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SUPPLY RESPONSE OF PIGEONPEA IN INDIA – COINTEGRATION AND VECTOR ERROR CORRECTION ANALYSIS

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ABSTRACT

The present work analysed the supply response of Pigeonpea pulse crop with the help of acreage response relation and yield response relation at all India level. The analysis has been done using time series data for the period 1975-76 to 2015-16. The acreage response relation was analysed with the help of Cointegration and Vector Error Correction Approach and results revealed that there exists long run association between acreage and price and non-price variables and farmers do respond positively to the price variable. The yield response function is estimated with the help of multiple regression model as all the variables concerned are stationary at levels. The results of the yield response showed that weather risk influences negatively and technological development over a period of time has significant positive impact on the yield. But the analysis revealed that whenever resource allocation is concerned famers preferred to allocate irrigated land to other competing crops which are more remunerative and high yielding than Pigeonpea crop. This calls for effective incentive measures by the government to encourage the farmers to enhance the area under Pigeonpea crop.

Keywords: Production, Yield, Cointegration, Vector Error Correction , Acreage
JEL Classification: Q11, C51,C52

INTRODUCTION

Pigeonpea also known as tur is one of the important pulse crops grown in different parts of India. This is the second largest pulse crop next only to Chickpea crop. India is also the largest producer of Pigeonpea in the world accounting for 63 percent of the world production and having 73 percent of the world area under the crop. The productivity of Pigeonpea is low compared to Philippines which ranked first with the average yield of 1699 kgs/hectare followed by Burundi and Grenada (Tiware & Shivahare, 2016). Pigeonpea being a legume crop possess the property of fixing nitrogen into the soil thus enhancing the soil fertilities. Piegonpea is a rich source of protein and people get vegetable protein mainly from pulses. Its husk acts as an important source of cattle feed. Despite its importance area, production and yield of Pigeonpea crop has shown marginal improvement over a period of time. Governments both at the centre and state level are making lot of efforts to increase area, production and productivity of Pigeonpea through various programmes as it is consumed by the mass and the demand for it is growing continuously. In this backdrop an effort has been made in the present paper to understand the supply aspect of Pigeonpea by analysing acreage response relation and yield response relation with the help of suitable econometric techniques and the findings of the study will be of importance to the various stakeholders of the economy.

LITERATURE REVIEW

Present analysis intends to study the supply response of Pigeonpea crop at all India level based on the time series data. Literature review exhibited that number of studies have been done by the researchers on agricultural supply response of commodities in India and in other countries of the world. Some of the relevant works are reviewed in this section. The supply response analysis of potato in Bangladesh using Vector Error Correction Approach (VEC) showed that price significantly influenced the supply, hence, suggested for effective price policy for attaining desired output level (Huq & Arshad, 2010). Cointegration and VEC approach was used to study the long-run and short-run dynamics of the supply response of Maize in Ethiopia and results led to the conclusion that price factors were more important in the long-run than in the short-run in influencing the supply of maize (Ayalew, 2015). Cointigration approach was adopted to study the supply response of Rice in Ghana and the time series analysis showed that the land area cultivated under rice was considerably influenced by the price and non-price factors hence, necessitated effective policies on the part of the government on various aspects of supply of rice (Kuwornu, 2011). Using cointegration approach supply analysis of rubber in Malaysia had been analysed and from the results it was found that Malaysian farmers responded rationally to the price incentives hence, recommended for proper economic incentives for the famers to stimulate the output at the desired level (Mustafa, latif & Eawuma, 2016). Many studies had been conducted using VEC, Cointegration and multiple regression approaches to study the supply response of agriculture commodities in India (Beag & Singla, 2014, Bhagat, 1985, Savadatti, 1997,2007). The literature review facilitated in building the theoretical frame work and required empirical model for the present analysis.

