The Andhra Agric. J 69 (3): 425-435, 2022

Supply Response of Sorghum & Ragi Millets in Andhra Pradesh.

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ABSTRACT

Millet are the small -seeded grasses also called as nutria cereals or dryland cereals which includes sorghum, bajra, ragi, small millet, proso millet, barnyard millet, kodo millet, foxtail millet, etc. A study on supply response of sorghum and ragi millets in Andhra Pradesh and five major districts growing each crop were selected. The required data for period from 1990-91 to 2017-18 was collected from various published documents of the Directorate of Economics and Statistics, Government of Andhra Pradesh. Nerlovian adjustment model was used. The results of area response at state level showed that lagged area (At-1) has positively influenced the current years' area allocation by farmers under sorghum (0.54) and ragi (0.81). The production response of the selected millet crops showed that lagged farm harvest price (Pt-1) of sorghum has positive influence in Andhra Pradesh and Guntur but negative influence in Ananthapur. The yield response model of millet crops showed that price risk (PR), total rainfall (TRFt) of sorghum and lagged yield (Yt-1) of sorghum has influenced the yield in Andhra Pradesh. The non-price elasticities were found to be elastic in area allocation by farmers in all the selected millets. The coefficient of adjustment was quicker for area response of sorghum in Guntur and Kadapa. In ragi crop, production adjustment require more time in majority of the districts and state level also. The speed of yield adjustment was 12.70 years in Guntur for sorghum while it was almost in the range of 1-6 years for majority of the selected districts for the selected millets in Andhra Pradesh. There is need to increase demand for millets by giving effective system of available knowledge about nutritional advantage of millets and improved processing technology and enhancement of crops value chains thereby the area, production and yield of millets can be increased by use of new technologies.

Keywords**:** *Long run & short run elasticities, Millets, Nerlovian supply response, Ragi and Sorghum.*

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Millets are highly nutritious, non-glutinous and not acid forming foods. Compared to rice, especially polished rice, millets release lesser percentage of glucose and over a longer period of time. The world's millet production was estimated at 28.45 million tons FAOSTAT, 2017. India is the largest producer of millets with a 41.04 % of global market share. Millets are cultivated in low- fertile soils, tribal, mountainous and rainfed-areas which include Andhra Pradesh, Chattisgarh, Gujarat, Haryana, Karnataka, Tamilnadu and some other states. Kurnool is the major district growing the total major millets in Andhra Pradesh. Sorghum, bajra, ragi, korra, varugu and samai are the various millets grown in the state among which sorghum, bajra and ragi constitutes 91 per cent of total area among these millets. In India, the year 2018 was declared as national year of millets and the year 2023 is going to be international year of millets as declared by Food and Agricultural Organisation (FAO). Sorghum ranks fourth in the major food grain crops of our country and ranks second after rice in Andhra Pradesh. It is now grown in more than 24,000 ha area in rice fallows with an average productivity of 6.5 t/ha in Andhra Pradesh, which is highest in the country. In Andhra Pradesh, sorghum is cultivated in 1,40,000 ha with production of 3,33,000 tones. Kurnool is having highest cultivated area and Guntur tops in production of sorghum. Finger millet commonly known as ragi is important minor millet grown in India. Among the important millet crops grown in the world, finger millet, ranks fourth in importance after sorghum, pearl millet and foxtail millet. Finger millet constitutes about 85% of the minor millets produced in India and the rest by kodo millet, foxtail millet, little millet, proso millet and barnyard millet. In India, finger millet is grown over an area of 1.13 Mha with an annual

production of 1.98 MT and productivity of 1661 kg/ha. In Andhra Pradesh, it is cultivated in an area of 35,000 ha with a production of 44,000 tonnes and having a productivity of 1045 kg/ha. Visakhapatnam tops first in both area and production of ragi.

The supply behaviour of farmers is important to probe into several aspects like, whether the increase in production is area led (extensive cultivation) or yield led (Intensive cultivation) and the factors responsible for this increase in area and yield, which in turn contributes to the increase in the output supply. The estimation of various factors influencing the area allocation or growth of the crop at the national level or by states and regions is very important in reorienting the programs and priorities of agricultural development to achieve the estimated targets. These factors include the rainfall, area sown, proportion of irrigated area, fertilizer, farm harvest price, seeds, land development, soil conservation, improved method of cultivation etc., The degree of influence of these factors may vary from region to region which result in variation of the growth pattern. Supply response also provides the information on long-run and short-run price relations which are needed in agricultural planning. A study has been taken on "Supply response of sorghum and *Ragi* millets in Andhra Pradesh" with the following objectives.

