Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 8 [10] September 2019 : 81-86

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
Global Impact Factor 0.876
Universal Impact Factor 0.9804
NAAS Rating 4.95
ORIGINAL ARTICLE **OPEN ACCESS**

Analyzing the Impact of Fertilizer Price in Indian Agriculture– A statistical Approach

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ABSTRACT
Fertilizer consumption in India has been increasing over the years and today. Between 2017 and 2021 the fertilizer industry will invest close to US$ 110 billion in more than 65 new production units, increasing global capacity by 90 million tones products. The main objective of the study is to analyze the trend in production and consumption of fertilizer in India and to analyze the price volatility for three major fertilizer prices and its impact on agriculture. The result of the study shows there is astrong integration of major fertilizer markets in India and also confirmed that the price of one market influence the price of other markets. Table of Garch model shows that all the selected fertilizers markets showed unidirectional causality except urea market which showed bidirectional causality with DAP market.
Key words: *Fertilizer. Arch model, Garch model, Unit root*

Received 23.07.2019 Revised 14.08.2019 Accepted 02.09. 2019

INTRODUCTION

Agriculture is the significant occupation in India where more than 70 per cent of the people rely on agriculture for employment and income. The total food grain production in the country rose from 151.2 million tonnes in 1980s (1981- 82 to 1990-91,) to 190.6 million tonnes in the 1990s and 212 million tonnes in 2000s (2001-02 to 2009-10), Ministry of Agriculture). With the advent of seed-fertilizer revolution in mid-sixties there had been significant changes in the agricultural scenarios of the country.

During the earlier days farmers in India practiced only organic farming and the production was very less to meet out the growing demand. Green revolution in early 1960's started to increase the yield through improved agronomic technology especially in wheat crop. In this period, Indian Chemical fertilizer industry started in 1906 with Single Super Phosphate production facility at Ranipet near Chennai [1] and started operation in a big scale since 1940s. Later there was a bloom in the fertiliser sector and increased the crop yields dramatically.

Recent data shows that, India is the third largest producer and second largest consumer of chemical fertilizer in the world [1]. Fertiliser consumption in India has been increasing over the years and today.

Since Independence, India's food grain production has registered an over a five-fold increase, to around 273 million tonnes in 2016-17 [3]. This impact is due to the utilization of fertilizer worldwide. There had been variation in the consumption of fertilizer state wise and crop wise. Some Scientist argue that-fertiliser was an important as seed in the Green Revolution.

Between 2017 and 2021 the fertilizer industry will invest close to US$ 110 billion in more than 65 new production units, increasing global capacity by 90 million tones products. Global ammonia capacity is projected to reach 234 Mt NH_3 in 2021. Large increases in capacity are expected in EECA, North America and Africa. By the end of 2021 global nitrogen supply would expand by 1.8% p.a. while demand would see a 1.2% annual increase [2]. Global fertilizer demand is seen as growing on average by 1.5% per annum (p.a.) between the base year (average of the three-year period 2014/15 to 2016/17) and 2021/22. Aggregate world demand is projected to reach 199 Mt at the end of the outlook period. Reflecting the progressive adoption by farmers of best management practices that result in N use efficiency improvements, as well as the increasing recycling of organic nutrient sources, K demand is forecast to grow more firmly (2.1% p.a.) than demand for P (1.5% p.a.) and N (1.2% p.a.) [1].

Objectives

The main objective of the study is to find out the demand and volatility in fertilizer price that affects agriculture and the specific objective is

1. to analyze the trend in production and consumption of fertilizer in India
2. to analyze the price volatility for three major fertilizer prices and its impact on agriculture.

MATERIAL AND METHODS

Secondary data has been used in this study. The price data of Urea, DAP, SSP (Single Super Phosphate) and Crude oil were taken as variables. For statistical analysis secondary data were collected from fertilizer outlook, fertilizer association of India and also from various statistical sources for the period 1990 to 2017.

Tools of analysis

1.Augmented Dickey-Fuller Test

Augmented Dickey–Fuller test (ADF) is a test for a unit root in a time series sample. This test is used for a larger and more complicated set of time series models. The augmented Dickey–Fuller (ADF) statistic, used in the test, is a negative number. The more negative it is, the stronger the rejection of the hypothesis that there is a unit roots at some level of confidence.

$$\Delta y_t = \beta y_{t-1} + \sum_{i=0}^{N} \Delta y_{t-i} + u_t$$

Yt= Relevant time period

When using the ADF test, the data is first tested to determine if it contains a unit root, i.e. it is I(1) and not I(0).If it is not I(0), it could be I(1), I(2) or have a higher order of unit roots. In this case the ADF test needs to be conducted on the differenced variable to determine if it is I(1) or I(2). (It is very rare to find I (3) or higher orders).

