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Measuring the Dis-Equilibrium in Acreage Response of Black Gram (*Vigna mungo* (L.) Hepper) in Tamil Nadu – A Vector Error Correction Model

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Authors' contributions

This work was carried out in collaboration among all authors. Author RS designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors KRK and PAP managed the analyses of the study. Author PAP managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The study has observed an increasing trend in pulses production, driven mainly by yield improvements. The contributions of area expansion and prices to black gram growth have been erratic, suggesting that these cannot be the sustainable sources of black gram growth. Further, farmers' area allocation decisions to pulses are not price-dependent, but depend on non price factors, mainly rainfall. However, the growth in pulses production in the long-run must come from technological changes. Numerous past studies on black gram cultivation in Tamil Nadu is criticized for using the weaker Nerlovian Partial Adjustment models and for analytical interpretation through Ordinary Least Square (OLS) creating spurious results for time series data. This problem can be avoided if Econometric technique of co-integration is used. It is for the present paper measuring the dis-Equilibrium in acreage response of black gram by using a vector error correction model. Our unit root analysis indicates that underlying data series were not stationary and are all integrated of order one, that is I(1). The Johansen co-integration approach indicates the presence of a co-integrating relationship in the acreage response model. Black gram acreage is significantly influenced by relative price of black gram, and other competing crops such as groundnut whenever

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resourceallocation is concerned famers preferred to allocate irrigated land to other competing crops which are more remunerative and high yielding than black gram crop. The black gram supply elasticity's are found to be inelastic both in the short-and long-run. The long-run and short run price elasticity's were 0.41 and 0.28, respectively.

Keywords: Cointegration; vector error correction; acreage response; unit root test.

1. INTRODUCTION

India is the largest producer of black gram (*Vigna mungo* (L.) Hepper), with a share of 70 per cent of global production. But the pulses production has not in pace with their domestic consumption eventually demanding an import of 0.36 lakhs tonnes of black gram per annum [1]. Even though there is a widening gap between the demand and supply of pulses both at the nation and state, which results in soaring price of pulses, there has been stagnant yield and stagnant acreage. The stagnant yield has lead to significant decline in their per-capita availability, from 61g/day in 1951 to 52 g/day in 2019, one-third less than the recommended intake of 60g/day and 55g per day for adult male and female [2]Further, the mismatch between demand and supply has made the black gram market more volatile. Closing the gap between demand and supply of pulses would require production to grow at least by 12.39 per cent per annum. To achieve this rate, the Central and State Governments had launched two focused pulses programmes in 2007-08 such as Accelerated Pulses Production Program (A3P) and National Food Security Mission (NFSM). The objective of NFSM was area expansion and productivity enhancement in pulses. The study particularly was worked on Black Gram alone for better understanding. Despite the efforts, the area, production and yield of black gram has shown marginal improvement over the period. In this context, an effort has been made in this paper to understand the supply aspect of black gram by analyzing acreage response relation with the help of suitable econometric techniques. This finding of the study will be of importance to the various stakeholders of the economy and the marginal improvement claim in Black Gram must be proved prior to analyzing supply-side issues.

2. DATA BASE AND METHODOLOGY

Black gram has accounted for nearly 55 percent of total pulse production in Tamil Nadu. The present analysis aimed at understanding the supply behavior of black gram crop. Data used for this study were compiled from the Agricultural Statistics, Directorate of economics and statistics, Tamil Nadu. 'On farm' harvest prices were collected from Agricultural Prices in India; Minimum support prices were taken from reports of the Commission on Agricultural Costs and Prices; and rainfall data were taken from Dept of economics and statistics, Tamil Nadu. Wherever needed, these data were supplemented with data from other sources. The time series data on area, production, and prices were smoothed by applying Hodrick-Prescott filter with an adjustment factor of 4.0. The Hodrick-Prescott filtered data series were used for analyzing the patterns and sources of growth. The annual time series data on all the required variables were collected for the period 1996-97 to 2017-18. The data analysis is carried out with the help of Eviews-11 statistical software.

