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Supply Response of Arhar and Gram in Eastern Region of Uttar Pradesh

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Abstract

Agriculture is the mainstay for the economic development of the country. Pulses are the most important ingredient of a vegetarian food basket. But the area under pulses is declining. This study attempted to undertake the task of investigating the relative impacts of various factors on acreage response of different pulse crops by analyzing time series data from 1970-2012. Supply response model was used in this study. It is apparent that the area under the pulse crops is decreasing at an alarming rate. Its price is also increasing but farmers are not getting fair remuneration. This indicates that farmers do not have proper incentives to adjust to desired pulse area. Short and long run elasticities has also been calculated to show price responsive behaviour of farmer. Demand and supply has been projected for the years 2019-20 and 2029-2030. The study revealed that there can be a huge amount of negative gap between demand and supply. The present study aimed at examining the response behavior of arhar and gram growers to the changes in price and selected non price variables in all districts of eastern region of Uttar Pradesh.

Keywords: Agriculture, vegetarian, animal protein, nerlovian, arhar

Agriculture is the mainstay for the economic development of the country. It is a predominant sector which contributes highest in employment generation and creation of livelihood. More than 60% of population depend on it directly. During 1960s there was a wave of green revolution that made India self-sufficient in food. But this success was confined only up to wheat in northern India such as Punjab, Haryana and western Uttar Pradesh resulting in a limited contribution to overall economic development of the country. The second wave during 1980s covered the country as a whole and other crops were included like rice. This was very much necessary to raise the rural income and alleviate poverty. Such a rise of rural India as a market led to all sector development after 1990s.

Pulses are the main ingredient in the protein basket of a vegetarian food. Since pulses are cheaper than meat (animal protein) it is often referred to as 'poor man's meat in developing countries like India. These are leguminous annual crops which are not only consumed for its protein content but is also used as a fodder crop and it also contributes to healthy soils. Pulses production in India is characterized by diversity of crops and their regional specificity based on adaptation to prevailing agro-climatic conditions. This group of crops can utilize limited soil moisture and nutrients more efficiently than cereals and for that reason farmers have chosen them to grow under highly adverse conditions. Important pulse crops grown in India are Chickpea, Pigeonpea, Gram, Lentil, Red kidney beans, Peas etc. India is the largest producer (25% of global production), consumer (27% of world consumption) and importer (14%) of pulses in the world. Pulses account for around 20 per cent of the area under food grains and contribute around 7-10 per cent of the total food grains production in the country. Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh and Karnataka are the top five pulses producing states (Mohanty and Satyasai, 2015)

Prices play a very important role in the selection of crops. If a farmer expects higher price for a crop in the

next year then in this year he will cultivate that crop on a larger area. Therefore, price of the crop is an important determinant of the area under the crop. The responsiveness of farmers to price incentives determine the contribution of agriculture to the economy. Production is a major component of supply and is determined by the amount of planted acreage and yield per hectare. The planted area in the last year is considered an important indicator to the partial adjustment process that farmers face when making their production decisions. Nerlove and Addison (1958) were the first to include this variable in the supply response functions.

Objectives:

1. To estimate the supply response of Arhar and Gram in Eastern region of Uttar Pradesh.
2. To estimate the short run and long run price elasticities of acreage in Eastern region of Uttar Pradesh.
3. To estimate the demand and make projections for supply of total pulses for 2020-2030 of Uttar Pradesh.

Methodology

In this study an attempt is made to examine the response behaviour of arhar and gram growers to the changes in price and selected non price variables in all districts of eastern region of Uttar Pradesh. This was estimated by the application of Nerlovian price expectation adjustment model. Purposively Eastern Uttar Pradesh was selected as the study area on the basis that the shift in area is maximum in this zone as compared to other economic zones of Uttar Pradesh.

Source of data: The secondary data was collected from Directorate of Agricultural Statistics and Crop Insurance Lucknow Uttar Pradesh, various publications like economic survey, Uttar Pradesh Bulletin of Agriculture Statistics apart from books and journals, Govt. of India, Dept of Agriculture and Cooperation, Ministry of Agriculture, India's Comprehensive Statistical Analysis are some sites.

Period of study: The study was undertaken in all the districts of Uttar Pradesh using secondary data for the period of 42 years:

1. Pre liberalization period- 1970-90
2. Post liberalization period-1991-12,

pertaining to area, productivity, farm harvest price, monsoon season rainfall and irrigated area of main and competing crop. Arhar and Gram were selected for study as the area shift under these crops was maximum as compared to other crops. Competing crop of Arhar is Lentil and Gram is Rapeseed and Mustard which is based on scoring the highest negative correlation coefficient.

Analytical Framework

TFirst objective: The Nerlovian Adjustment Model was used for the study.

$$A^*_t = a + bP_{t-1} + U_t \quad (1)$$

$$A_t - A_{t-1} = \beta(A^*_t - A_{t-1}); 0 \le \beta < 1 \quad (2)$$

$$A_t = a_0 + b_0 P_{t-1} + c_0 A_{t-1} + u_t \quad (3)$$

Where,

$a_0 = a\beta$

$b_0 = b\beta$

$c_0 = 1 - \beta$

$V_t = \beta\, u_t$

A^*t is the acreage farmers would plant in period t if there were no difficulties of adjustment. As A^*t is unobservable, equation (1) cannot be estimated. Therefore assuming that acreage actually planted in period t equals acreage actually planted in period t-1 plus a term that is proportional to the difference between the acreage farmers would like to plant now and the acreage actually planted in the preceding period, hypothesis (2) is made. Technological or institutional factors prevent the intended acreage from being realised during the period and the parameter (C) is called the acreage adjustment coefficient. Expressing A^*t in terms of directly observable variables estimating equation is (3).