Hypothesis

$H_0: \varphi = 1$

$H_1: |\varphi| < 1$

$$Reject\ H_0\ if\ t_{\hat{\varphi}-1} < CV$$

$H_0: \delta = 0$

$H_1: \delta < 0$

$$Reject\ H_0\ if\ t_{\hat{\delta}=0} < CV$$

Pairwise Granger Causality Test

The Granger causality test is a statistical hypothesis test for determining whether one time series is useful in forecasting another. A major implication of Granger causality is that if two variables say, x and y, are co-integrated, then either x must Granger cause Y or vice-versa.

$$Yt = a0 + a1\,Yt - 1 + \cdots . + ap\,Yt - p + b1\,Xt - 1 + \cdots . + bp\,x\,t - p + Ut$$

$$Xt = c0 + c1\,X\,t - 1 + \cdots . + cp\,xt - p + Yt - 1 + \cdots . + dp\,Yt - p\,Vt$$

Testing

$$Ho : b1 = b2 \ldots . = bp = v$$

Against $H1 \# H0$ is a test that Xt does not Granger-cause Yt.

Similarly, testing $H0: d1 = d2 = \cdots = dp = 0$ against

$H1: Not\ H0$ is a test that Yt does not Granger cause Xt.

In each case, a rejection of the null hypothesis implies there is Granger causality between the variables.

- $Decision\ rule: reject\ H0\ if\ P - value < 0.05.$
- $DNR - do\ not\ reject$

GARCH Model

The generalized autoregressive conditional heteroskedasticity (GARCH) model will be used to model the volatility in global fertilizer and crude oil prices. This model is mostly used for symmetric shocks.

- ❖ GENERALIZED- more general than ARCH model
- ❖ AUTOREGRESSIVE-depends on its own past
- ❖ CONDITIONAL-variance depends upon past information
- ❖ HETEROSKEDASTICITY- fancy word for non-constant variance

The GARCH-class of models are not like simple linear ones
Hence OLS cannot be used Instead, maximum likelihood techniques are used
A GARCH (p,q) model has three components:

$$rt = f(xt) + ut$$

$$ut = et\sqrt{ht}$$

$$ht = \omega + \Sigma\alpha + \Sigma\beta$$

$$q$$

$$= \omega + \Sigma\alpha i\, ut - i \; + p\beta$$

$$i = 1$$

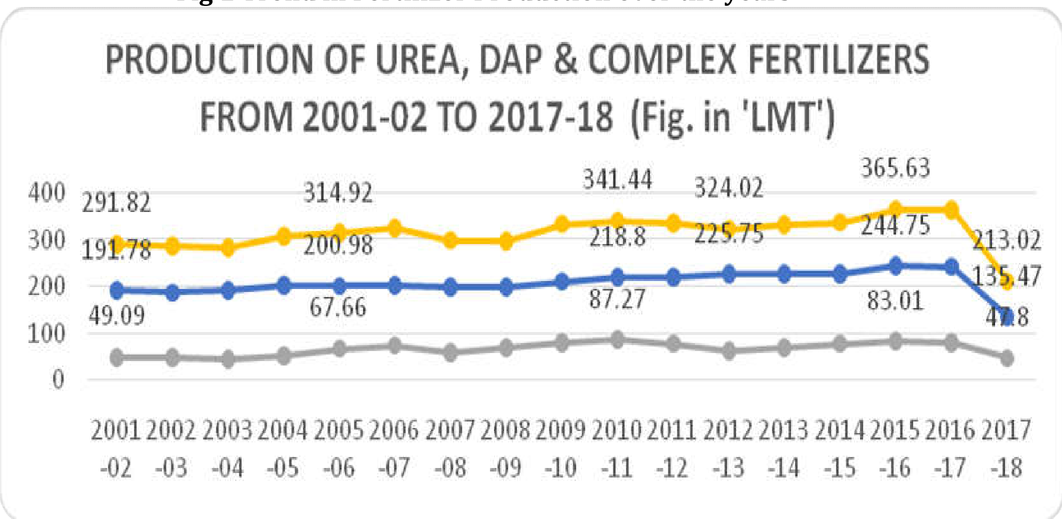
xt : independent variable
ut : residuals of "mean" equation
ht: conditional variance
GARCH(1,1) is a restricted infinite order ARCH model
yet only needs three parameters to be estimated