2.1 Supply Response

Most of the time series have unit root problem and are often suspected to be non-stationary. To overcome this problem, we tested for stationarity by using Augmented Dickey-Fuller (ADF) test [3] (Dickey and Fuller, 1981). The method of Cointegration and Error Correction Mechanism (ECM), when combined with the partial adjustment and adaptive expectation of farmers, gives the distinct long-run and short-run supply elasticities [4]. This technique can be used with non-stationary time series to avoid spurious regression [5]. The ADF test is denoted by Equation (3):

$$\Delta X_t = \mu_0 + \mu_1 t + (\delta - 1)X_{t-1} + \sum_{i=1}^{k} \varphi_i \Delta X_{t-1} + e_t$$

where, et is the pure white noise error-term and k is the chosen lag length. The null hypothesis H_0 holds that μ_1=0 against alternative hypothesis H_1 that if H_0 is rejected, then the series (X) is stationary. If not, the first difference is taken to make it stationary. Once the stationarity of individual series is established, linear combinations of integrated series are tested for cointegration. If these are found cointegrated, it implies a long-run equilibrium relationship. The analysis is carried out by applying Johansen [6] cointegration test which involves the VECM framework of the following form:

$$\Delta X_t = C + \sum \alpha_j \Delta X_{t-1} + \delta D_t + \gamma T + \lambda \varepsilon_{t-1} + \upsilon_t$$

where, ε_{t-1} = ln $X_{t-1} \sum b_j \Delta X_{jt-1}$ (error/ equilibrium correction-term), and D_t is a vector of stationary exogenous variables; δ is vector of parameters of exogenous variables; and λ is the coefficient of error correction - term ε_{t-1}. A co-integration analysis is the equation of long run relationship among co-integrated series or the variables contained in X_t. The Johansen approach provides two test statistics for the number of cointegrating vectors given by the co-integration rank r: Trace and the Maximum Eigen Value statistics. When the co-integration rank r is equal to 1, the Johansen single equation dynamic modelling and the Engle- Granger approaches are valid. When r equals 1, the normalisation restriction for the parameters produces a unique estimate [7]. (). When there are more than one co-integration equations, the Johansen approach is preferred over Engle-Granger approach [8,9]. Once the cointegration among the variables is confirmed, the ECM is used to analyze the short-run and long-run dynamics. The ECM is dynamic in the sense that it involves lags of the dependent and explanatory variables, and thus captures short-run adjustment to the changes in adjustments into past disequilibria and contemporaneous changes in the explanatory variables and also displays the co integrating relationship between or among variables. The adaptation agricultural supply response is modelled as a two-step procedure. A farmer first decides on the area allocation to a crop based on its expected price and then yield response is estimated as a function of different inputs and climate.

$$A_t = f(RP_t, AR_t, GIR_t, D, T)$$

where, A^t is the area allocated under the black gram crop during year t; RP_i is the relative price, which is the ratio of farm harvest price of the black gram crop to the farm harvest price of its competing crop (maize); AR_i is the actual average rainfall during the crop growing period; Regarding rainfall variable, so far no satisfactory measure of this variable has been found in the literature. Variables used in the studies are rainfall in pre-sowing period, absolute deviation from normal rainfall, frequency of number of stations reported below 20% normal to total in a region. So, the rainfall in pre-sowing period was included in the area response function. GIR_i is the crop gross area irrigated (ha); D is a dummy variable of pre and post NFSM on Pulses.

3. RESULTS AND DISCUSSION

The black gram per ha, or Y, was used as the dependent variable in the study's model. Relative price, pre sowing rainfall, gross irrigated crop and Yield of competing crop were all included in the model as independent variables. This model used data of area, production, productivity and average rainfall were collected from Seasonal and crop report, Directorate of economics and statistics, from 1996 to 2018. The other Price data (including Groundnut Price, MP and BGP) were collected from Agricultural Price in India, 2018. Statistical profiles of the data are reported in Table 1.

The black gram area showed large variations from 1996 to 2018. For example, the mean of black gram area is 281009 ha, while the black gram area is as low as 185736 ha (minimum), and as high as 429784 (maximum). The measure of skewness and kurtosis confirmed that the areas of black gram are normally distributed. Fig. 1 shows that the black gram area during the period sharply increased from 1996 to 2018 (y = 8982x+17770, R^2 = 0.603). During the area of expand, the maximum average rain fall was 1304 mm, and the minimum average rainfall was 598 mm. Fig. 2 shows that the average yield during the acreage response period gradually increased from 1996 to 2018 (y = 15.98x+323.1, R^2 = 0.329).

