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Topic of the Lecture: Economic Impact of Lentil Cultivation on Marginal and Small Farm Households in Eastern India

Authors and Co-Authors:
Soumitra Chatterjee[1] Boubaker Al Bashir Dhehibi[2]
Sabyasachi Karak[3] Soumavho Hazra[3]
Rajib Nath[4] Ashutosh Sarker[5]

Speaker: Dr. Soumitra Chatterjee
Assistant Professor in Agricultural Economics
Bidhan Chandra Krishi Viswavidyalaya
Mohanpur, Nadia, West Bengal, 741252

Introduction

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- Lentil is one of the most nutritious cool season food legume crops grown around the world
- It has been a part of the human diet since the aceramic (before pottery) Neolithic times, being one of the first crops domesticated in the Near East
- Archeological evidence shows that the crop was eaten 9,500 to 13,000 years ago
- Lentil colors range from yellow to red-orange to green, brown and even black
- Lentils also vary in size, and are sold in many forms, with or without the skins, whole or split (Erskine *et. al.* 2011)
- Today, approximately half of the world's area (48.2%) under lentil cultivation is in southern Asia, where indigenous lentils are of a specific ecotype with a marked lack of variability

Lentil in World Perspective: An Overview

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- The FAO reported that the world production of lentils for calendar year 2009 was 3.917 Mt which is gone upward to 6.3 Mt in 2018, primarily coming from Canada, India, USA, Turkey and Australia (UN Food & Agriculture Organization Report 2019)

- Among the main producers, all the leading countries are showing fluctuating and varying level of production over the years. However production increases after 2014 in all the leading countries

- About a quarter of the worldwide production of lentils is from India, most of which is consumed in the domestic market

- Canada is the largest export producer of lentils in the world and Saskatchewan is the most important producing region in Canada

- Statistics Canada estimates that Canadian lentil production for the year 2018 is a record 3.2 million tons with highest per capita production of 87.0 kg

