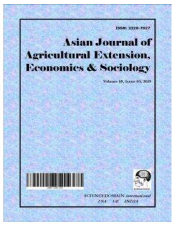

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Acreage Response of Principal Agricultural Crops in Andhra Pradesh, India

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study examines the scope of this mechanism by estimating the supply response for major principal crops in the Andhra Pradesh state from 1970 to 2005 using Nerlovian adjustment adaptive expectation model. The acreage response functions are estimated and supply response elasticities were derived. The results reveal that the coefficients of time trend, acreage and yield response performed to be substantial, whereas, the supply elasticity with respect to sowing season rainfall found to be highly significant and relative price is inelastic for rice crop. As we expected, the elasticity of acreage response and relative price were found crucial factors for the commercial crops like groundnut, tobacco, chillies, cotton and sugarcane validate that the farmers respond to price incentives similarly to non-price factors.

Keywords: Supply elasticity; acreage; yield response; Nerlovian model; Andhra Pradesh.

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1. INTRODUCTION

The Indian economy has faced dramatic changes over the past decades, strongly influenced productivity leaps in agriculture enabled by the green revolution. India is a world player in agricultural world markets yet its high population growth and dietary changes will continue to put increasing pressure on domestic food supplies [1]. For India's rural population of 833 million, agriculture is the main livelihood as well as nutritional security and the average size of land holding was less than 1.15 hectares, which is stable declining over periods [2]. Furthermore, a declining agricultural land availability creates food self-sufficiency, a central goal for the Indian government, a key challenge. Moreover, a huge cross state differences in food security persist. Consequently, the government pursues several policies to expand output. In this context an understanding of Indian farmer´s cropping pattern shifts assume importance in the contextual of planning for crop diversification or concentration. A considerate of the underlying factors is relevant not only for international and national, but not least sub-national policy.

When farmers' land is suitable for cultivation of different crops, and when they have the necessary inputs, farmers face decision making problems regarding the allocation of land across various crops. The allocation decisions for the cultivation of various crops depend on relative prices and non-price factors such as yield, rainfall during the sowing season, proportion of irrigated area and risk factors: price and yield risk. There are two dominant models for analysing crop supply response, the Nerlovian model and rational expectations models. The former was first introduced by [3], who found it counterintuitive that earlier studies described very low farmer response to price factors. By adding price expectations and an adjustment factor his seminal paper enhanced the understanding of both price and non-price factor´s influence on acreage response. The model has been extensively applied and enhanced to assess both developed and developing country agricultural sectors (e.g. [4,5,6]). The rational expectations models or supply function models (see e.g. [7,8]) requires detailed input prices and builds on a high degree of competition in input markets such as land and labor markets. Since the focus of this paper is the output supply function, this study uses a Nerlovian approach. The hypothesis to test in this study are as follows: whether a non-price factor of inadequate rainfall has a negative effect on distinctive crop selection and production; and what extent the relative prices influence the farmers' decision making choice to allocate a specific crop and adjust of crop area among various other crops.

Several studies are available for India at the crop level, but a few scholars have attempted to document the detailed performance of acreage supply response of Andhra Pradesh, [9,10]. Nevertheless, none of those are not exemplified by crop wise, for this motive, this paper focuses acreage response of crop wise in Andhra Pradesh, which produces most of India's important crops but suffers relatively low food security. Besides, the crop wise analysis has an added benefit particularly, an increasing the output of specific crops is concerned. The geographical area of Andhra Pradesh covers 0.276 million sq. kms, with a population of 84.6 million total as per agricultural census 2011. The paper uses secondary data to describe the acreage response of farmers, using the Nerlovian adjustment cum adaptive expectation model. By focusing on the period 1970/71-2004/05 this analysis captures the entire pre and post reform periods of green revolution and its subsequent to assess the crop changing pattern during this important transformation. The major objective of this paper is to estimate acreage response for major principal crop includes rice, coarse cereals (maize, sorghum, pearl millet, finger millet, pigeon pea) and commercial crops (groundnut, cotton, tobacco, sugarcane and chillies) in Andhra Pradesh.

This paper is organized as follows. In the first section provide a brief overview of previous studies that have focused on the supply response analysis. Section II, present the methodological framework employed, followed by a description of the data and the empirical model. A discussion of the results of the acreage response of principal agricultural crops includes cereals and non-cereals. Finally, the summary with concluding observations.

2. DATA AND METHODOLOGICAL FRAMEWORK

In this section we describe the data used for this study and explain the implementation of the model dealing with acreage of farmers' response in Andhra Pradesh.

