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ORIGINAL ARTICLE

STOCHASTIC FRONTIER ANALYSIS FOR MEASURING TECHNICAL EFFICIENCY OF NEEM COATED UREA : EVIDENCE FROM NORTH INDIA

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Abstract : This study[1] depicts level of efficiencies of the techiniques applied by mustard farmers after implication of Neem Coated Urea (NCU) in different agro-climatic zones of Punjab and Haryana (North-Western) States of India. The Stochastic Frontier Model (with half-normal distribution) under ad-hoc truncation was used to estimate the Technical Efficiency (T.E.) The Propensity of Yield under Score Match method (PYSM) was applied to trace the role of treated NCU and other type of Urea (NCU-NT) or Farm Yard Manure (FYM). A total of 300 farmers, comprising 150 users of NCU and remaining were using other Urea, randomly selected from six districts of the studied zones. Farm-size, seeds, types of fertilizer and irrigation had significantly positive effect, labor and pesticides had insignificant negative effect on mustard yield. Farmers who used NCU were found more technically efficient than who used Urea. The T.E. level of users of NCU was found 0.228 means about 22.8 per cent and for Urea (NCU-NT) it was found 0.181 means 18.1 per cent both were at 10 per cent statistical significance level for the PYSM for mustard crops. This means farmers who are using Urea is less efficient by 4.7 per cent than those who are using NCU. A significant difference of about 16 per cent in T.E. was observed in mean estimates of technical efficiencies for NCU and Urea, which were about 64 per cent and 48 per cent respectively, under stochastic measures with an inverse count of probability weights for mustard yield. This gap in T.E. is held responsible for a significant effect on farmers income. Therefore, this study has a clear recommendation that awareness to use NCU among mustard growers should be encouraged.

Key words : Neem coated urea, Stochastic frontier, Technical efficiency, Mustard, Yield.

JEL Codes : O13, O14, O21, O33, Q12, Q18

1. Introduction

The Government of India established an appropriate regulatory institution for bio-safety, which is quite transparent and also responsible for time-bound delivery of Neem Coated Urea, since its implementation in 2014. Bio-fertilizer is an essential input to facilitate the emergence of vertical integration between input and yield output variables in high-value agriculture. Indian farmers are gradually trying to meet the international standards of agricultural production and also developing brand equity. Now, it is the time for major contribution from the public private partners and It was really very discouraging that it took a long decade time period to de-register the license for dairy and sugar industries. In many others fields too, agro-processing are still waiting, including the processing of groundnuts and mustard oil seeds, reserved for Small-Scale industries [Abdulai *et al.* (2018)]. To ensure food safety, laws need to be duly enforced to adopt ecofriendly measures to enhance the farmer's technical efficiency with Sanitary and Phyto-Sanitary (SPS) standards, which are needed to be adopted. It is also commendable to encourage the large processing facilities with adequate storage capacity. In the wake of doubling of farmers income with sustainable agricultural developmental practices along with increased technical efficiency of agricultural farmers, government of India introduced Neem Coated Urea (NCU) in 2014. This study focused on analyzing the impact of NCU[2] on farmers efficiency

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of agricultural output and adopted the stochastic production function techniques with its fixed and partial effects models as both models allow in estimation of effects in each dummy zones under different districts. It also need not to restrict any assumption in order to agro-climatic zone wise impacts and made them independent to covariates.

The zone wise dummies have been included in the regression equation to capture the zone-specific effects that are invariant over time. In terms of building yield gap bridge, technical efficiency parameters are essential to include in the model specified for enhancing productivity. According to Laha and Bengal (2013), technical efficiency was defined as a farmer's maximum possible outreach to grow the optimum level of yield output possible from presently available set of input variables and cultivation technologies. This type is highly co-related with each small farm's yield practices besides comparison to best-cropping-practices in order to measure the input-output relationship or production frontier [Birthal *et al.* (2019)]. The most suitable or best cropping practices in delivering higher yield, output frontier are established and adopted by the most technical efficient farmers [Aigner *et al.* (1977)]. Thus, the possible changes in personal or individual farm size for cropping practice from the yield frontier point of view would certainly helpful in measures the technical efficiency (TE) [Thiam *et al.* (2001)]. From cross-sectional observation, the best cropping practice for yield growth is to measuring the efficiency of input variables [Sekhar (2012a)].

Hence, the TE in this case, is a gap of actual and expected yield from change in specific input used (NCU and Urea) in different agro-climatic zones and the change in capacity yield of the crops with traditional input (Urea). Here in this case TE[3] evaluated as in ability of producing a unit (e.g., a farm) to maximize the yield with given NCU type as input variables and other input technology. According to other standard definition of technical efficiency, the TE can be a component to maximize the production and measured in product form as per allocation. Also, allocation refers to produce a level of output using area specific cost minimizing with all other input ratios. The production frontier can be used as models and developed based on farming practices [Birthal *et al.* (2020)] by classifying in type (a) parametric data and type (b) non-parametric data. Parametric production frontiers, completely depends on form of a function, can be delivered as stochastic. This study involves above mentioned approaches to resume the PSM values and to designate the coordinates of technical feasibility. The parametric approach involves specific method of estimation for a parametric yield or output function (or price function) and that representing by price minus cost for best available technology [Aigner *et al.* (1977)]. In this method a simple way for testing the hypothesis to obtain results are highly useful besides sensitive in parametric form.