The specified model is given below:

$$A^*t = b_0 + b_1Pt\text{-}1 + b_2P^c_{t-1} + b_3Y_{t-1} + b_4Y^c_{t-1} + b_5RP_t + b_6RY_t + b_7MR_t + b_8IR_t + b_9IG_t + b_{10}D + U_t \quad (1)$$

$$A_t - A_{t-1} = \beta(A^*_t - A_{t-1}); 0 \le \beta < 1 \quad (2)$$

The final equation of the model can be obtained as follows:

$At = \beta\,(A^*t\text{-}At\text{-}1) + At\text{-}1$

$At = \beta A^*t - ?At\text{-}1 + At\text{-}1$

$At = \beta A^*t - At\text{-}1(1-\beta)$ (3)

By substituting the value of A^*_t from equation (1) in equation (3),

$$A_t = \beta(b_0 + b_1P_{t-1} + b_2P^c_{t-1} + b_3Y_{t-1} + b_4Y^c_{t-1} + b_5RP_t + b_6RY_t + b_7MR_t + b_8IR_t + b_9IG_t + b_{10}W_{t-1} + b_{11}D + U_t) + A_{t-1}(1 - \beta)$$

$$A_t = \beta b_0 + \beta b_1 P_{t-1} + \beta b_2 P^c_{t-1} + \beta b_3 Y_{t-1} + \beta b_4 Y^c_{t-1} + \beta b_5 RP_t + \beta b_6 RY_t + \beta b_7 MR_t + \beta b_8 IR_t + \beta b_9 IG_t + \beta b_{10} W_{t-1} + \beta b_{11} D + U_t) + A_{t-1} (1 - \beta)$$

Yield Response Model

$$Y_t = b_0 + b_1 P_{t-1} + b_2 P^c_{t-1} + b_3 RP_t + b_4 Y^c_{t-1} + b_5 RP_t + b_6 RY_t + b_7 MR_t + b_8 IR_t + b_9 IG_t + b_{10} D + U_t$$

$$Y_t = \beta (b_0 + b_1 Pt_{-1} + b_2 P^c_{t-1} + b_3 RP_t + b_4 Y^c_{t-1} + b_5 RP_t + b_6 RY_t + b_7 MR_t + b_8 IR_t + b_9 IG_t + b_{10} D) + U_t$$

$$Y_t = \beta b_0 + \beta b_1 P_{t-1} + \beta b_2 P^c_{t-1} + \beta b_3 RP_t + \beta b_4 MR_t + \beta b_5 IR_t + \beta b_6 IG_t + \beta b_7 W_{t-1} + \beta b_{11} D + Y_{t-1} (1-\beta)$$

Where;

A_t = area of pulse crop in hec in the current year (hectare)

P_{t-1} = farm harvest price of pulse crop lagged by one year (₹/qtl)

P^c_{t-1} = farm harvest price of competing crop lagged by one year (₹/qtl)

Y_{t-1} = yield of pulse crop lagged by one year (kgs/ ha)

Y^c_{t-1}=yield of the competing crop lagged by one year (kgs/ha)

RP_t = price risk variable

RY_t = yield risk variable

MR_t = rainfall during monsoon period in mm in current year (mm)

IR_t =irrigated area of pulse crop in current year (hectare)

IG_t= irrigated area of competing crop in current year (hectare)

A_{t-1} = area of concerned pulse crop in ha lagged by one year (hectare)

D = Dummy variable 'liberalisation'

U_t = a disturbance term

Which is the proper dependent variable to study farmers' response to price: Area or Supply? This is an important issue to be resolved at the outset. Those, who support acreage function view that output is subject to more fluctuation than area because of uncertain random factors such as temperature, rainfall etc. Hence to understand the behavioral pattern, area is the appropriate variable. Even in land variable, one has to distinguish between explaining total area changes and area shifts between crops given the total land size. Hence even if farmers are profit maximisers in a neoclassical sense total cultivated area is not likely to respond to price in the short run. Therefore the price response is likely to be confined mainly to area allocation between crops rather than to total cultivated area. Some studies utilize ratio of acreage under a crop to total cropped area for studying shifts in area among the crops. This has its own limitations that the simultaneous changes in the crop area and the total area will conceal variations. Due to this factor, absolute area is used in the study.

Second Objective: The short run and long run price elasticites of acreage were 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 elasticity of acreage = Short run price elasticity/ 1-C

where,

1 – C = ( ) Coefficient of adjustment

Third Objective: The demand for year 2020-30 for the pulse crop was obtained through the following equation used from the study of Kumar *et al*.

$$D_t = d_0 * N_t (1+y*e)^t$$

Where,

D_t= demand of a pulse in year t

d_0= per capita demand of the pulse in the base year

y= growth in per capita income

e= expenditure elasticity of demand for the pulse

N_t= projected population in year t

To make the short term supply projection of pulses from year 1967-68 to 2013-14, the acreage response function for different regions were selected. The trend analysis was done for the acreage projection. The variables like prices of main and competing crop, rainfall, yield and price risk, irrigation were assumed to be constant, while the values of the yield were predicted on the basis of the past trends. The trend variable for the years were denoted by the corresponding number of that year in the time series and then using data the acreage projection was calculated varying the dynamic variable i.e. At-1.