2.1 Data Sources

For this model, the required time series data for major principal crops on acreage, yield, farm harvest prices and rainfall were obtained from secondary sources of various issues like the Season and Crop Reports of Andhra Pradesh, Statistical Abstracts of Andhra Pradesh, Farm Harvest Prices of Principal Crops in Andhra Pradesh for the period of green revolution from 1969-70 and subsequently until 2004-05. Rainfall data was collected from the Statistical Abstract Andhra Pradesh, Published by the Directorate of Economics and Statistics, Government of Andhra Pradesh, Hyderabad.

2.2 Theoretical Model

The partial equilibrium framework of the Nerlovian model builds on farmer's partial adjustment to adaptive price expectations. The adjustment is only partial in the short term, because factors beyond the farmer's control impede the full realization of adjustment of land allocation to these expectations. Hence, firstly farmers make their crop and acreage decision as based on historical prices. The expected price for the present harvest equals the anticipated price of the last harvest, adding the difference between the expected and actual price at last harvest multiplied by an adjustment factor (the farmer's learning process).

In the present study the following acreage response model based on the Nerlovian framework is used.

$$A^*{}_t = B_0 + B_1 RP_{t-1} + B_2 Y_{t-1} + B_3 R_t + B_4 {}^{\sigma}P_t + B_5 {}^{\sigma}Y_t + B_6 T_t + U_T \quad (1)$$

$$A_t - A_{t-1} = B(A^* - A_{t-1}) \quad (2)$$

Where $A^*{}_t$ = acreage that farmers would allocate to the crop if there were no difficulties of adjustment, A_t = acreage under the crop in time t, RP_{t-1} = price of the crop relative to substitutable crop[1] in time t-1, In addition, the farm harvest prices[2] of the crop concerned and its competing crops are used to computing the relative price, which obtained by deflating the prices of the competing crop, Y_{t-1} = yield of the crop in the year t-1, R_t = total rainfall[3] in the sowing season of the crop in the current year t, ${}^{\sigma}P_t$ = standard deviation of the relative prices of the crop during the preceding three years (i.e. relative prices during the years t-3, t-2, t-1), ${}^{\sigma}Y_t$ =standard deviation of the yields of the crop during the preceding three years, T_t =time trend t, U_T = error term of t or disturbance term of t, B = Nerlovian coefficient of adjustment.

Because of temporal fixities in farmer assets among other, it is assumed that farmers can increase the acreage of the crop in any year only to the extent of a fraction B of the difference between the acreage that they would like to plant and the acreage actually planted in the preceding year. This is the partial adjustment component of the model. If the farmers are very slowly adjusting their acreage to the changes in the factors affecting acreage, then B takes a value close to zero. If the farmers are quickly adjusting their acreage to the changes in the factors affecting acreage, then B takes a value near one.

Since data for variable $A^*{}_t$ are not available, it is not possible to estimate model 1 directly. Instead a model through which the parameters of equation 1 can be estimated is needed. Such a model can be arrived from equation 1 and 2. It is called the reduced form equation:

$$A_t = b_0 + b_1 RP_{t-1} + b_2 Y_{t-1} + b_3 R_t + b_4 {}^{\sigma}P_t + b_5 {}^{\sigma}Y_t + b_6 T_t + b_7 A_{t-1} + V_T \quad (3)$$

Where

$$b_0 = B_0 B, b_1 = BB_1, b_2 = BB_2, b_3 = BB_3, b_4 = BB_4, b_5 = BB_5, b_6 = BB_6, b_7 = 1 - B, V_T = VU_t$$

By estimating the parameters of equation 3 the Nerlovian coefficient of adjustment, the parameters of the equation 1 and the short-run[4] and long-run[5], elasticities of the acreage response functions are derived.

2.3 Empirical Model

In order to estimate the parameters of the reduced form equation 3 ordinary least squares is used. The short-run elasticities of the various factors included in acreage response functions are estimated at the mean values. The long-run elasticities are obtained by dividing the short-run elasticities with Nerlovian coefficient of adjustment. The dependent variable is acreage of land dedicated for the crop (*Acreage*). In the model crop price compared to the price of its main substitute crop (*Relative price*) is the main explanatory variable of interest. Here farm gate prices of the crop concerned and its main competing crop is used to compute the relative price, by deflating the price of the competing crop. The method of finding the crop which competes most with each of the crop under consideration, for land is explained in Table 1, which also provides information relating to competing crops for principle agriculture crops in the State.[6] The farmer's expectation of the current year's yield is based on that of last year (*Yield).*

Table 1. Andhra Pradesh competing crops for the principal agricultural crops

Crop	Competing crop
Rice	Maize
Sorghum	Cotton
Pearl Millet	Cotton
Maize	Finger Millet
Finger Millet	Pigeon pea
Pigeon pea	Sorghum
Groundnut	Pearl Millet
Tobacco	Pigeon pea
Chillies	Finger Millet
Cotton	Sorghum
Sugarcane	Sorghum

Note: Authors calculation based on the crop data collected in various statistical abstracts.

