mechanization and scientific cultivation to the farmers.

***Key words*:** Farm-mechanization, Agricultural sector, Rice production, Tractorization, Fertilizers, Tractor distribution

Agriculture is considered as the backbone of Indian economy because of its contribution in the GDP and employment generation. In 2016 it employed 59 percent of the country's total workforce and contributed 23 percent of the GDP. It also supplies different raw materials to the manufacturing sector and serves as the market for its finished products. Modernizing the agricultural sector has been a big challenge for many decades in the past owing to several reasons. Farm-mechanization is regarded as a crucial factor in raising the productivity levels. Thus, it plays an important role in determining the farm output in the long run. It is the need of the hour to figure out the present challenges, to meet the expectations and aspirations, to formulate and implement the long-term strategies for mechanization and modernization of Indian agriculture till 2020. There would be 1.8 percent annual growth rate in population and it would increase up to 230.81 million till 2020. In order to feed such a large population and to become self-sufficient, the food grain has to be increased 70 million tonnes annually. To achieve this target, it will require productivity levels to be increased from 21.57 q/ha to 35.00 q/ha and the same amount of quantity has to be increased in all other crops and items by 2020 [1].

India is the world's largest producer of milk, pulses and jute, and holds the position of the second largest producer of rice, wheat, sugarcane, and groundnuts. It produces 10.9 percent and 8.6 percent of the world's fruits and vegetables. It is also one of the world's leaders in the production of spices, fish, poultry, animals and plantation crops. This country is the world's third biggest economy after the US and China worth having $ 2.1 trillion. It holds the position of 6th largest economy by size of the GDP and the third-largest by purchasing power parity in the world. The nation positions 139th in per capita GDP (ostensible) with $2,134 and 122nd in per capita GDP (PPP) with $7,783 starting at 2018 (World Bank 2019). Agribusiness accounted for 23 percent of GDP, and utilized 59 percent of the nation's absolute labour force in 2016. Agriculture, with its associated areas, is the biggest source of livelihood for the people of the country. Around 70 percent of the rural families actually rely upon agriculture for their living. About 275 million tons (MT) of absolute food grain production was assessed in the year 2017-18. India produces 25 percent of the global production, consumes 27 percent of the world's total consumption and imports 14 percent of world's pulses. In the year (2017-18) the annual milk production in India was 165 MT, making it the world's largest producer of milk, jute and pulses. The significance of Indian agribusiness and its creation and profitability can be acknowledged by the way that it needs to take care of 135.26

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crore individuals and the consistently growing population at a rate of 1 percent in 2018. The commitment of agrarian growth in the economy. is that it utilizes half of the Indian labour force and contributes 17-18 percent in GDP (Food and Agriculture Organization of the United Nations) [2].

Agriculture has a key role to play in a fast-emerging economy like India. There is a huge potential for the growth of Indian food production and processing industry because of its increasing contribution to world food trade. The food and grocery market of India is the world's sixth largest in the world and it contributes to 70 percent of the total sale. It also contributes 32 percent in the whole country in terms of food market. India ranks second in terms of fruit production in the world and horticulture production in the year 2018-19 was estimated at 313.9 million metric tonnes. Agricultural export also increased to 38.54 billion US Dollar in FY 2019. There is a huge scope for the application of modern farm machinery and equipment which could lead to higher growth and productivity in the Indian agricultural sector [3].

In India, tractors constitute the major portion among the tools used in agricultural activities. It is true in almost all the states of the country and its share consists of 10-15 percent of the total farm equipment market and it has 7 percent global market share in which 80 percent contribution is made by tractor. The main players involved in manufacturing tractors are Eicher Motors, Gujarat Tractors, TAFE Ltd. Escorts Tractors Ltd and Mahindra & Mahindra. Till now India has not become self-sufficient in tractor production and still imports from countries like USA, U.K, Germany, France, Belarus etc. The irony is that India is a country where the majority of farmers are marginal and small who require small farm machines which could easily be used in small areas of land [4]. There are many industries which manufacture mini tractors which could easily be used by small farmers. These industries are Mahindra, Swaraj, Sonalika, Eicher, Massey Fergusson etc. In order to sow seeds farmers can use seed drillers which are provided by various companies.