Leading Exporters Country of Lentil in World

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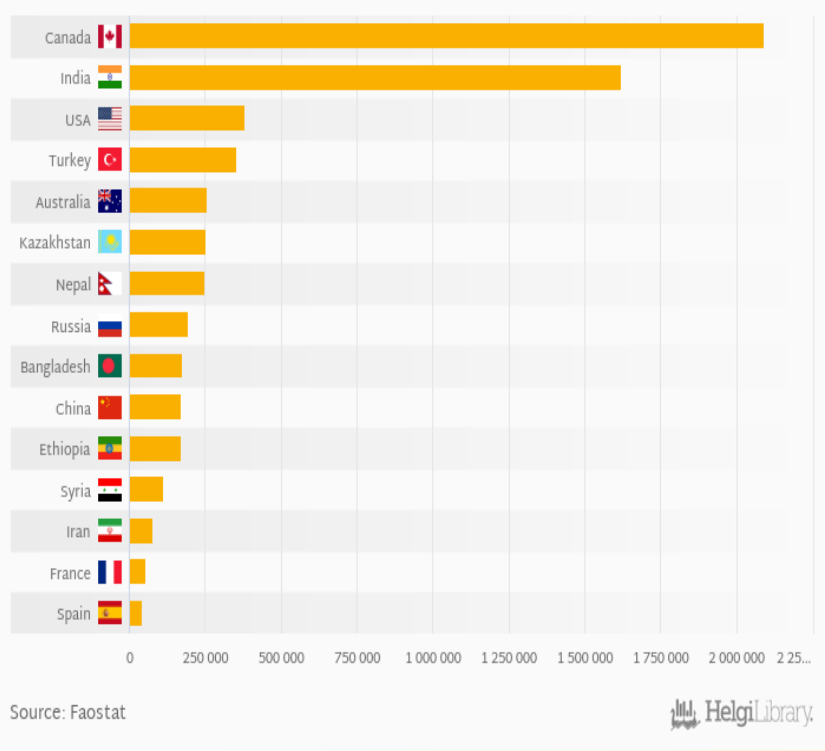
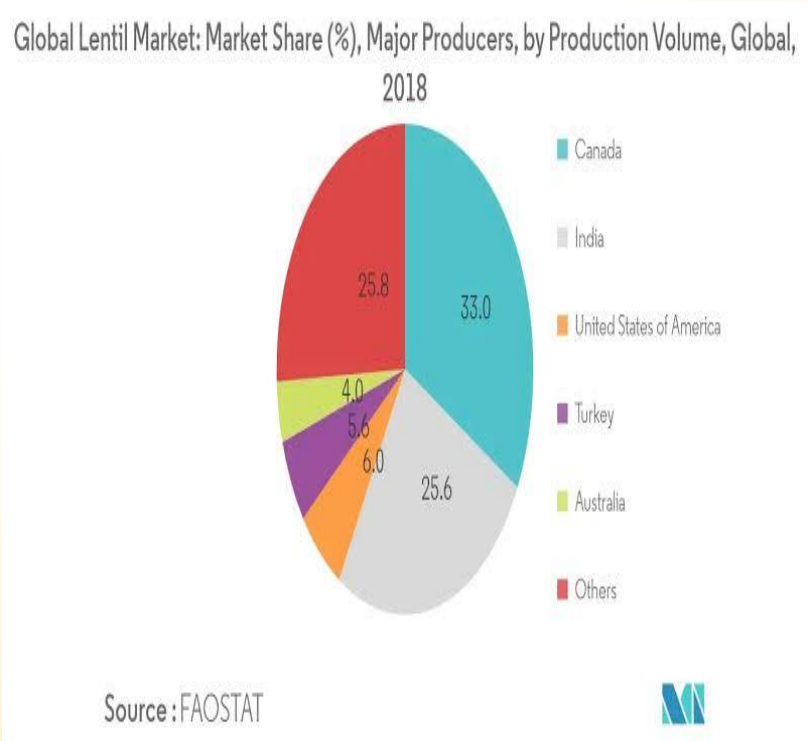
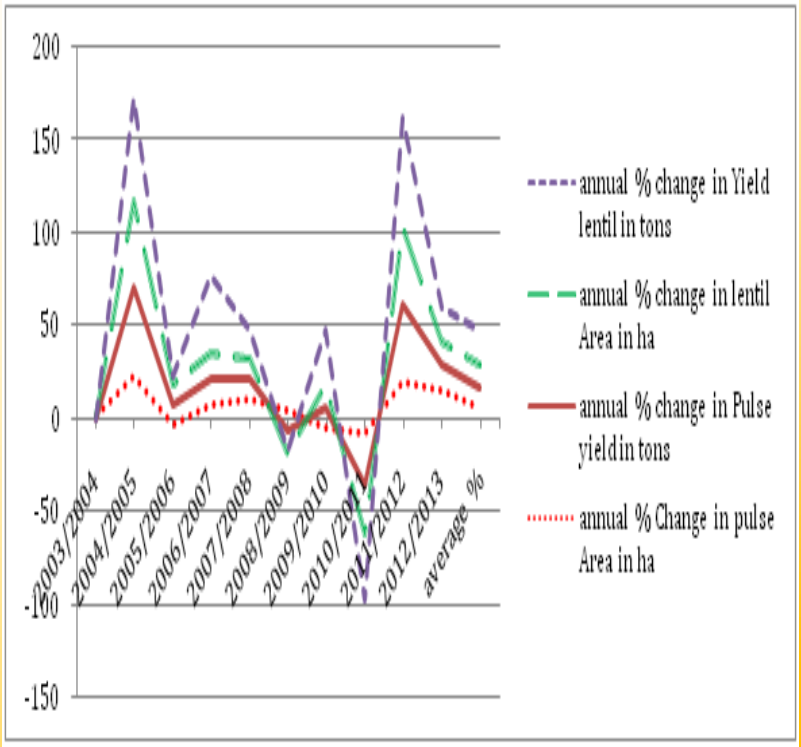
- Canada being the leading exporters of Lentil in the world comprising bulk of the share (48.2 per cent to total) followed by Turkey (11.8 per cent), Australia (10.7 per cent), United Arab Emirates (6.5 per cent) and United States of America (5.2 per cent). India rank 11th after Egypt with only 0.7 per cent export share in world

(*source: http://www.worldstopexports.com/top-lentils-exporters-by-country/*)