A large part of Indian agriculture is rain fed agriculture. Irrigation facilities together with the soils and climate determine the type of crops that can be grown. Therefore, a variable is included to represent rainfall. Rainfall plays a key role in deciding acreage under various crops. In the earlier studies for rainfall different specifications such as pre-sowing season rainfall, sowing season rainfall, crop season rainfall, and deviation of the rainfall from normal in the crop season are used. However, we follow praxis of most studies and use total rainfall in the sowing season (Rainfall). The farmer can derive his risk apprehension from the predictability of crop prices and yield during the past several years. Here the standard deviations for the past three years are used for variables *Price Risk* and *Yield Risk*, respectively. In order to capture the great technological leap that took place for some of the crops during the period studied, time is used as a proxy for technological progress (*Time Trend*).

3. RESULTS AND DISCUSSION

The estimated parameters of the acreage response of principal crops, short-run and long-run elasticities of the explanatory variables used in the model were summarized in Table 2 and Table 3. Multicollinearity is tested for by comparing the value of R with zero-order correlation coefficients[7]. Due to the model's use of a dependent variable with a lag as explanatory variables, serial correlation may be present. This is tested for with the Durbin Watson d and h-statistic tests [11][8].

3.1 Cereal Crop (Rice)

The cereal crop rice is a leading crop of state of Andhra Pradesh, which accounts 9.9 per cent of the country's rice production and stands third position amid the rice producing states in India in 2013-14. The zero-order correlation matrices of the variables used in the model are presented in the Appendix Table 1. In the estimated model, there is a serious problem of multicollinearity, although it is free from the problem of negative serial correlation. The value of $\overline{R}^2$ is statistically significant and the explanatory variables chosen in the model together explains 71 percent of the variation in the acreage. The coefficients of lagged acreage, sowing season rainfall and time trend are positive and statistically significant and the estimated parameters of yield risk is negative and statistically significant. It indicates farmers are preferring more open to changes in non-price factors than the price variable in distributing their acreage under rice [12]. On the other side, the coefficient of acreage adjustment is 0.61 indicating adequate adjustment. The short-run and long-run yield elasticities are -0.4196 and -0.6877 indicating no moderate response in the sense that it is weak in short-run as well as long-run. The elasticities of yield risk are -0.0791 and -0.1296.

3.2 Coarse Cereals (Sorghum, Pearl Millet, Maize, Finger Millet and Red Gram)

The observed results on the extent of awareness of price and non-price factors in acreage allocation under selected coarse cereal crops: sorghum, pearl millet, maize, finger millet and red gram are summarized in Appendix Table 2 to 6. Though, the outcomes of the acreage response, short-run and long-run elasticities of the explanatory variables used in the model are presented respectively in the same Table 2 and Table 3. The value of $\overline{R}^2$ is high and statistically significant and ranged between 0.78 to 0.97. Evidently, the coefficients of lagged acreage, sowing season rainfall, time trend, lagged relative price, and price risk vary statistically significant crossways the individual coarse cereals crop in a distinctive situation. The estimated lagged area allocation for all cereal crops include sorghum, maize and finger millet are positive and statistically significant. As we expected the highest coefficient of lagged acreage was estimated for maize (1.18) and the lowest for pearl millet (0.12). From 2000-01 onwards, the area expansion under maize crop noticed increasing growth in Andhra Pradesh, due to the adoption of single cross hybrids (Kumar et al. 2013). The elasticities of price risk for pearl millet crop in short-run is 0.0983 and long-run is 0.117 indicates acreage adjustment is influenced more by the non-price than the price factors. The comparison of long run and short run price elasticities among the cereal crops includes maize crop (0.2581) has better response in short run. But, for the crop red gram, the responsiveness of price elasticities is weak both in short-run and long-run. The Nerlovian coefficient of adjustment provides info about the rate of adjustment acreage among the coarse cereal crops, the highest coefficient of adjustment was pearl millet (0.88), followed by red gram (0.87) and the rest of the crops indicate the magnitude of adjustment below 0.35. The higher rate of adjustment specifies that the farmers are prefer to replace rapidly to the area under other crops. Nevertheless, the slow adjustment rate of maize crop hints that farmers are adjusting the area under of maize crop at a low rate with varying levels of technological factors [13].