1. To examine supply response of the selected millet crops and
2. To estimate short run and long run price elasticities.

Methodology : Andhra Pradesh is purposively selected as it is popularly known as granary of South India because of its abounding surpluses in the production of food crops. In Andhra Pradesh, the top five districts were selected which accounts more than 50 per cent of cultivated area under each millet crop and also at state level. The districts selected for the study includes Kurnool, Chittoor, Kadapa, Ananthapur, Guntur, West Godavari, East Godavari, Visakhapatnam, Vijayanagaram and Srikakulam. Supply response and short-run and long-run elasticities were estimated for sorghum, bajra, ragi and korra millet crops. Data for the period 1990-91 to 2017-2018 at the state level on area, production, yield, rainfall and farm harvest prices of the selected millet crops and their competing crops were collected from Directorate of Economics and Statistics of Andhra Pradesh, Agriculture at a glance of Andhra Pradesh, Crop and Seasonal Report of Andhra Pradesh, Government of India, Department of Agriculture and Cooperation.

Model Specification for Supply Responses Nerlove's Supply Response Model

Marc Nerlove (1958) had attempted to estimate the supply response of acreage of wheat, corn and cotton in U.S.A for the period 1909 to 1932. The model incorporates distributed lags and thereby introduces a realistic assumption about the farmers adjustment behaviour. He had postulated a price expectation model in which he assumed that acreage was not a function of previous year's price alone, but also of this year's expected price. He further assumed that the proportion of error by which the farmers assumed that the proportion of error by which the farmer revise their expectation to be constant. B is the coefficient of expectation, which lies between zero and one.

(a) Area response model

$$At = a + b1Pt\text{-}1 + b2Yt\text{-}1 + b3\ TRFt + b4\ P\ c\ t\text{-}\ 1 + b5Y\ c\ t + b6\ At\text{-}1 + b7\ PR + b8\ Tt + \mu t$$

Where, At = Area under the crop studied in hectares in the current year

Pt-1 = Farm harvest price of the crop studied (Rs/Q) lagged by one year

Yt-1 = Yield of concerned crop (Q/ha) lagged by one year

TRFt = Total rainfall in mm

P c t-1 = Farm harvest price of the competing crop (Rs/Q) lagged by one year

Y c t = Yield of the competing crop (Kg/ha)

At-1 = Area under the crop studied in hectareslagged by one year

PR = Price risk

Tt = Trend variable

μt = Error term

(b) Production response model

$$Qt = b0 + b1Pt\text{-}1 + b2TRFt + b3Qt\text{-}1 + b4Tt + \mu t$$

Where, Qt = Production of concerned crop in tonnes in the current year

Pt-1 = Farm harvest price of the concerned crop (Rs/Q) lagged by one year

TRFt = Total rainfall in mm

Qt-1 = Production of the concerned crop in tonnes lagged by one year

Tt = Trend variable

μt = Error term

(c) Yield response model

$Yt = b0 + b1Pt-1 + b2PR + b3TRFt + b4Yt-1 + b3Tt + \mu t$

Where, Yt = Yield of concerned crop (Q/ha) in the current year

Yt-1 = Yield of concerned crop (Q/ha) lagged by one year

Pt-1 = Farm harvest price of the concerned crop (Rs/Q) lagged by one Year

PR = Price risk

TRFt = Total rainfall in mm

Tt = Trend variable

μt = Error term

Short run and long run price elasticity analysis: The short run and long run price elasticities of acreage are obtained from the following formula used from the study of Nerlove (1956).

Short run elasticity = Coefficient of lagged price x Mean price Mean acreage

Long run price elasticity of acreage = Short run price elasticity/1-C

where, 1 - C = Coefficient of adjustment (B)

Coefficient of adjustment (B) The B coefficient in the Nerlovian Adjustment Lag Model will give the coefficient of adjustment. If it is nearer to one, it indicates that the farmers have no constraints in adjusting their area to the desired level in a short period. But, if it is nearer to zero, then it implies that the farmers will take long time to adjust. Based on the estimated coefficients of regression, corresponding to lagged dependent variable, the coefficient of adjustment is taken to be the deviation from one.

Speed of adjustment / Coefficient of rigidity (N): The coefficient of rigidity which reflects the number of years required for adjustment of area/production/ yield to the desired level.

