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RESEARCH ARTICLE :

Functional analysis of productivity change in precision tomato cultivation in North West region of Tamil Nadu

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SUMMARY : The study was conducted in North West region of Tamil Nadu in May 2015, to investigate the technological change in tomato production in the selected two districts in Tamil Nadu using the output decomposition analysis approach. The study adopted a descriptive research design, based on a cross-sectional survey strategy. The study involved 216 sampled tomato farmers (108 adopters of the precision farming and 108 non-precision farming) using a two-stage stratified random sampling and one stage purposive sampling method involving operational areas, revenue villages and farmers. Data were collected by pre-tested questionnaire by the researcher. The Cobb-Douglas production and a modified decomposition analyses techniques were used to decompose the sources of productivity differences between the precision and non-precision tomato cultivation. Total sample size was 216. Resulted that the observed productivity difference was 46.41 per cent and the estimated productivity difference was 37.13 per cent of the precision and non-precision tomato cultivation. The total estimated difference in the productivity between the precision tomato and the non-precision tomato was 37.13. Of this, technical change contributed 34.75 per cent. The neutral technical and non-neutral technical changes revealed at 31.39 per cent contribution in the scale parameter (*i.e.*, neutral technical change) and 3.36 per cent contribution from the slope parameters (*i.e.*, non-neutral technical change). The Study concluded that appropriate extension strategies (institutional linkage) and capacity building are needed to improve the resource use efficiency of the farmers to increase productivity. Also, the promotion of technology dissemination processes should be integrated with an effective input supply and credit supply systems to enable farmers' adoption and subsequent uptake of precision farming for enhanced productivity.

KEY WORDS :
Precision farming, Resource use, Decomposition, Productivity

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BACKGROUND AND OBJECTIVES

Agriculture is the core sector and plays vital role in most developing economies and provides livelihood to a significant proportion of the population, especially in rural areas. Since, this sector facing the largest brunt of underemployment, unemployment and poverty, a growing agriculture and allied sector is expected to contribute vastly to overall growth and poverty alleviation. There has been a decline in the share of the agricultural sector in the overall gross domestic product (GDP). The share of agriculture in GDP which was 55 per cent during 1950 fell to 17.4 per cent during the period 2015-16 and to 18.3 per cent during 2013-14.Technology initiations have initiated and sustained the process for modernising the Indian agriculture. The new strategy in farming often heralded as the "green revolution", had profound impact on the economics of tropics, The green revolution in 1966 and latest theme of modified the same, initiated the phase of transformation of Indian agrarian economy, from subsistence (production led) to commercial (market led with quality concern) farm business, presently moving towards second green revolution and sustainable agriculture. Scott (2007) Agricultural and its technological sustainability includes the goal of food production, welfare of the food producers, and preservation of non-renewable resources. Ajay (2012) denoted raise agricultural productivity levels exponentially; devise long term agricultural development strategies that support the development of local agricultural markets and focus on farmers' needs. Wilson *et al.* (2001), farmers who seek information, have more years of managerial experience and have a large farm are achieved with higher levels of technical efficiency in the farming. Maheswari *et al.* (2008) 'Precision Farming' or 'Precision Agriculture' aims at increasing productivity, decreasing production costs and minimizing the environmental impact of farming. Karthick and Mani (2010) concluded that limited scope for expanding land frontiers and further there is increasing trend in diversion of cultivable land for non agricultural purposes. The technological developments, precision farming has emerged as a promising option for increasing and sustaining the (Basavaraja *et al.*, 2008) horticultural productivity in the semi arid tracks. Scope to improve the technical efficiency and strengthening marketing infrastructure to get better prices for increased level of production would enhance the net returns to farmers.

Existing research on the crop production Dibba (2010) neglect to consider the nature (*i.e.*, whether technological change is neutral or non-neutral) and magnitude of the change in the technology of crop production from the precision to non-precision farming practices (Resmi *et al.,* 2013). However, no systematic analysis of how these factors explain the productivity differences between the precision and non-precision farming was carried out. Moreover, existing research in Tamil Nadu has failed to address these two key issues on the technological change associated with precision farming. This study has the potential to provide a better theoretical and practical understanding of the nature and magnitude of the technological change associated with the precision farming. This study further decomposes the sources of productivity differences between the adopters and non-adopters of the precision farming.

Objectives:

– To analyze the production function for factors determining the production of tomato under precision and non-precision farming.

– To estimate productivity differences between the sample group with decomposition process.

RESOURCES AND METHODS

The eighteen sample villages were chosen for collect the primary data from the districts of Dharmapuri and Krishagiri and the number of villages eight and ten, respectively. The six of the farm household selected for collection of data in each village and with two groups of farm households, the farmers were enrolled and following Precision Farming practices and conventional practices in agriculture. The respondents were selected randomly from these villages in such a way of 108 tomato growers under precision and 108 non-precision (conventional) farms. Thus, the total sample size was 216.