After making the acreage projections, the supply figures were obtained by multiplying the acreage with the expected yield. The functional form of the trend equation was:

Y = a + bt

where,

Y = lagged area from 1967 -68 to 2011- 2012

a = slope

b = regression coefficient

tt = time trend

Results and Discussion

Factors determining supply behavior of pulses

(i) **Allahabad:** Results revealed that the lagged area under arhar and gram is an important determinant of the area under these crops. The regression coefficient of this variable being 0.477 and 0.58 was significant at 1% probability level. The area under the crop is increasing but at a decreasing rate than the last year. The next important shifter in case of arhar is found to be lagged yield with the coefficient -0.004 significant at 5% probability level. So it is also an important factor in determining the current acreage decision of the farmer. This means that with the increase in yield of main crop the area decreases in the current year. Since the farmers grow pulse crops only for consumption so increase in yield will have no impact over there earning so they allocate the area under some other crop which is more remunerative. In case of gram lagged price coefficient 0.176 significant at 5% level. This implies that the price of gram has a positive influence in determining the area allocation. The relative price with 0.057 coefficient and monsoon rainfall with -0.052 coefficient at 5% probability level is found to be the next important shifter. This means that a percent increase in the relative price of arhar will induce farmers to increase area by 0.057%. The negative relation of monsoonal rainfall implies that as the rainfall increases farmer allocate there area under some other profitable crops. Rest of the variables like lagged price of competing crop, lagged yield in case of gram, yield of competing crop, relative price in case of arhar, relative yield, rainfall in case of arhar, irrigated area under both main and competing crop and dummy variable are found to be insignificant in log linear model. The fact that the coefficients were not significant for the rest of the cases implied that these variables had no definite consequences on the variation in the area.

(ii) **Azamgarh:** The regression coefficient of lagged area under arhar is found to be 0.856 significant at 1% probability level. The area under the crop is increasing but at a decreasing rate than the last year. Impact of relative price is found to be significant at 5% probability level with 0.016 as regression coefficient. This means that a percent increase in the relative price will induce farmers to increase area by 0.016%. That is, farmers would allocate their limited land resources to that crop enterprise towards which the relative price movements tend to be favourable. This was however, quite logical and rational as the allocation of land to a better priced crop would fetch more revenue to farmers. The regression coefficient of monsoonal rainfall is -0.052 significant at 10% probability level. The statistically significant relation of this variable with area of arhar implied that the farmers' area allocation decision pertaining to arhar depended upon the amount of rainfall received. The negative relation implies that the farmer will decrease the area under the main crop and will allocate the area to other profitable enterprises. The lagged price of arhar is found to be positive but insignificant which implies that the farmers of this region do not have profit motive in growing the crop. They grow arhar for consumption purpose only and the surplus amount is sold in the market. Rest of the variables like lagged price of main crop and competing crop, lagged yield of main and competing crop, relative yield, irrigated area under both main and competing crop and dummy variable are found to be insignificant in log linear model.

(iii) **Behraich:** The regression coefficient of lagged area under arhar 0.139 and gram 0.472 were found to be significant at 1% level. The area under the crop is increasing but at a decreasing rate than the last year. The other important shifter which has a positive influence on the area allocation under arhar is lagged price with regression coefficient 0.097 significant at 5% level. Relative price of both the crops at 5% level with values 0.106 and 0.101 respectively. This means that a percent increase in the relative price will induce farmers to increase area by 0.106% in case of arhar and 0.101% in case of gram. The regression coefficient of monsoonal rainfall for arhar is -0.429 significant at 10% level and for gram is -0.741 at 5% level. The negative relation implies that the increase in amount of rainfall will induce farmers to allocate area under some other remunerative enterprise. The lagged yield coefficient in case of gram is -0.814 significant at 5% level. The negative relation implies that as there was an increase in yield by one percent last year there was a decrease in the area allocated this year by 0.814% under arhar. The irrigated area under competing crops i.e. masoor and rapeseed and mustard were significant at 5% level with values 1.308 and 0.494 respectively which implies that as the irrigated area under competing crops will increase the area under the main crops will also increase. The rest of the variables were non significant.

(iv) **Balia:** The regression coefficient of lagged area under arhar 0.306 is found to be significant at 1% level. The area under the crop is increasing but at a decreasing

rate than the last year. The lagged price of arhar with regression coefficient 0.402 is significant at 5% level. So this implies that as the price of arhar increases the area allocated under it will also increase. The rest of the variables like lagged price of competing crop, lagged yield, lagged yield of competing crop, relative price, relative yield, monsoonal rainfall, irrigated area under both the crops and dummy variable were insignificant. This implies that rest of the insignificant variables have no explanatory power.

(v) **Pratapgarh:** The regression coefficient of lagged area under arhar is found to be significant at 1% level with -0.71 value. The area under the crop is increasing but at a decreasing rate than the last year. The other important shifters are lagged yield of arhar and relative price significant at 5% level with values -0.272 and 0.026 respectively. The negative relation in case of lagged yield implies that as there was an increase in yield last year there is decrease in the area allocated this year under arhar. The positive relation of relative price implies that a percent increase in the relative price will induce farmers to increase area by 0.026%. That is, farmers would allocate their limited land resources to that crop enterprise towards which the relative price movements tend to be favourable. In case of gram the lagged area coefficient -0.549 was significant at 1% level which implies that as the area increased by 1% last year there was decrease in area under gram by 0.549%. The regression coefficient of relative yield is -0.039 significant at 5% which implies that one% increase in the relative yield will induce farmer to decrease area under the main crop by 0.039%. The regression coefficient of irrigated area under gram is -0.265 significant at 1% level and irrigated area under competing crop i.e. rapeseed and mustard is 0.1 significant at 10% level. The rest of the variables were non significant.