3.3 Commercial or Cash crops (Groundnut, Tobacco, Chillies, Cotton and Sugarcane)

The estimated results of the acreage response model for commercial or cash crops i.e., groundnut, tobacco, chillies, cotton and sugarcane were presented in the Table 2 and 3. The zero-order correlation matrices of the variables used in the model estimated for analysing the acreage response behaviour is free from the serious multicollinearity problem are summarized in the Appendix Table 7 to 11. The most imperative variable influencing acreage of these commercial crops was lagged acreage and lagged relative price. These coefficients were statistically significant in all crops except tobacco crop in lagged acreage, cotton and sugarcane in lagged relative price. However, the sowing season rainfall has shown significant impact on area under groundnut crop, while, the insignificant factors of lagged yield and price risk reflects domestic price fluctuation due to negative impact on oilseeds production [14,15]. The explanatory factors described the highest variance in groundnut crop (0.91) and the adequate variance in tobacco crop (0.41). The effect of lagged yield was also found insignificant in tobacco, chillies and cotton crops. The price elasticities exhibited its influence on area allocation under groundnut, tobacco and chillies in the state of Andhra Pradesh. The coefficient of yield risk and time trend is insignificant in all the commercial crops includes groundnut, tobacco, chillies, cotton and sugarcane. The coefficient of adjustment is higher in tobacco (0.79) followed by chillies (0.71) crop, which means the acreage response behaviour of the farmers in the case of tobacco is totally different from other cash crops, and prefer to substitute of the alternatives at a high rate. On the other side, the magnitude of adjustment is relatively low for cotton (0.31), groundnut (0.16), and sugarcane (0.14) shows the rate of changing their area under these crops were select for concentration rather than larger changes in the acreage.

The overall results confirmed that the lagged acreage, lagged yield, time trend and sowing season rainfall performed to be most significant determinants of area under dominant cereal crop rice, while lagged acreage, time trend and sowing season rainfall were found crucial in the case of coarse cereal crops. For the commercial crops, the relative price and lagged acreage were obtained vital factors for groundnut, tobacco, chillies, cotton and sugarcane. Based on these findings, the acreage response model intends that non-price factors still influence the area of rice, sorghum, maize, finger millet, pearl millet, groundnut, cotton and sugarcane crop more than price related factors in the state of Andhra Pradesh. Possibly, farmers comprehended that cotton crop is prone to pests and diseases and prices being subjected to high fluctuations [16]. However, farmers may have the

Table 2. Area response equations of crops in Andhra Pradesh (Period 1970-71 to 2004-05)

CropΩ	Regression coefficient										Durbin-watson serial correlation test	
	Constant term	Yield in (t-1)	Relative[1] price in (t-1)	Rainfall In year t	Std. deviation[2] of relative price	Std. deviation[2] of yield	Acreage In (t-1)	Time Trend t	R^2	$\overline{R}^2$	d -statistic	h-statistic
Rice	2379200 (2.93)*	-720.54 (-2.01)***	-493700.00 (-1.14)	1591.60 (6.49)*	34516.00 (0.03)	-2141.10 (-2.72)*	0.39 (2.93)*	42458.00 (2.39)**	0.77	0.71	1.89	-0.26
Sorghum	1325700 (2.38)**	-61.44 (-0.23)	53758.00 (0.20)	-327.77 (-2.13)**	-562620.00 (-0.85)	-550.09 (-0.90)	0.65 (4.90)*	-25627.00 (-2.23)**	0.98	0.97	2.00	-0.92
Pearl millet	385170 (3.01)*	-37.68 (-0.78)	36501.00 (0.40)	94.40 (3.34)*	833660.00 (2.33)**	138.22 (1.11)	0.12 (0.71)	-11853.00 (-2.80)*	0.98	0.97	1.60	1.12
Maize	-100300 (-0.72)	15.78 (0.75)	92158.00 (0.95)	-37.90 (-0.74)	-365240.00 (-1.77)***	5.04 (0.08)	1.18 (6.01)*	-637.49 (-0.35)	0.83	0.78	1.81	-4.60
Finger millet	22065 (0.40)	-1.73 (-0.06)	44942.00 (1.34)	57.89 (3.56)*	122520.00 (1.22)	-66.90 (-0.87)	0.67 (5.23)*	-1875.50 (-1.55)	0.97	0.97	1.86	1.19
Pigeon pea	127490 (2.32)**	-102.22 (-1.17)	-24921.00 (-2.55)**	58.27 (1.73)	10848.00 (0.48)	-113.79 (-0.53)	0.13 (0.68)	9569.60 (4.96)*	0.92	0.90	1.66	0.66
Groundnut	-554740 (-2.88)*	-25.34 (-0.15)	187320.00 (3.96)*	468.17 (3.14)*	-74100.00 (-1.43)	532.54 (1.38)	0.84 (12.43)*	-7748.00 (-2.49)*	0.93	0.91	2.15	-2.26
Tobacco	69546 (0.80)	30.84 (0.54)	21899.00 (2.96)*	17.74 (0.43)	-52095.00 (-1.74)***	-36.75 (-0.42)	0.21 (1.20)	-1853.80 (-1.54)	0.59	0.47	2.02	-1.00
Chillies	25078 (0.63)	29.51 (1.60)	5253.80 (2.59)**	-0.47 (-0.02)	25732.00 (2.29)**	192.25 (0.98)	0.29 (1.97)***	635.03 (0.55)	0.72	0.65	1.95	-0.50
Cotton	-127880 (-0.63)	111.62 (0.31)	20455.00 (0.75)	140.27 (1.06)	-7332.50 (-0.38)	-120.81 (-0.83)	0.69 (3.35)*	7808.10 (1.07)	0.87	0.84	2.15	-1.71
Sugarcane	-125960 (-1.07)	14.00 (1.70)***	33256.00 (1.53)	-18.07 (-0.43)	74967.00 (2.13)**	-10.69 (-0.72)	0.86 (4.17)*	667.81 (0.65)	0.69	0.61	1.98	0.76