The primary data was collected from selected farmers by personal interview method administering pre-tested questionnaire (Year, 2014-15). The information collected from the respondents relevant to major variables frames in the objectives of the study, *viz.*, socio-economic conditions of farmer's (family size, sex, age, education, occupational status and experiences in farming), size of land holding, source of irrigation, cropping pattern, input use, production, technology adoption, income and expenditure of household, asset position and investment, yield particulars, livestock and non-farm activities.

Decomposing the productivity changes with functional analysis :

Differences in productivity, income and employment under the precision and conventional farming's work out the cost cultivation data. Sources of the productivity (Tsinigo *et al*., 2016) difference between the precision (Maheswari *et al.*, 2008) and conventional farming's are identify by decomposing the productivity changes, following Bisaliah (1977) and Abdullahi (2012). Cobb-Douglas production functions, for precision and non-precision farming's are fitting as follows:

$$\ln Yp = \ln bp0 + bp1 \ln X_1p + bp2 \ln X_2p + bp3 \ln X_3p + bp4 \ln X_4p + bp5 \ln X_5p + bp6 \ln X_6p + bp7 \ln X_7p + bp8 \ln X_8p + bp9 \ln X_9p + Up \quad ......(1)$$

$$\ln Ynp = \ln bnp0 + bnp1 \ln X_1np + bnp2 \ln X_2np + bnp3 \ln X_3np + bnp4 \ln X_4np + bnp5 \ln X_5np + bnp6 \ln X_6np + bnp7 \ln X_7np + bnp8 \ln X_8np + bnp9 \ln X_9np + Unp \quad ......(2)$$

where,

Y = Yield of crop (kg/ha),

X_1 = Value of seed/seedlings Rs. per ha,

X_2 = Farm yard manures in tonnes per ha

X_3 = Total labour in man days per ha,

X_4 = Total plant protection chemical Rs. per ha,

X_5 = Irrigation water (ha-cm),

X_6 = Total nitrogen in kg per ha,

X_7 = Total phosphorus in kg per ha,

X_8 = Total potash in kg per ha,

X_9 = Machine power HP hours/ha

bi = Parameters to be estimated,

u = Random-error term,

Subscript p = Technology adopted farming

Subscript np = Non-technology farming.

Taking differences between Eq. (1) and (2), adding and subtracting some terms and on rearranging these terms, one gets Eq.(3):

$$\ln (Yp/Ynp) = \{\ln (bp0/ bnp0)\} + \{(bp1 - bnp1) \ln SEEDnp + (bp2 - bnp2) \ln MANUREnp + (bp3 - bnp3) \ln LABOURnp + (bp4 - bnp4) \ln PPCnp + (bp5 - bnp5) \ln IRRIGATIONnp + (bp6 - bnp6) \ln Nnp + (bp7 - bnp7) \ln Pnp + (bp8 - bnp8) \ln Knp + (bp9 - bnp9) \ln MPnp \} + \{bp1 \ln (SEEDp/SEEDnp) + bp2 \ln (MANUREp/MANUREnp) + bp3 \ln (LABOURp/LABOURnp) + bp4 \ln(PPCp/PPCnp) + bp5 \ln (IRRIGATIONp/ IRRIGATIONnp) + bp6 \ln (Np/Nnp) + bp7 \ln (Pp/Pnp) + bp8 \ln (Kp/Knp + bp9 \ln (MPp/MPnp)\}+ [(U2 - U1)] \quad ...(3)$$

The LHS of Eq. (3) denotes the difference in per hectare productivity of precision and non-precision methods, while the RHS decomposes the difference in productivity into the changes due to technology as well as input-useequation (3) has three major terms on RHS. These, respectively refer to (i) gap attributable to neutral technological change, (ii) gap attributable to non-neutral technological change and (iii) change due to input-use.

Stochastic frontier production function:

The factors influencing the technical efficiency (Bravo-Uteta and Rieger, 1991) of crop production (Duraisamy, 2007) under precision and non precision farming are examine with stochastic frontier production function (Tim, 2015), proposed by Kachroo *et al.* (2010) was applied, as given below:

$$Ln(Yp_i) = \ln bp0 + bp1 \ln X_1p_i + bp2 \ln X_2p_i + bp3 \ln X_3p_i + bp4 \ln X_4p_i + bp5 \ln X_5p_i + bp6 \ln X_6p_i + bp7 \ln X_7p_i + bp8 \ln X_8p_i + bp9 \ln X_9p_i + (Vp_i - Up_i) \quad ......(1)$$