(vi) **Varanasi:** The regression coefficient of lagged area under arhar 0.454 is found to be significant at 1% level which implies that if there was an increase in last year's area by one percent there will be increase in current year area allocation by 0.454%. The area under the crop is increasing but at a decreasing rate than the last year. The regression coefficient of lagged price is 0.065 significant at 5% level. So the lagged price has a positive influence on the farmer while taking decision about the area allocation. The regression coefficient of lagged yield of masoor which is a competing crop is 0.26 significant at 1% level and implies that with the increase in yield of competing crop by one percent there will be increase in the area allocated under the main crop by 0.26%. The regression coefficient of monsoonal rainfall is -0.095 significant at 5% level and for dummy variable it is -0.266 significant at 1% level. In case of rainfall the negative relation implies that as there is an increase in the rainfall farmer will allocate the land under some other remunerative enterprises since the pulse crops are grown only for consumption and not for profit earning purpose. In case of gram the coefficient of lagged area under gram is -0.838 significant at 1% level which implies that as there is an increase in area last year there will be decrease in area by 0.838%. The other important shifters are lagged yield of rapeseed and mustard with the coefficient 0.278 significant at 5% level and monsoonal rainfall with -0.003 significant at 5% level and irrigated area under main crop with -0.186 coefficient significant at 5% level. The rest of the variables are non significant.

(vii) **Ghazipur:** The regression coefficient of lagged area under arhar is found to be significant at 1% level with 0.436 value which implies that as the area under arhar was increased by one percent the area under it this year will increase by 0.436%. The area under the crop is increasing but at a decreasing rate than the last year. The coefficient of the lagged price of the competing crop masoor is -0.158 significant at 5% level which implies that if there will be increase by one% in the price of competing crop there will be decrease in area under arhar by 0.158%. The regression coefficient of lagged yield is -0.109 which implies that increase in yield of the main crop by one percent will decrease in the area allocated under arhar by 0.109% since the farmer grow pulse crops only for consumption purpose so the surplus yield will have no meaning for him. So he will allocate the area under some other remunerative crop. The lagged yield of competing crop i.e masoor is 0.125 significant at 5% level. The relative yield coefficient is 0.048 significant at 5% level which implies that one percent increase in relative will decrease the area under arhar by 0.048%. The rest of the variables are non significant.

(viii) **Jaunpur:** The regression coefficient of lagged area under arhar 0.449 is found to be significant at 1% level which implies that if there was an increase in the area under the crop last year by one percent there will be increase in area by 0.449% this year. The area under the crop is increasing but at a decreasing rate than the last year. The regression coefficient of irrigated area under arhar is -0.108 significant at 1% level. The negative relation implies that if there is an increase in irrigated area the farmer will allocate the land to some other remunerative crops rather than allocating it to the pulse crop. The regression coefficient of irrigated area under the competing crop i.e. masoor is 0.067 significant at 1% level which will have a positive influence on the farmer will allocating the land. The regression coefficient of the

dummy variable is 0.075 significant at 10% level which implies that with the privatisation and globalisation there was a positive impact on the farmers decision in allocation of area under pulse crop in this region of Uttar Pradesh.

(ix) **Mirzapur:** The regression coefficient of lagged area under arhar 0.459 is found to be significant at 1% level which implies that if there was an increase in area under arhar last year by one percent then there will be increase in area this year by 0.459%. The area under the crop is increasing but at a decreasing rate than the last year. The coefficient of lagged price of arhar is 0.078 significant at 5% level which implies that the price will have a positive effect on decision of the farmer related to area allocation under arhar. The regression coefficient of lagged yield is -0.084 which implies that increase in yield of the main crop by one percent will decrease in the area allocated under arhar by 0.084% since the farmer grow pulse crops only for consumption purpose so the surplus yield will have no meaning for him. So he will allocate the area to some other remunerative crop. The rest of the variables are insignificant.

(x) **Deoria:** The regression coefficient of lagged area under arhar 0.603 is found to be significant at 1% level which implies that if there was an increase in area under arhar last year by one percent then there will be increase in area this year by 0.603%. The area under the crop is increasing but at a decreasing rate than the last year. The coefficient of lagged price of arhar is 0.036 significant at 5% level which implies that the price will have a positive effect on decision of the farmer related to area allocation under arhar. The relative price is 0.049 significant at 5% level which implies that if there is an increase of one percent in relative price then there will be an increase in the area by 0.049%. The irrigated area is -0.196 significant at 5% level. This negative relation shows that with the increase in irrigated area the farmer will shift the area from pulses to some other important enterprise that require irrigation. The rest of the variables are non significant.

(xi) **Basti:** The regression coefficient of lagged area under arhar is found to be significant at 1% level with 0.285 value which implies that if there was an increase in the area of arhar last year by one percent then this year there will be increase in area by 0.285%. The area under the crop is increasing but at a decreasing rate than the last year. The regression coefficient of lagged price is 0.019 significant at 5% level. So the lagged price will have a positive influence on the decision of famer in allocation of land. The relative price is 0.013 significant at 5% level which indicates that the farmer of this region will respond favourably to the relative price. The regression coefficient of irrigated area is -0.748 significant at 5% level. This indicates that the farmer will shift the area under the main crop to some other crops if the irrigation facilities will improves. This shows that pulse crops are mainly meant for consumption for the farmers. The regression coefficient of monsoonal rainfall is -0.064 significant at 10% level. So as the rainfall amount will increase the under will get shifted to other crops. The rest of the variables are insignificant.