RESEARCH METHODOLOGY

Theoretical Background

The supply analysis of the Pigeonpea (Tur) crop has been done with the help of two relations Acreage Response Relation and Yield Response Relation. The prerequisite for the advanced time series analysis is the stationarity of the time series under consideration. Time series are said to be stationary (weakly) if their mean and auto-covariance are time invariant. If the series are not stationary, then they are known as nonstationary series. Before performing any time series analysis series have to be made stationary in case of nonstationary series which is performed by the differencing technique. A differenced stationary time series is known as Integrated and denoted as I(d) where 'I' stands for Integration and 'd' for order of integration (number of times the series is to be differenced in order to make it stationary). There are many tests available for testing the stationarity of the time series. Among them Augmented Dicky Fuller (ADF) test and Phillips-Peron (PP) tests are popular. In our analysis PP test has been used for testing the stationarity of the series under consideration. The ADF test estimates the following equation with the help of Ordinary Least Squares (OLS) method. But there is a problem

$$Y_t = \gamma + \emptyset Y_{t-1} + \cup_t \qquad \text{---------------------- (1)}$$

of serial correlation which is addressed in ADF test by incorporating the lagged variables of the first differenced Y_t on the right side of the above equation. PP test also uses the similar kind of the regression equation to estimate and the results are used to calculate the test statistics. But PP test statistics are made more robust to serial correlation.[1] Once the series are made stationary in case of non-stationarity then Integrated series are tested for long run association through cointegration technique. The cointegration analysis is done with the help of Johansen test (1991). Johansen process uses maximum likelihood method to determine the number of the cointegrating vectors in non-stationary time series data. Johansen's model is as follows

$$\Delta Y_t = \gamma + \sum_{i=1}^{n} \delta_i \Delta y_{t-i} + \alpha \varphi' Y_{t-1} + \varepsilon_t \qquad \text{------------------------------------ (2)}$$

Where

Y_t *is vector of non − stationary series of the order n x 1*

δ_i *is matrix of coefficients of dimension n x n*

α *is a matrix of error correction coefficients of dimension n x r*

φ *is a matrix (n x r) of r cointegrating vectors*

Further Johansen (1991) mentions two test statistics for identifying cointegration between variables under consideration. Those are Trace test and Maximum Eigenvalue Test. Under the Trace test the null hypothesis that there exist no cointegrating vector ($(H_0 : r = 0)$) against the alternative hypothesis that there exists cointegrating vector ($H_1 : r > 0$). Under maximum eigenvalue test the null hypothesis is number of cointegrating vectors is equal to r against the alternative hypothesis that the number of cointegrating vectors equal to r+1 (Maggiora & Skerman, 2009)

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{g} ln(1 - \widehat{\lambda_i})$$

$$\lambda_{max}(r, r+1) = -T \sum_{i=r+1}^{g} ln(1 - \widehat{\lambda_{r+1}})$$

Where r is the number of cointegrating vector under the null hypothesis and $\widehat{\lambda_i}$ is the estimated i^{th} ordered eigenvalue from the $\alpha\varphi'$ matrices. In Johansen's procedure lag length of the term is decided based on the Akaike Information Criteria (AIC) and the Schwarz Information criteria (SIC). The estimated Vector Error Correction Model (VECM) will be evaluated with various diagnostic checks like serial correlation LM test, model stability test, etc.

Data

The present analysis aimed at understanding the supply behaviour of Pigeonpea (Tur) crop. For the analysis the time series data on various variables namely area under the crop, yield of the crop and gross area irrigated under all crops were collected from the data source Centre for Monitoring Indian Economy (CMIE), required data on area irrigated under the tur crop, sowing period rainfall and growing period rainfall were collected from data sources india.stat.com and Indian Meteorological data available on the web site respectively ; thirdly data on minimum support price of Tur were collected from Reserve Bank of India data base : Data Base of Indian Economy (DBIE). The annual time series data on all the required variables were collected for the period 1975-76 to 2015-16. The data analysis is carried out with the help of Eviews-9 statistical software.