(1-B)N = 0.05 Taking logarithm on both sides of the equation

N log (1-B) = log 0.05 log0.05 N= log 1-B

RESULTS & DISCUSSION

Nerlovian Lagged Adjustment Model was applied to estimate the supply response functions of area, production and yield of sorghum and ragi crops in Andhra Pradesh at the state and the district level. Since the Multicollinearity is inevitable, but unsignificant not seriously affecting parameteric estimation except the trend variable (Tt) which showed high collinearity and hence it has not been considered in supply response models. The autocorrelation was tested by using Durbin Watson's statistics and the values of d statistic are within the acceptable limits.

Acreage response function of selected millet crops in Andhra Pradesh

Sorghum

The factors influencing the acreage allocation of sorghum crop are presented in Table 1. The coefficient of multiple determination (R^2) for sorghum crop at state level analysis was found to be 0.72 which suggested that acreage allocation decision by farmers under sorghum crop was explained by 72 per cent by the variables considered under the study. The regression coefficient of lagged area (At-1) under sorghum at state level was estimated to be 0.54 which was positively influencing the farmers' current year's land allocation decision. The other important shifter which has a negative influence on the area allocation under sorghum was total rainfall (TRFt) with regression coefficient -177.33 means rainfall may distort the farmers decision on cropping choice towards more remunerative rainfed crops than sorghum thus may exert to negative influence over the sorghum area. Mohan *et al.* (2017).

The district level results of Kurnool and Prakasam showed similar response as shown by state level analysis where farmers' land allocation decision is influenced by lagged area (At-1) under the crop by one year and total rainfall (TRFt) whereas the price of competing crop (Pc t-1) for sorghum i.e., maize in Guntur and paddy in Kadapa districts with regression co-efficient of 35.75 and -10.66 has influenced acreage response, meaning that as the yield of competing crops increased, acreage under sorghum cultivation increased in Guntur and decreased in Kadapa significantly. In Guntur lagged yield (Yt-1) under the crop has also negatively influenced the current area allocation of sorghum. In Kadapa district, the coefficient of price risk was found to be 31.40 suggesting a positive influence on area of sorghum which means a stable price of crop might have influenced to increase the area allocation by farmers. It is inferred that the acreage allocation of sorghum in

the state as well as districts was mainly influenced by non-price parameters mainly total rainfall lagged area and price of competing crop.

Ragi

The area of the crop in previous year (At-1) was the major variable in all the selected districts and state level which was positively influencing the area allocation of ragi by farmers (Mohan *et al*. (2017). In the state, the co-efficient of lagged area (At-1) under ragi was 0.81 which implied that one acre increase in lagged area increases the present area allocation of ragi by 0.8 acre. The coefficient of competing crop of ragi *i.e.*, maize yield (Yc t) was -2.61 which was significantly influencing the area allocation under ragi in Andhra Pradesh. It is inferred from the district level analysis that the previous year area (At-1) has positively influenced the farmers' decision regarding area allocation under ragi in Visakhapatnam (0.53), Chittoor (0.33), Vizayanagaram (1.02), Srikakulam (0.82) and Ananthapur (0.92). In other districts, yield of competing crop (Yc t) *i.e.*, paddy by one year in Visakhapatnam with coefficient of 2.99, lagged price of competing crop (Pc t-1) *i.e*., ground nut in Chittoor with coefficient of -1.88 and in Vizayanagaram the lagged yield (Yt1) of crop (-1.48) and price risk(1.79) are significantly influencing the area allocation of ragi. The results revealed that the farmers increase the current area by considering the previous year cultivated area under ragi in majority of the selected districts and also at state level, (Table 2).

Production response function of selected millets in Andhra Pradesh

Sorghum

At the state level, The lagged farm harvest price (Pt-1) of sorghum crop was indentified as significant parameter influencing the production response in Guntur (88.81), Ananthapur (-16.08) and state level analysis (82.82), but in Prakasam district, lagged production (Qt-1) of sorghum crop by one year influenced the production response with regression coefficient of 0.34, similar results was also shown by Prabakaran. (2004) who studied production response of sorghum crop in Andhra Pradesh and he concluded that sorghum is still cultivated as a subsistence crop and only commercialization can bring in positive production changes in response to the price changes rather than nonprice changes (lagged production). Based on the above discussion it can be inferred that production decisions were influenced by farm harvest price and lagged production of the crop in Andhra Pradesh. The analysis showed that the farmers' will increase the production of sorghum by increasing the area by use of high yielding varieties and hybrids due to price changes for the crop in Andhra Pradesh and Guntur, while unexploited soil fertility might have influenced the farmers' decision to respond for the lagged production for the crop in Prakasam district, (Table 3).