The non-parametric methods are used [Farrell (1957)] and has their own profit for conducting and applying to a non-priori state of parametric conditions for the existing underlying used technology [Fare *et al.* (1985)]. The older one method is used in this article. The priori-deterministic methods has their assumption and conditions of deviation from production frontier caused by inefficiency, vice-versa in stochastic models approves for a statistical noise.

The basic problem in stochastic frontiers is of measuring noise errors, and stochastic sources of changes in input variable, is attached in single-sided factors. Due to outliers in stochastic frontier it can have a significant impact on estimates and held responsible for lower yield *i.e.* shortcoming for specification of such type of model could change to decreased efficiency estimates. The stochastic frontier model involves a priori risk factor at a higher level while composed noise error for the input-output structure with double-sided symmetric. The singular-sided factors reflect inefficiency, while the two or multiple-sided noise error holds random variable impacts exogenously in yield unit involves errors in estimating the empirical results. Presently the stochastic production frontier models delivered noise issues similar to previously deterministic or fixed DEA frontiers. Stochastic frontier models have also help in estimating standard errors and to summarise as well as to prove the significance of hypotheses, not done in deterministic approaches due to not attaining the level of certain necessary and satisfactory assumptions of maximum likelihood (ML) [Aigner *et al.* (1977)]. Some work by Chen and Song (2008) provided insights and approach for estimating single farm efficiency using the SFA model. An objection which still works as on date with SFA models is that scarcity of early information for selection of form in particular to distributional of SFA models for single-sided inefficiency error [Chavas *et al*. (2005)].

2. Model

Within the sight of agriculture information advertise rigidities as well as joint innovation of farm and non-farm practices, the fitting degree of examination is the cross-sectional family thinks about. Estimating rural yield effectiveness at single farm labor(rather the family) can not be treated valid for settings contended above for the clients and non-clients of NCU.

$$y = \beta' x_i + v - u \quad (1)$$

$$u = |U| \text{ and } U \sim N\,(NCU, NCU\text{–}NT)[0, \sigma_u^2]$$

$$\log y = \beta' x_i + v - u \quad (2)$$

$$y = \beta' x_i + v + u,\ u = |U|,\ Cost \quad (3)$$

2(a) Predictions, Residuals and Partial effects

$$(NCU, NCU\text{–}NT) e_i = y_i - \beta' x_i \quad (4)$$

Where, y_i denotes the yield output at the *NCU-T* observation (*NCU* = 1, 2, 3... *n*) for the Urea farm (*NCU-NT* = 1, 2, 3, ... *n*); x_{it} is a (1×k) vector of values of *NCU* and *NCU-NT* in mustard production function with other independent input variables, which are associated with the impact of use of *NCU* in production. The fertilizers related *TE* (i.e. *NCU*) model was independently proposed by Aigner *et al*. (1977) and the inefficiency is decomposed in the following TIE and AIE with mixing up them can produce economic inefficiency (*EIE*). (EIE = TIE×AIE). A mustard farmer is allocatively inefficient when yield took marginal hike in its physical value of total output also less or equal to marginal factor cost of mustard produce using

$$E[\upsilon|\varepsilon] = X/(1+\lambda^2)[\{\phi(\omega)/(1-\Phi(\omega))\}-\omega]\ \varepsilon = \varpi \pm \upsilon,\ \omega = \varepsilon\lambda/\sigma \quad (5)$$

$$\sigma = (\sqrt{\sigma_\varpi^2+\sigma_\upsilon^2}),\ \lambda = (\sigma_\upsilon / \sigma_\varpi) \quad (6)$$

$$E\,[y_i\,|x_i] = \beta' x_i - E\,[\upsilon_i|\beta'_i] \quad (7)$$

β' is a (1×*k*) vector of unknown or random variables, parameters estimated; the V_i are assumed to be identical with $N(0, \sigma_\upsilon^2)$ random errors, independently distributed of the U_i's [Battese and Coelli (1995)].

2(b) The Ordinary Least Square Estimator

Corrected or Modified Ordinary least squares-C/M OLS for NCU-T and NCU-NT and Starting values for the MLE. The efficiency of mustard growers expected based on the random term u_i as shown in the following Equations (8)-(10):

$$y - \beta' x + v - u,\ u - |U| \quad (8)$$

where, $y = \beta_0 + \beta'_1 x_1 + v - u$

$$y = (\beta_0 - E[u]) + \beta'_1 x_1 + v - (u - E[u])$$

$$y = a + \beta'_1 x_1 + e \quad (9)$$

$$\text{Efficiency} = \exp(-u_i) \quad (10)$$

Var[*e*] = Var [*v*] + Var [*u*] (as skewness [*e*]= Skewness [*u*]) whereas the other form in

$$m_2 = (1/n) \textstyle\sum_\iota e_i^2 \quad (11)$$

and to give the following subsequently for

$$m_3 = (1/n) \textstyle\sum_\iota e_i^3 \quad (12)$$

Both functions on the RHS are identified for the half normal and exponential models. In particular, for both (NCU-T & NCU-NT) the half normal model, the moment equation is

$$m_2 = \sigma_\varpi^2 + [1 - 2/\pi]\sigma_\upsilon^2 \quad (13)$$

The model is illustrated in Equation (14) and simplified in Equation (15).