Variables of the model

The present study analyses the supply response of the Pigeonpea with the help of two relations one area relation and yield relation comprising of the following variables

Acreage Response function is presented as below

$Y_{1t} = f\ (X_{1\ t-1}, X_{2t}, X_{3t})$ -------------------------------- (3)

Where

Y_{1t} $= Area\ under\ the\ Pigeonpea\ in\ '000'\ hectares\ in\ the\ year\ 't'$

X_{1t-1} $= minimum\ support\ price\ (MSP) of\ Piegonpea\ in\ Rs.Quintal\ in\ period\ 't-1'$

X_{2t} $= Area\ irrigated\ under\ all\ crops\ '000'\ hectares\ in\ the\ year\ 't'$

X_{3t} $= Sowing\ period\ weather\ risk\ in\ the\ year\ 't'$

Yield Response function is given below

$Y_{2t} = f\ (X_{4t}, X_{5t}, X_{6t}, T)$ --------------------------------------(4)

Where

Y_{2t} $= Yield\ of\ Pigeonpea\ in\ Kgs\ per\ hectare\ in\ the\ year\ 't'$

X_{4t} $= Growing\ period\ rainfall\ in\ mms\ in\ the\ year\ 't'$

X_{5t} $= Growing\ period\ weather\ risk\ in\ the\ year\ 't'$

X_{6t} $= Area\ irrigated\ under\ Pigeonpea\ crop\ '000'\ hectares\ in\ the\ year\ 't'$

T $= Time\ trend\ variable\ assuming\ values\ as\ 1975-76 = 1, \dots\dots\dots..., 2015-16 = 41$

RESULTS AND DISCUSSION

Acreage Response Relation

The variables of the area response function are tested for the stationarity as it is essential that the series under consideration need to be stationary for further analysis, using Phillips-Perron (PP) test of stationarity. The stationary test results are presented in Table 1. Various specifications have been tried for the variables by including constant, time trend, etc., and the results presented in the Table 1 are clearly showing that all the variables (area, price, irrigated area and weather risk) are integrated of order one I (1). All the series under consideration for the area response function are stationary after first difference at 1% significance level as the respective probabilities are < 0.01.

The PP test indicated that all the series are I(1) so the relation cannot be estimated with the help of Ordinary Least Squares (OLS) method. So we have to look for alternative method and in this case Vector Error Correction Method (VECM) may be more suitable. But application of VEC model necessitates that the series integrated of the same order are cointegrated. As discussed in the methodology Johansen method suggested two tests namely the Trace test and the Maximum Eigen Value statistic tests. These two tests help in deciding the number of cointegrating equations among the series. Cointegrating equation provides the long run equilibrium association between the cointegrated series. The results of the Johansen cointegration tests are shown in Table 2. The lag length is determined based on the AIC and BIC criteria. Cointegration tests for Acreage function comprising of variables price, gross irrigated area and weather risk showed the rejection of null hypothesis of no cointegrating vector between the variables. Both the trace and maximum

Eigen value tests reject H_0 = at most one cointegrating vector, at 5% significance level suggesting

Variable		**Test Critical Values**			**#PP test stat**		
		(Adj t-stat)					**Implication**
		1%	**5%**	**10%**	**Adj t-stat**	**Prob***	
Area Under Crop (Y_{1t})	At levels	-3.6056	-2.9369	-2.6068	-1.6858	0.4306	I(0) Non-stat
	1st Diff	-3.6104	-2.9389	-2.6079	-15.0040	0.0000	I(1) stat**
Minimum Support Price (X_{1t-1})	At levels	-3.6055	-2.9369	-2.6068	2.6667	1.0000	I(0) Non-stat
	1st Diff	-3.6104	-2.9389	-2.6079	-4.5557	0.0007	I(1) stat
Gross Area Irrigated (X_{2t})	At levels	-3.6055	-2.9369	-2.6068	-1.1113	0.7020	I(0) Non-stat
	1st Diff	-3.6104	-2.9389	-2.6079	-7.9362	0.0000	I(1) stat
Sowing Period Weather Risk (X_{3t})	At levels	-3.6155	-2.9411	-2.6090	-2.3254	0.1695	I(0) Non-stat
	1st Diff	-3.6210	-2.9434	-2.6102	-5.9848	0.0000	I(1) stat

that there exists cointegrating relationship among the variables in the acreage response relation. The area relation has one cointegrating vector thus suggesting unique long-run relationship in case of acreage function. The long run VECM estimates of acreage response relation are presented in Table 3.