Notes: (1) Relative price is the ratios of the price of the crop relative to the price of the main competing crop. The following were considered as substitute crops for the crops whose area response equations are given in the table. Rice-Maize, Sorghum-Cotton, Pearl millet- Cotton, Maize-Finger millet, Finger millet-Pigeon pea, Pigeon pea-Sorghum, Groundnut-Pearl millet, Tobacco-Pigeon pea, Chillies- Finger millet, Cotton-Sorghum and Sugarcane-Sorghum.

(2) Standard deviations of price and yield are with reference to price and yield data of the three preceding production periods.

Figures in parenthesis are t-values.

** represents significance at 1 Percent level, ** significance at 5 Percent level and *** significance at 10 Percent level.*

Ω: Cereal (rice), coarse cereals (maize, sorghum, pearl millet, finger millet, pigeon pea), commercial/cash crops (groundnut, tobacco, cotton, sugarcane, and chillies)

Table 3. Estimated value of coefficient of adjustment and the price and non-price elasticities of acreage response function of major crops in Andhra Pradesh

CropΩ	Coefficient of adjustment	Price elasticity		Non-price elasticities							
				Yield		Rainfall		Price risk		Yield risk	
		Short run	Long run	Short run	Long run	Short run	Long run	Short run	Long run	Short run	Long run
Rice	0.61	-0.1477	-0.2422	-0.4195***	-0.6877	0.4022*	0.6594	0.0007	0.0011	-0.0791*	-0.1296
Sorghum	0.35	0.0372	0.1063	-0.0286	-0.0816	-0.1916**	-0.5475	-0.0174	-0.0496	-0.0268	-0.0765
Pearl millet	0.88	0.0255	0.0290	-0.0791	-0.0899	0.2634*	0.2993	0.0983**	0.1117	0.0405	0.0460
Maize	-0.18	0.2581	-1.4339	0.0893	-0.4961	-0.0985	0.5472	-0.0711***	0.3949	0.0039	-0.0214
Finger millet	0.33	0.0937	0.2838	-0.0096	-0.0290	0.2787*	0.8446	0.0375	0.1135	-0.0281	-0.0851
Red gram	0.87	-0.1961**	-0.2254	-0.1022	-0.1175	0.1779	0.2045	0.0151	0.0174	-0.0201	-0.0231
Groundnut	0.16	0.3181*	1.9882	-0.0135	-0.0844	0.2470*	1.5438	-0.0306	-0.1914	0.0304	0.1902
Tobacco	0.79	0.4168*	0.5275	0.1900	0.2405	0.0947	0.1199	-0.0978***	-0.1238	-0.0336	-0.0425
Chillies	0.71	0.1779**	0.2505	0.2348	0.3308	-0.0022	-0.0031	0.0876**	0.1234	0.0425	0.0599
Cotton	0.31	0.1223	0.3945	0.0381	0.1229	0.1988	0.6413	-0.0165	-0.0531	-0.0416	-0.1341
Sugarcane	0.14	0.2807	2.0048	0.4716***	3.3687	-0.0833	-0.5952	0.1038**	0.7416	-0.0442	-0.3154

** Significance at 1 Percent level, ** Significance at 5 Percent level.*

Ω: Cereal (rice), coarse cereals (maize, sorghum, pearl millet, finger millet, pigeon pea), commercial/cash crops (groundnut, tobacco, cotton, sugarcane, and chillies) same experience for other commercial crops, therefore, the acreage response of tobacco, chillies and sugarcane are influenced more by price factors and acreage decisions.