$$Ln(Ynp_i) = \ln bnp0 + bnp1 \ln X_1np_i + bnp2 \ln X_2np_i + bnp3 \ln X_3np_i + bnp4 \ln X_4np_i + bnp5 \ln X_5np_i + bnp6 \ln X_6np_i + bnp7 \ln X_7np_i + bnp8 \ln X_8np_i + bnp9 \ln X_9np_i + (Vnp_i - Unp_i) \quad .(2)$$

where,

Y = Yield of crop (kg per ha),

X_1 = Value of seed/seedlings Rs. per ha,

X_2 = Farm yard manures in tonnes per ha

X_3 = Total labour in man days per ha,

X_4 = Total plant protection chemical Rs. per ha,

X_5 = Irrigation water (ha-cm)

X_6 = Total nitrogen in kg per ha,

X_7 = Total phosphorus in kg per ha,

X_8 = Total potash in kg per ha

X_9 = Machine power HP hours per ha,

v = An independently and identically distributed random error,

u =A non-negative variable associated with technical inefficiency in production

Subscript p_i = Technology adopted farming

Subscript np_i = Non-technology farming

i = 1,2,3,….n.

OBSERVATIONS AND ANALYSIS

The results obtained from the present study as well as discussions have been summarized under following heads:

Cobb-Douglas production function for finding the resource utilization :

The OLS method of Cobb-Douglas production function was attempted separately for finding the resource utilization of precision and non-precision tomato farmers. The functional analysis was separately fitted to the 108 tomato precision farms and 108 tomato non-precision farms and the results are given in Table 1.

It could be seen that the co-efficient of multiple determination (R^2) was 0.93 and 0.82 for precision and non-precision tomato farmers, respectively indicating that the production model was a good fit.In case of the precision farmers, the co-efficient of labour, plant protection chemicals, phosphorus and potash were found to be significant at one per cent level. While the farm yard manures was found to be significant at five per cent level. The sum of elasticity of regression co-efficients was worked out to be 1.85 which implied an increasing return to scale for precision tomato farmers. In case of the non-precision tomato farmers, R^2 value of 0.82 for precision turmeric farms indicated that the 82 per cent of the variation in yield was explained by the chosen independent variables. The co-efficient of seedling, farm yard manure and nitrogen were found to be significant at one per cent level. The labour was found to be significant at five per cent level and plant protection chemical at ten per cent level. The sum of elasticity of regression co-efficients was worked out to be 2.08 which implied an increasing return to scale for non-precision tomato farmers.

Technical efficiency in tomato farms:

In the present study, in order to understand the

Table 1 : Regression estimates of production function for tomato cultivation using ordinary least square method

Sr. No.	Tomato particulars	Precision farming			Non -precision farming		
		Mean	Co-efficient	Std. error	Mean	Co-efficient	Std. error
1.	Constant	46575.97	-0.703*	2.731	25581.64	1.772***	0.459
2.	Value of seed/seedlings in Rs. per ha	6071.51	0.169 NS	0.122	7297.59	0.092***	0.030
3.	Farm Yard Manures in tonnes per ha	14.68	0.055**	0.245	8.53	-0.041***	0.012
4.	Labour in man days per ha	1326.77	2.213***	0.378	836.92	0.121**	0.531
5.	Plant protection chemical in Rs. per ha	10543.71	-0.450***	0.164	7488.43		0.016
6.	Irrigation water in ha-cm	128.63	0.155NS	0.287	107.41	0.021 NS	0.014
7.	Nitrogen in kg per ha	207.17	0.140 NS	0.161	138.32	0.081***	0.029
8.	Phosphorus in kg per ha	110.21	-0.827***	0.200	77.98		0.010
9.	Potash in kg per ha	150.85	1.705***	0.656	114.24	-0.017 NS	0.027
10.	Machine power in HP hours/ha	422.05	-0.612 NS	0.551	347.12	0.014 NS	0.017
	R Square	0.93			0.82		
	Adj. R	0.92			0.76		
	F Value	140.03***			5.16***		
	N	108			108		

*, ** and *** Indicate significance of values at P=0.1, 0.05 and 0.01, respectively NS- Non-significant

Table 2 : Maximum likelihood estimates of stochastic frontier function for tomato cultivation

