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Economics of Tissue culture Banana: A Case Study of Gorakhpur District in Uttar Pradesh

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ABSTRACT

The technological improvements play key role in enhancing the yield of agricultural crops. Tissue culture technology is a key intervention in banana, which have the potential to benefit the banana farmers in multiple ways. We have tested this by using primary survey of 100 farmers from the Gorakhpur district of Uttar Pradesh, a traditional sugarcane cultivated belt which is fast getting covered by banana plantations. Both adopters and non-adopters of the technology were surveyed and their performance was analysed using cost concepts, Cobb-Douglas production function, frontier analysis *etc.* The adopters of tissue culture technology were young and educated farmers, who had better land holding and household income. As compared to the sucker propagated banana, tissue culture banana yieldedbetter. Planting material, human labour, plant protection chemicals, machine and bullock labour had a positive and significant impact on the yield of tissue culture banana. Frontier technical efficiency analysis revealed that the average technical efficiency level of adopters was 0.94 and that of non-adopter was 0.86. The risk due to wind, drought and other abiotic factors was identified as the major constraint in the adoption of tissue culture banana in the region.

Key words: Tissue culture banana, sucker propagated banana, frontier analysis, cobb-douglas production function.

INTRODUCTION

The direction of agricultural diversification in India,now favours the high value commodities and livestock sectors, mainly for augmenting farm income (Verma *et al.,* 2007). In the past two decades, the horticulture sector of India has gained the reputation of one of the fastest growing agricultural sectors in the country (Idris *et al.,* 2015). Fruit crops accounts for the second major share, in horticulture production of India, after vegetables, and it holds 26.9 per cent of area and 32.3 per cent of production of the overall horticulture sector. Among fruit crops banana leads the scene, with a total production of about 291 lakh tonnes(NHB, 2015). The supply of banana from its primary producing areas to other parts of the country is not hassle free. Its high perishability makes the logistics to key markets, without quality deterioration, increasingly difficult, or at only high transaction/transportation cost. To tackle these issues, the agriculturists have now identified the strategy of broadening the production base of the crop to non-traditional banana growing states of the country.

Uttar Pradesh is a state, which consumes considerable volume of banana compared to its production. Ample scope for development of banana cultivation exists in Uttar Pradesh since the crop yields 44 tonnes per hectare in the state which is very well comparable with the national average. The availability of warm and humid climatic requirement of the crop also gives green signal for its adoption in the state.In recent years a large number of farmers in Gorakhpur district of Uttar Pradesh, who were traditionally engaged in sugarcane cultivation, have shifted to banana for better returns. Peasants here find banana crop more suitable, as it involves less financial investments and also lesser hassles than sugarcane cultivation. The role of tissue culture banana plants is also believed critical in the acreage increase of the crop in the district.

The use of tissue culture technique in banana has numerous advantages like ensuring the availability of pest and disease free planting materials, synchronous growth in plants, uniform fruiting, shorter crop cycle, and better yields (Robinson, 1996). In addition, the safer transportation and quick dissemination of newly released

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cultivars are also possible by using tissue culture technology (Diekmann and Putter, 1996). While there is general concurrence in the potential of tissue culture technology, its suitability to specific regions needs to be explored (Renkow and Byerlee, 2010). Some of the technological characteristics may not suit the farmers in some specific region, which could lead to non adoption or very slow adoption (Suri, 2011; Smale and Tushemereirwe, 2007).

Since the tissue culture banana technology has recently gained popularity in the Gorakhpur district, an attempt is made here to study the impact of tissue culture technology in the yield, input use, and income of banana farms in the region, and the extend adoption of the technology by farmers. Debate exists on the potential and actual benefits of the technology for farmers (Njuguna *et al.,* 2010), and the literature lacks evidences such assessments. We try to address this gap through our analysis built on a survey of banana growing farmers in the study region.