Lentil in India: An Overview

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- Lentil is most important pulse in *rabi* season grown mainly in Uttar Pradesh, Madhya Pradesh, Chhattisgarh, Bihar and West Bengal. These states all together account for 80-90% of the total area under lentil (1.42 million ha area with a production of 1.17 million tonnes and a productivity of 828.00 kg/ha (5-year average between 2013-14 to 2017-18)

- In Bihar, lentil production mainly comes from the districts of Patna (27722 ha), Aurangabad (13612 ha), Nalanda (12013ha) and West Champaran (10238 ha)

- The productivity of lentil is highest in Patna district (1489 kg/ ha). Major varieties which are under cultivation in Bihar are PM-5, Pant L-406, DPL-62, Arun, HULL 57 etc

- In West Bengal, lentil was grown mainly in Nadia (24135 ha), Murshidabad (16922 ha), North 24-Parganas (7844 ha) and Birbhum (5864 ha) districts of West Bengal. The maximum productivity of 1145 kg/ha comes from Murshidabad district. Major varieties under cultivation are WBL-58, B-77 etc
- The crop is generally grown as a rainfed one in West Bengal and the seeds are generally broadcast instead of being sown in line as a *paira* crop in a standing crop of rice 7 to 10 days before the rice is harvested (relay cropping)
- There is tremendous potential for growing lentil as a *paira* crop in the lower Gangetic belt of West Bengal, particularly in Nadia and Murshidabad districts

Objectives

- To evaluate the technological change in lentil cultivation prior to the initiation of ICARDA in West Bengal India (2008-09 to 2013-14)
- To assess the economic impact of lentil production with improved package of practices provided by ICARDA in this region
- To compare the differences in socio-economic livelihood status of the lentil growers under ICARDA and traditional cultivators in the region

Materials and Methods

1. Data Envelopment Analysis (DEA-Malmquist Indices)

- To evaluate the level of total factor productivity (TFP) change in lentil cultivation in West Bengal over the period 2008-09 to 2013-14 prior to the initiation of ICARDA and to disaggregate the TFP change into technical change and efficiency change DEA-Malmquist productivity indices have been performed using DEAP 2.1 software version.

- DEA is a linear programming methodology that uses data on the input and output quantities of a group of states to construct a piece-wise linear surface over the data points. This frontier surface is constructed by the solution of a sequence of linear programming problems – one for each state in the sample. The degree of technical inefficiency of each state (the distance between the observed data point and the frontier) is produced as a byproduct of the frontier construction method.

2. The Malmquist total factor productivity (TFP) index

- The Malmquist productivity index makes use of the distance functions to measure productivity change. It can be defined using input or output-oriented distance functions. This approach was first proposed by Caves et al. (1982) and later by Coelli et al. (2003a). We look only at the output-oriented Malmquist productivity index (MPI).

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Using period s technology:

$$m_o^s(q_s, q_t, x_s, x_t) = \frac{d_o^s(q_t,x_t)}{d_o^s(q_s,x_s)}$$

Using period t technology:

$$m_o^t(q_s, q_t, x_s, x_t) = \frac{d_o^t(q_t,x_t)}{d_o^t(q_s,x_s)}$$

Since there are two possible multifactor productivity (MFP) measures, based on period s and period t technologies, the MFP is defined as the geometric average of the two:

$$m_o(q_s, q_t, x_s, x_t) = [m_o^s(q_s, q_t, x_s, x_t) \times m_o^t(q_s, q_t, x_s, x_t)]^{0.5} = [\frac{d_o^s(q_t,x_t)}{d_o^s(q_s,x_s)} \times \frac{d_o^t(q_t,x_t)}{d_o^t(q_s,x_s)}]^{0.5}$$

It can be decomposed into an efficiency change and a technical change and the product is termed as the MPI.

$$m_o(q_s, q_t, x_s, x_t) = \frac{d_o^s(x_t,q_t)}{d_o^s(x_s,q_s)}[\frac{d_o^s(x_t,q_t)}{d_o^t(x_t,q_t)} \times \frac{d_o^s(x_s,q_s)}{d_o^t(x_s,q_s)}]^{0.5}$$

The first part of the product $\frac{d_o^s(x_t,q_t)}{d_o^s(x_s,q_s)}$ is due to the efficiency change of the farmer and the second part $[\frac{d_o^s(x_t,q_t)}{d_o^t(x_t,q_t)} \times \frac{d_o^s(x_s,q_s)}{d_o^t(x_s,q_s)}]^{0.5}$is due to the technical change of the inputs.