Sr. No.	Tomato particulars	Precision farming		Non-precision farming	
		Co-efficient	Std. error	Co-efficient	Std. error
1.	Constant	-16.601***	0.008	12.930***	1.920
2.	Value of seed/seedlings Rs. per ha	0.141***	0.005	-0.169***	0.088
3.	Farm Yard Manures in tonnes per ha	0.010***	0.001	0.039**	0.017
4.	Labour in man days per ha	3.572***	0.022	-0.062NS	0.264
5.	Plant protection chemical Rs. per ha	-0.130 NS	0.119	0.304***	0.003
6.	Irrigation water (ha-cm)	-0.772***	0.005	-0.066 NS	0.216
7.	Nitrogen in kg per ha	-0.083 NS	0.112	-0.111***	0.006
8.	Phosphorus in kg per ha	-0.530***	0.002	-0.183 NS	0.149
9.	Potash in kg per ha	0.066**	0.010	0.983*	0.543
10.	Machine power HP hours/ha	0.694***	0.013	-0.498NS	0.388
	Sigma Square	0.023***		0.007***	
	Gamma	0.896***		0.821**	
	Log LH	124.633		139.031	
	N	108		108	

*, ** and *** indicate significance of values at P=0.1, 0.05 and 0.01, respectively NS= Non- significant

technical efficiency of selected respondent farms, the stochastic frontier functions. The results of MLE of stochastic frontier function for tomato farms using Stata 11 software are furnished in Table 2. The log likelihood ratio of 124.63 and 139.03 for tomato farms of precision and non precision, respectively, were significantly different from the zero and this would clearly indicate the goodness of fit of the model. The gamma measures the share of changes in the technical inefficiency with respect to the total variability of the model errors. Thus, the estimator of gamma indicates that 89 per cent of precision farms and 82 per cent of the total variation in the tomato yield was due to technical inefficiencies in the area under study. The remaining portion therefore eleven and eighteen per cent was due to factors beyond the farmers' control. For the precision tomato farmers, the co-efficient of inputs namely, value of seedlings, farm yard manures, labour, irrigation water, nitrogen, phosphorus and machine power was significant at one per cent level of significance and potash was five per cent significant level. Likewise, for the non-precision tomato farmers, the co-efficient of value of seedlings, plant protection chemicals, nitrogen were found to be significant at one per cent level, farm yard manure were five per cent level and potash were ten per cent level of significance.

Decomposition of productivity:

The sources of the productivity differences between the precision and non-precision tomato are shown in Table 3. The observed productivity difference was 46.41 per cent and the estimated productivity difference was 37.13 per cent of the precision and non-precision tomato cultivation. The total estimated difference in the productivity between the precision tomato and the non-precision tomato was 37.13. Of this, technical change contributed 34.75 per cent. The neutral technical and non-neutral technical changes revealed at 31.39 per cent contribution in the scale parameter (*i.e.,* neutral technical change) and 3.36 per cent contribution from the slope parameters (*i.e.,* non-neutral technical change). Decomposition resulted that the total contribution of changes in the levels of input use to the productivity differences between two cultivation practices was 2.38 per cent. The highest input contributor to the productivity differences was labour, which contributes to 2.07 per cent, followed by potash share of 1.61per cent. Similarly, the seedlings was (0.17%), irrigation (0.15%), nitrogen (0.13%) and farm yard manure was 0.04 per cent. The phosphorus, machine power and plant protection chemical was negative contribution of -0.77 per cent, -0.59 per cent and -0.43 per cent, respectively. High intensities of labour and fertilizer (nitrogen and potash) used by the precision tomato farmers had led to yield increases by 2.07 and 1.74, respectively. This implies that the adopters gained a higher yield by spending more on labour and fertilizer than the non-precision precision farmers' inputs. Generally, the resulted that the total increases in productivity due to the shift from the non-precision tomato to the precision tomato was 34.75 per cent, which was mainly due to non-neutral technical change, *i.e.*, the shift in the slope co-efficients.

Table 3 : Decomposition of productivity differences between precision farmers Vs non-precision crop of tomato

Sr.No.	Source of productivity differences	Per cent contribution
I.	Observed differences in output	46.41
II.	Sources of contribution	
	Due to differences in technology	
1.	Neutral technical change	31.39
2.	Non-neutral technical change	3.36
	Total due to technology	34.75
	Due to difference in input use	
3.	Value of seed/seedlings Rs. per ha	0.17
4.	Farm yard manures in tonnes per ha	0.04
5.	Labour in man days per ha	2.07
6.	Plant protection chemical Rs. per ha	-0.43
7.	Irrigation water (ha-cm)	0.15
8.	Nitrogen in kg per ha	0.13
9.	Phosphorus in kg per ha	-0.77
10.	Potash in kg per ha	1.61
11.	Machine power HP hours/ha	-0.59
	Total due to all inputs	2.38
	Estimated difference in output (A + B)	37.13

Conclusion :

For the results above illustrate that perhaps appropriate extension strategies (institutional linkage) and capacity building are needed to improve there source use efficiency of the farmers to increase productivity. Also, the promotion of technology dissemination processes should be integrated with an effective input supply and credit supply systems to enable farmers' adoption and subsequent uptake of precision farming forenhanced productivity.

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