Table 1: Philips-Perron Stationarity Test Results for Variables of Area Relation
Phillips-Perron test statistic ; *MacKinnon (1996) one-sided p-values ; ** stationary
Source: Data Analysis

Table 2: Johansen Cointegration Test Results for Area Relation

Unrestricted Cointegration Rank Test (Trace)			
Hypothesized No. of CE(s)	**Trace Statistics**	**0.05 Critical Value**	**Probability ****
None *	81.02639	63.87610	0.0009
At most 1	41.75365	42.91525	0.0651
Trace test indicates 1 cointegrating eqn(s) at the 0.05 level * denotes rejection of the hypothesis at the 0.05 level **MacKinnon-Haug-Michelis (1999) p-values			
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)			
Hypothesized No. of CE(s)	**Max-Eigen Value**	**0.05 Critical Value**	**Probability ****
None *	39.27274	32.11832	0.0056
At most 1	22.77178	25.82321	0.1202
Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level * denotes rejection of the hypothesis at the 0.05 level **MacKinnon-Haug-Michelis (1999) p-values			

Source : Data Analysis

The results in Table 3 show that the coefficient of price is positive and statistically significant at 1% level. This means price significantly influences the farmers' acreage behaviour. Higher price of Pigeonpea will motivate farmer to allocate more land to Pigeonpea crop in the long run. This means acreage response of farmers for Pigeonpea crop is price responsive which rules out the notion that pulse supply response is price insensitive.

Table 3: Long -Run VEC estimates for Acreage function

Variable	Area under the Crop (Y_{1t})	Minimum Support Price (X_{1t-1})	Gross Area Irrigated (X_{2t})	Sowing Period Weather Risk (X_{3t})	Constant C
Coefficient value	1.000000	32.31111***	-1631.856***	-2160.271***	114578.3
Standard Error		(5.76553)	(366.173)	(428.969)	
t-statistics		[5.60419]	[-4.45651]	[-5.03596]	

*** indicate significant at 1% level ; Source: Data Analysis

The coefficient of gross area irrigated under all crops is statistically significant at 1% level but having negative sign indicating that when more irrigational facilities are available, farmer prefers to allocate irrigated land to other more remunerative and high yielding crops than to pulse crops. So, higher irrigational facilities will reduce land allocated to Pigeonpea crop in the long run. More irrigational facilities take away land from Pigeonpea crop to other competing crops as the pulse crops are more prone to pests and disease which in turn result into lower pulse yields compared to other competing crops. Sowing period weather risk is impacting the acreage negatively and significantly (1% level) displaying that farmers do respond to weather risks as Pigeonpea is grown in the rainfed area. More the weather risk lower will be the land allocated to the Pigeon pea crop in the long run.

The short run Vector Error Estimates of acreage response function are presented in Table 4 below. The results reveal that the model fits fairly better as the R-square is 42% and the F – statistics is 2.08. The coefficient of Error Correction Term (ECT) is having expected negative sign but not significant. ECT indicates that only 1% of the deviation from the long run equilibrium is corrected in the current period. Coefficient of area under irrigation has negative sign though not significant indicating that during short run availability of irrigational facilities motivate farmers to allocate area to the other more remunerative and high yielding crops. Coefficients of price and weather risk are not significant. The fitted acreage response model is tested for its adequacy based on the different tests and the results of the same are presented in Table 5.