The above statistics help us to understand the critical position of Indian agriculture. The achievements regarding production of food grains and exports are often associated with a multitude of challenges. Although it is claimed that India became a self-sufficient country in terms of food production after the green revolution, recent developments have shown a projected decline in the coming future. It is projected that India's kharif crop production in 2019 would decline to a record high for three consecutive years (CRISIL, 2020). It is estimated that India's population would increase to 1.5 billion by 2030 and to 1.66 billion in 2050 (Times of India, 2020). To feed such a large population food production also has to be increased significantly [5]. There is a great need to increase agricultural production and productivity to match the increasing population demand of the country. This could be possible only by raising the productivity levels further which in turn depends on the utilization and implementation of large-scale mechanization and modernization processes of the agriculture sector of the country. In this context, raising the productivity level of Indian agriculture through faster mechanization is very crucial [6]. The study attempts to capture the trends in the rice production and analyses the change in productivity as an outcome of mechanization by focusing on the rice production [7]. The findings of the research would be of far-reaching impact in terms of extending the analysis to other major crops as well as in evolving the most appropriate policies.

MATERIALS AND METHODS

This study is quantitative in nature based on the secondary data collected from various Government agencies such as Department of Agriculture Cooperation and Farmers' Welfare and Directorate of Economics and Statistics DAC and FW and Department of Fertilizer. The time series data pertaining to the production of rice, usage of fertilizers and farm mechanization is used for analysis. Thus, the corresponding variables, namely, rice yield, sale of tractors, and consumption of fertilizer have been used. Rice yield is used as the dependent variable and sale of tractors and consumption of fertilizers are taken as the independent variables. The data covers the time period from 1970 to 2018. The year 1970 is selected in order to capture the effects of mechanization in the post green revolution in India.

For the analysis purpose, various statistical tools are used. With the help of a graphical method, the trends in rice production are captured. The forecasting is done by using the ARIMA model. The impact of mechanization in the production of rice is measured with the help of linear regression. The equation of linear regression is as follows:

$$y = mx + c$$

Where, y is the dependent variable estimated in the equation and x is the independent variable, the changes in which determine the changes in the dependent variable. This is the input variable as it could be controlled, manipulated or modified. m is the slope of the equation which shows the line or angle. It is denoted by the symbol B (beta). c is the intercept which is a constant, giving the value of the dependent variable when the independent variable is zero.

Multiple linear regression model is employed to measure the impact of the sale of tractors and the consumption of fertilizers on the rice yield. It is mainly used when there are more than one independent variable and the researcher has to find the relative effect of these multiple independent variables on the dependent variable. The model employs a single straight line which tells the relationship between the dependent and the independent variable. This regression helps to detect any anomalies or outliers involved in the model.

RESULTS AND DISCUSSION

There are three key variables chosen in the study for analysis. It is pertinent to trace the trends of them in order to understand the pattern over the time period. The trend associated with different variables of the study, namely, the rice production, the sale of tractors and the consumption of fertilizers is shown below:

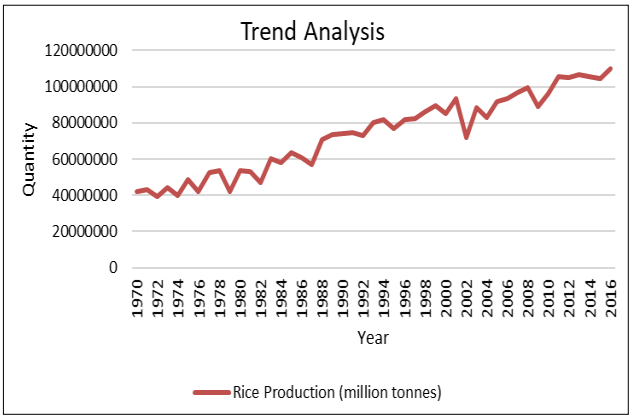

Fig 1 Trend in rice production

(Fig 1) above clearly depicts the pattern of movement of rice production. The trend line exhibits a consistent progress under the time period of study.