Ragi

In the production response of ragi crop, the significant influencing factors was lagged production(Qt-1) of ragi crop by one year in Vizayanagaram, Srikakulam, Ananthapur and state level with positive co-efficients as 0.82, 0.80, 0.85 and 0.81 respectively. In Chittoor, the regression co-efficients of lagged farm harvest price (Pt-1) of the crop and total rainfall (TRFt) were -2.49 and 12.26 respectively influenced the production response, whereas lagged farm harvest (Pt-1) price was -13.61 in Visakhapatnam district which has negatively influenced the production response, (Table 4).

Yield response function of selected millets in Andhra Pradesh

Sorghum

The state level analysis of yield response of sorghum showed that the co-efficients of price risk (PR), total rainfall (TRFt) and lagged yield (Yt-1) of the crop are positively influencing the yield response of sorghum in Andhra Pradesh. In Guntur district, total rainfall (TRFt) and lagged yield (Yt-1) of the crop were the significant parameters. In Kadapa district, the yield response function was positively influenced by price risk (PR) and total rainfall (TRFt) In Ananthapur, lagged yield (Yt-1) of sorghum(0.63) by one year is the only variable influencing the yield response, whereas in Kurnool and Prakasam district the yield response was not influenced by any of the included variables which might be due to influence of other variables like fertilizer and irrigation under the crop. The results showed that price risk (PR), total rainfall (TRFt) and lagged yield (Yt-1) influenced the productivity of the crop in Andhra Pradesh, it can be

inferred that the low price risk and its lagged yield (Yt-1) has encouraged the farmers to prefer the sorghum crop for cultivation which might be due to adoption of modern technology thereby increase in yield of the crop. Equal distribution of rain fall in the state might have positively influenced the yield response of sorghum, (Table 5).

Ragi The reason for low R2 value might be due to influence of other variables on yield response such as fertilizer, seed and irrigation etc., and hence none of the selected variables in the model has influenced the yield response. In Chittoor district the lagged farm harvest price (Pt-1) and price risk (PR) were significant parameters on yield response, while in Vizayanagaram and Srikakulam districts, lagged yield (Yt-1) of crop by one year influenced the yield response. In Visakhapatnam, Ananthapur and state level analysis, the yield response was not influenced by any of the included variables; this might be due to other variables influencing the yield response, (Table 6).

Short-run and long-run elasticities of selected millets in Andhra Pradesh

Sorghum

Area response It was observed that the rainfall (TRFt) elasticities in short run were -0.25, -0.34 and -0.55 and in long run were -0.52, -0.97 and -1.22in Kurnool, Prakasam and at the state level respectively. The negative sign indicated that the farmers were unable to adjust the area in response to rainfall in both the short run and long-run, (Table 7).

Production response The magnitude of short-run (1.94) and long run price elasticities (2.11)were found to be high in Guntur signaling better production responsiveness of growers to price change which reflects that sorghum growers would bring 1.94 per cent in short-run and 2.11 per cent in long-run of additional production for every one per cent increase in the price. In Andhra Pradesh, one per cent increase in the lagged price (Pt-1) bring about 0.26 per cent and 0.31 per cent increase in production response of sorghum crop in short-run and long-run respectively , (Table 8).

Yield response The short run and long run lagged yield (Yt-1) elasticities were high in Guntur (0.74, 3.54), Ananthapur (0.64, 1.74) and Andhra Pradesh (0.53, 1.22). The positive and high values in long-run indicated that the farmers in these districts as well as state have realized good yield by adopting advanced technology in the long run. The price risk (PR) elasticities in Kadapa (0.14 and 0.21) and state level (0.11 and 0.20) were positive and of lower magnitude reflecting inelastic nature of farmers with respect to variability in prices in both short-run and long-run, (Table 9).

Ragi

Area response The short and long run elasticities obtained from the regression coefficient for ragi of one year lagged yield(Yt-1) was found to be -0.22 and -1.26 respectively in Vizayanagaram which showed that the farmers were not responsive to lagged yield changes in allocating the area under ragi in both the short run and long run. In Vizayanagaram, price-risk (PR) elasticities were observed to be -0.01and -0.73 in short-run and long-run respectively reflecting the averseness of the farmers to the variability in the prices (Table 10).

Production response The price elasticities of production response for ragi were negative in Visakhapatnam (-0.32,-0.34) and Chittoor (-0.18, -0.25) districts for both short-run and long-run which showed that farmers were not price responsive. In Vizayanagaram, Srikakulam, Ananthapur and state level analysis showed that the magnitude of lagged production (Qt-1) elasticities in long run were found to be of higher with elasticities values 4.81, 4.52, 6.00 and 4.76 respectively signaling better production responsiveness of growers to production changes by adopting advance technologies, (Table 11).