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A correlation and multiple stepwise regression between lentil productivity (kgha^{-1}) in West Bengal and its input use were performed in order to identify the factor most contributing towards the change in yield over the period under study (2008-09 to 2013-14).

3. Bisaliah (1976) method of decomposition

- To confer the second objective, Bisaliah (1976) method of decomposition technique has been used to compare the regression coefficient of various input use and output produced between ICARDA and traditional lentil cultivators. Allover a sum total of 507 farm households (249 number of ICARDA farmers and 258 traditional lentil growers)) were surveyed and taken into regression model fitting, covering six major lentil producing districts in the lower gangetic belt of West Bengal, India.

- To sort out the contribution of technology and resource use differences from the total productivity difference between using the improved package of practices and traditional lentil cultivation methods the log linear production function (Cobb-Douglas production function) was specified for both technologies. Specifically:

$$Y = aX_1^{b1}X_2^{b2}X_3^{b3}X_4^{b4}X_5^{b5}X_6^{b6}\ X_7^{b7}u_i \qquad (1)$$

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The production function was specified on a per hectare basis since the purpose is to compare productivity differences per hectare. Where

Y is the lentil yield (kg/ha)
X1 is the quantity of seed used (kg/ha)
X2 is the quantity of NPK used (kg/ha)
X3 is the quantity of Organic Manure used (kg/ha)
X4 is the quantity of plant protection chemicals used (gm/ml/ha)
X5 is the amount of machine labour used (hour/ha)
X6 is the amount of bullock labour used (pair hour/ha)
X7 is the amount of human labour used (man-days/ha)
ui is a random disturbance term in conformity with the ordinary least squares assumptions
bi is a regression coefficient of respective parameters
a is a scale parameter or intercept.

Before proceeding with the decomposition analysis of the productivity difference between the improved packages of practice and traditional ones, it is necessary to determine whether there is a structural break or not in the production relations between improved and traditional cultivation packages. To identify this, output elasticities were estimated by ordinary least squares method by fitting the log linear regression separately for improved and traditional farmers. The pooled regression analysis was run in combination with those for the improved and traditional packages, including a dummy variable for improved technology. The dummy variable was set at 1 for improved technology and 0 for the traditional lentil cultivators.

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The following equations derived from the equations were estimated by identifying the structural break:

$\ln Y_{imp} = \ln\beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + u_{imp}$……**(2)**

$\ln Y_{trad} = \ln\alpha_0 + \alpha_1 \ln X_1 + \alpha_2 \ln X_2 + \alpha_3 \ln X_3 + \alpha_4 \ln X_4 + \alpha_5 \ln X_5 + \alpha_6 \ln X_6 + u_{trad}$…… . **(3)**

$\ln Y_{pooled} = \ln \gamma_0 + \gamma_1 \ln X_1 + \gamma_2 \ln X_2 + \gamma_3 \ln X_3 + \gamma_4 \ln X_4 + \gamma_5 \ln X_5 + \gamma_6 \ln X_6 + \gamma_7 \ln X_7 + u_{pooled}$……. **(4)**

Equation **(2)** and equation **(3)** represent the multiple regression equations for lentil cultivators using the improved technology and traditional cultivators. Equation **(4)** represents the pooled regression model, including traditional and improved cultivators and including a dummy variable (X7).