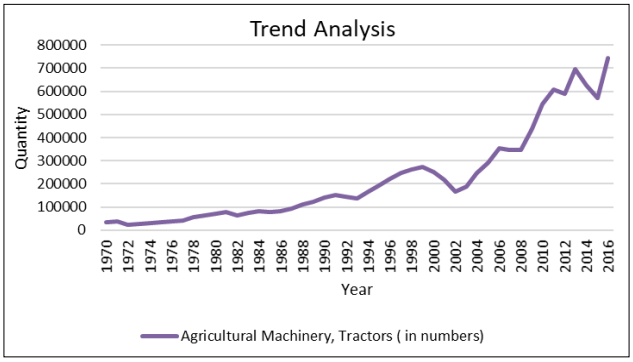

Fig 2 Trend in sale of tractors

(Fig 2) clearly depicts the pattern of data related to the sale of tractors. The trend line reveals that it is consistent with significant fluctuations between. Tractor utilization growth is gradual in the initial years which has taken a steep rise in the latter half of the time period.

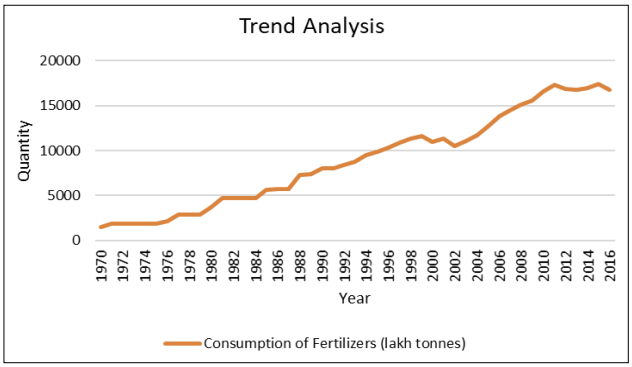

Fig 3 Trend in consumption of fertilizers

(Fig 3) represents the pattern of movement of consumption of fertilizers. The trend line exhibits a consistent progress during the time period under consideration. There is only slight fluctuation in the consumption pattern in the mid years of the timeline.

In order to analyze the impact of tractor utilization and fertilizer consumption on the rice production multiple regression analysis is used. The following table shows the result of testing unit root in the time series data.

Table 1 Augmented Dickey fuller test for unit root

Variables	Level		1st Difference		2nd Difference	
	C	C &T	C	C &T	C	C & T
Rice production	0.8760	0.0000	0.0000	0.0000	0.0000	0.0001
Sale of tractors	0.9860	0.5130	0.0004	0.002	0.0000	0.0000
Consumption of fertilizers	0.9821	0.2655	0.0000	0.0000	0.0000	0.0000

Data depicted in (Table 1) shows the result of the stationarity test in the time series data. The general rule of thumb to check stationarity in time series data is to check for unit root test. If the variables suffer from a unit root, then the time series data is not stationary and hence can give misleading results. To check if a particular variable is having unit root, the probability value would be looked into. If the p-value of the variable is less than 5 percent (0.05) critical t value then it means that the variable is stationary otherwise it has unit root. In the above table, we have calculated the probability values of the respective variables at three different levels as indicated in the table. If we look at the table all the three variables: rice production, sale of tractors and consumption of fertilizers are stationary at first and second difference both at the intercept and trend and intercept level. Thus, the dataset is stationary at the first difference.

In order to capture the impact of tractor utilization and fertilizer consumption on the production of rice multiple regression analysis is resorted to. The following table details the results of regression analysis.

Table 2 Regression analysis

Variable	Coefficient	Std. Error	t- Statistics	Prob.
C	35715267	1595328	22.38741	0.0000
Tractors	-23.52996	10.09368	-2.331157	0.0245
Fertilizers	4846.879	367.9803	13.17157	0.0000
R-squared	0.956456			
Adjusted R-squared	0.954431			
Durbin-Watson stat	2.016641			