Yield response In Chittoor district, the price elasticities (Pt-1) were negative reflecting that the farmers were not price responsive in both short-run and long-run (- 0.20, -0.20). In Srikakulam district, the short-run and long-run elasticities of lagged yield (Yt-1) were 0.38 and 0.61 respectively while it was negative in Vizayanagaram district. The price risk (PR) elasticities in Chittoor were observed to be indifferent in short-run (0.16) and long-run (0.16), (Table 12).

Adjustment Coefficients and Speed of Adjustment/Co-efficient of rigidity for selected millet crops in Andhra Pradesh

The rapidity with which the farmers adjust the acreage, production and yield of a crop in response to the movements in selected variables may be seen from the numerical values of adjustment coefficient 'B'. A high coefficient of adjustment implies, in Nerlovian sense, a general lack of rigidity which inhibits equilibrium output and also an indication for quicker adjustment in decision making process.The coefficient of rigidity/speed of adjstment which reflects the number of years required for adjustment of area/ production/yield to the desired level presented in **Sorghum.** The coefficient of area adjustment of sorghum was found to be very high in Guntur (0.97) followed by Kadapa (0.94) while the coefficient of adjustment were low in Kurnool (0.49), Prakasam (0.35) and at the state level (0.45) analysis which require more time for adjustment *i.e.*, 4.44, 6.95 and 5.01 years respectively. The number of years required for production adjustment in Guntur, Kadapa, Prakasam and state level were 1.18, 1.86, 2.77 and 1.63 years respectively, (Table.13).

Ragi The speed with which the area of ragi responded was slow in Ananthapur (35.92 years), Srikakulam (15.09 years) and Andhra Pradesh (15.09 years), while Visakhapatnam and Chittoor took 4.71 and 2.70 years respectively. The co-efficient of production adjustment was high in Visakhapatnam (0.96) followed by Chittoor (0.73) districts and It was found to be low in Vizayanagaram (0.18), (Table.14).

Table 1 : Acreage response function of sorghum in Andhra Pradesh

Districts/State	constant	P_{t-1}	Y_{t-1}	TRF_t	P^c_{t-1}	Y^c_t	A_{t-1}	P_R	R^2	d-statistic
Kurnool	107199.3***	7.68	-14.42	-53.66**	-31.15	-1.2	0.51***	23.67	0.89	2.4
	-31637.23	-21.77	-9.12	-22.74	-28.21	-3.09	-0.15	-30.89		
Guntur	-4676.86	-8.15	-3.50**	-8.04	35.75*	1.29	0.03	26.11	0.68	2.54
	-6891.27	-19.25	-1.62	-9.17	-19.29	-1.2	-0.19	-21.49		
Prakasam	9576.12*	5.72	-2.77	-10.75*	-1.51	-1.06	0.65***	18.48	0.86	2.68
	-4947.78	-5.34	-1.75	-6.27	-4.91	-1.45	-0.06	-12.91		
Kadapa	5804.51	4.8	1.79	-5.3	-10.66**	2.42	0.06	31.40**	0.44	2.35
	-5597.44	-4.18	-2.44	9	-4.87	-1.88	-0.19	-13.37		
Ananthapur	71958.70*	-18.99	-13.12	-28.79	0.69	-4.5	-0.21	-5.11	0.31	2.1
	-19457.94	-17.8	-9.34	25.06	-7.81	-8.13	-0.22	-38.23		
Andhra Pradesh	167991.4***	79.41	5.16	-177.33***	-135.77	1.85	0.54***	170.86	0.72	2.74
	-62799.14	-138.27	-25.37	-63.94	-176.48	-21.2	-0.15	-151.63		

*** Significant at 1 per cent level
** Significant at 5 per cent level
* Significant at 10 per cent level
Figures in the parenthesis indicates standard error