METHODOLOGY

A survey of banana farmers was carried out in the Gorakhpur district of Uttar Pradesh. Gorakhpur district was selected purposively based on the information on the banana production and distribution of tissue culture plantlets provided by various institutions. Banana growing blocks were first selected within the district,and within those blocks the villages where tissue culture banana dissemination had taken place were deliberately chosen. Primary data was then collected from randomly selected farmers, through well structured, pre-tested and comprehensive schedules, using personal interview method. The sample farmers were classified into two category based on adoption of the tissue culture technology *i.e.,* adopters and non-adopters. Out of the total 100 farmers surveyed, 63 were adopters and 37 were non-adopters of the technology.

The impact of the technology was assessed in terms of enhancement in yield, income, and improvement in efficiency. Further, to analyze the profitability of the banana production, cost concepts were used as follows:

Cost A_1= Wages of hired labour, cost of input, hired machinery charges, imputed value of owned machine power, depreciation on implements and farm buildings, land revenue and interest on working capital.

Cost B_1= Cost A_1 + interest on value of owned fixed capital (excluding land).

Cost B_2= Cost B_1 + rental value of owned land.

Cost C_1= Cost B_1 + imputed value of family labour.

Cost C_2= Cost B_2 + imputed value of family labour.

Cost C_3= Cost C_2 + 10 per cent of Cost C_2 accounting for managerial input

Farm business income = Gross income – Cost A_1

Family labour income = Gross income – Cost B_2

Net income over Cost C_1 = Gross income – Cost C_1

Net income over Cost C_2 = Gross income – Cost C_2

Net income over Cost C_3 = Gross income – Cost C_3

Regression analysis is a useful tool in analyzing the resource productivity in any production activity including farming.

The Cobb-Douglas type of production function has been the most popular of different algebraic forms of production functions available, as it provides a compromise among (i) adequate fit to the data, (ii) computational simplicity, and (iii) sufficient unused degrees of freedom for statistical testing. One of its serious limitations is that it accommodates constant/ increasing/decreasing marginal productivity and does not allow an input-output curve embracing all the three relationships. Despite this limitation, it has the greatest use in diagnostic analysis as the regression parameters represent the elasticities and reflect the marginal productivity at the geometric mean level of the input and the output. Because of such overwhelming advantages over the other forms, Cobb-Douglas type of production function was employed for the current study.
The specific Cobb-Douglas type of production function used for the study is:

$$Y = aX_1^{b_1} X_2^{b_2} X_3^{b_3} X_4^{b_4} X_5^{b_5} X_6^{b_6} U$$

Where,

Y = Gross returns (₹/ha)

a = Intercept, a scale parameter

X_1 = Suckers/plantlets cost (₹/ha)

X_2 = Chemical fertilizers (₹/ha)

X_3 = Human labour (₹/ha)
X_4 = Bullock / Machine labour (₹ / ha)

X_5= Plant protection chemicals (₹ / ha)

X_6 = Irrigation (₹/ ha)

Efficiency estimation

To capture the ability of farmers to achieve the maximum realizable crop outputs with minimum level of inputs under the existing situation and given technologies, a careful examination of farm specific technical efficiency of the farmers is necessary. Technical efficiency evaluate the farm's ability to obtain the maximum possible output from a given set of resources. Stochastic frontier production function was used to assess the farm level technical efficiencies. The analysis was carried out separately for adopters and non-adopters of tissue culture technology. The stochastic frontier production function model is specified as

$$\ln Y = a + \Sigma \beta i \ln x_i + (v_i - u_i) \quad \ldots (6)$$

i=1 to N

Where $v \sim N[(0,\sigma v^2]$, The amount by which the observed individual fails to reach the optimum (the Frontier) is u, where $u = |U|$ and $U \sim N[0,\sigma u^2]$.

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X_3 = Human labour (₹ /ha)
X_4 = Bullock / Machine labour (₹ / ha)
X_5= Plant protection chemicals (₹ / ha)
X_6 = Irrigation (₹ / ha)
V_i = Random error component which is outside the control of the farmer.