Both functions on the RHS are identified for the half normal and exponential models. In particular, for both (NCU-T & NCU-NT) the half normal model, the moment equations are here

$$m_3 = (2/\pi)^{1/2} + [(1-4)/\pi]\sigma_\upsilon^3 \quad (14)$$

for

$$\hat{\sigma}_\upsilon = \left[\left(m_3\sqrt{(\pi/2)}\right)/(1-4)\pi\right]^{1/3} \quad (15)$$

$$\hat{\sigma}_v = \sqrt{\left[m_2 - (1-2)/\pi\right]\hat{\sigma}_x^2} \quad (16)$$

The NCU-T and NCU-NT have their expectations from their used technologies and therefore the random variables with statistical noise and errors can not be omitted in the equations derived for their technical efficiency. Equation (17) shows their level of efficiency with different NCUs

$$\hat{\alpha} = \alpha + Est\ E[u] = \alpha + \hat{\sigma}_\upsilon\sqrt{2/\pi} \quad (17)$$

In this study, an efficient mustard farm producer on its yield output possibility frontier can be represented with the following stochastic frontier model as: $U_{it}=Z_{it}\delta+W_{it}$,here Z_i is a (1 × m) vector of explanatory variables associated with NCU (N & NT) the technical inefficiency effects; δ is a (m × 1) vector of unknown parameters of NCU (N & NT) to be estimated and

W_{it} is an unobservable random variable [Kumbhakar (1987)]. The parameters of NCU (N & NT) indicated the effects of factors in Z for TE. The negative value of the coefficient of input variables indicates an efficient level of TE of the growers and vice versa.

$$\mu_1/\sigma_\upsilon = 0 \quad (18)$$

and $$\mu_2 = \sigma^2_\varpi + 1/\theta^2 \quad (19)$$

and therefore,

$$m_3 = -2/\theta^3 \quad (20)$$

Hence,

$$\therefore\ \theta = [-2/m_3]^{1/3}$$

and $$\hat{\sigma}_v = \sqrt{(m_2-1)/\theta^2} \quad (21)$$

after substracting

$$\alpha = a + 1/\theta \quad (22)$$

and $$\text{Var}[u] = [(\pi-2)/\pi]\sigma^2_u \quad (23)$$

The U_x s are non-negative arbitrary factors, related with specialized wastefulness of mustard yield, which are thought to be freely conveyed for examples for improving agricultural extension services beyond par but the random error can be depicted for reducing the standard errors in residuals of both type of NCU used by the farmers. The U_{it}s is acquired by truncation (at zero) of typical dispersion with mean, **'**Z**'** in λ and a change in μ^2 is a vector of informative factors related with specialized wastefulness of yield of mustard makers after some time, (m×1) and λ **'**Z**'** is a vector of obscure coefficients [Aigner *et al*. (1977)]. Conditions (1-23) indicate the stochastic outskirts yield work with standard structure as far as the first yield estimates. In any case, the specialized wastefulness impacts or varieties came in presence because of utilization of NCU(T and NT) kinds of compost, are thought to be an element of a lot of illustrative factors [Battese and Coelli (1995)], the **'**Z**'** and an obscure vector of coefficients of λ.

The illustrative factors which incorporates both the sorts of neem covered urea (treated and non-treated) in the inefficiency model may remember some information factors for the stochastic frontiers, ace vided the inefficiency impacts are stochastic. On the off chance that the main z-variable of the capacity under (NCU-T) produce of mustard has an estimation of one and the coefficients of all other z-factors (NCU-NT) are zero, at that point in these cases the portrayal of the model determined in Birthal *et al*. (2019), Stevenson (1980) and Battese and Coelli (1995). On the off chance that every one of the components of the - vector are equivalent to zero, at that point the technical efficiency impacts of utilizing NCU (T and NT) are not identified with the z-factors thus the half normal truncation of stochastic production function initially determined in Aigner *et al*. (1977) is gotten. In the event that communications in the middle of these ranch explicit preparing input factors are incorporated as z-factors, at that point a non-impartial stochastic frontiers under both the suppositions of NCU (T & NT), proposed and is gotten. The technical efficiency impact, in the stochastic frontier model (1) could be

$$(\text{NCU, NCU-NT})\ e_i = y_i - \beta' x_i \quad (24)$$

specified in equation $U_{it} = Z_{it}d + W_{it}$, here the random variable W_{it} is defined by half normal distribution for truncation with a 0 mean and variance, s^2, *i.e*. of truncation is $Z_{it}\, d_{it}$, *i.e.*, $W_{it} = -Z_{it}\, d_{it}$ [Kumbhakar (1987)]. These assumptions are consistent with U_{it} being a non-negative truncation of the $NZ_{IT}d_{it}$, s^2 distribution. Consider a mustard growing farm family using NCU (T & NT) with m_1 and m_2 type of NCU respectively, making yield output, consumption and NCU utilization decisions of farmers during a point of time. Let $NCU=NCU_1....NCU_m$ be the amount of NCU used in farm-ploughing process practices in the farm, where NCU_1 is the amount of NCU thrown by the farmer, *i*th is the maximum used NCU, $i = 1, ..., m$. The farm family uses NCU, NCU-NT yields a vector of farm yield of *y*. The NCU can also reduce its estimating NCU and NCU-NT fertilizers inefficiency and efficiency measures with Equation (24)