❑Decomposition and analytical model

Equations (2) and (3) were estimated using the OLS technique. Since the production function is per unit area (hectare), multi-collinearity was not a problem as indicated by the zero-order correlation matrix. Taking the difference between equations (2) and (3), performing slight algebraic manipulations, and rearranging some terms, the following decomposition model was arrived at:

$[\ln Y_{imp} - \ln Y_{trad}] = [\ln\beta_0 - \ln\alpha_0] + [\ln X_{1trad}(\beta_1-\alpha_1) + \ln X_{2trad}(\beta_2-\alpha_2) + \ln X_{3trad}(\beta_3-\alpha_3) + \ln X_{4trad}(\beta_4-\alpha_4) + \ln X_{5trad}(\beta_5-\alpha_5) + \ln X_{6trad}(\beta_6-\alpha_6)] + [\beta_1 \ln(X_{1imp}/X_{1trad}) + \beta_2 \ln(X_{2imp}/X_{2trad}) + \beta_3 \ln(X_{3imp}/X_{3trad}) + \beta_4 \ln(X_{4imp}/X_{4trad}) + \beta_5 \ln(X_{5imp}/X_{5trad}) + \beta_6 \ln(X_{6imp}/X_{6trad})] + [u_{imp} - u_{trad}]$…(5)

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3. F test

To measure the changes between traditional and improved Lentil growers, overall regression analysis with F test has been performed. If there are n data points to estimate parameters of both models from, then one can calculate the F statistic, given by:

$$F = \frac{(RSS1 - RSS2)/(p2 - p1)}{(RSS2/n - p2)}$$

4. Principal component analysis

To confer the third objective, socio-economic livelihood status of the sample farm families have been worked out based on the following parameters:

Age, Sex, Educational level, Caste, Operational Holding size (ha), Non-farm income per annum, Total valuation of assets, Gross return from crop + animal husbandry, Total consumption expenditure.

On the basis of following parameters, principal component analysis (PCA) is performed to identify the various factor contribution and variability of each component so that the sample farm households can be categorized into four distinct clusters with specific characteristic features with regards to high medium low and poor socio-economic status.

Results

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Table 1. Summary statistics of socio-economic status for the surveyed lentil cultivators (ICARDA and non-ICARDA) in West Bengal India

Parameters	Units	Districts						
		Nadia	24-Parganas (N)	Bankura	Purulia	Murshidabad	Hooghly	Overall
		Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Farmer's age	Years	52±10.92	48±7.31	44±4.91	40±4.23	44±9.40	48±12.47	48±10.44
Sex/Gender	Code	1±0.00	1±0.00	1±0.28	1±0.51	1±0.44	1±0.14	1±0.27
Education	Code	3±0.93	3±0.72	3±0.54	2±0.62	3±0.72	2±0.66	2±0.85
Religion	Code	1±0.46	1±0.20	1±0.00	1±0.00	1±0.00	1±0.14	1±0.32
Caste	Code	3±0.90	3±1.17	3±1.14	3±0.56	3±1.48	2±0.93	3±1.07
Cultivated own land	Hectare	0.76±0.56	0.73±0.53	1.05±0.80	0.69±0.19	0.75±0.64	0.81±0.74	0.80±0.63
Non-cultivated land	Hectare	0.00±0.00	0.12±0.24	0.00±0.00	0.00±0.00	0.00±0.00	0.50±0.61	0.11±0.34
Leased in land	Hectare	0.13±0.28	0.05±0.12	0.06±0.20	0.00±0.00	0.00±0.00	0.23±0.33	0.11±0.25
Leased out land	Hectare	0.05±0.24	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.01±0.09	0.02±0.15
Total operational holding	Hectare	0.83±0.51	0.90±0.49	1.11±0.77	0.69±0.19	0.75±0.64	1.12±0.81	0.88±0.61
Non-farm income	₹annum^{-1}	84223±66144	31313±29696	36692±23615	10822±2975	6938±5163	67859±120264	54670±74312
Total valuation of current assets (including land, pond, dwelling house and farm machineries)	₹annum^{-1}	2735966± 2529459	825985± 711276	763628± 543540	347043± 86853	1444502± 1213960	1138739± 1203098	1594429± 1914255
Gross return from farm enterprises	₹annum^{-1}	167947±87857	93482±43503	91076±60718	66366±18614	73280±20002	143074±143204	126054±96349
Total consumption expenditure	₹annum^{-1}	103977±29653	100738±27147	66514±30080	55783±6313	97901±12750	131633±72590	98876±46378

SD, Standard deviation
Note: Code for Sex/Gender: Male-1 Female-2 Education: Illeterate-1 Upto primary-2 High school-3 Graduate and above-4 Religion: Hindu-1 Muslim-2 Caste: Scheduled Caste-1 Scheduled Tribe-2 Other backward class-3 General-4 Others-5