Table 2 : Acreage response function of Ragi in Andhra Pradesh

Districts/State	constant	P_{t-1}	Y_{t-1}	TRF_t	P^c_{t-1}	Y^c_t	A_{t-1}	P_R	R2	d-statistic
Visakhapatnam	22091.69**	-6	-2.48	-4.42	-6.53	2.99*	0.53***	11.15	0.9	2.3
	-10857.32	-5.95	-3.11	-4.44	-5.88	-1.64	-0.2	-11.2		
Chittoor	7717.32**	2.53	-0.38	3.18	-1.88**	0.93	0.33*	-9.9	0.8	2.16
	-3255.39	-2.67	-1.34	-3.22	-0.89	-1.33	-0.16	-7.93		
Vizayanagar	187.58	-0.23	-1.48**	-0.2	0.56	0.26	1.02***	1.79*	1	2.82
	-1589.989	-1.83	-0.62	-1.48	-1.95	-0.34	-0.06	-3.56		
Srikakulam	-1601.88	0.76	1.12	-0.02	-2.79	0.72	0.82***	7.29	1	2.04
	-2199.91	-2.24	-1.53	-0.03	-3.6	-0.7	-0.08	-11.7		
Ananthapur	-276.73	1.31	-0.49	2.93	-0.32	0.67	0.92***	-4.74	0.9	2.86
	-1622.71	-1.15	-0.47	-2.61	-0.43	-0.76	-0.1	-4.35		
Andhra Pradesh	11060.13	-11.2	2.49	11.64	17.13	-2.61***	0.81***	-2.53	1	2.44
	-18824.61	-12.5	-10.48	-9.99	-17.69	-1.51	-0.12	-27.1		

*** Significant at 1 per cent level
** Significant at 5 per cent level
*Significant at 10 per cent level
Figures in the parenthesis indicates standard error

Table 3 : Production response function of Sorghum in Andhra Pradesh

Sl.no	Districts/State	constant	Pt-1	TRF_t	Qt-1	R2	d-statistic
1	Kurnool	12980.91***	-1.05	4.8	-0.22		
		(4679.18)	-1.52	-5.9	-0.21	0.1	1.66
2	Guntur	-21627.2	88.81***	-42.11	0.07		
		-18785.61	-13.31	-34.2	-0.15	0.83	2.21
3	Prakasam	10252.91	4.74	-14.68	0.34**		
		-6181.46	-3.73	-13.33	-0.16	0.26	1.22
4	Kadapa	11802.94*	3.72	-12.52	0.2		
		-6779.13	-3.22	-15.68	-0.18	0.13	2.27
5	Ananthapur	43852.68***	16.08***	-18.29	0		
		-12784.38	-5.53	-23.03	-0.21	0.4	2.11
6	Andhra Pradesh	217977.2***	82.82***	-149.42	0.15		
		-82553.54	-31.89	-123.46	-0.19	0.32	2.12

***Significantat1percentlevel
**Significantat5percentlevel
* Significantat10percent level
Figures in the parenthes is indicates standard error

Table 4: Production response function of ragi in Andhra Pradesh

Sl.no	Districts/State	Constant	P_{t-1}	TRF_t	Q_{t-1}	R^2	d-statistic
1	Visakhapatnam	32925.63** -13192.21	-13.61*** -4.91	5.58 -10.15	0.04 -0.21	0.5	1.97
2	Chittoor	4714.63 -4458.53	-2.49* -1.44	12.26** -5.97	0.27 -0.19	0.5	1.97
3	Vizayanagaram	2907.9 -676.53	-1.24 -1.97	-1.07 -4.87	0.82*** -0.13	0.8	2.14
4	Srikakulam	124.7 -1054.19	0.62 -0.89	-0.01 -0.03	0.80*** -0.06	0.9	2.4
5	Ananthapur	-535.26 -3358.28	-0.16 -1.34	5.18 -6.46	0.85*** -0.11	0.8	2.46
6	Andhra Pradesh	4126.75 -25729.12	-5.94 -9.61	20.89 -26.63	0.81*** -0.13	0.9	2.27

***Significant at 1 per cent level
**Significant at 5 perc ent level
* Significant at 10 per cent level
Figures in the parenthes isindicates standard error

Table 5: Yield response function of sorghum in Andhra Pradesh

Sl.no	Districts/State	constant	Pt-1	P_R	TRF_t	Yt-1	R^2	d-statistic
1	Kurnool	1032.71*** -254.55	-0.01 -0.08	0.02 -0.35	0.19 -0.24	-0.16 -0.21	0.06	1.96
2	Guntur	462.74 -634.01	-0.99 -0.63	0.28 -2.36	-0.79*** -1.14	0.79* -0.11	0.91	2.09
3	Prakasam	287.04 -403.04	0.18 -0.33	2.23 -1.53	0.46 -0.85	0.36 -0.22	0.44	1.94
4	Kadapa	-0.76 -391.31	-0.09 -0.17	2.90*** -1.11	1.45** -0.73	0.23 -0.19	0.13	1.88
5	Ananthapur	211.51 -341.69	-0.1 -0.14	-0.25 -0.81	0.65 -0.53	0.63*** -0.19	0.56	1.92
6	Andhra Pradesh	-191.83 -351	0.27 -0.27	2.22*(1.28)	1.01** -0.54	0.55*** -0.17	0.78	2.04

***Significant at 1 per cent level
**Significant at5 per cent level
* Significant at10 per cent level
Figures in the parenthes is indicates standard error

