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Technological Diversion on of Dryland Agriculture in Bundelkhand Region of Uttar Pradesh

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ABSTRACT
A study was conducted in Jhansi and Lalitpur block of Bundelkhand region of U.P. to study the technological diversion in dryland agriculture of Bundelkhand region. A total of 300 farmers were selected through simple random sampling method. Cotton, Sorghum and Bajra are main crops of this region so, technology used in cultivation of these crops is measured through technology adoption index and to quantify the nature of functional technology Cobb-Douglas production functional form is used. Study of the impact of technology diversification on the employment of female labour is also done.
Keywords *: Bundelkhand, Agriculture, Technology Diversification, Women.*

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INTRODUCTION
Around 108 million hectare of land comes under dryland agriculture in India, which includes north-western desert of Rajasthan, the plateau region of Central India, the alluvial plains of Ganga, Yamuna river basin, the central highland of Gujarat, Maharashtra and Madhya Pradesh, the rain shadow regions of Deccan in Maharashtra, the Deccan plateau of Andhra Pradesh and the Tamil Nadu highlands [1]. 50% of cotton, oilseeds and coarse cereals in the country are produced in dryland areas.

The Bundelkhand region comprising of seven districts of U.P. and six districts of M.P. state in complex, diverse, rainfed, risky, under invested, vulnerable, socio-economically heterogeneous, ethnically unique, agrarian and backward to other regions. It is hard rock area with limited or inadequate ground water resources, lacks of infrastructure, access to improved technologies, markets and inputs with low productivity [2].

Apart from its productivity impact, technological change is also an important determinant of employment in agriculture. In this paper, attention is drawn to this aspect, recognizing that women account for a sizeable proportion of the work force, and that employment effects of new technologies may well vary by gender. Our focus is on the state of Uttar Pradesh.

In particular, the objectives of this study are: (i) To develop a technology index that takes into account the various categories of technology package, (ii) To estimate production functions for various categories of technology adoption and examine how different the response functions are, (iii) To quantify the impact of technological change on productivity and (iv) To examine the impact of technological change on female labour employment in rainfed agriculture..

METERIAL AND METHODS
In order to control for differing agro-climatic conditions and differential access to new technology, a two stage stratified random sampling procedure has been followed. In the first stage, Jhansi and Lalitpur blocks were selected purposively because obtained from them and the local offices of the Agricultural Department a list of villages where the new dryland farm technologies could be adopted on a wide scale. From this list, ten villages in each block were randomly selected. We elicited information about the specifics of the dryland farm technologies appropriate to the selected villages, including details about the method of their application, from the scientists of the Regional Research Station. A list of all farmers in each of the villages was prepared and from this list, 15 farmers were selected by simple random sampling.

Every selected farmer was contacted personally to discern whether he has adopted any new technology listed as being appropriate to the village. He was retained in the adopter category if he had adopted at least one of the technologies. If not, he was replaced by another farmer (selected by simple random sampling again) who has. The process was continued until 15 adopters were identified in the village. Thus a sample of 150 adopters in each block working within the same agro-climatic conditions and access to technical information was selected.

An additional ten villages distributed in varying distances from the Regional Research Station were also selected, and the same procedure as outlined above was followed. Thus the total sample size was 300 farmers. All the sample farmers were interviewed personally to collect the required primary data, with special attention to the factors that determine the adoption of a set of technological practices.

TECHNOLOGY ADOPTION INDEX

In principle, the new farm technologies developed at the Regional Research Station, Jhansi Research Station, Lalitpur, meet the twin goats of both higher productivity and more employment. However the full potential of the new technologies is rarely raised; there is a gap in the adoption of technology and consequently a gap in yields as well.

Variations in agricultural productivity in different states across the country are mainly due to large differences in the level of adoption of selected agricultural technologies and the underlying determinants of adoption of these technologies [3]. We therefore first attempt to quantify technology adoption in a departure from much of the available literature, technology here is measured in multivariate terms. We incorporate the fact that the technology package may include improved practices rather than the application of a new input. In doing so, we recognize that there are several components of technology not all of which may be adopted due to factors such as the perceptions of farmers on their relative importance, and the scarcity of resources. Thus, we obtained information, on the following ten components of the package: (i) disc ploughing (per cent of area covered, number of times), (ii) summer ploughing (per cent of area covered), (iii) drought-tolerant variety (per cent of area covered), (iv) seed rate (kg/hectare), (v) seed treatment (culture pockets per hectare/potassium chloride mix/hectare), (vi) gorru sowing (percent of area covered), (vii) organic manure (tones/hectare), (viii) chemical fertilizers (nutrient value in kilograms per hectare), (ix) plant protection chemicals (Rupees per hectare), (x) mixed/intercropping (per cent of area covered).