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Table 2. Malmquist index summary for lentil in West Bengal (2008-09 to 2013-14)

Year	EFFCH	TECHCH	TFPCH
2009-10	1.000	1.326	1.326
2010-11	1.000	1.333	1.333
2011-12	1.000	2.066	2.066
2012-13	1.000	0.906	0.906
2013-14	1.000	1.493	1.493
Geometric mean	**1.000**	**1.376**	**1.376**

Note: EFFCH – efficiency change; TECHCH – technical change; TFPCH: – total factor productivity change

Measurement of technological change in lentil cultivation for West Bengal India during 2008-09 to 2013-14

- To evaluate the technological change in lentil cultivation prior to the impact of ICARDA in the state of West Bengal India, DEA-Malmquist TFP indices has been worked out for the state where the mean effect of technology has been recorded 1.376 for the state.
- However, the entire TFP change has been segregated into technical and efficiency change (Table 2) and it has been guided by the technical substitution of input, not by the farmers' efficiency or knowledge gaining.

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Table 3 & 4. Pearson correlation matrix between lentil productivity with various inputs used in West Bengal during 2008-09 to 2013-14 and Stepwise regression output between lentil productivity with various inputs used in West Bengal during 2008-09 to 2013-14

	Y	X_1	X_2	X_3	X_4	X_5
Y	1.000	0.831*	0.751	-0.175	0.059	0.289
		(0.040)	(0.085)	(0.741)	(0.911)	(0.579)
X_1		1.000	0.674	-0.211	-0.088	0.342
			(0.142)	(0.689)	(0.867)	(0.507)
X_2			1.000	-0.359	-0.303	-0.352
				(0.485)	(0.559)	(0.493)
X_3				1.000	0.773	0.485
					(0.071)	(0.329)
X_4					1.000	0.584
						(0.224)
X_5						1.000

Regression equation	Contributing factor	Remarks
Y = -0.235 + 0.196 X_1*	X_1: seed	Lack of quality seed is the sole contributing factor beyond the overall productivity change of lentil

*Note: * means significant at P0.05 level*

Note: Y is lentil productivity (kg/ha); X_1 is seed use (kg.); X_2 is NPK use (kg); X_3 is organic manure (Qtl.); X_4 is bullock labor (pair hour) and X_5 is human labor (hour)

Figures in the parentheses indicate the respective probability value of the correlation coefficient

** means significant at the $P_{0.05}$ level*

Table 5. Comparative Economics of Lentil cultivation in West Bengal INDIA

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Item	ICARDA	non-ICARDA	Overall
Operational Holding (Hectare)	0.91	0.68	0.88
Area under Lentil (Hectare)	0.24	0.12	0.22
Quantity seed use (kgha^{-1})	37.45±15.28	32.62±4.83	34.99±11.49
Seed cost (₹ha^{-1})	2,495/-	1,742/-	2,384/-
Quantity NPK use (kgha^{-1})	94.76±73.40	80.67±46.24	87.59±61.45
NPK cost (₹ha^{-1})	9,464/-	3,374/-	8,567/-
Quantity manure use (qha^{-1})	11.43±13.12	9.64±1.03	10.52±9.26
Manure cost (₹ha^{-1})	873/-	162/-	768/-
PPC use (g or mllit^{-1}ha^{-1})	133.00±178.22	186.05±197.70	160.00±190.06
PPC cost (₹ha^{-1})	3,998/-	8,758/-	4,699/-
Irrigation cost (₹ha^{-1})	NIL	NIL	NIL
Machine labour use (hours ha^{-1})	15.47±9.23	12.50±8.47	13.96±8.97
Machine labour cost (₹ha^{-1})	6,963/-	4,988/-	6,672/-
Bullock labour use (pair hours ha^{-1})	7.91±6.29	9.36±7.58	8.65±7.01
Bullock labour cost (₹ha^{-1})	779/-	1,343/-	862/-
Human labour use (man daysha^{-1})	90.37±43.30	97.62±56.73	94.06±50.66
Human labour cost (₹ha^{-1})	18,278/-	16,840/-	18,066/-
Total operational cost (₹ha^{-1})	42,851/-	37,208/-	42,020/-
Productivity (q ha^{-1})	10.60±6.22	7.59±2.62	9.91±5.29
Price (₹kg^{-1})	45/-	36/-	44/-
Gross return (₹ha^{-1})	56,621/-	26,735/-	52,220/-
Net return (₹ha^{-1})	13,771/-	(-)10,473/-	10,201/-
B:C ratio	1.32	0.71	1.24