$$E[u|\varepsilon] = \sigma\lambda/(1+\lambda^2)\ [\{\phi(w)/1-\Phi(w)\}-w] \quad (25)$$

here, $\varepsilon = v + u$, $w = S\varepsilon\lambda/\sigma$

2(c) Estimating Technical or Cost Efficiency of NCU and NCU-NT

The NCU-NT compares the technical efficiency of users or farmers, who adopted one or more type of varieties with that of non-users or controlled farmers that are similar in terms of observable characteristics [Kumbhakar (1987)] and also partially control for non-random selection of participants in high yield varieties of mustard farm-ploughing process farming. The average neem coated treatment effect on the treated (NCU-T), accounted impacts of users of NCU-T and NTfor estimating T.E. of farmers, who actually used

NCU-T and NT in mustard crops under not-treated NCU, yield and crop output measured higher besides T.E than all mustard farmers who potentially could have adopted the (NCU-T) technologies. NCU-T is calculated as above in the Equation (24). It is also possible to estimate the average NCU-NT effect on the untreated or control groups (NCU-NT)

$$\log y = \beta' x + v - u \quad (26)$$

$$\text{EFF} = \{y/\text{Optimal}\ (y)\}\text{- Exp}(-u) \quad (27)$$

$$Pr(Y = y) = (\varepsilon^{-\lambda} \lambda^{\psi})/\psi^{!},\ y = 0, 1, 2, 3 \quad (28)$$

$$f(Y_i / X_i) = (\mu^{\psi} \varepsilon^{-\mu})/\Psi^{!},\ \text{Y} = 0, 1, 2, 3, \quad (29)$$

Here, $\Psi^{!} = \Psi \times (\Psi-1) \times (\Psi-2) \times 2 \times 1$

$$\Psi_{!} = \text{E}\ (\Psi_{!}) + \upsilon_{\iota} = \mu_{\iota} + \upsilon_{\iota} \quad (30)$$

$$\ln\ (\text{l}) = \beta' X_i \quad (31)$$

$$\ln \text{L} = \sum_{i=0,1,2,\ldots,n} \left[-\lambda_{i} + y_i + \beta' x_i - \ln \psi_i ! \right] \quad (32)$$

and

$$A = \beta_0 + \beta_1 x_1 + u \quad (33)$$

$$\text{Therefore, } A_0 = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + u_i - v_i + e_i \quad (34)$$

$$\text{NCU-NT=E[Y(1)-Y(0)]=E[Y(1)]-E[Y(0)]} \quad (35)$$

$$\text{NCU-T = E[Y(1)-Y(0)|G=1]} \quad (36)$$

$$\text{NCU-NT = E[Y(1)-Y(0)|-Y(0)|G = 0]} \quad (37)$$

which accounted impact of users of NCU-T and NT on T.E. would it be for farmers not using the NCU-T technology. NCU-NT is expressed by Equations (26-37).

2(d) SFA estimates and model

The generalized likelihood ratio test is applied to estimate the exact relationship in the use of either the Cobb-Douglas or the translog functional form and also to evaluate and ascertain the significance between users of NCU-T and NCU-NT mustard farmers yield output and their socioeconomic cum farm-specific factors [Kumbhakar (1987)]. Therefore, generalized likelihood ratio test is in the form given below in Equation (38).

$$\text{k} = -2[\ln\{\text{L(H}_{\text{A}})\}/\ln\{\text{L(H}_0)\}]$$
$$= -2[\ln\{\text{L(H}_{\text{A}})\} - \ln\{\text{L(H}_0)\}] \quad (38)$$

Where, seed and irrigation are the estimations of the probability work for NCU-T and NCU-NT under the other option and invalid theories for client ranchers. The estimation of k has a Chi-square of half-typical conveyance under stochastic generation work, chi square (or blended chi-square) appropriation with Wald test and furthermore with the quantity of degrees of opportunity at 10 percent equivalent to the contrast between the quantity of NCU (treated or not treated) parameters included. In this way, Cobb-Douglas practical structure viable of NCU parameters is determined in condition (39)

$$\ln Y = \beta_0 + \ln \beta_1 x_1 + \ln \beta_2 x_2 + \ln \beta_3 x_3 + \ln \beta_4 x_4 + v_i - u_i \quad (39)$$

Y is mustard yield (yield output in kg), x_1 is family labor, x_2 is seed used in (kg), x_3 is farm size (ha). x_4 is pests (grams), $\boldsymbol{x_5}$ is type of NCU. Here, **...** is literacy (in years), maculinity (dummy 1 = male, 0 = female), finance (dummy 1 = access, 0 = no access), subsidy on fertilizer (dummy 1 = access, 0 = no access), ext. services (dummy 1 = access, 0 = no access) and is predicted values of adoption of NCU-T.