Then, for each of the above ten components, the actual level of use is expressed as a percentage of the levels recommended on the basis of adoptive trials conducted by the Department of Agriculture, Government of Tamil Nadu. To aggregate these individual components into a single measure of technology adoption, we use cost shares as weights that is the cost of adopting the component expressed as percent of the total cost of adopting all ten components to achieve the standard yield. We term this the Technology Adoption of a package of technology practices for each crop. Its value would vary across the farms depending on the deviation of actual practices from recommended practices. The Technology Adoption Index is then used to classify the farms into three groups (a) poor adopters with TM of 1.00 to 33.33 called Low Technology Adopters (LTA), Moderate Technology Adopters with TM of 33.34 to 66.66 (MTA) and High Technology Adopters with TM of 66.67 or above (HTA). An alternative classification-of farms with TAT less than 50 constituting one group, and those with TA greater than 50 a second group-is also used in some of the econometric work to conserve degrees of freedom.

PRODUCTION FUNCTIONS

The economic definition of technology is based on the production function which in turn defines that maximum output obtainable from a given level of inputs. Technological change, in this approach, is defined as the shift in the production function or a creation of a new production function [4].

To quantify the nature of the production technology, we use the Cobb Douglas functional form. As a first step, we use the entire sample of 300 farmers for each of the major crops. Such estimation enables product with input price. In our estimation, we abstract from the well-known problems of endogeneity and aggregation. In logarithmic terms, the production function for each crop is specified as.

$$\text{In } Y = \text{In } A + \beta \text{ In } Se + \beta_2 \text{ In } Fm + \beta_3 \text{ in } FM + \beta_3 \text{ in } NF + \beta_4 \text{ in } HI + \beta_6 \text{ in } BI + \beta_7 \text{ in } MP + \beta_8 \text{ in } Pp + \beta_9 \text{ in } Fs + \beta_{10} \text{ in } Mc + u$$

Where,

Y = yield (kg/ha),

Se= seed rate (kg/ha),

Fm = organic manure (t/ha),

Nf = Nitrogen fertilizers (kg/ha),

Pf = Phosphorus fertilizers (kg/ha),

HI = Labour (man-days/ha),

BI = Bullock power (pair-days/ha),
Mp = Machine power (hours/ha),
Pp = plant protection (Rs./ha),
Fs = Size of farm in ha.
Mc = Mixed cropping (Proportion of area put to mixed crop/intercrop),
u = random error term.

Data problems precluded the disaggregation of the labour in put by gender. Therefore, descriptive evidence of trends in female employment has been provided in a separate section.

Cases of zero-values of some input variables in production studies often arise in agricultural economics. By using a dummy variable, associated with the incidence of the zero observations, the appropriate parameters of Cobb-Douglas production functions can be estimated in an unbiased way [5]. An additional advantage of using the Cobb-Douglas formulation is that it is possible to undertake a decomposition exercise where the difference between two estimated functions (between low and high technology adopters, for example) can be attributed to neutral shifts in technological parameters (changes in the constant and response coefficients) as well as changed levels of input use. The technology component thus represents the increase in productivity that may be realized without the increased application of inputs. Therefore, as a second step, we estimated separate production functions for low and high technology adopters. To conserve degrees of freedom, we aggregated some of the inputs, and also reconstituted the groups to consist only of two; with group one consisting of farmers with TM less than 50, and group two, those whose TAT exceeded 50 (as noted earlier).

RESULTS AND DISCUSSION

QUANTIFYING THE IMPACT OF TECHNOLOGICAL CHANGE

Cotton is the principal crop in the study area, accounting for 41 per cent of the cropped area, and cultivated by 58 per cent of all farmers. Sorghum (cholam) and bajra (cumbu) rank next; in all the three crops accounted for 73 percent of the total cropped area of the sample farms. We therefore focus on these three crops alone.

It is important to not at the outset that the relative importance of these crops in the cropping pattern varies significantly across adoption groups. Among the LTA farmers, food crops (sorghum, bajra and cotton) occupied 92 per cent of the crop area; these farmers are thus primarily subsistence-oriented. It is only among the MTA and HTA groups the cotton is cultivated to an appreciable extent. Relative to sorghum and bajra, cotton is far more remunerative. In fact, among the latter two groups, there is also appreciable area under coriander, sunflower, soybean and gingelly. The percentage of area devoted to non-food crops (including cotton) was 55 per cent among the MTA, and 75 per cent among the HTA. Crop diversification especially into non-food crops, is thus strongly correlated with technology adoption.