Table 6: Yield response function of ragi in Andhra Pradesh

Sl.no	Districts/State	constant	P_{t-1}	P_R	TRF_t	Y_{t-1}	R^2	d-statistic
1	Visakhpatnam	1079.26*** -362.22	0.06 -0.14	-0.39 -0.64	0.05 -0.3	-0.18 -0.22	0.1	2.03
2	Chittoor	889.70*** -315.85	-0.27* **-0.16**	1.82** **-0.89**	0.53 -0.41	0 -0.19	0.2	1.97
3	Vizayanagaram	1457.48*** -314.05	-0.15 -0.14	0.38 -0.93	0.48 -0.35	-0.41** **-0.2**	0.2	1.87
4	Srikakulam	715.52*** -242.38	0.19 -0.15	-0.87 -0.97	0 0	0.38** **-0.18**	0.3	2.18
5	Ananthapur	1479.5*** -540.32	0.03 -0.3	-0.35 -1.91	0.16 -1.01	0.19 -0.22	0	1.91
6	Andhra Pradesh	1451.28 -346.96	-0.07 -0.08	-0.32 -0.59	0.04 -0.21	-0.2 -0.23	0.2	1.89

Table 7 : Short run and long run elasticities of acreage response of sorghum in Andhra Pradesh

Sl.no	Districts/State	Price elasticities		Non-price elasticities					
		P_{t-1}		Y_{t-1}		TRF_t		P_R	
		SRE	LRE	SRE	LRE	SRE	LRE	SRE	LRE
1	Kurnool	0.07	0.14	-0.22	-0.46	-0.25**	-0.52**	0.03	0.06
2	Guntur	-0.72	-0.74	-1.34	-1.38	-0.54	-0.56	0.3	0.31
3	Prakasam	0.35	1.02	-0.28	-0.8	-0.34*	-0.97*	0.11	0.33
4	Kadapa	0.33	0.36	0.15	0.16	-0.16	-0.17	0.29	0.31
5	Ananthapur	-0.64	-0.53	-0.43	-0.35	-0.34	-0.28	-0	-0.01
6	Andhra Pradesh	0.37	0.82	0.04	0.1	-0.55***	-1.22***	0.08	0.18

Table 8: Short run and long run elasticities of production response of sorghum in Andhra Pradesh

Sl.no	Districts/State	Price elasticities		Non-price elasticities			
		P_{t-1}		Q_{t-1}		TRF_t	
		SRE	LRE	SRE	LRE	SRE	LRE
1	Kurnool	-0.08	-0.06	0.19	0.15	-0.2	-0.2
2	Guntur	1.94***	2.11***	0.06	0.07	-0.5	-0.5
3	Prakasam	0.27	0.4	0.36**	0.55**	-0.4	-0.6
4	Kadapa	0.23	0.29	0.21	0.26	-0.4	-0.5
5	Ananthapur	-0.62***	-0.62***	0	0	-0.2	-0.2
6	Andhra Pradesh	0.26***	0.31***	0.15	0.17	-0.3	-0.4

Table 9: Short run and long run elasticities of yield response of sorghum in Andhra Pradesh

Sl.no	Districts/State	Price elasticities		Non-price elasticities					
		P_{t-1}		Y_{t-1}		TRF_t		P_R	
		SRE	LRE	SRE	LRE	SRE	LRE	SRE	LRE
1	Kurnool	0	0	-0.15	-0.13	0.09	0.07	0	0
2	Guntur	-0.25	-1.23	0.74*	3.54*	-0.10***	-0.51***	0	0.03
3	Prakasam	0.11	0.17	0.36	0.56	0.14	0.22	0.14	0.21
4	Kadapa	-0.07	-0.09	0.23	0.3	0.52**	0.68**	0.31***	0.41***
5	Ananthapur	-0.1	-0.28	0.64***	1.74***	0.24	0.65	-0.02	-0.07
6	Andhra pradesh	0.13	0.31	0.53***	1.22***	0.33**	0.75**	0.11*	0.20*

Table10: Short run and Long run elasticities of acreage response of ragi in Andhra Pradesh