3. Empirical Results and Discussion

Table 1 contains the descriptive statistics of variables in the studied region of the mustard farmers. The results show the mean age of mustard farmers was about 43.85 years. The yield of mustard was 2.87 mt/ha (average mean) in the study area compared with the national achievable yield of 5.1 mt/ha, the yield gap can be reduced with the uses of NCU-T farm-ploughing process practices and combining the right input mix. The mean quantity of mustard plant density was 7.6, 589.5 kg/ha for NCU and 841.3 grams/ha for pesticides as presented in Table 1. This suggests a moderately youthful cultivating populace and with satisfactory inspiration, they can help raise mustard yield. Average of 2.4 long stretches of formal instruction is characteristic of low degree of formal training and the way that most mustard ranchers couldn't make it past essential two. By and large, a family had a ranch size of about a hectare for mustard ranch furrowing process with three relatives giving work on this plot. Determinants of appropriation of mustard ranch furrowing process innovations and its after effects of the determinants of reception as appeared in Table 2 demonstrate that rent in cultivating, rancher' bunch affiliation and access to rural augmentation had positive and huge impact on selection of mustard developing advancements.

$$\ln = \beta_0 \sum_{k=1}^{3} \beta_k \lambda v X_{ik}$$

Table 1 : Description values of statistics of input variables.

Variable description	Mean	Min	Max
Farmers_Age_yrs	43.85	18	75
Ferti_use {dummy, 1=NCU-T,0, otherwise (NCU-NT)}	0.82	0	1
Qty_of_ferti_kg	637.5	40	1235
Yield_of_Mustard_kg	1440.50	100	756
Edun_No_of_years_in_school	1.5	0	12
Farm_size_hectares	1	0.5	4
Fam_lab (No. of persons)	2.9	1	16
Lease-in-farming (dummy, 1 = yes, 0,otherwise)	0.43	0	1
Seed_used (in kg)	8.2	0.5	40
Pests_used (in grams)	950.4	0	1478
Ext_ser (dummy, 1 = access, 0, otherwise)	0.7	0	1
Mustard_cult_training (dummy, 1 =access, 0,otherwise)	0.7	0	1
FGA (dummy, 1 = yes, 0, otherwise)	0.6	0	1
Ferti_subsidy (dummy, 1=access, 0, otherwise)	0.5	0	1
Crd_dummy, 1= access, 0, otherwise)	0.1	0	1
Gender_of_farmers (dummy, 1 =male, 0, female)	0.7	0	1

Source: Authors' estimation from primary field survey, 2019.

$$+1/2\sum_{k=1}^{3}\sum_{\varphi=1}^{3}\beta_{kj}\lambda\nu X_{ik}\lambda\nu\ X_{ij}+V_i+Y_\iota \qquad (40)$$

Therefore, the Equation (41) derives the calculation

$$TE_i = \delta_0+\delta_1K_1+\delta_2K_2+\delta_3K_3+\delta_4K_4+\delta_5K_5 +\delta_6K_6+ e_i \qquad (41)$$

as a matter of first importance, rent in cultivating was huge at 1 percent and positively affected reception. This implies that mustard growers who took leased in land at specified rent tends to be more technically efficient than those farmers who did not used the practices of leased in land for cultivation of mustard. Besides, bunch enrolment affected appropriation and was factually noteworthy at 1 percent. This suggests, ranchers who had a place with a rancher bunch had more noteworthy likelihood of receiving more mustard ranch furrowing process procedures which is in accordance with Sekhar (2012a), that gathering enrolment had positive effect on reception. In any case, Abdulai *et al*. (2018) found a negative impact of the various gathering enrolment on selection. Gathering participation gives in addition to other things, positive companion impact and chance to take in great practices from companions. Thirdly, there was a positive relationship (huge at 1 percent) between access to agrarian augmentation administration and selection of mustard yield innovations. This is steady with the discoveries of Abdulai *et al*. (2018) however opposite, who revealed a negative impact of agricultural ex-strain on NCU-T reception.

3(a) Trial of Speculations

The summed up probability proportion test found the translog utilitarian structure proper for the stochastic frontier model (Table 3). The invalid theory that the financial factors did not clarify the stickiness of technical efficiency was likewise dismissed in this examination.

3(b) Factors augmented yield of Mustard

The assessed after effects of (MLE) appraisals of stochastic frontiers for mustard yield are depicted and appeared in Table 4. The yield and information factors were standardized form which were found against their individual mean qualities and consequently the primary term factors could be translated as versatilities of yield comparative with input factors. The main input factors considered for the model have been found positive except for seed, affecting the efficiency of farmers for the production of mustard. For instance, the coefficient of seed was - 0.058 and measurably critical 1 per penny.

This implies when the farmers were applying NCU-NT then the yield is significantly lower and the input variables required in amount of seed planted is having increment by 100 percent, holding all other variable information factors consistent, yield would be decline by about 5.8 percent, acquiring the light that proposes

Table 2 : Estimates of Poisson distribution and MLE.

Variable	Coeff. Value	Std. err.	*p*-value
Constant	0.284	0.1843	0.210
Lease_in_farming	0.843***	0.372	0
Frmrs_usr_grp_NCU_T	0.483***	0.194	0.003
Frmrs_usr_grp_NCU_NT	0.221	0.071	0.0005
Farm_size	–0.002	0.084	0.758
Acs_ext_ser	0.873***	0.178	0

Source: Authors' estimation from primary field survey, 2019.
***Significant at 1% level.

"pesticide and compost" had inefficient coefficient and factually critical in this manner were supplements to another mustard yield [Sekhar *et al*. (2018)]. In any case, the collaboration terms for factors, for example, "family work and pesticide", "family work and compost"; "seed and land size" just as "pesticide and land size" had negative coefficients and consequently the input factors for cultivation of mustard have clarified their substitutes to one another to optimise the yield and demonstrated an appropriate as well as predefined distributional supposition for the term, Ui, which has

Table 3 : Functional form choice and technical inefficiency tests.