COTTON

The estimated parameters of the Cobb-Douglas production function for cotton based on pooled data are presented in Table 1. The magnitudes of the response negative coefficients associated with seed and bullock labour are in-significant. These is some evidence of constant returns to scale (the sum of elasticities is 0.978). A comparison of the marginal products (MP) with the ratio of input to output price (R) suggests they are approximately equal (MP1.3; R1.25).

Table 1: Cotton Cobb-Douglas production function estimates

Technology adopters	Pooled data	Low technology adopters	High
Seed (kg/ha)	-0.025 (0.018)		
Farm yard manure (t/ha)	0.032 (0.016)		
Nitrogenous fertilizer (kg/ha)	0.3 94 (0.092)		
Phosphatic fertilizer (kg/ha)	0.157 (0.125)		
Labour (person-days/ha)	0.356 (0.089)	0.328 (0.109)	0.359 (0.167)
Bullock labour (pair-days/ha)	-0.014 (0.033)		
Machine labour (hours/ha)	0.03 7 (0.018)		
Plant protection (Rs./ha)	0.047 (0.069)		
Farm size (ha)	0.008 (0.008)		
Mixed cropping (per cent)	0.014 (0.027)		
Capital (aggregate)		0.237 (0.142)	0.274 (0.163)
Fertilizer and manure		0.362 (0.063)	0.339 (0.183)
R-squared	0.59	0.54	0.58
Sample size	173	123	50

Note: Figures in parentheses are standard errors

Estimated separately for low and high technology adopters, the production function estimates suggest that the response coefficients for human labour and capital are slightly higher for the second group as compared to the first, while the reverse obtains for fertilizer and manure-in fact the t-ratio for this input is low for the second group of farmers. A Chow test also suggests that the two functions are distinct. Disaggregating the change in the two production functions (evaluated at geometric means) indicates that of the approximately 29 per cent difference in productivity between the two groups, 13 per cent was due to technology factors (including higher response coefficients) and the remaining 16 per cent was due to higher input use levels. Note once again that the technology component may be interpreted as in the increase in productivity levels that are in principle realisable without an increase in input use.

SORGHUM

The estimate production function for sorghum and the related test statistics are presented in Table 2. Many of the coefficients-including that associated with labour are not significant. Among those inputs with significant parameter estimates there is evidence that seed rates are being used in optimally, for the seed MP (0.88) is strictly less than its R (1.13). The reserve inequality obtains with nitrogenous fertilizer (IVIP=2.8; R=1.8) suggesting that the farmers would benefit by expanding its use.

Estimated separately for low and high technology adopters, the production function estimates for the second group (high technology adopters) are not well determined, with only one input-fertilizers and manure-being statistically significant.

Table 2: Sorghum Cobb-Douglas production function estimates

Technology adopters	Pooled data	Low technology adopters	High
Seed (kg/ha)	-0.022 (0.010)		
Farm yard manure (t/ha)	0.099 (0.345)		
Nitrogenous fertilizer (kg/ha)	0.345 (0.140)		
Phosphatic fertilizer (kg/ha)	0.164 (0.142)		
Labour (person-days/ha)	0.216 (0.128)	0.185 (0.083)	0.250 (0.272)
Bullock labour (pair-days/ha)	-0.005 (0.006)		
Machine labour (hours/ha)	0.049 (0.034)		
Plant protection (Rs./ha)	0.020 (0.023)		
Farm size (ha)	0.004 (0.002)		
Mixed cropping (per cent)	0.025 (0.057)		
Capital (aggregate)		0.237 (0.142)	0.331 (0.621)
Fertilizer and manure		0.362 (0.063)	0.203 (0.095)
R-squared	0.52	0.54	0.59
Sample size	68	123	42

Note: Figures in parentheses are standard errors

The insignificance may be on account of multicollinearity between the various inputs, the estimates for the first group are most sensible with only the capital input coefficient being insignificant, the Chow test does indicate that the parameters of the two functions are indeed distinct; however, given the ill-determined nature of the estimates in the second group, we do not present results of the decomposition exercise, although these are available with the authors on request.

BAJRA:

The results for bajra are presented in Table 3. Three of the inputs have statistically significant coefficients nitrogen fertilizer, human labour and machine labour. As noted earlier, the insignificance of the remaining coefficients may well be due to collinear nature of the data set. There is some evidence of constant returns to scale in bajra with the sum of elasticities amounting to 0.95. The MP for human labour (at 7.7) is higher than the input- output price ratio R (of 7.1).