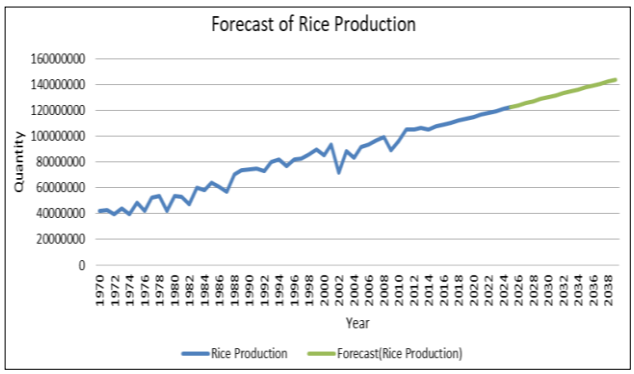

Fig 4 Forecasting the Rice Production

Analysis of data in (Table 2) showcases the change in productivity as an outcome of mechanization. The analysis reveals the impact of tractor utilization and fertilizer consumption on rice yield. The multiple regression result shows that p value is less than 10 percent level. It implies that there is a strong impact of sale of tractors and fertilizer utilization on rice yield. The R-squared and the adjusted R-squared values show 95 percent and 95 percent respectively which explains the suitability of the model. The value of DW statistic around 2 shows there is no autocorrelation in the data set. The above graph shows the trend associated with the forecasting of rice production. This is shown from 2025 till 2038 which is highlighted with the green line. The ARIMA model is applied to estimate the future forecasts. They show a

consistent uptrend for future years with minimum fluctuations [8]. The value of rice production is estimated to be 122558944.7 million tonnes in 2025 which is projected to increase to 142360132.8 million tonnes by 2038.

The population in India is increasing at a tremendous pace and it is estimated that it would surpass China by 2031. This steep rise in population would create a huge increase in demand for food-grains, vegetables, and fruits which in turn may exert huge pressure on the agriculture sector to multiply the production levels [9]. Meeting such high levels of demand for food grains would be possible only if we modernize and mechanize the agricultural sector at the required pace. The utilization and implementation of modern agricultural machines and the use of high-quality fertilizers could create a manifold impact on the production and productivity of various crops [10]. It would not only increase the production and productivity but also would reduce the time gap in growing two crops. The study examines the impact of farm mechanization on the production levels of rice. The findings reveal that there is a strong relationship between rice production and the variables under consideration, such as the sale of tractors as well as the consumption of fertilizers [11]. Hence, it can be said that it is very necessary to use modern agricultural machines and tools as well as high quality seeds in order to increase the production and productivity of different crops [12].

Table 3 Dataset

Year	Rice Production (Million tonnes)	Agricultural Machinery, Tractors (Numbers)	Consumption of Fertilizers (Lakh tonnes)
1970	42220000	33399	1487
1971	43070000	37839	1875.5
1972	39240000	21802	1875.5
1973	44050000	25425	1875.5
1974	39580000	31881	1875.5
1975	48740000	34352	1875.5
1976	41920000	36066	2148.6
1977	52670000	40946	2913.35
1978	53770000	54322	2913.35
1979	42330000	62275	2913.35
1980	53630000	72012	3678.1
1981	53250000	79467	4669.45
1982	47120000	63073	4669.45
1983	60100000	74318	4669.45
1984	58340000	80317	4669.45
1985	63830000	76886	5660.8
1986	60560000	80164	5716
1987	56860000	93157	5716.8
1988	70490000	110323	7251
1989	73570000	122098	7386
1990	74290000	139828	7997.2
1991	74680000	151121	8046.3
1992	72860000	144337	8426.8
1993	80300000	138753	8788.3
1994	81810000	164770	9507.1
1995	76980000	191329	9822.8
1996	81730000	222684	10301.8
1997	82540000	248141	10901.8
1998	86080000	262169	11353.8
1999	89680000	273182	11592.7
2000	84980000	251939	10920.2
2001	93340000	217456	11310.2
2002	71820000	168182	10474.1
2003	88530000	189518	11077
2004	83130000	246469	11713.9
2005	91790000	291680	12723.3
2006	93360000	352827	13772.9
2007	96690000	346501	14419.1
2008	99180000	347010	15090.5
2009	89090000	440331	15580
2010	95980000	545109	16558.2
2011	105300000	607658	17300.3
2012	105230000	590672	16820.9
2013	106650000	696828	16750.1
2014	105480000	626839	16945.4
2015	104410000	571249	17372.3

Source: Directorate of Economics and Statistics, DAC&FW; India Stat and Department of Fertilizer, Department of Agriculture, Cooperation & Farmers Welfare

As per various studies conducted both the ratio of male and female labour-force participation in the agricultural sector is decreasing year by year due to which the share of GDP from the agriculture sector comes down. The (LFPR) labour force participation in India is almost 40%, despite this for females it is just 22.5 per cent. The difference in male–female workforce participation is to such an extent that the LFPR for females living in rural areas with the age of more than 15 years is just 35.8 percent, while for male population it is just twice which is 81.3 percent. This is quite surprising in a country where the working population has such a large demographic dividend. The reason for this phenomenon has been associated with education and income effects [13-14].