(xii) **Faizabad:** The regression coefficient of lagged area under arhar 0.626 is found to be significant at 1% level which indicates that if there was increase in the area under by one percent in the last year then there will be increase in the current area under arhar by 0.626%. The area under the crop is increasing but at a decreasing rate than the last year. The regression coefficient of lagged price of arhar 0.083 significant at 5% level which implies that price will have a favourable impact over the decision of farmer regarding area allocation under arhar. The relative price is 0.023 significant at 5% level which implies that with an increase of percent rupee in relative price there will be an increase in the area under by 0.023%. The regression coefficient of irrigated area under competing crop i.e. masoor is -0.55 significant at 5% level indicates a negative influence on the farmer's decision. The coefficient of monsoonal rainfall is -0.185 significant at 5% level indicates that as the rainfall will increase there will be decrease in the area under arhar. The regression coefficient of irrigated area under masoor is 0.505 significant at 5% level. The rest of variables are insignificant.

(xiii) **Sultanpur:** The regression coefficient of lagged area under arhar 0.72 is found to be significant at 1% level which indicates that if there was an increase in area under arhar by one percent last year then there will be increase in area in current year. The area under the crop is increasing but at a decreasing rate than the last year. The regression coefficient of lagged price of arhar 0.031 is found to be significant at 5% level which indicates that there is a positive relation between last year's price and area under main crop this year. The regression coefficient of relative price is 0.014 significant at 5% level which means that if there is an increase by one rupee in relative price then it will induce farmers to increase area under arhar by 0.014 hectare. The regression coefficient of irrigated area under masoor is 0.136 and dummy variable is 0.122 all significant at 5% level. The significance of dummy variable indicates that privatisation and globalisation have a positive impact on the farmer's decision in area allocation.

(xiv) **Gonda:** The regression coefficient of lagged area under arhar 0.781 is found to be significant at 1% level which implies that if there was an increase in area last year by one percent the there will be increase in area this year by 0.781%. The area under the crop is increasing but at a decreasing rate than the last year. The regression coefficient of lagged price of arhar is 0.298 significant at 5% level which implies that the last year price have favourable impact on the present year's area allocation. The regression coefficient of monsoonal rainfall significant at 10% level -0.078 indicates that as the rainfall will increase there will be decrease in the area under arhar. The rest of the variables are insignificant.
(xv) Mau: The regression coefficient of lagged area under arhar 0.608 is found to be significant at 1% level which implies that if there was an increase in area last year by one percent the there will be increase in area this year by 0.608%. The area under the crop is increasing but at a decreasing rate than the last year. The regression coefficient of monsoonal rainfall is -0.054 significant at 10% level. The negative relation implies that if there is increase in rainfall then the farmer will allocate the area to other remunerative crops so as to gain profit. The rest of the variables like price of arhar, price of competing crop, yield of main and competing crop, relative price and relative yield, irrigated area under both the crops and dummy variables are found to be insignificant.

(xiv) **Gonda:** The regression coefficient of lagged area under arhar 0.781 is found to be significant at 1% level which implies that if there was an increase in area last year by one percent the there will be increase in area this year by 0.781%. The area under the crop is increasing but at a decreasing rate than the last year. The regression coefficient of lagged price of arhar is 0.298 significant at 5% level which implies that the last year price have favourable impact on the present year's area allocation. The regression coefficient of monsoonal rainfall significant at 10% level -0.078 indicates that as the rainfall will increase there will be decrease in the area under arhar. The rest of the variables are insignificant.
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(xvi) **Gorakhpur:** The regression coefficient of lagged area under arhar 0.409 is found to be significant at 1% level which implies that if there was an increase in area last year by one percent the there will be increase in area this year by 0.409%. The area under the crop is increasing but at a decreasing rate than the last year. The regression coefficient of lagged price of arhar is 0.03 significant at 5% level which implies that the last year price have favourable impact on the present year's area allocation. The regression coefficient of lagged price of masoor is -0.158 significant at 5% level indicates a positive relation between last year's price and this year's area under arhar. The regression coefficient of irrigated area under arhar is -0.583 significant at 5% level. This indicates that the farmer will shift the area under the main crop to some other crops if the irrigation facilities will improve. The regression coefficients of lagged yield of arhar is 0.7 and monsoonal rainfall is -0.101 both significant at 10% level. The rest of the variables are non significant.

(xvii) **Shravasthi:** The regression coefficient of lagged area under arhar 0.67 is found to be significant at 1% level which implies that if there was an increase in area last year by one percent the there will be increase in area this year by 0.67%. The area under the crop is increasing but at a decreasing rate than the last year. The regression coefficient of lagged price of arhar is 0.092 significant at 5% level indicates a positive relation between last year's price and this year's area under arhar. The regression coefficient of irrigated area under masoor is 0.03 significant at 5% level and monsoonal rainfall is -0.047 at 10% level. The negative relation between rainfall and current year's area indicates that as the rainfall will increase there will be decrease in the area under arhar. The rest of the variables are insignificant.

Analysis of short run and long run elasticities

The results are presented in table 3 and 4. The estimates of elasticity of supply and coefficients of adjustment for all the districts of Uttar Pradesh are presented in table 4.2. The coefficient of adjustment indicates the nature of adjustment of the acreage that farmer make response to changing circumstances. These estimates will provide an objective measure of response and adjustment behaviour at district level.

(i) **Allahabad:** In case of arhar the coefficient of adjustment is 0.523. The short run and long run elasticities obtained from the regression coefficient of one year lagged prices are found to be -0.0082 and -0.015

respectively. It indicates that the farmers are not price responsive. In case of gram beta coefficient is 0.42. The short run and long run elasticities are 0.0598 and 0.1422 respectively. The elasticites were turned out to be positive wherever price had positive impact on hectareage. However, the magnitudes of the values of both the short and long-run price elasticities were minimal and inelastic except in case of long run elasticity of gram.