4. SUMMARY AND CONCLUSIONS

In general, our results suggest that the area allocation for rice crop and other coarse cereal like maize, sorghum, pearl millet and finger millet influenced by lagged acreage followed by the sowing season rainfall in most of the analysed cases. However, the price factors have relatively low influence in the short run on farmer's acreage decisions for coarse cereal crops. This is in line with the available literature about price elasticities in agricultural foodgrains in developing countries (e.g. [14,1]). In this respect it is interesting to note that the price elasticity is higher for the crops like groundnut, tobacco and chillies that are of a more commercial nature in the state of Andhra Pradesh.

Yield risk due to unfavourable climatic conditions is an important factor, although it is not statistically significant in the model. Perhaps, the situation of agricultural production system seems to exist in which crops important for local food security may be insulated from market risk, by depending only little on price signals, while at the same time pointing to the challenge of matching local producer decisions to national food security needs. The results are support to the other studies like [9,17,18,13], which concluded that the responsiveness of non-price factors are the most important than price related factors in Andhra Pradesh. In particular, the role of rainfall was witnessed to an important non-price factor for rice, sorghum, pearl millet, finger millet and groundnut crops. A further research is desirable to enhance agricultural technology and price mechanisms to induce marginal farmers crop choices in the state for higher agricultural growth.

NOTES

1. The method of finding the crop which competes most with each of the crop under consideration, for land is explained in table 1. This table 1 also provides information relating to competing crops for principle agriculture crops in the State.
2. Earlier studies show that among various price formulations farm harvest price is observed to be the best in explaining acreage response. This price formulation is used in many studies.
3. Rainfall plays a key role in deciding acreage under various crops. In the earlier studies for rainfall different formulations such as pre-sowing season rainfall, sowing season rainfall, crop season rainfall, deviation of the rainfall from normal in the crop season are used. But in most of the studies total rainfall in the sowing is used. But in most of the studies total rainfall in the sowing season is used.
4. In the reduced from equation (3), $b_1$is the coefficient of relative price. The short-run price elasticities of acreage response is given by $\overline{RP}_{t-1} / \overline{A}_t (b_1)$ where $\overline{RP}_{t-1}$ is the mean relative price and $\overline{A}_t$ is the mean of actual acreage.
5. The long-run price elasticity of acreage response is given by $\left[\overline{RP}_{t-1}.(b_1)/\overline{A}_t\right]/B$ where B is the Nerlovian coefficient of adjustment.
6. Earlier studies [19,20] show that among various price specifications farm gate price is observed to be the best in explaining acreage response.
7. The problem of multicollinearity is not serious if the coefficient of correlation between any two variables is less than the value of R. See [21], "Introduction to Econometrics", Prentice Hall of India, New Delhi p.101.
8. The test is given by $h = r\sqrt{\frac{n}{1-n\left[\operatorname{var}(b)\right]}}$, where n is the sample size. $r = \frac{\sum_{t=2}^{n} e_t e_{t-1}}{\sum_{t=2}^{n} e_{t-1}^2}$ where $e's$ are the estimated residuals by ordinary least squares.–For h>1.645 the hypothesis of zero auto correlation at the 5% level should be rejected [1]. $\operatorname{Var}(b)$ is the estimate of the sampling variance of the coefficient of the lagged dependent variable. Since this test does not apply when n $\operatorname{Var}(b) \geq 1$. In such cases Durbin Watson h-statistic is used instead to test the serial correlation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

Table 1. Zero-order correlation matrix of the variable used in the model (3) of crop Rice in Andhra Pradesh

Variables	Acreage A_t	Yield in (t-1)	Relative price in (t-1)	Rainfall in year t	Std. deviation of relative price	Std. deviation of yield	Acreage in (t-1)	Time Trend t
Acreage A_t	1.000							
Yield in (t-1)	0.218	1.000						
Relative price in (t-1)	-0.191	0.416	1.000					
Rainfall in year t	0.718	0.030	-0.283	1.000				
Std. deviation of relative price	0.131	-0.256	-0.207	0.001	1.000			
Std. deviation of yield	-0.282	0.156	0.190	-0.082	-0.346	1.000		
Acreage in (t-1)	0.400	0.444	0.211	-0.031	0.253	-0.203	1.000	
Time Trend t	0.205	0.952	0.434	0.046	-0.330	0.350	0.336	1.000