Type of Test	(H0)	Ln(H0)	Value of λ	Critical Value	Accept/ Reject
Functional form test	$H_0:\beta_1=\ldots=\beta_{26}=0$	–158.601	62.179	18.274(13)	Reject H0: Translog val. found appropriate
Tech. ineff.	$H_0:\beta_1=\ldots=\beta_6=0$	–104.1589	58.820	31.238(9)	Reject H0

Notes : Critical values are significant at 5% level and obtained from χ^2 distribution. Figures in parenthesis are number ofrestrictions.

to keep a greatest check in regards to thickness among mustard plant during their initial development process. In any case, family work of the farmers, pesticides, manure and land size had a significant and positive yield versatilities of 0.269, 0.517, 0.235 and 0.228 individually.

The above-mentioned result indicates that each input variable/s *i.e*. pesticides, NCU-T and NT and field size is increased by cent per cent, mustard yield would increase by 51.7, 23.5 and 22.8 per cent respectively, *Ceteris paribus* [Dagar *et al*. (2018)]. The information variable with the most elevated halfway flexibility (0.623) was pesticides. Weeds rival plants for supplements, irrigational water in other subsequently, pesticides are progressively being filled in for different techniques for anti-weeds land cultivation practices or arrangement following planting [Hotz *et al*. (2012)].

Furthermore, the squared estimations of family work, seed, pesticides and land size were factually noteworthy and had negative signs, which implies that their ceaseless use over the long haul would prompt a decrease underway of mustard. The communication terms of the factors clarify whether the yield input factors are substitutes or supplements in mustard yield. For instance, "family work and seed"; "family work and land size"; "seed and pesticide"; "seed and manure" and been responsible for inefficiency. The profits to scale estimation of 1.191 showed expanding comes back to scale. This implies that the yield of mustard in studied districts has been measured lower due to poor cultivation with respect to yield capacity and consequently input factors have been under-utilized. Along these lines, an expansion in the utilization of the information factors in the yield procedure would prompt a more than proportionate increment in absolute yield.

3(c) Technical inefficiency and its factors

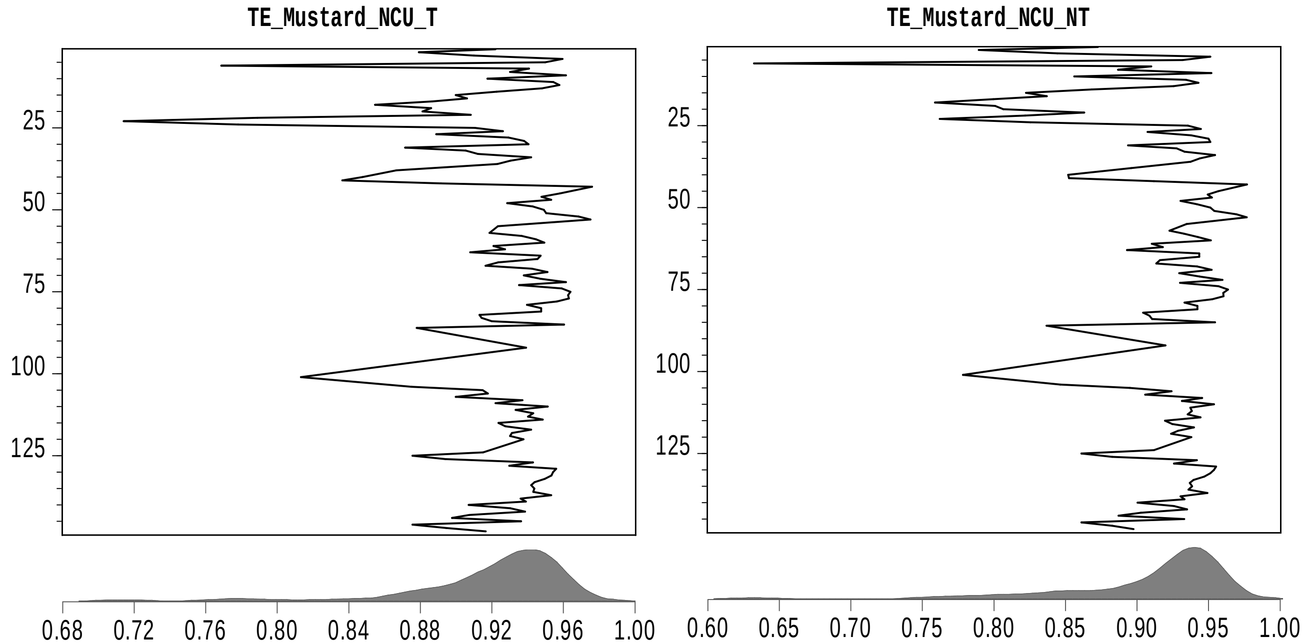
The determinants of TE are clarified in Table 4 by utilizing the evaluated (θ) coefficients related with TE impacts. The financial factors with efficient coefficient associations with TE and the other way around. The determinants of specialized TE were access to credit, expansion and new creation advances. Regardless, access to credit had constructive outcome on wastefulness and measurably critical at 1 percent. A large number of the ranchers in the considered zone did not approach formal credit. Mustard growers had woefully deficient credit sum which even had negative impact on their technical efficiency. The sigma squared estimation of 33.612 was altogether not quite the same as zero at 1 per cent level. Regardless, access to farming expansion had positive coefficient and factually huge in the investigation. Fig. 1 shows that the farmers

Table 4 : Estimates of translog (MLE) and technical inefficiency models.