(ii) **Azamgarh:** In case of arhar the coefficient of adjustment is 0.144. The short run and long run elasticities are 0.0096 and 0.0667 respectively. The elasticites were turned out to be positive wherever price had positive impact on hectareage. However, the magnitudes of the values of both the short and long-run price elasticities were minimal and inelastic.

(iii) **Behraich:** In case of arhar the coefficient of adjustment is 0.861. The short run and long run elasticities are 0.0158 and 0.0184 respectively. In case of gram the coefficient of adjustment is 0.528. The short run and long run elasticities are 0.0148 and 0.0281 respectively. In both the cases elasticities are minimal. The difference between the short and long run is very less in case of arhar which implies that farmers do not take much time to respond to the change in prices.

(iv) **Balia:** The coefficient of adjustment is 0.694. The short and long run elasticities are 0.0437 and 0.0631 respectively. The elasticites were turned out to be positive wherever price had positive impact on hectareage. The magnitudes of the values of both the short and long-run price elasticities were minimal and inelastic

(v) **Pratapgarh:** The coefficient of adjustment is 0.29. The short and long run elasticities are 0.024 and 0.084 respectively. In case of gram the coefficient of adjustment is 0.451. The short and long run elasticities are 0.0052 and 0.011. Positive relation indicates the price responsive behaviour of farmers.

(vi) **Varanasi:** In case of arhar the coefficient of adjustment is 0.546. The short run and long run elasticities are 0.0104 and 0.0191 respectively. In case of gram the coefficient of adjustment is 0.162. The short run and long run elasticities are 0.015 and 0.094 respectively. Positive relation indicates the price responsive behaviour of farmers.

(vii) **Ghazipur:** The coefficient of adjustment is 0.564. The short and long run elasticities are 0.00036 and 0.0006 respectively. The very low values of elasticities indicate that they farmers are highly inelastic towards price changes.

(viii) **Jaunpur:** The coefficient of adjustment is 0.551. The short and long run elasticities are 0.00542 and 0.00984 respectively. Positive relation indicates the price responsive behaviour of farmers but the values are very low which implies the case of inelasticity.

(ix) **Mirzapur:** The coefficient of adjustment is 0.541. The short and long run elasticities are 0.00572 and 0.0105 respectively. Positive relation indicates the price responsive behaviour of farmers.

(x) **Deoria:** The coefficient of adjustment is 0.397. The short and long run elasticities are 0.0101 and 0.0255 respectively. Positive relation indicates the price responsive behaviour of farmers.

(xi) **Basti:** The coefficient of adjustment is 0.715. The short and long run elasticities are 0.00247 and 0.00345 respectively. Positive relation indicates the price responsive behaviour of farmers but the values are very low which implies the case of inelasticity.

(xii) **Faizabad:** The coefficient of adjustment is 0.374. The short and long run elasticities are 0.0134 and 0.036 respectively. Positive relation indicates the price responsive behaviour of farmers.

(xiii) **Sultanpur:** The coefficient of adjustment is 0.28. The short and long run elasticities are 0.00311 and 0.0111 respectively. Positive relation indicates the price responsive behaviour of farmers.

(xiv) **Gonda:** The coefficient of adjustment is 0.219. The short and long run elasticities are 0.0393 and 0.1794 respectively. Positive relation indicates the price responsive behaviour of farmers

(xv) **Mau:** The coefficient of adjustment is 0.392. The short and long run elasticities are 0.1925 and 0.491 respectively. Positive relation indicates the price responsive behaviour of farmers. The long run elasticity is higher than short run elasticity.

(xvi) **Gorakhpur:** The coefficient of adjustment is 0.591. The short and long run elasticities are 0.0042 and 0.0072 respectively. Positive relation indicates the price responsive behaviour of farmers.

(xvii) **Shravasthi:** The coefficient of adjustment is 0.33. The short and long run elasticities are 0.0304 and 0.0921 respectively. Positive relation indicates the price responsive behaviour of farmers.

Demand and Supply projection

The results are presented in table 5. The household demand projection of total pulses of Uttar Pradesh was calculated as data for arhar, gram and pea separately was not available and projections were made for population, per capita income, per capita consumption and state domestic product for the year 2019-20 and 2029-30. Based on the calculation made by Kumar *et al.* (2009)

Table 1: Supply Response of Arhar for Different Districts of Eastern Uttar Pradesh