- ❖ α_0 is the constant
- ❖ α_1 is the effect of last period's error
- ❖ $\beta_1$is the effect of last periods variance
- ❖ $\alpha_1 + \beta_1$ gives the persistence of the volatility:
  - $\alpha_1 + \beta_1 < 1$ implies volatility decays
  - $\alpha_1 + \beta_1 \approx 1$ implies very slow decay
  - $\alpha_1 + \beta_1 > 1$ implies volatility explodes

RESULTS AND DISCUSSION

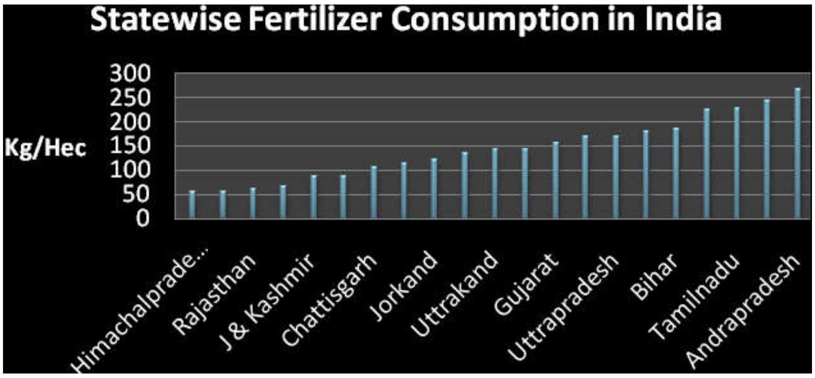
Fig.1 shows the trend in fertilizer production and there exist a decreased production during the year 2017-18.

Fig.1 Trend in Fertilizer Production over the years



Source: FAI, Annual Report ,2017-2018

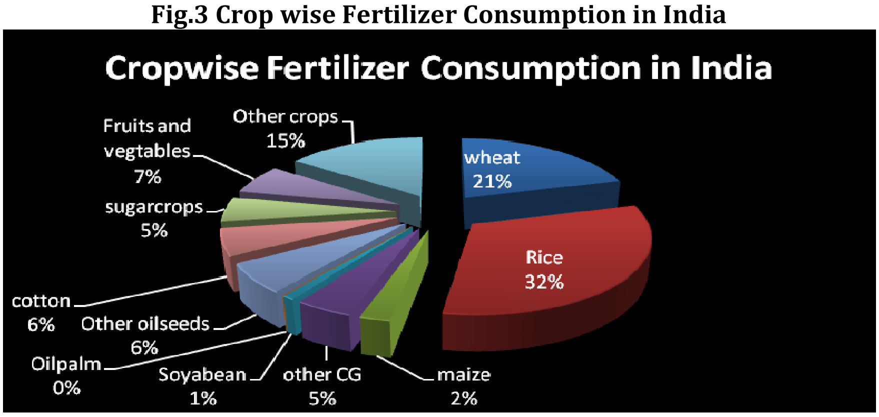
Fig.2.Statewise Fertilizer Consumption in India



It is observed from Fig.2 that the consumption of fertilizer was found to be high in the states of Andhra pradesh, Punjab and Tamil Nadu as compared to other states of India. The main fertilizer produced in India is Urea, Di-Ammonium Phosphate, Complexes, Single Super Phosphate.

As India is the agricultural country has different agro climatic regions vast majority of the population consume rice and wheat and the area under rice and wheat cultivation will be more than other crops. Obviously, fertilizer consumption will be higher for these crops.Fig.3also shows that crops like wheat and rice alone accounts for nearly 53 percent of the fertilizer consumption in India.