Input variables (Coded)	β Values	Val. of Coeff.	Val. of Std. Error	*p*-value
Constant_s	β0	9.13	0.0298	0
Fam_lab	β1	0.319***	0.0291	0
Seed	β2	–0.088***	0.0843	0
Pests	β3	0.847***	0.0934	0
Fert (NCU-T)	β4	-0.235***	0.0743	0.056
Fert (NCU-NT)	β5	0.138*	0.0568	0.005
Farm size	β6	0.888***	0.0784	0
Fam_lab squared	β7	–3.848***	0.984	0
Seed squared	β8	–0.297***	0.0832	0
Pests squared	β9	0.483	0.385	0.943
Fert squared (NCU-T)	β10	–0.289**	0.09	0.21
Fert squared (NCU-NT)	β11	-0.068*	0.05	0.11
Farm size squared	β12	–0.847**	0.518	0.102
Fam_lab*Seed	β13	0.102***	0.0182	0
Fam_lab*Pests	β14	–0.325**	0.131	0.013
Fam_lab*Fert (NCU-T)	β15	0.0432	0.145	0.002
Fam_lab*Fert (NCU-NT)	β16	–0.372***	0.089	0
Fam_lab*Farm size	β17	0.797***	0.204	0
Seed*Pests	β18	0.199**	0.064	0.002
Seed*Fert (NCU-T)	β19	-0.178***	0.0328	0.07
Seed*Fert (NCU-NT)	β20	0.081***	0.0162	0
Seed*Farm size	β21	–0.172**	0.069	0.013
Pests*Fert (NCU-T)	β22	-0.917**	0.369	0.094
Pests*Fert (NCU-NT)	β23	0.318*	0.129	0
Pesticide*Farm size	β24	–0.645***	0.099	0
Fert (NCU-T)*Farm size	β25	-0.109**	0.389	0.779
Fert (NCU-NT)*Farm size	β26	-0.088*	0.174	0.447
Measures of Technical Inefficiency				
Constants	–1.176	0.459	0.13	
Gend_r	0.213	0.264	0.346	
Acs_to_crdt	1.763***	0.341	0.17	
Acs_to_ext_ser	1.738***	0.374	0.28	
Predictcd_val_adpt_NCU-T	–0.783***	0.28	0.32	
$\Sigma\sigma^2$	–38.828*	251.371	0.071	
γ	0.386***	0.031	0.28	
T_ret_to_scale	1.281			
Ln_likelihood	121.238			

Source: Authors' estimation from primary field survey, 2019. *, ** and *** tends to Significant at 10, 5 and 1 per cent level, respectively.

who utilizes NCU-T has a higher level of TE in all other aspects too. The technical efficiency is far higher for individual mustard growers who took leased in land on rent than those who did not with a standard error of 0.06. To wrap things up, the anticipated estimation of appropriation had negative coefficient and factually noteworthy at 5 percent. This implies that mustard growers who received the mustard developing advances were all the more in fact productive (or less in fact wasteful) than the individuals who did not embrace with standard mistake of 0.07 as introduced in Fig. 1. The evaluated factors of technical efficiency



Source : Author's estimates of technical efficiency for all farmers using NCU (T & NT) from field survey.

Fig. 1 : Technical efficiency estimates of all farmers using NCU (T % NT).

Table 5 : NCU-(T) and (NT)Score Match Estimates.

Range of Efficiency	(NCU-T)		(NCU-NT)		Score Match Data	
	Frequency of Scores	Per cent (%)	Frequency of Scores	Per cent (%)	Frequency of Scores	Per cent (%)
0 ≤ 0.50	64	42.67	67	44.67	131	43.67
0.51–0.60	35	23.33	30	20.00	65	21.67
0.61–0.70	12	8.00	15	10.00	27	9.00
0.71–0.80	10	6.67	10	6.67	20	6.67
0.81–0.90	13	8.67	15	10.00	28	9.33
0.91–1.00	16	10.67	13	8.67	29	9.67
Total	150	100.00	150	100.00	300	100.00
Mean (TE)	0.64		0.48		0.58	
Min. Val. (TE)	0.0017		0.018		0.00174	
Max. Val. (TE)	0-1		0-1		0-0.99	
SD of (TE)	16.384		0.168		0.24	

Source: Calculations and authors' estimation from primary field survey, 2019.

for mustard farmers has increased from 82 to 94 per cent with a mean of 61 percent. This implies there is a gigantic potential to expand mustard yield up to 46 percent without in-wrinkling the current degree of input factors.

Moreover, around 40 percent of mustard growers had a technical efficiency scores above 0.60 while 50 percent of respondents had scores of 0.50 or less.While the technical efficiency score was found low in the studied region, contrasted and for example, who discovered mean technical efficiency of 51 and 53 percent for flooded and non-watered mustard yield in North-western conditions of India (Specially Punjab and Haryana) just as who had a mean technical efficiency of 88 percent (Table 5) for mustard farmers in Punjab and Haryana with 27 percent has an average TIE. for mustard farmers the studied area was 0.54 with standard deviation of 0.24. At above 0.73 technical efficiency score, the adopters had high technical efficiency (51.7 per cent) compared with their non-adopter counterparts (28.4 per cent).