3.1 Unit Root Test

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, First, we conducted the Augmented Dickey Fuller (ADF), Philip-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests to find whether the variables are of order I(0) or I(1). The results of ADF and PP tests – with intercept; with intercept and trend; and without intercept and trend – show that all the variables (area, relative price, irrigated area and rainfall) 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. Result of all the individual series (in logarithms) used in the estimations is given in Table 1. ADF statistics for log-level series of BA (area under Black gram) was -4.570, RP (Relative price of black gram) was -1.166, RF (Rainfall) was -3.032, GIA (Gross irrigated area) was -0.895 and dummy Variable(DV) was -1.376, which were smaller in absolute term than their respective critical value. It indicates that they were non-stationary. Consequently, we applied the ADF test on the log of the differenced series, to make them stationary. ADF statistics for first difference series of BA (area under Black gram) was -5.569, RP (Relative price of black gram) was -5.676, RF (pre sowing rainfall) was -4.869, GIA (Gross irrigated area) was -6.245 and dummy Variable(DV) was -5.484, which were more negative than their respective critical value. 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. From the results of KPSS test for the given data, it could be interpreted that the LM statistic is lesser than the critical value at all significant levels. Thus, the null hypothesis is accepted; hence the data series is said to be stationary in acreage response of black gram.

Table 1. Descriptions of the study variables

	Area Under Crop (ha)	Pre sowing Rainfall(mm)	Relative Price (units)	Gross Irrigated area (ha)	Dummy Variable
Mean	281009	941	3.42	37311	0.54
Median	264897	937	3.26	27890	1.00
Maximum	429784	1304	5.39	91372	1.00
Minimum	185736	598	2.38	11851	0.00
Std. Dev.	75109	194	0.79	24256	0.50
Skewness	0.728	-0.133	0.73	0.993	-0.18
Kurtosis	2.386	2.165	2.900	2.704	1.033