Fig.3 Crop wise Fertilizer Consumption in India

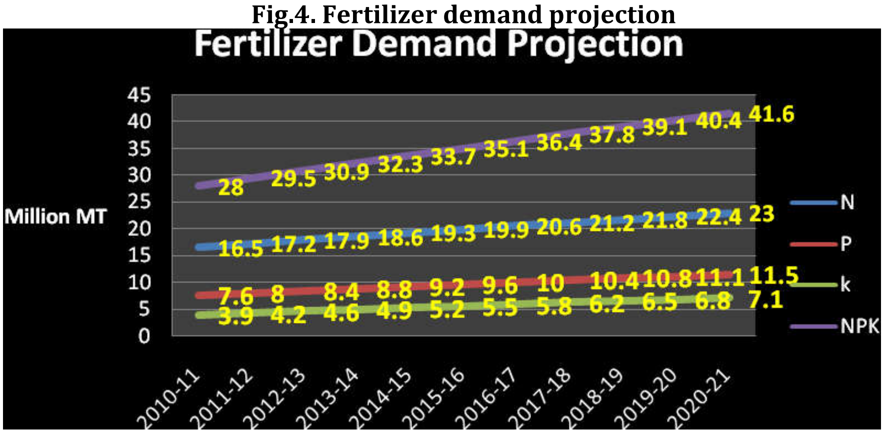


Source: FAI,2016

Demand for fertilisers

Demand and supply of fertilizers are mainly depends upon the price factors like input prices and output prices. Recently the world fertilizer demand gets raised with 2.4 percent with a demand of 186 mt (fertilizer outlook -2017) during 2016-17. It is also observed from fig.4 that estimated demand for nitrogenous fertilizer is found to be (23 MMT) higher than potassium and phosphatic fertilizer.

Fig.4. Fertilizer demand projection



Source: FAI,2016

Stationarity Test – Augmented Dickey Fuller (ADF) Unit Root Test

To verify level and first differenced price series were indeed stationary, Augmented Dickey-Fuller (ADF) unit root test was used. The ADF test results are presented for the period January 1990 to December 2017. The equations were estimated with an intercept and time trend. The results are presented in Table 1 for Augmented Dickey-Fuller (ADF) unit root tests for each series.
The null hypothesis of non - stationarity was tested based on the critical values reported by MacKinnon. All the price series appeared non stationary in the levels, but all the series were stationary after taking first differences. After confirming the series were stationary in their first differences, co integration between the markets was tested using Johansen's maximum likelihood procedure. The bivariate co integration technique of Engle and Granger was also tested for the presence of long run relationship existing between fertilizer price in different markets.

Table 1. Augmented Dickey Fuller-Unit Root Test

	ADF statistics	First difference	Critical Value
DAP	-2.097	-8.27	-3.460
Potash	-2.940	-3.59	
Urea	-1.402	-6.79	

In general, augmented dickey fuller test compares the null hypothesis and usually will be in negative value. If the negative value is more then we strongly reject the null hypothesis. The results of table.1 shows that unit root test for three fertilizers and the first differences of natural logs. It shows all the three fertilizer prices are stationary when they are first differenced. So, the null hypothesis is rejected here.

Granger Causality Test

The causal relationship among the price of major fertilizer market in India was approached through Granger's Causality technique and results are presented in Table 3. It could be seen from the results that all the selected fertilizers markets showed unidirectional causality except urea market which showed bidirectional causality with DAP market. Thus, a strong integration of major fertilizer markets in India is confirmed that the price of one market influence the price of other markets through the result of the study.

Table.2 Results of Pairwise Granger Causality Test.

Null Hypothesis:	F-Statistic	Prob.	Decision	Type of causality
Potash does not Granger Cause DAP	0.65340	0.5213	DNR H_o	Unidirectional
DAP does not Granger Cause Potash	33.3867	2.E-13	Reject H_0	
Urea does not Granger Cause DAP	36.9640	2.E-14	Reject H_0	Bi-directional
DAP does not Granger Cause Urea	8.09064	0.0004	Reject H_0	
Crudeoil does not Granger Cause DAP	17.9999	6.E-08	Reject H_0	Unidirectional
DAP does not Granger Cause Crudeoil	1.44829	0.2373	DNR H_o	
Urea does not Granger Cause Potash	15.5307	5.E-07	Reject H_0	Unidirectional
Potash does not Granger Cause Urea	1.75816	0.1749	DNR H_o	
Crudeoil does not Granger Cause Potash	6.65287	0.0016	Reject H_0	Unidirectional
Potash does not Granger Cause Crudeoil	1.47709	0.2306	DNR H_o	
Crudeoil does not Granger Cause Urea	22.8180	1.E-09	Reject H_0	Unidirectional
Urea does not Granger Cause Crudeoil	3.42396	0.0344	DNR H_o	

Table.2 presents the causality test to find out cause and effect relationship between two variables. Grangers causality is tested here for the prices of Urea, DAP, Potash, and Crude oil. The oil prices are used here to predict the fertilizer prices.