The mechanization and modernization of the agriculture sector will help in solving this issue. The adoption and utilization of different machines such as tractors, threshers, seed drillers, planters will reduce the requirement of more labour and in turn will increase the production and productivity of different crops. As the climate is changing it puts the agriculture sector at great risk of especially disappearing monsoon and uncertain rainfall. The phenomenon of frequent drought is also becoming a serious issue nowadays. The modernization of the agriculture sector with innovative ideas such as drip irrigation, sprinkler irrigation, roof-top cultivation, rainwater harvesting, green house, solar power irrigation can play a crucial role in mitigating the tough challenges faced by the agriculture sector in the present day [15].

There is a great scope in the area of mechanizing and modernizing the agriculture sector of India. This is because India is experiencing an increase in the number of companies and organizations which supplies different types of modern agricultural machines and tools [16]. At present there are 850 manufacturers operating in different parts of the country (India.gov.in). With this there is also an increase in the volume of sales mainly tractors. The previous year of 2020-21 was a great year for the tractor industry as the general sales increased from 7,85,059 to 9,88,043 along with an upward increase in domestic sales by 26.9 percent and the export sector also saw an increase by 16.4 percent in comparison to the year 2019-20. This tremendous growth led to domestic sales to 8,99,480 and resulted in export of 88,563. This brought an overall increase in the sale by 25 percent in 2020-21 as compared to previous year (Tractor Gyan Blog).

The results throw light on the policy prescriptions for the government. The Government should formulate and implement policies to provide various modern agricultural machines and high-quality fertilizers to poor farmers, especially for farmers who cannot afford it [17]. This can be done by following the model of Public Distribution System (PDS) adopted for the distribution of essential food grains to poorer sections of people [18]. The same system could be adopted in distributing tractors to poor farmers through the agencies of the Central, State and local Governments. These agencies can purchase the machines and equipment and could pass on to various district heads who in turn can procure and supply the machines, tools and high-quality seeds to various heads of the village panchayats of the corresponding districts. The farmers can avail them and use them for different crops according to the season. It is also important to have checks and balances related to the procedures of using them with proper maintenance.

Faster mechanization is indispensable in addressing the gap between the supply and demand for food grains in future. It makes it imperative for the Government at various levels to initiate awareness campaigns among farmers about the use of machinery, equipment, fertilizers and high-quality seeds. Also, the farmers need to be equipped with various aspects of scientific farming [19]. It necessitates proper coordination among the government officials, farmers and organizations. Besides, adequate storage facilities as well as proper linkage between production and marketing will enable the farmers to ensure fair prices for their products.

CONCLUSION

In conclusion, the study shows the positive relationship between the sale of tractors and fertilizer consumption with rice production. The use of tractors and fertilizers in the agriculture process leads to increase in productivity of rice. Hence, the government intervention is pertinent by way of subsidizing the fertilizers (which is being practiced currently) and agricultural credit facilities. Accessibility to these facilities is a major concern, especially with regard to small and marginal farmers. Thus, it is crucial on the government's part to devise discretionary policies in ensuring the supply of agricultural machines (tractors) to the farmers, especially the ones who cannot afford them. It is projected that India would be the most populous country in the world by 2045. Hence, it is indispensable to increase the production and productivity of various agricultural crops at the same rate to feed such a large population. There are claims that the country has already attained self-sufficiency in the food grains' production, a significant rise in production and productivity is inevitable to meet the future demand. We argue that mechanization and modernization of Indian agriculture is the only way out to achieve this goal. Crop-specific analysis could provide a clear picture regarding the impact of modernization on the production levels. Extending the analysis to other major crops would throw light on the significance of various attributes of modernization in raising the production levels.

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