The stochastic production model was utilized to

Table 6 : Effects of NCU (T&NT) on mustard production technologies.

Category	Propensity of Yield Score Matching (PYSM)		Other Districts Score Match (ODSM)		Stochastic adjustment	
	Coeff. Val.	S.E.	Coeff. Val.	S.E.	Coeff. Val.	S.E.
NCU-NT	0.181*	0.189	0.164**	0.06		
NCU-T	0.228*	0.72	0.245**	0.876		
σ_TE NCU-T					0.428***	0.028
σ_ TE NCU-NT					0.346***	0.065

Source:Calculation and Authors'estimation from primary fields urvey, 2019.*, **and*** are significant at 10, 5 and 1 per cent, respectively.

gauge the determinants of yield and technical efficiency while affinity score coordinating was additionally used to investigate the normal treatment impact (NCU-NT and T) of appropriation on technical efficiency as contained in Table 6. The NCU-T esteem was 0.121 for farm producers who embraced and recorded an expanded degree of efficiency in their technical efficiency by around 12 percent and this was huge at 10 percent for the PSM with comparable outcomes got for the other locale coordinating (ODSM). The NCU-NT estimation of 0.102 which was likewise factually huge at 10 percent implies that all mustard growers face a decreased in their technical efficiency by 10.2 percent. Besides, the mean specialized effectiveness gauges for NCU-T and NCU-NT adopters were around 58 and 48 percent individually under relapse modification and opposite likelihood loads.

The truth of existing a gap of 10 per cent in technical efficiency due to use of NCU-T and NCU-NT in the production of mustard, proves a credit of significant impact of fertilizer use on farmer's T.E., therefore the need of the hour indicates towards intensified efforts should be taken to encourage the use of NCU-T for improved mustard yield.

4. Conclusion

Mustard farmers who used type of NCU-T urea for their crops in the studied region were more technically efficient than those who are using NCU-NT. This study utilised the techniques of PYSM to assess the effect of use of NCU-T and NT in mustard production farmers' technical efficiency in Jhajjar, Hisar, Sirsa, Bathinda, Fazilka and Mukatsar Districts of North-western states of India (Specially Punjab and Haryana) were found significantly dependent on use of NCU in mustard cultivation therefore, the area specific extension service programs should involve honorarium for using NCU to influence and to encourage the non users of NCU to use. Farmers' using fertilizers from cooperative societies or from other local facilities should avail only NCU for farming techniques. Also, this study shows that farmers have higher technical efficiency who use NCU than those who did not, latter should be encouraged to continue the practices of cultivation with usage of NCU specially for mustard growers.

Those farmers, who are delivering the improved practices of organic cultivation should opt the NCU which reduce the harmful impact of urea in sustainable agricultural production. The average mean technical efficiency estimates for users and non users of NCU were 0.64 and 0.48, respectively. A technical efficiency gap of 0.16 in sampled mustard growers show that the farmers should use NCU to enhance their technical efficiency relative to those who are not using. Another most important fatcor which has a significant effect of NCU use on farmer's technical efficiency is soil fertility and sustainability. Therefore, this study recommends that more mustard farmers should be encouraged to use NCU to enhance output and to improve their level of technical efficiency.

[1]This paper is an outcome of an individual study based on regular primary field survey conducted during 2014-18, for otaining cross sectional data of Variables comes under 'Cost of Cultivation' annually published by Commission for Agricultural Costs and Prices (CACP), Directorate of Economics and Statistics, Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Government of India, to analyze the variations in technical efficiencies of farmers' in different agro-climatic zones of the states of Punjab and Haryana in the wake of 'doubling of farmers income' by the researchers of 'Agricultural Economics Research (AER) Centre, DSE Campus, University of Delhi'.

[2]There are numerous references accessible on Nitrogen that demonstrates that the recuperation of

nitrogen under flooded and submerged condition is not really 35% because of different sort of loses it is exposed to, for example, de-nitrification, smelling salts volatilization and filtering. On the planet half of nitrogen is provided through Urea and the situations in India are the same. So as to keep the nitrogen misfortunes at least level, farming researcher have turned out with different agronomical proposals, to lessen these loses. The predominant proposals are part application, band position, and profound arrangement utilizing the see drill. Every one of these practices make accessible correct amounts of necessity at the spot of retention. Utilization of greater granules of urea impedes the disintegration. Notwithstanding agronomical practices of nitrification inhibitors, for example, Nitrapyrin (N-Serve) and Terrazole (Dwett) were created in USA.

[3]Hypothetical meaning of a creation capacity delivering from the optimum measures of yield, possible from given information and packs of inputs with fixed innovation has been acknowledged for a long time. Furthermore, for nearly as long, econometricians have been assessing normal generation capacities. It has just been since the spearheading work of Farrell (1957) that genuine thought has been given to probability of assessing yield capacities, with hypothesis and observational work. This paper proposed another way to deal with the estimation of escalating production capacities with best available alternatives. This includes the determination of the error term as being comprised of two segments, one typical and the other from an uneven circulation.

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