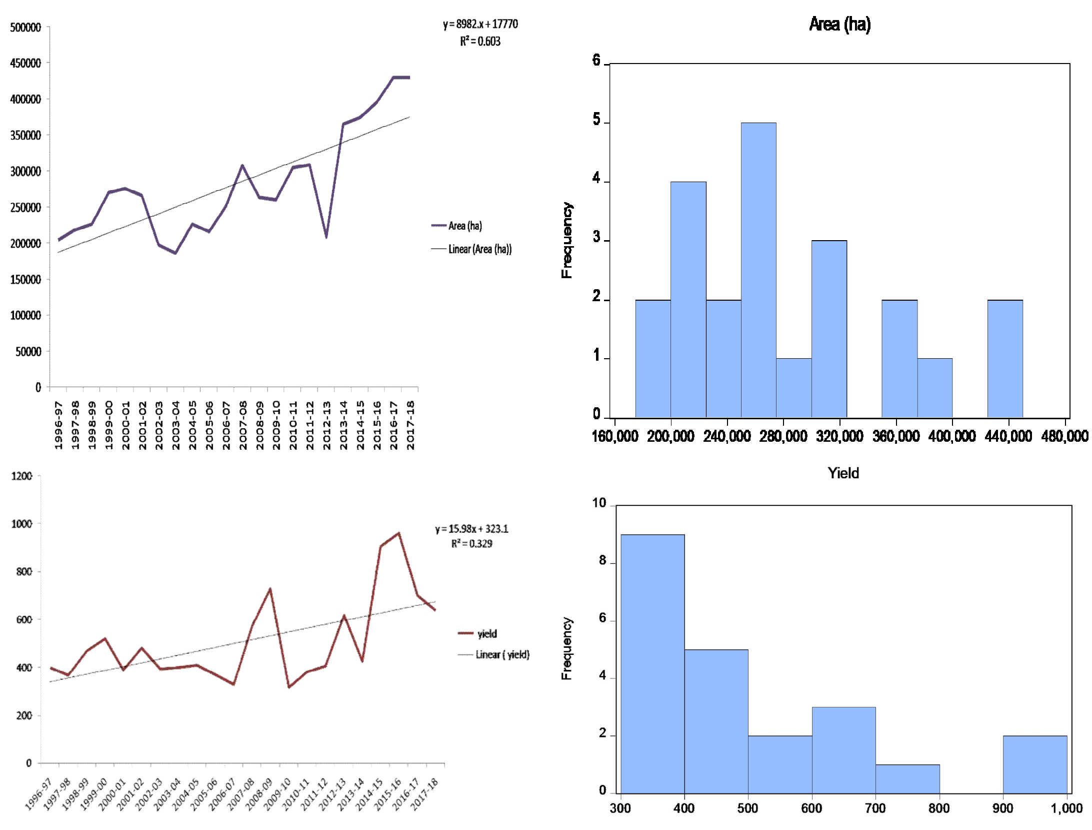

Fig. 1. Black gram area during the period sharply increased from 1996 to 2018

Table 2. Unit-root test (ADF) for black gram area and relative price at level and first difference

	Intercept				Intercept and Trend				None			
	Level		First Difference		Level		First Difference		Level		First Difference	
	t stat[a]	p value	t stat	p value	t stat	p value	t stat	p value	t stat	p value	t stat	p value
Augmented Dickey Fuller												
Area under Crop	-4.570	0.133	-5.569	0.000***	-2.769	0.013**	-4.471	0.002***	0.815	0.424	-5.485	0.000***
Relative Price	-1.166	0.258	-5.676	0.000***	-2.391	0.028**	-5.495	0.000***	2.886	0.009***	-4.279	0.000***
Sowing Period rainfall	-3.032	0.007	-4.869	0.000***	-3.050	0.007***	-4.650	0.000***	-0.653	0.522	-4.956	0.000***
Gross Area Irrigated	-0.895	-0.382	-6.245	0.000***	-2.939	0.009***	-6.246	0.000***	1.373	0.187	-5.936	0.000***
Dummy Variable (Pre and Post NFSM)	-1.376	0.185**	-5.484	0.000***	-2.889	0.010**	-5.466	0.000***	0.512	0.614	-5.445	0.000***
Phillips-Perron test												
Area under Crop	-0.801	0.796	-6.546	0.000***	-2.411	0.363	-11.45	0.000***	2.533	0.995	-5.541	0.000***
Relative Price	0.239	0.968	-4.960	0.000***	-1.546	0.777	-5.183	0.002***	2.735	0.997	-3.925	0.000***
Sowing Period rainfall	-3.205	0.034	-6.066	0.000***	-3.231	0.106	-5.748	0.001***	-1.032	0.261	-6.144	0.000***
Gross Area Irrigated	1.012	0.9953	-4.804	0.001***	-0.244	0.986	-5.541	0.001***	1.956	0.984	-4.351	0.000***
Dummy Variable (Pre and Post NFSM)	-1.000	0.7325	-4.358	0.003***	-2.018	0.556	0.000	0.0177***	-4.242	0.670	-4.242	0.000***
Kwiatkowski-Phillips-Schmidt-Shin test												
Area under Crop	0.595	0.463	0.500	0.347	0.142	0.119	0.500	0.216	-	-	-	-
Relative Price	0.577	0.463	0.173	0.739	0.145	0.145	0.088	0.345	-	-	-	-
Sowing Period rainfall	0.150	0.890	0.204	0.463	0.089	0.119	0.146	0.739	-	-	-	-
Gross Area Irrigated	0.424	0.145	0.318	0.008	0.156	0.150	0.132	0.463	-	-	-	-
Dummy Variable (Pre and Post NFSM)	0.534	0.739	0.093	0.347	0.095	0.119	0.092	0.463	-	-	-	-

Implies LM Stat for KPSS

3.2 Johansen Co Integration Test for Area Relation

The ADF 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 must 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 3. 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 rainfall showed the rejection of null hypothesis of no cointegrating vector between the variables. Both the trace and maximum Eigen value tests reject H0 = at most three cointegrating vector, at 5% significance level suggesting that there exists cointegrating relationship among the variables in the acreage response relation. The area relation has three cointegrating vector thus suggesting unique long-run relationship in case of acreage function.