Districts/ Variables	Constant	A_{t-1} Lagged Area of main crop	P_{t-1} Lagged price of main crop	P^c_{t-1} Lagged price of competing crop	Y_{t-1} Lagged yield of main crop	Y^c_{t-1} Lagged yield of competing crop	RP_t Relative Price	RY_t Relative Yield	MR_t Monsoon Rainfall	IR_t Irrigated Area of main crop	IG_t Irrigated Area of competing crop	D Dummy variable	R^2
Allahabad	7.833	0.477***	-0.146	0.07	-0.004	0.044	-0.03	-0.065	-0.338	0.028	0.002	-0.217	0.753
Bahraich	7.1	0.139***	0.097**	-0.05	-0.416	0.468	0.106**	0.043	-0.429*	-0.105	1.308**	1.11**	0.936
Balia	25.533	0.306***	0.402**	-0.09	-0.234	1.745	0.113	-0.21	-0.994	0.127	-0.125	-0.263	0.781
Pratapgarh	2.736	0.71***	0.289	0.23	-0.272	0.043**	0.026**	-0.06	-0.047	-0.055	0.027	-0.056	0716
Varanasi	5.59	0.454***	0.065**	-0.17	-0.093	0.26***	0.012	-0.009	-0.095**	-0.006	0.012	-0.266***	0.738
Ghazipur	6.063	0.436***	0.002	-0.16*	-0.109*	0.125*	0.023	-0.048***	-0.056	-0.013	0.004	-0.9	0.98
Mirzapur	4.93	0.459***	0.078**	-0.11	-0.084**	-0.33	0.009	-0.003	-0.077	-0.002	0.006	0.101	0.745
Faizabad	2.739	0.626***	0.083**	-0.11	-0.395	0.016	0.023**	-0.042	-0.185*	-0.055*	0.505**	0.119	0.96
Sultanpur	2.791	0.72***	0.031**	-0.11	-0.018	0.149	0.014**	-0.013	-0.06*	-0.003	0.136**	0.122**	0.897
Gonda	1.52	0.781***	0.298**	-0.21	-0.204	0.211	0.006	-0.003	-0.078*	-0.002	0.091	0.015	0.906

*: Significant at 10.0 per cent level of significance

**: Significant at 5.0 per cent level of significance

***: Significant at 1.0 per cent level of significance

Table 2: Supply Response of Gram for Different Districts of Eastern Uttar Pradesh

Districts/ Variables	Constant	A_{t-1}	P_{t-1}	P^c_{t-1}	Y_{t-1}	Y^c_{t-1}	RP_t	RY_t	MR_t	IR_t	IG_t	D	R^2
Allahabad	3.72	0.58***	0.176**	-0.07	-0.103	-0.026	0.057**	-0.016	-0.052*	-0.032	0.125	0.475	0.978
Azamgarh	1.572	0.856***	0.104	-0.24	-0.103	0.028	0.016**	-0.05	-0.052*	0.037	0.081	0.037	0.997
Deoria	2.243	0.603***	0.036**	-0.01	-0.025	0.077	0.049**	-0.027	-0.027	-0.196**	-0.028	0.124	0.994
Basti	-1.447	0.285***	0.019**	-0.02	-0.062	0.068	0.013**	-0.017	-0.064*	-0.748***	0.047	0.069	0.998
Gorakhpur	-0.727	0.409***	0.03**	-0.16**	0.7*	0.146	0.016	-0.008	-0.101*	-0.583***	0.143**	0.052	0.997
Jaunpur	5.297	0.449***	0.061	-0.1	-0.007	0.302	0.014	-0.014	-0.029	-0.108***	0.067***	0.075*	0.993
Bahraich	7.624	0.472	0.196	-0.05	-0.814**	0.24*	0.101**	0.029	-0.741**	-0.902***	0.494**	0.456	0.957
Pratapgarh	2.938	0.549	0.039**	-0.11	-0.02	0.106	0.01	-0.039**	-0.024	-0.265***	0.1*	0.02	0.967
Varanasi	0.043	0.838	0.175**	-0.16	-0.107	0.278**	0.004	-0.027	-0.003**	-0.186*	0.012	0.104	0..982

*: Significant at 10.0 per cent level of significance

**: Significant at 5.0 per cent level of significance

***: Significant at 1.0 per cent level of significance

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Table 3: District-wise Short-run and Long-run Elasticity of Arhar, Eastern Uttar Pradesh

Districts	Beta (1-C*)	Short Run Elasticity	Long Run Elasticity
Allahabad	0.523	-0.008231316	-0.015738654
Bahraich	0.861	0.015859602	0.018419979
Balia	0.694	0.043796195	0.063106909
Pratapgarh	0.290	0.024384648	0.084084995
Varanasi	0.546	0.010466047	0.019168584
Ghazipur	0.564	0.000368865	0.000654016
Mirzapur	0.541	0.005727606	0.010587073
Faizabad	0.374	0.013470476	0.036017315
Sultanpur	0.280	0.003117093	0.011132476
Gonda	0.219	0.039309671	0.179496213

*: Coefficient of lagged area of arhar

Table 4: District-wise Short run and Long run Elasticity of Gram, Eastern Uttar Pradesh

Districts	Beta (1-C*)	Short Run Elasticity	Long Run Elasticity
Allahabad	0.420	0.059753225	0.142269584
Azamgarh	0.144	0.009618629	0.066796037
Basti	0.715	0.002473846	0.003459924
Deoria	0.397	0.010138578	0.02553798
Gorakhpur	0.591	0.004299241	0.00727452
Jaunpur	0.551	0.005425362	0.009846392
Bahraich	0.528	0.014874359	0.028171134
Pratapgarh	0.451	0.005249649	0.01164002
Varanasi	0.162	0.015325596	0.094602444

*: Coefficient of lagged area of gram

Table 5: Demand, Supply and Gap for Pulses in Uttar Pradesh

Year	Total Pulses Demand (Million tones)	Total Pulses Supply (Million tones)	Gap (Million tones)
2020	2.07	1.6104	0.459
2030	2.87	1.3054	1.57

expenditure elasticity of pulses for rural and urban India was assumed to be expenditure elasticity of Uttar Pradesh by taking weighted average of rural and urban expenditure elasticities. By using the projected values of variables demand was obtained for the years 2019-20 and 2029-30. For the year 2019-20 the estimated demand is 1.99 million tonnes and for the year 2029-30 it is 2.31 million tonnes.

Acreage under pulses in Uttar Pradesh as a whole was projected for years 2019-20 and 2029-30 with the help of linear trend equation. In order to obtain supply in the same years the projected acreage was multiplied by estimated yield. The supply of total pulses is expected to be 1.604 million tonnes in 2019-20 and 1.305 million tonnes in 2029-2030.