Table 4: Short run Vector Error Correction Estimates for Acreage Relation

Error Correction:	$D(Y_{1t})$ (Area)	$D(X_{1t-1})$ (Price)	$D(X_{2t})$ (Irrigated Area)	$D(X_{3t})$ (Weather Risk)
CointEquation1	-0.001074	0.001647	-0.000110***	0.000376***
	(0.00298)	(0.00260)	(2.9E-05)	(0.00010)
	[-0.36082]	[0.63304]	[-3.83642]	[3.65066]
$D(Y_{1t}(-1))$	-0.379485**	0.428159***	0.002411	-0.013029**
	(0.17784)	(0.15540)	(0.00171)	(0.00615)
	[-2.13386]	[2.75527]	[1.41303]	[-2.11947]
$D(Y_{1t}(-2))$	-0.587128**	-0.005206	-0.003237	-0.002111
	(0.23884)	(0.20870)	(0.00229)	(0.00826)
	[-2.45820]	[-0.02495]	[-1.41259]	[-0.25573]
$D(X_{1t-1}(-1))$	0.294767	0.279797	0.005602**	-0.013020
	(0.27021)	(0.23611)	(0.00259)	(0.00934)
	[1.09089]	[1.18504]	[2.16067]	[-1.39395]
$D(X_{1t-1}(-2))$	-0.347766	0.195521	0.005346**	-0.007706
	(0.24298)	(0.21232)	(0.00233)	(0.00840)
	[-1.43124]	[0.92089]	[2.29325]	[-0.91747]
$D(X_{2t}(-1))$	-7.828043	18.58454	-0.439937**	0.261728
	(19.9931)	(17.4700)	(0.19183)	(0.69108)
	[-0.39154]	[1.06380]	[-2.29342]	[0.37872]
$D(X_{2t}(-2))$	-1.619246	-17.50290	0.072426	-1.654219**
	(19.0441)	(16.6408)	(0.18272)	(0.65828)
	[-0.08503]	[-1.05181]	[0.39638]	[-2.51295]
$D(X_{3t}(-1))$	4.873513	3.341784	-0.169559***	0.225422
	(5.11731)	(4.47151)	(0.04910)	(0.17688)
	[0.95236]	[0.74735]	[-3.45345]	[1.27441]
$D(X_{3t}(-2))$	-0.693605	1.122765	-0.056120	0.083168
	(4.96118)	(4.33508)	(0.04760)	(0.17149)
	[-0.13981]	[0.25900]	[-1.17898]	[0.48498]
C	69.58473	50.64700	0.491259	4.613616**
	(58.2246)	(50.8767)	(0.55864)	(2.01258)
	[1.19511]	[0.99549]	[0.87938]	[2.29238]
R-squared	0.418366	0.506930	0.534969	0.572126
Adj. R-squared	0.217031	0.336252	0.373997	0.424016
Sum sq. resids	1048254.	800371.4	96.49789	1252.456
F-statistic	2.077963	2.970095	3.323364	3.862842
Log likelihood	-236.1059	-231.2494	-68.82983	-114.9700
Akaike AIC	13.67255	13.40274	4.379435	6.942776
Schwarz SC	14.11242	13.84261	4.819301	7.382642

***, ** indicate significance at 1% and 5% level respectively

Source : Data Analysis

The Jarque-Bera test (Table 5) for testing the normality of the residuals showed that residuals are normal as probability is high so fail to reject the null hypothesis. Similarly, Breusch-Godfrey serial correlation LM test also indicates the absence of the problem as the corresponding probability is greater than 0.05. There is no problem of Auto Regressive Conditional Heteroskedasticity (ARCH) among residuals as validated by the test having high probability. Most of the model adequacy tests are signalling that the estimated acreage response relation is fairly good and fits the data reasonably.

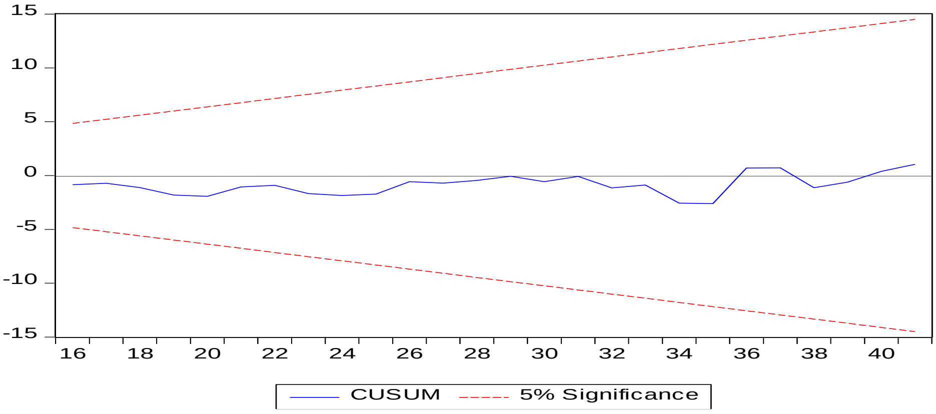
Table 5: Model Adequacy Tests for Residuals (Fitted Acreage Relation)

Normality Test Jarque – Bera (J-B)	J-B	Probability
H_0 : Residuals are normal	0.514653	0.773116
Serial Correlation LM Test Breusch-Godfrey	Observations*R-Square	Probability Chi-Square (2)
H_0 : No Serial Correlation among residuals	0.213003	0.8990
Heteroskedasticity Test ARCH	Observations*R-Square	Probability Chi-Square (1)
H_0 : No ARCH among Residuals	0.789755	0.3742

Source: Data Analysis

The stability of the estimated coefficients of the model are tested with Cusum test and the results of the same are presented in Figure 1. The figure 1 clearly shows that the blue trend line is within the 5% bound indicating that the estimated coefficients are dynamically stable.