Table 2. Zero-order correlation matrix of the variable used in the model (3) of crop Sorghum in Andhra Pradesh

Variables	Acreage A_t	Yield in (t-1)	Relative price in (t-1)	Rainfall in year t	Std. deviation of relative price	Std. deviation of yield	Acreage in (t-1)	Time Trend t
Acreage A_t	1.000							
Yield in (t-1)	-0.761	1.000						
Relative price in (t-1)	-0.403	0.444	1.000					
Rainfall in year t	-0.104	-0.065	-0.283	1.000				
Std. deviation of relative price	0.338	-0.453	-0.485	0.059	1.000			
Std. deviation of yield	-0.148	0.020	-0.184	0.196	0.288	1.000		
Acreage in (t-1)	0.979	-0.750	-0.431	-0.050	0.371	-0.095	1.000	
Time Trend t	-0.979	0.813	0.434	0.046	-0.381	0.124	-0.979	1.000

Table 3. Zero-order correlation matrix of the variable used in the model (3) of crop Pearl Millet in Andhra Pradesh

Variables	Acreage A_t	Yield in (t-1)	Relative price in (t-1)	Rainfall in year t	Std. deviation of relative price	Std. deviation of yield	Acreage In (t-1)	Time Trend t
Acreage A_t	1.000							
Yield in (t-1)	-0.711	1.000						
Relative price in (t-1)	0.397	-0.403	1.000					
Rainfall in year t	0.018	-0.071	0.102	1.000				
Std. deviation of relative price	0.486	-0.446	0.631	-0.013	1.000			
Std. deviation of yield	-0.164	0.181	0.038	-0.202	0.007	1.000		
Acreage in (t-1)	0.976	-0.663	0.329	-0.047	0.406	-0.228	1.000	
Time Trend t	-0.952	0.745	-0.382	0.046	-0.497	0.303	-0.957	1.000

Table 4. Zero-order correlation matrix of the variable used in the model (3) of crop Maize in Andhra Pradesh

Variables	Acreage A_t	Yield in (t-1)	Relative price in (t-1)	Rainfall in year t	Std. deviation of relative price	Std. deviation of yield	Acreage in (t-1)	Time Trend t
Acreage A_t	1.000							
Yield in (t-1)	0.699	1.000						
Relative price in (t-1)	-0.006	0.076	1.000					
Rainfall in year t	-0.118	-0.025	0.119	1.000				
Std. deviation of relative price	-0.211	-0.045	-0.067	-0.092	1.000			
Std. deviation of yield	0.122	0.041	0.127	0.149	-0.140	1.000		
Acreage in (t-1)	0.887	0.725	-0.120	-0.105	-0.096	0.124	1.000	
Time Trend t	0.702	0.876	0.198	0.046	-0.059	0.029	0.753	1.000

Table 5. Zero-order correlation matrix of the variable used in the model (3) of crop Finger Millet in Andhra Pradesh

Variables	Acreage A_t	Yield in (t-1)	Relative price in (t-1)	Rainfall in year t	Std. deviation of relative price	Std. deviation of yield	Acreage in (t-1)	Time Trend t
Acreage A_t	1.000							
Yield in (t-1)	-0.479	1.000						
Relative price in (t-1)	0.702	-0.397	1.000					
Rainfall in year t	0.072	-0.065	-0.053	1.000				
Std. deviation of relative price	0.598	-0.200	0.631	-0.143	1.000			
Std. deviation of yield	-0.329	0.192	-0.002	0.154	-0.087	1.000		
Acreage in (t-1)	0.973	-0.467	0.649	-0.025	0.533	-0.358	1.000	
Time Trend t	-0.945	0.568	-0.722	0.046	-0.625	0.310	-0.941	1.000

Table 6. Zero-order correlation matrix of the variable used in the model (3) of crop Pigeon pea in Andhra Pradesh

Variables	Acreage A_t	Yield in (t-1)	Relative price in (t-1)	Rainfall in year t	Std. deviation of relative price	Std. deviation of yield	Acreage in (t-1)	Time Trend t
Acreage A_t	1.000							
Yield in (t-1)	0.592	1.000						
Relative price in (t-1)	0.399	0.231	1.000					
Rainfall in year t	0.093	-0.463	0.116	1.000				
Std. deviation of relative price	0.066	0.150	0.169	-0.212	1.000			
Std. deviation of yield	0.309	0.187	0.091	0.044	-0.250	1.000		
Acreage in (t-1)	0.923	0.673	0.502	0.002	0.157	0.296	1.000	
Time Trend t	0.925	0.650	0.531	0.046	0.103	0.410	0.922	1.000