Table.3 Result of ARCH-GARCH Analysis

Price	α value	β value	α + β value
DAP	1.04174	-0.00215367	1.03
Urea	1.03291	0.00856450	1.04
Potash	1.16848	-0.0144018	1.15
Crude oil	1.13767	-0.0890204	1.04

To assess the presence of price fluctuations in the domestic markets for Urea, Pottash and crude oil by using Arch - Garch analysis was carried out as given in Table 3. The sum of coefficients of Arch and Garch were closer to 1 in almost all the fertilizers and crude oil markets. Hence, there existed persistence of price shocks across the market.

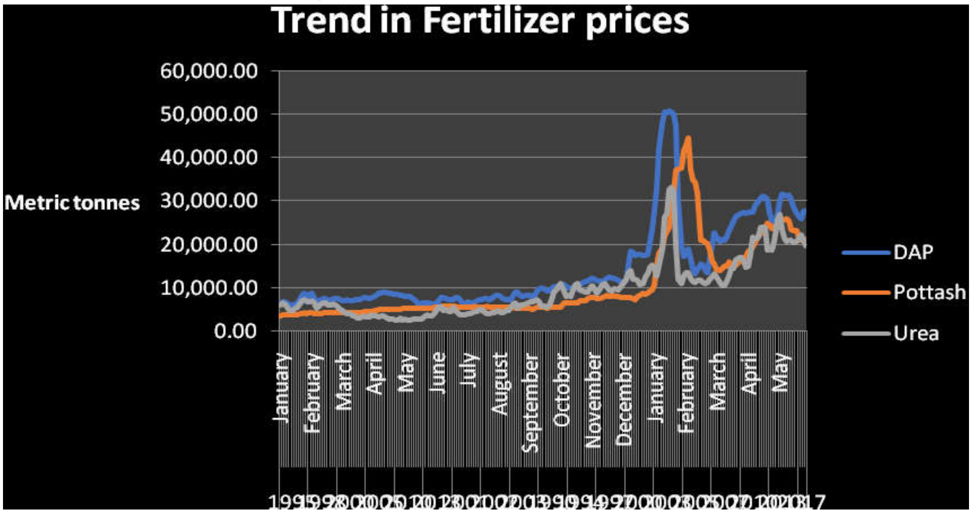
Fertilizer Price volatility

Effects of Volatility

International price of DAP is significantly affected by the price of Ammonia natural gas, available stock, phosphate rock, sulphur and the price of Brent crude oil, etc. Gas and oil price have been normally showing an upward trend. Since from beginning of 2000s natural gas prices increased incredibly which in turn has made the fertilizer cost higher [4]. Price of fertilizer from 1990-2017 is presented in figure. It is clearly evident that from the graph that fertilizer price showed higher volatility in domestic markets across India.

Volatility in fertilizer prices bring extremely high risks and hurts economic growth and trade. prices have a direct effect on farmers as well as impact the earnings of fertilizer companies.

Fig. 5. Trend in Fertilizer Prices



Department of agriculture and co-operation, ministry of agriculture, GOI, 2017

CONCLUSION

Many studies revealed that the contribution of fertilizer to agricultural growth and poverty reduction has declined steadily over time [3]. The present study also aimed to study the effect of crude oil prices with fertilizer prices. The result of the study shows there is astrong integration of major fertilizer markets in India and also confirmed that the price of one market influence the price of other markets. Table of Garch model shows that all the selected fertilizers markets showed unidirectional causality except urea market which showed bidirectional causality with DAP market. The fact during late 80's and 90's was that there has been no increase in the fertilizer prices. Later government implemented the hike of 30 per cent fertilizer prices to minimize the drain on budgets. In recent years due to continues failures of monsoon and loss in agricultural productivity, the hike in fertilizer prices are becoming burden to farmers. Policy reforms in agricultural inputs prices must be given much emphasis to safeguard the Indian farmers.

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CITATION OF THIS ARTICLE

S. Usha Nandhini, David Chella Baskar, V. Kavitha, and Sangeetha.R. Analyzing the Impact of Fertilizer Price in Indian Agriculture– A statistical Approach. Bull. Env. Pharmacol. Life Sci., Vol 8 [10] September 2019: 81-86