Figure 1: Model Stability Diagnostic – Cusum Test



Yield Response Relation

Yield relation includes variables like, tur area irrigated, growing period rainfall, weather risk and time variable for the analysis. The time series collected on these variables are tested for stationarity using Phillips-Perron unit root test and the results of the same are shown in the Table 6 below.

Table 6: Philips-Perron Stationarity Test Results for Variables of Production Relation

Variable		Test Critical Values (Adj t-stat)			#PP test stat Adj t-stat	Prob*	Implication
		1%	5%	10%			
Yield of Tur Crop (Y_{2t})	@ At levels	-4.2050	-3.5266	-3.1946	-6.6248	0.0000	I(0) stat
Growing Period Rainfall (X_{4t})	At levels	-3.6055	-2.9369	-2.6068	-6.5488	0.0000	I(0) stat
Growing Period Weather Risk (X_{5t})	At levels	-3.6104	-2.9389	-2.6079	-3.9666	0.0039	I(0) stat
Tur Area Irrigated (X_{6t})	At levels	-3.6104	-2.9389	-2.6079	-2.6683	0.0886	I(0) Non-stat
	1st Diff	-4.2191	-3.5330	-3.1983	-7.28366	0.0000	I(1) stat

Phillips-Perron test statistic; *MacKinnon (1996) one-sided p-values ; ** stationary
@ Stationary with intercept and trend; Source: Data Analysis

It is clear from the results in Table 6 that all the variables are stationary at levels I(0) except Pigeonpea area irrigated which is stationary at first difference I(1). Hence, it is decided to run the linear regression for the yield response relation excluding the area irrigated variable. The Ordinary Least Squares (OLS) method was used to estimate the model and the results are presented in Table 7. The estimated model fits the data reasonably well as R-square value (0.72) is high and statistically significant at 1% level. The estimated coefficients of the variables are having expected sign and statistically significant except growing period weather risk which is insignificant. Growing period rainfall significantly influences the yield as Pigeon pea is mainly grown on rainfed areas and irrigational facilities are hardly available. Time trend variable is included to capture the impact of technological developments on the Pigeonpea yield over a period of time. This variable is significant at 1% level and has a positive impact on the yield of the crop. So, the technology impacts positively Tur yield.

Table 7: Regression Results of the fitted Yield Relation

Dependent Variable: Yield (Y_{2t})				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	387.3010***	114.3337	3.387461	0.0018
Rainfall (X_{4t})	1.383193**	0.681839	2.028621	0.0502
Weather risk (X_{5t})	-1.364456	1.658012	-0.822947	0.4161
Time Trend	8.126156***	0.865094	9.393375	0.0000
R-squared	0.724978***			
Adjusted R-squared	0.701404			
S.E. of regression	60.43144	Akaike info criterion		11.13781
Sum squared residual	127818.6	Schwarz criterion		11.30843
Log likelihood	-213.1873	Hannan-Quinn crit		11.19903
F-statistic	30.75414	Durbin-Watson stat		2.276793
Prob (F-statistic)	0.000000			

***, ** indicate significant at 1% and 5% levels respectively
Source: Data Analysis

The estimated model has been tested with the help of number of model adequacy tests and the results are presented in the following discussion. The essential test is to examine whether the residuals of the estimated model are stationary or not and it has been done with the help of Phillips-Perron test and the results are shown in Table 8.