Table 7. Zero-order correlation matrix of the variable used in the model (3) of crop Groundnut in Andhra Pradesh

Variables	Acreage A_t	Yield in (t-1)	Relative price in (t-1)	Rainfall in year t	Std. deviation of relative price	Std. deviation of yield	Acreage in (t-1)	Time Trend t
Acreage A_t	1.000							
Yield in (t-1)	0.328	1.000						
Relative price in (t-1)	0.640	0.092	1.000					
Rainfall in year t	0.283	0.153	0.090	1.000				
Std. deviation of relative price	-0.435	0.048	-0.493	0.102	1.000			
Std. deviation of yield	-0.036	-0.121	-0.189	-0.150	0.232	1.000		
Acreage in (t-1)	0.916	0.406	0.495	0.135	-0.376	0.055	1.000	
Time Trend t	0.550	0.079	0.530	0.046	-0.460	0.296	0.609	1.000

Table 8. Zero-order correlation matrix of the variable used in the model (3) of crop Tobacco in Andhra Pradesh

Variables	Acreage A_t	Yield in (t-1)	Relative price in (t-1)	Rainfall in year t	Std. deviation of relative price	Std. deviation of yield	Acreage in (t-1)	Time Trend t
Acreage A_t	1.000							
Yield in (t-1)	-0.596	1.000						
Relative price in (t-1)	0.612	-0.579	1.000					
Rainfall in year t	-0.107	0.104	-0.062	1.000				
Std. deviation of relative price	-0.183	0.023	0.015	0.385	1.000			
Std. deviation of yield	-0.164	0.260	-0.026	0.034	-0.313	1.000		
Acreage in (t-1)	0.508	-0.662	0.297	-0.031	-0.125	-0.286	1.000	
Time Trend t	-0.602	0.835	-0.470	0.046	-0.154	0.423	-0.607	1.000

Table 9. Zero-order correlation matrix of the variable used in the model (3) of crop Chillies in Andhra Pradesh

Variables	Acreage A_t	Yield in (t-1)	Relative price in (t-1)	Rainfall in year t	Std. deviation of relative price	Std. deviation of yield	Acreage in (t-1)	Time Trend t
Acreage A_t	1.000							
Yield in (t-1)	0.698	1.000						
Relative price in (t-1)	0.392	0.089	1.000					
Rainfall in year t	0.060	-0.070	0.107	1.000				
Std. deviation of relative price	0.014	-0.304	0.009	0.109	1.000			
Std. deviation of yield	0.063	0.109	-0.090	-0.026	-0.170	1.000		
Acreage in (t-1)	0.604	0.620	0.117	-0.202	-0.005	-0.087	1.000	
Time Trend t	0.742	0.917	0.199	0.046	-0.303	0.122	0.645	1.000

Table 10. Zero-order correlation matrix of the variable used in the model (3) of crop Cotton in Andhra Pradesh

Variables	Acreage A_t	Yield in (t-1)	Relative price in (t-1)	Rainfall in year t	Std. deviation of relative price	Std. deviation of yield	Acreage in (t-1)	Time Trend t
Acreage A_t	1.000							
Yield in (t-1)	0.600	1.000						
Relative price in (t-1)	0.142	0.189	1.000					
Rainfall in year t	0.087	-0.065	0.044	1.000				
Std. deviation of relative price	0.052	0.362	0.071	0.105	1.000			
Std. deviation of yield	0.332	0.236	-0.224	-0.149	-0.237	1.000		
Acreage in (t-1)	0.894	0.557	-0.007	-0.065	0.011	0.396	1.000	
Time Trend t	0.907	0.687	0.102	0.046	0.074	0.492	0.918	1.000

Table 11. Zero-order correlation matrix of the variable used in the model (3) of crop Sugarcane in Andhra Pradesh

Variables	Acreage A_t	Yield in (t-1)	Relative price in (t-1)	Rainfall in year t	Std. deviation of relative price	Std. deviation of yield	Acreage in (t-1)	Time Trend t
Acreage A_t	1.000							
Yield in (t-1)	-0.364	1.000						
Relative price in (t-1)	0.088	-0.292	1.000					
Rainfall in year t	0.056	-0.257	-0.050	1.000				
Std. deviation of relative price	0.186	-0.170	-0.001	0.153	1.000			
Std. deviation of yield	-0.085	0.163	0.145	-0.099	-0.312	1.000		
Acreage in (t-1)	0.750	-0.599	-0.060	0.152	-0.035	-0.022	1.000	
Time Trend t	0.546	-0.174	0.185	0.046	-0.212	0.198	0.595	1.000

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