Demand- Supply Scenario

The scenario presents an alarming situation by the year 2030 for pulses since the demand and supply gap is 10.13 million tonnes as demand in 2029-30 is 2.31 million tonnes and supply is merely 1.305 million tonnes. Uttar Pradesh would have to cater excess

domestic demand through import of different pulses. Since the different types of pulses are not close substitutes for consumption in India, appropriate strategies for different pulses should be followed augment their domestic supply.

Conclusion

Supply response

Results revealed that lagged area under arhar is an important determinant of supply response in all the districts of eastern Uttar Pradesh. It has a positive influence on the farmer's decision related to acreage allocation. As the area under the pulse was increased last year there was an increase in the current area.

The next important determinant is last year's price of pulse crop. It has a positive and significant response in most of the cases like Behraich, Balia, Mirzapur, Basti, Faizabad etc. So the farmers decide their area based on the price received last year. It could be noted that the price elasticities of area of arhar and gram were less in magnitude and inelastic in nature. The relatively lower values of coefficients of area adjustment in all the cases suggested that the farmers in these districts and in the eastern region in general were confronted with rigid technological and institutional constraints in the production of pulses and thus relatively longer period was needed for the adjustment of the area.

The competing crop's price lagged by one year, showed no significance in the acreage allocation except in the case of Ghazipur and Gorakhpur. But to talk about eastern Uttar Pradesh as a whole its impact is insignificant.

The yield, lagged by one year showed significant response only in four cases out of all the cases which indicates that it has minimum significance in the acreage allocation. The competing crop's yield lagged by one year is also of less significance.

The bearing of price risk on acreage was positive and significant in few regions only. At state level this picture advocates that farmers in general are not conscious of the variations in prices. The yield risk variable showed negative and significant results only in two out of all the responses which implies its insignificance.

The rainfall factor indicated the negative and significant impact in most of the regions. This implied that as the rainfall amount increases farmers change their decision to grow pulse crops. Instead they grow some other remunerative crops like rice, wheat, vegetables etc. This variable is an important determinant in determining the acreage under pulse crops as these crops have less water requirement. So when there is plenty of rainfall farmer tries to grow those crops which he is unable to grow in dry conditions.

The irrigated area under pulse crop showed negative response. This implies that when there are proper irrigation facilities then the farmers go for those crops which he was unable to grow under improper conditions. The pulse crops require less irrigation and they are less remunerative too. So their decision of area allocation under pulse crop is inversely related to the availability of irrigated area.

The competing crop's yield has no or minimal importance in acreage allocation. The dummy variable representing presence or absence of privatization and globalization was not significant. This implies that farmers do not significantly differ between pre and post liberalization and globalization. It is true that mere these reforms are not going to contribute to the strengthening of response unless the pulse crops are made more attractive by providing farmers some price incentives.

The results of supply response implies that only last year's area, monsoonal rainfall, presence of irrigation and up to some extent last year's price are important variables that farmers keep in mind while allocating area under pulse crops eastern region of Uttar Pradesh.

Short run and long run elasticity

The lower value of short and long run elasticity is indicative of the fact that farmers of this region i.e. eastern Uttar Pradesh are less price responsive or we can say that their nature is inelastic to price. The comparative closeness of long run elasticity to short run elasticity reveals a greater degree of adjustment in this region. This implies that pulses are not grown for profit purpose. It is mainly meant for family consumption. Farmers do not find this crop profitable that is why the area under it is declining. It should be made more attractive to farmers.

Demand and Supply Projection

The demand and supply projections act as indicators to policy makers to formulate their medium and long term agricultural policies. The demand and supply was projected for the years 2019-20 and 2029-30. The estimated demand for the year 2019-20 is 1.99 million tonnes and for the year 2029-30 it is 2.31 million tonnes whereas the supply is of total pulses is expected to be 1.604 million tonnes in 2019-20 and 1.305 million tonnes in 2029-2030. The present study shows the alarming situation by the year 2030 for pulses since the demand

and supply gap is 10.13 million tonnes as demand in 2029-30 is 2.31 million tonnes and supply is merely 1.305 million tonnes. Uttar Pradesh would have to cater excess domestic demand through import of different pulses. Since the different types of pulses are not close substitutes for consumption in India, appropriate strategies for different pulses should be followed to augment their domestic supply.

Policy Implications

The results obtained from the present study conducted with a view to analyze the acreage responses of different pulse crops in different districts and eastern Uttar Pradesh as a whole could be of immense use in prescribing policy measures to promote the supply of pulses. The main policy implications include:

1. There is need for more widespread and effective system of available knowledge about nutritional advantage of pulses to farmers.
2. In order to enhance the production of pulses, the on-going price policy should be directed towards assuring appropriate remunerative prices to the pulse producers of the State. Price incentives along with suitable mechanisms for management of price and yield risks can prove to be critical for new policy strategy.
3. More research and development should be encouraged in the field of pulses so as to develop new varieties; disease free varieties which can prove to be remunerative only then farmers can adopt new varieties.
4. In view of increasing demand in future there is need to raise level of production of pulses through technological change, while research and development needs emphasis. The gap in supply and demand is negative which implies that the state will have to rely on imports from some other states to meet the domestic requirement. Thus we need to have policy initiatives to increase the supply in future. Since agricultural growth is limited, imports can help improve the state's supply situation for short term only. For long term, the state will need to focus on productivity enhancement. Changes in policy will induce efficiency and can help in maintaining balance between production and demand.

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