Table 3: Bajra Cobb-Douglas production function estimates

Technology adopters	Pooled data	Low technology adopters	High
Seed (kg/ha)	-0.022 (0.010)		
Farm yard manure (t/ha)	0.067 (0.063)		
Nitrogenous fertilizer (kg/ha)	0.513 (0.236)		
Phosphatic fertilizer (kg/ha)	0.097 (0.105)		
Labour (person-days/ha)	0.216 (0.103)	0.260 (0.085)	0.290 (0.284)
Bullock labour (pair-days/ha)	-0.001 (0.197)		
Machine labour (hours/ha)	0.043 (0.018)		
Plant protection (Rs./ha)	0.014 (0.211)		
Farm size (ha)	0.008 (0.005)		
Mixed cropping (per cent)			
Capital (aggregate)		0.208 (0.121)	0.240 (0.135)
Fertilizer and manure		0.411 (0.193)	0.366 (0.256)
R-squared	0.67	0.63	0.60
Sample size	92	58	34

Note: Figures in parentheses are standard errors

Disaggregating by level of technology adoption, it would appear that the constant term associated with the second group is higher than that of the first group is higher than that of the first group. However, all the coefficients in the first group (including the constant) are ill-determined. Thus, we do not report the result of the decomposition analysis, although the results are available with the authors.

TRENDS IN FEMALE LABOUR USE:

As noted earlier, data limitations precluded the inclusion of female employment in the production function estimation. However, some trends are readily apparent in the study villages. First, while overall (both male and female) labour use appears to be positively correlated with the level of technology adoption, the effect on hired female labour is particularly noteworthy. For example, in the case of cotton, the proportion of hired female labour to total labour employed increases from 48 per cent in low technology adopters (LTA) to 53 percent among high technology adopters (HTA). In India, agriculture sector employs 65 percent of all economically active women as compared to 50 percent of men according to the Census 2011. Nearly 28 per cent of the cultivators and 48 percent of the agricultural labourers in the country are women. According to the NSSO Employment and Unemployment Surveys, the share of women out of the total farmers increased from 38 percent during 1999–00 to 42 percent by 2004–05 [6].Furthermore, there appears to be a decline in the percentage of family labourparticipation with increased technology adoption, similarly participation with increased technology adoption. Similarly, in the case of sorghum, the use of hired female participation with increased technology adoption increases from 41 per cent (of total labour employed) among low technology adopters to 51 per cent among high technology adopters. There is also a decrease in the percentage of family labour participation with increased technology adoption categories in bajra is similar to that found in cotton and sorghum. The proportion of hired female labour to total labour employed goes up from 41 per cent among LTA to 46 per cent among HTA. Once again, as was the case with the other two crops, there is an inverse relationship between technology adoption and the extent of female labour participation [3-6].

There are marked gender-based differentials in wages; during the lean season, male casual wages, at Rs. 50 are twice that paid to women. During peak seasons, daily wages are much higher, but the differential persists. Thus the prevailing wage rate during peak season was Rs. 75 per day for men, and Rs. 40 per day for women, several factors contribute to this disparity. Restrictions placed on the mobility of women outside the home environs limit their ability to travel in search of higher wages. Second, bearing a disproportionate burden of domestic chores also places restrictions on time available for paid work, and the ability to seek remunerative work. Furthermore, prevalent attitudes label women's earning as merely secondary to that of men. Paradoxically through in times of stress, it is women's earnings that must sustain the household. Such periods of stress-for example when the rains fail which are not infrequent in the study area.

CONCLUSIONS AND POLICY IMPLICATIONS

One of the unique features of our study is that we construct an index of technology adoption which captures the multi-faceted nature of a technology package, and use it categories farmers as 'low' or 'high' adopters, for each of three crops. A simple production function analysis suggests that production response surfaces are indeed different for the two groups, although in some crops, important variables have insignificant coefficients. A decomposition analysis suggests that in the case of cotton, half of the difference in productivity levels between low and high technology adopters may be attributed to technical change; the other half arising out of higher input use. A comparison of marginal products with the input-output price ratio suggests that many inputs are used sub-optimally. However, the application of less than recommended doses of inputs is the characteristic of dryland farming, and occurs largely due to the presence of risky returns. The production function analysis undertaken here does not incorporate risk considerations.

Technology adoption is positively correlated with the use of female labour particularly hired labour in all three crops. This is also accompanied by a decline in the relative share of family labour, presumably because family labour is not sufficient to meet the higher labour demand associated with technology adoption.

Wages increase, as expected, during times of peak agricultural activity-with peak wages being one-and-a-half times that during the lean season. However, there are considerable wage differences among men and women, with men being paid nearly twice as much as women. Interestingly, the differential does not decline appreciable in the peak season. Unfortunately, in this study area, women's work is considered as merely secondary to that of men, even though families frequently subsist on women's earnings. The new technology appears not to have touched this fundamental inequity.

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