3.3 Lag Length Selection

To avoid any serial correlation bias, it is important to choose an appropriate lag length. For this, we used the Akaike Information Criterion (AIC), as suggested by [10], to select the optimum lag length of the vector autoregressive (VAR) model. The AIC criterion offers dynamic results with exceptional properties compared to the Schwartz Bayesian Criteria. Since the aim is to select the optimum lag order for the VAR, we selected a high enough order, up to 1. Two VAR (p), p=0,1, models were estimated for the period from 1996-97 to 2017-18. Accordingly, we choose VAR (1) model as appropriate for our sample size (Table 4). For the annual data, the maximum order length should be 1 [11,12].

3.4 Supply Response of Black Gram in Tamil Nadu Area Response

Before applying VECM, it is ensured that area series are co-integrated. Table 5 shows the results of co integration rank test with the trace statistics and maximum eigen value. The combination shows the area function that included black gram area, relative price, gross area irrigated, Rainfall and Dummy variable. Both the test statistics rejected the hypothesis of more than one co integrating vector at 5 per cent level of significance, indicating that there exists a three co integrating vector between the concerned variables in the area equation. The optimal lag length is one lags for area equation. When only one co integrating vector exists, its parameters can be interpreted as estimates of long-run co integrating relationship between the concerned variables [13]. Thus, the area model has one co integrating vector. The normalized co integrating equation for area of black gram in Tamil Nadu is: $A = 8.2936 + 0.4111\ RP_c + 4.429\ GIA + 0.1876T$.

The coefficient of trend variable as a proxy of various chronological savings and technological improvement was not able to provide incentives to the farmers. The black gram crop in Tamil Nadu is grown under the rainfed conditions which may be the reason regarding the price-insensitive behavior of farmers in the state. The short run Vector Error Estimates of acreage response function of black gram to its relative price, Gross area irrigated, and rainfall presented in Table 5. The results reveal that the model fits better as the R-square is 81% and the F – statistics is 7.45. The coefficient of Error Correction Term (ECT) is having expected negative sign but not significant. ECT indicates that the 13% of the deviation from the long run equilibrium is corrected in the current period. In the short-run relationship, the significance of negative error correction coefficient (-0.133) as expected suggests that about 13 per cent of deviation from long-run equilibrium is made up or adjusted within one time period. It also implies that the speed with which price of black gram adjusts from short-run disequilibrium to changes in black gram supply in order to attain long-run equilibrium is 28 per cent within one year. The value of coefficient for relative price of black gram with respect to the price of groundnut in terms of area allocation of Tamil Nadu in the long-run is positive but statistically significant at 5% level. This means price significantly influences the farmers' acreage behavior. Higher price of black gram will motivate farmer to allocate more land to black gram crop in the long run. This means acreage response of farmers for black gram crop is price responsive which rules out the notion that pulse supply response is price insensitive. Similarly, the technological advancement indicated by the trend variable is positive but non-significant. This indicates that in the long-run farmers are price-insensitive.

The coefficient of gross area irrigated under black gram is positive and statistically significant at 5% 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 black gram crop in the long run. More irrigational facilities take away land from black gram 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 whereas the coefficient of rainfall is positive and significant at 1 per cent level. This implies that the farmers value rainfall more than the price in their area allocation decisions. The significant coefficient on year dummy indicates that after 2007 the area allocation has improved, which may be the positive effect of government interventions. The result is also consistent with the fact that in the recent period area effect has contributed most to the growth of black gram in the state.

Table 3. Johansen co integration test for area relation

Unrestricted co integration rank test (Trace)					**Unrestricted co integration rank test (Maximum eigen value)**		
Hypothesized no. of CE(s)	**Eigen value**	**Trace statistic**	**Critical Value 0.05**	**Prob.****	**Max-eigen statistics**	**Critical Value 0.05**	**Prob.****
None *	0.981887	196.8786	95.75366	0.0000	76.21170	40.07757	0.0000
At most 1 *	0.950110	120.6669	69.81889	0.0000	56.96074	33.87687	0.0000
At most 2 *	0.897493	63.70615	47.85613	0.0008	43.27862	27.58434	0.0002
At most 3	0.496424	20.42752	29.79707	0.3943	13.03439	21.13162	0.4491
At most 4	0.319754	7.393134	15.49471	0.5324	7.320703	14.26460	0.4519
At most 5	0.003805	0.072431	3.841465	0.7878	0.072431	3.841465	0.7878