Note: Mean±SD

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Table 6. Regression estimates in lentil cultivation under improved technology adoption and traditional lentil cultivation (per ha) in West Bengal INDIA

Serial number	Particulars	Parameters	Lentil growers using improved ICARDA technology	Traditional lentil growers	Pooled
1	No. of farmers observed	N	249	258	507
2	Intercept	a	0.85* (0.46)	1.32^{NS} (0.87)	0.12^{NS} (0.32)
3	Seed (kg)	X_1	-0.05^{NS} (0.08)	-0.25^{NS} (0.17)	-0.04^{NS} (0.07)
4	NPK (kg)	X_2	0.04^{NS} (0.03)	-0.01^{NS} (0.02)	0.00^{NS} (0.02)
5	Organic manure (kg)	X_3	-0.05^{NS} (0.06)	-0.28^{NS} (0.18)	-0.08* (0.05)
6	Plant protection chemicals (gm or ml. lit^{-1})	X_4	-0.05** (0.03)	-0.01^{NS} (0.04)	-0.03^{NS} (0.02)
7	Machine labour (hour)	X_5	0.33*** (0.05)	0.13*** (0.03)	0.23*** (0.03)
8	Bullock labour (pair hour)	X_6	-0.16*** (0.06)	0.08** (0.04)	-0.04^{NS} (0.03)
9	Human labour (man days)	X_7	0.30*** (0.07)	0.40*** (0.06)	0.41*** (0.05)
10	Dummy variable for pooled		-	-	0.34*** (0.04)
11	Coefficient of multiple determination	R^2	0.38	0.47	0.45
12	Adjusted R square	R^2	0.36	0.45	0.44
13	F value	F	20.85	31.29	51.09
14	F critical	F	2.05	2.05	1.96

*Note: *, **, and *** indicate significance of values at P = 0.1, 0.05 and 0.01, respectively.*
Figures in the parentheses indicate standard error of the respective coefficients.

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- F statistics appeared to be very high (51.09) as compared to critical value (1.96). Indicating significant differences between ICARDA and traditional Lentil growers

- Inspite of applying same level of input and advised technology, still some significant differences have been observed among the lentil growers under ICARDA. It may be knowledge gaining by individual cultivators that may make significant differences amongst them. R-sq value appeared to be not high (0.38), still showing significance because of large number of samples. An efficient use of machine labour and human labour have shown significant contribution and important factor for improved cultivators as compared to traditional one and has shown subsequent impact to the regression model as a whole

- Land preparation is showing some significant positive contribution on overall productivity gaining of Lentil under ICARDA, although contribution of other factors like seeds, fertilizer, manure have shown no real significant effect on the productivity of Lentil in West Bengal as a whole. PPC have a significant impact on lentil cultivation under ICARDA in the state

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Table 7. Technology decomposition of lentil cultivators under ICARDA in West Bengal INDIA

Serial no.	Particulars	Estimated level of change over traditional cultivation practices (%)
I	Total observed difference in productivity	39.72
II	Sources of output growth	
1	Due to technology difference	24.93
A	Neutral technological gap	-47.13
B	Non-neutral technological gap	72.07
2	Gap attributable to relative change in input use level weighted by the slope coefficient of productivity function	8.42
A	Seeds	-0.67
B	NPK fertilizer	0.66
C	Organic manure	-0.81
D	Plant protection chemicals	1.78
E	Machine labour	6.99
F	Bullock labour	2.77
G	Human labour	-2.29
III	Total estimated difference in productivity (1+2)	33.36
IV	Experimental Error	6.36

- There is a 33.36% estimated change in productivity over observed one (39.72%). Out of this 24.93% change was occurred due to technological change in Lentil cultivation in West Bengal.
- The change is non-neutral (exhibit +72.07%) rather than neutral (exhibit -47.13%) as the entire economy of lentil cultivation follows varying return to scale rather than constant scale of return.
- However substitution of inputs has played a significant part (8.42%) in the overall change of lentil productivity under ICARDA.
- The use of machine labour (6.99%) and bullock labour (2.77%) have shown significant positive impact on the productivity while use of surplus human labour has shown detrimental effect (-2.29%) on the overall change in productivity of lentil in the lower gangetic plains of India (Table 7).