Sl. No	Districts/State	Price elasticities		Non-price elasticities					
		P_{t-1}		Y_{t-1}		TRF_t		P_R	
		SRE	LRE	SRE	LRE	SRE	LRE	SRE	LRE
1	Visakhapatnam	-0.13	-0.29	-0.07	-0.16	-0.1	-0.22	0.03	0.06
2	Chittoor	0.2	0.3	-0.03	-0.05	0.13	0.19	-0.09	-0.13
3	Vizayanagaram	-0.02	1	-0.22**	-1.26**	-0	0.89	0.01***	-0.73***
4	Srikakulam	0.1	0.6	0.29	1.64	-0	-0.06	0.1	0.6
5	Ananthapur	0.21	2.67	-0.17	-2.15	0.17	2.18	-0.08	-1.07
6	Andhra Pradesh	-0.13	-0.69	0.04	0.23	0.09	0.49	-0.002	-0.01

Table 11: Short run and long run elasticities of production response ragi in Andhra Pradesh

Sl.no	Districts/State	Price elasticities		Non-price			
		P_{t-1}		Q_{t-1}		TRF_t	
		SRE	LRE	SRE	LRE	SRE	LRE
1	Visakhapatnam	-0.32***	-0.34***	0.04	0.04	0.14	0.14
2	Chittoor	-0.18*	-0.25*	0.28	0.38	0.47**	0.64**
3	Vizayanagaram	-0.08	-0.48	0.86***	4.81***	-0.07	-0.42
4	Srikakulam	0.06	0.34	0.90***	4.52***	0	-0.02
5	Ananthapur	-0.01	-0.08	0.90***	6.00***	0.15	1.03
6	AndhraPradesh	-0.05	-0.32	0.86***	4.76***	0.14	0.77

Table 12 : Short run and long run elasticities of yield response of ragi in Andhra Pradesh

Sl.No	Districts/ State	Price elasticities		Non-price elasticities					
		Pt-1		Yt-1		TRF_t		P_R	
		SRE	LRE	SRE	LRE	SRE	LRE	SRE	LRE
1	Visakhpatnam	0.04	0.03	-0.17	-0.15	0.03	0.03	-0.03	-0.02
2	Chittoor	-0.20***	-0.20***	0	0	0.21	0.21	0.16**	0.16**
3	Vizayanagaram	-0.08	-0.06	-0.40**	-0.28**	0.27	0.19	0.02	0.01
4	Srikakulam	0.1	0.17	0.38**	0.61**	0	0	-0.05	-0.08
5	Ananthapur	0.01	0.01	0.18	0.23	0.02	0.03	-0.01	-0.02
6	AndhraPradesh	-0.04	-0.03	-0.2	-0.16	0.02	0.01	-0.02	-0.01

Table 13: Estimated adjustment coefficients and speed of adjustment of area, production and yield for sorghum

Sl.no	Districts/State	Area Response		Production Response		Yield Response	
		B	N	B	N	B	N
1	Kurnool	0.49	4.44	-	-	-	-
2	Guntur	0.97	0.85	0.92	1.18	0.21	12.7
3	Prakasam	0.35	6.95	0.66	2.77	0.64	2.93
4	Kadapa	0.94	1.06	0.8	1.86	0.77	2.03
5	Ananthapur	-	-	-	-	0.37	6.48
6	Andhra Pradesh	0.45	5.01	0.84	1.63	0.44	5.16

Note: The speed of adjustment is not computed in case where the lagged dependent variables have negative sign

Table14: Estimated adjustment coefficients and speed of adjustment of area, production and yield for ragi

Sl.no	Districts/State	Area Response		Production		Yield Response	
		B	N	B	N	B	N
1	Visakhapatnam	0.47	4.71	0.96	0.93	-	-
2	Chittoor	0.67	2.7	0.73	2.28	-	0
3	Vizayanagaram	-0.02	0.76	0.18	15.09	-	-
4	Srikakulam	0.18	15.09	0.2	13.42	0.62	3.09
5	Ananthapur	0.08	35.92	0.15	18.43	0.81	1.8
6	AndhraPradesh	0.18	15.09	0.18	15.09	-	-

The area response at state level showed that lagged area has positively influenced the current years' area allocation by farmers under sorghum and ragi. The production response of the selected millet crops showed that lagged farm harvest price of sorghum has positive influence in Andhra Pradesh and Guntur. The yield response model of millet crops showed that price risk total rainfall of sorghum and lagged yield of sorghum has influenced the yield response model in Andhra Pradesh. The coefficient of adjustment was quicker for area response of sorghum in Guntur and Kadapa. In ragi crop, production adjustment require more time in majority of the districts and state level also. The speed of yield adjustment was 12.70 years in Guntur for sorghum while it was almost in the range of 1-6 years for majority of the selected districts for all the selected major millets in Andhra Pradesh. The overall results indicated that non-price factors are also the important determinants of supply response of millets; hence the government should focus on the development issues which are much needed for increasing the productivity.

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Received on 09.06.2022 and Revised on 21.09.2022