*Notes: * denotes rejection of the hypothesis at the 0.05 level and indicates the presence of 3 cointegrating vector between the study variables;**MacKinnon-Haug-Michelis (1999) p-values*

Table 4. Selection criteria for lag length

Lag	LogL	LR	FPE	AIC	SC	HQ
0	0.519542	NA	6.97e-08	0.548046	0.846765	0.606359
1	79.89831	103.1924*	1.10e-09*	-3.789831*	-1.698794*	-3.381639*

*Note: * Indicates the optimal order, that is, the lowest value in the respective criterion*

Table 5. Area response of black gram (VECM approach)

Long run		**Short run**	**D (In Area)**	
		Error correction	**Coefficient**	**P value**
In Area (-1)	1	Co integration Eq (1)	-0.133***	0.000
In RP (-1)	0.411**	D(In (Area(-1))	0.734	0.151
In GIA (-1)	4.429	D(In (Area(-2))	0.504	0.266
Trend	0.187	D(In (RP(-1))	-0.284	0.0728
Constant	8.293	D(In (RP(-2))	-0.218	0.709
		D(In (GIA(-1))	-0.077**	0.0524
		D(In (GIA(-2))	0.012	0.417
		Constant	-0.281	0.001
		In RF	0.0656***	0.002
		Dummy 2007	0.0902**	0.017

3.5 Model Adequacy Tests for Residuals (Fitted Acreage Relation)

The final stage of the VECM model is to check the stability of the model. The results of the diagnostic tests of serial correlation, heteroscedasticity (Breusch-Pagan-Godfrey), Jarque-Bera test and Ramsey RESET test are reported in Table 6. The Jarque-Bera test 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 signaling that the estimated acreage response relation is good and fits the data reasonably.

Table 6. Diagnostic test

R- Squared	0.81
Adjusted R Square	0.70
F Statistic	7.45
Akaike AIC	-2.55
Schwarz SC	-2.15

*Notes: D = difference, *** and **indicate the significance of coefficient at 1 per cent and 5 per cent levels, respectively*

The stability of the estimated coefficients of the model are employ with CUSUM and CUSUM of squares (CUSUMSQ). The CUSUM and CUSUMSQ statistics lie within critical bounds, implying that the estimated coefficients are dynamically stable. The Figs. 2 and 3 clearly shows that the blue trend line is within the 5% bound indicating that the estimated coefficients are dynamically stable.

This study is related to other investigations that establish that the production of beans in tropical savanna climates depends not only on economic factors, but is also influenced by climatic conditions, especially by rain and irrigation [14-18]. In this sense, the variability of rainfall and climate change present new and more demanding challenges to agricultural productivity [19,20]. Research that allows the repowering of agricultural productivity, including biotechnology, will be essential to overcome the stress caused by climate change and the variability of rainfall itself [21,22]. Crops that are reasonably successful in a relatively wide range of production conditions are needed [23-25] rather than those that can be very successful, but in a set limited weather condition.

Even without climate change, greater investment in agricultural science and technology is necessary in the country to meet the demand of a population of millions of people by 2050, for example. Many of these people will live in the developing world, will have higher incomes, and will desire a more varied diet. Solutions based on agricultural science and technology are essential to meet these demands, our study represents an important contribution to knowledge and to this type of approach to the best solutions.