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Table 8. Contribution of various socio-economic components among lentil farm households in West Bengal India and Table 9. Socio-economic clustering of lentil farm households in West Bengal India

Component	Eigen value	Percentage of variance	Cumulative percentage
Age	2.62	29.06	29.06
Sex	1.44	15.99	45.05
Education	1.11	12.32	57.37
Caste	0.92	10.23	67.60
Operational holding	0.79	8.81	76.41
Non-farm income	0.69	7.63	84.04
Assets	0.61	6.80	90.84
Gross return from crop	0.45	5.02	95.86
Consumption expenditure	0.37	4.14	100.00

Socio-economic cluster	Poor	Low	Medium to High
Farm households	455 (89.74%)	43 (8.48%)	9 (1.78%)

❖Nine socio-economic parameters have been taken under consideration to judge the overall livelihood status of the lentil growers.

❖They are age of the cultivator, sex, education, caste, operational holding (ha), non-farm income, total assets of the households, gross return from crop sector and total consumption income per annum.

❖ First three principal components (age, sex and education) have registered Eigen value greater than one with 57.37% cumulative variability of the dataset.

❖First four components have shown more than 60% variability of the data.

❖Age, sex and education level of the farmer became the prime contributor towards a sound cultivation practices as well as knowledge, perception, understanding in adopting newer technology and brings wisdom amongst the farming community.

❖ Entire community has been categorized into three distinct clusters where 89.74% farm households belong to poor socio-economic structure, 8.48% under low socio-economic structure and rest 1.78% farms has shown medium to high socio-economic livelihood status.

❖All over, the marginal and small farming community with operational holding less than 1.0 hectare suffers from poor and low socio-economic strata in lower gangetic plains of West Bengal India (Table 8).

Salient Findings

- Failure of NFSM in promoting pulse production, ICARDA went into act in eastern India particularly in the state of West Bengal with improved package of practices and improved technology (Chatterjee and Giri 2010)
- This is due to Lack of adequate financial flow, Inadequate delivery of the physical component of production and Lack of favorable monsoon and other weather parameters
- Development of short-duration and heat-tolerant varieties (PM-5, Pant L-406, DPL-62, Arun, HUL 57, WBL-58, B-77) and better management that have helped in improving yields of pulses in India (Suresh and Reddy, 2013)
- Transformation of pulses productivity since independence (567.0 kg/ ha in 1947-48 to 699.0 kg/ha in 2011-12) has not been registered remarkable
- ICARDA has registered lentil yield over one ton per hectare (1060.0 kg/ ha) in the state with 33.36% increase over traditional lentil growers
- Technology has contributed the major part for the massive productivity gain of lentil in West Bengal
- Proper land preparation and better disease pest management became the prime factor behind the enhancement of lentil productivity by ICARDA farm households and also the quality seed use with efficient labour management that could sustain the overall pulse production in West Bengal

Policy recommendations

- Identification of additional area by utilization of rice fallow lands (3 to 4 million ha) largely in Eastern India and which can yield around 2.5 million tones,
- Diversification of about 5 lakh ha area of upland rice, 4.5 lakh ha area of millets and 3 lakh ha area under barley, mustard and wheat, currently giving low yields can be brought under kharif/ rabi pulses, (Singh *et. al.* 2016).
- Region based recommendations of suitable lentil varieties for *paira* cropping with paddy (B-77 (Asha), B-56, K-75 (Mallika), WBL 58 (Subrata), Pant L 6, Pant L 406, Pant L 639, Subhendu(WBL 81), B-256 (Ranjan), NDL-1, WBL-77 (Moitrayee), KLS-2018, Hul-57, L-4717 (short duration)

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