Table 8: PP test of Stationarity for Residuals (Yield Relation)

Null Hypothesis: Residuals has a unit root				
			Adj. t-Stat	**Prob.***
Phillips-Perron test statistic			-7.141852	0.0000
Test critical values:	1% level		-3.615588	
	5% level		-2.941145	
	10% level		-2.609066	
*MacKinnon (1996) one-sided p-values.				
Source: Data Analysis				

The estimated residuals of the yield response relation are stationary as the probability of the P-P test is < 0.05 enabling us to reject the null hypothesis. The correlogram of the residuals presented in Figure 2 displays that none of the autocorrelation or partial autocorrelation are significant statistically as validated by the high probability values. The assumptions of the OLS are tested with relevant tests and the results are shown in Table 9. The normality assumption is tested with the Jarque-Bera Test and the probability > 0.05 hence, accepting H_0 suggesting that the residuals are normally distributed. Secondly, the presence of serial correlation among the

Figure 2: Correlogram of the Residuals (Yield Relation)

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.179	-0.179	1.3471	0.246
		2	-0.019	-0.052	1.3623	0.506
		3	-0.001	-0.014	1.3624	0.714
		4	-0.127	-0.135	2.0966	0.718
		5	-0.056	-0.111	2.2451	0.814
		6	-0.245	-0.308	5.1527	0.524
		7	-0.026	-0.186	5.1858	0.637
		8	0.146	0.040	6.2803	0.616
		9	-0.049	-0.077	6.4101	0.698
		10	-0.019	-0.163	6.4297	0.778
		11	0.037	-0.125	6.5076	0.837
		12	0.086	-0.030	6.9446	0.861
		13	-0.022	-0.078	6.9754	0.903
		14	-0.067	-0.106	7.2659	0.924
		15	0.038	-0.069	7.3616	0.947
		16	0.161	0.109	9.1685	0.906

Source: Data Analysis

Table 9: Model Adequacy Tests for Residuals (Fitted Yield Relation)

Normality Test **Jarque – Bera (J-B)** **H_0 : Residuals are normal**	J-B		Probability	
	0.116759		0.943292	
Serial Correlation LM Test **Breusch-Godfrey** **H_0 : No Serial Correlation among residuals**	Observations*R-Square		Probability Chi-Square (2)	
	1.497364		0.4730	
Heteroskedasticity Test **Breusch-Pagan-Godfrey** **H_0 : Residuals are Homoscedastic**	Observations*R-Square		Probability Chi-Square (3)	
	3.922667		0.2699	
Ramsey RESET Test **H_0 : There is no Specification Error**		Value	Degrees of Freedom	Probability
	t-test	0.347472	34	0,7304
	F-test	0.120737	(1,34)	0.7304
	Likelihood Ratio Test	0.138247	1	0.7100

Source: Data Analysis

residuals is checked with the Breusch – Godfrey LM test (Gujarti & Sangeeta, 2007). Here also we fail to reject H_0 as the relevant probability is very high and conclude that the serial correlation problem does not present in the estimated residuals. Thirdly, residuals are homoscedastic as revealed by the Breusch-Pagan-Godfrey test. Ramsey's Regression Specification Error Test (RESET) (Gujarti & Sangeeta, 2007) presented in Table 9 indicated that there is no specification error in the estimated yield model supported by the high value of the probability. All the assumptions of the OLS are satisfied hence, it may be concluded that the estimated model is technically adequate.

CONCLUSION AND POLICY IMPLICATIONS

The study clearly revealed that the price variable influences positively the farmers' acreage allocation decision to Pigeonpea crop. It is also observed that availability of more irrigational facilities farmers prefer to allocate land to other more remunerative and high yielding crops than Pigeonpea. Though the yield of pulses is showing an increasing trend over a period of time but not comparable favourably with the yield of the competing crops. Technological development has impacted the yield of Pigeonpea positively and significantly during the study period as it is evident by the results of the yield response relation. But the impact is not sufficient enough to enhance the yield of the Pigeonpea on par with the yield of the competing crops. Farmers do respond to weather risks also. It is implied from the results that the more effective and concerted efforts are required by the government and scientists in making the farmers to use the available technology to enhance the yield of the Pigeonpea so that it can compete well with the other crops for better resources like more fertile land and irrigation which will enhance the production of Pigeonpea at the desired level in due course of time. Effective and in large number extension activities are required to make the farmers to enable the farmers to use properly the available technology to enhance yield and in turn production to meet the ever-rising demand for pulses by the increasing population and livestock of the country. Further research may be required in understanding to what extent the new technology developed by the agricultural Scientists have reached farmers.

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