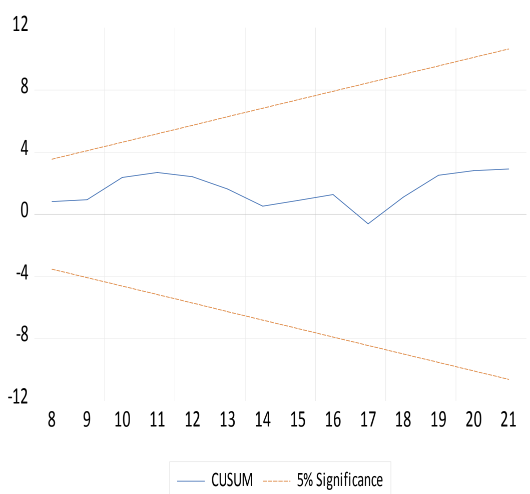

Fig. 2. CUSUM stability test

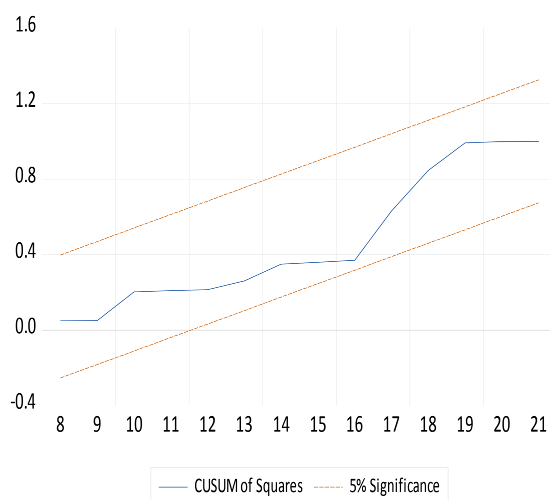

Fig. 3. CUSUM of squares stability test

Table 7. Model adequacy tests for residuals (fitted acreage relation)

S.No	Diagnostic Test Statistics	LM test	F-Verison
1	Serial correlation n	Chi-square(2) = 0.384	F stat (0.600) Prob. F(2,12) = 0.564
2	Heteroscedasticity (Breusch-Pagan-Godfrey)	Chi-square(6)= 0.677	F stat (0.967) Prob. F (6,14)= 0.481
3	Normality (Jarque-Bera)	4.047 Prob. (0.132)	Not Applicable
4	Model fit (Ramsey RESET Test)		F stat (0.184) Prob.F (1,13) = 0.674

One of the key lessons of the Green Revolution is that improving agricultural productivity, even if it is not directed at the poorest sectors, can be a powerful mechanism to indirectly alleviate poverty. Poverty through job creation and food price reduction. Productivity increases that improve farmers' resilience to the pressures of climate variability will likely have similar effects on poverty reduction [26,27,28]. Rural infrastructure is essential for farmers to take advantage of improvements in crop varieties and management techniques. Higher yields and cropping areas require the rural road network to be maintained and expanded to increase access to markets and reduce transaction costs. According to [29,30], it is also necessary to invest in irrigation infrastructure, especially to increase efficiency in the use of water, although taking care to avoid investments in places where availability is likely to decrease. of the water.

4. SUMMARY AND CONCLUSIONS

The coping strategies against the anomalous weather conditions should be strengthened by conducting farmer-focused workshops, trainings along with strengthening the extension and institutional support and services.

Present paper estimates the long-run relationship between black gram area, price incentives and non-price factors in Tam Nadu state by Using Johansen's Cointegration approach. Generally, the results conform to a priori expectations. Farmers' response to producer prices is statistically significant and positive. Two basic results turned out from the analysis - firstly, the estimated supply elasticities came out to be less than one, but they appeared to be high enough to imply that further agricultural reforms are required. Secondly, weather appeared to be important non-price variables explaining black gram area, which shows crop production in state, are still largely influenced by weather variability. The area response model has shown that farmers growing black gram in Tamil Nadu detect non-price factors better than price factors. Our result indicates that *groundnut* crops compete with black gram crop. The area allocation decision is primarily affected by the rainfall. Technological advancement and different institutional support in long-run in the form of various interventions through different national programs have not been able to put on a reasonable breakthrough in black gram production in the state. Black gram production in Tamil Nadu depends not solely on price or cost factors but is influenced by the climatic conditions (rainfall) and irrigation. Unless there is assured irrigation, the farmers would depend on weather conditions which are highly erratic and uncertain.

Supply elasticity in consideration to price is significantly positive, in case of black gram, for which price policies will be effective in obtaining the desired level of output. Producers react to the prices at the time of harvest it is for which any policy intervention about price must be made at that time. As the impact of price on production is higher in the long run compare to that of the short run, the government should focus on the factors that affect the long run price instability. Government should focus on the policies that ensure the profitable price to the producers in the long run. It also important to noted that, price alone has limited influence on farmers' resource allocation decisions, external factors, such as government agricultural and trade policies as well as weather conditions is critical for output supply.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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