Ui= Measures inefficiency

RESULTS AND DISCUSSION

Farm and household characteristics

Table 1 showed the socioeconomic characteristics of farms, households and other relevant variables from the sample farmers. Disaggregation according to the status of adoption of tissue culture technology revealed that the adopters of the technology were younger and better educated than the non-adopters. Average size of holding and area under banana cultivation were also higher for adopters. Their farming experience were surprisingly lesser and household income was higher than non-adopters. In general, significant difference was observed among the adopters and non-adopters of tissue culture banana in characters like average size of holding, family size and distance from the mark *et at* 5 per cent level of significance, and in farming experience, average size of banana cultivation and average annual income at 1 per cent level of significance.

Table 1: Socio economic characteristics of sample farmers

Descriptions	Adopter	Non adopter	P value(t test)
Average size of holding (ha)	2.52	2.07	0.08**
Average age (years)	37.87	56.81	2.81
Family size (numbers)	2.68	3.21	0.08**
Farming experience (years)	13.03	17.86	0.00***
Average years of schooling(years)	11	6	2.75
Average area of banana cultivation(ha)	2.31	1.41	0.00***
Distance from the input dealer(km)	8.51	3.91	1.04
Distance from the market (km)	7.57	11.28	0.09**
Average annual income (₹)	109984	62243	0.00***

Note: *, ** and *** represents significance at 10, 5 and 1 per cent levels, respectively

Comparison of cost of cultivation of tissue culture and sucker propagated banana

Table 2 describes the allocation of total cost under various heads in tissue culture banana cultivation. Planting material cost constituted the highest share in the total variable costs followed by hired wages (21%) and chemical fertilizers (21%). Land holding category wise examination revealed that for all category of farmers including marginal, small, semi-medium, medium& large farmers, planting material cost, hired labour cost, chemical fertilizer and harvest cost components contributed the maximum share in total variable cost. Total variable cost per hectare was highest in case of marginal farmers followed by small and semi-medium category of farmers

Table 2: Input costs and their share in total input costs in tissue culture banana cultivation (₹/ha)

Particulars	Marginal	Small	Semi Medium	Medium and large	All
Family Wages	4980 (5.1)	2420(2.4)	1955(2)	1879(1.9)	2205(2.3)
Hired Wages	20330(20.8)	19954(20.5)	20344(21.6)	19638(20.6)	20025(21)
Machinery charges	8650(8.8)	7068(7.2)	7126(7.5)	6698(7)	7163(7.5)
Planting material	46620(47.7)	46431(47.8)	43716(46.6)	44864(47.2)	44811(47.1)
FYM	5310(5.4)	3508(3.6)	3363(3.5)	3533(3.7)	3595(3.7)
Chemical Fertilizers	11698(11.9)	14375(14.8)	13782(14.6)	14478(15.2)	13868(14.6)
Plant protection chemical	4960(5)	5681(5.8)	5447(5.8)	5722(6)	5510(5.8)
Propping	9850(10)	9900(10.2)	8500(9)	7659(8)	8670(9.1)
Harvesting	10500(10.7)	10001(10.3)	9870(10.5)	8765(9.2)	9657(10.1)

Others	2800(2.8)	2600(2.6)	3200(3.4)	3420(3.6)	2985(3.1)
Total input costs	97568	97017	93778	94933	94972
Depreciation	4031	6613	10434	9710	9668
Interest on fixed assets	8683	10395	10678	9626	10596
Rental value	25000	25000	25000	25000	25000

Note: Figure in parenthesis indicates the percentage to total cost.

Table 3 showed the economics of sucker propagated banana cultivation. The share of planting material was highest in total variable cost, followed by hired wages and chemical fertilizers. Among different category of farmers, medium and large category of farmers had to incur higher variable cost followed by marginal farmers. Variable cost shares in all category of farmers showed the same trend. Planting material cost constituted the maximum share followed by hired labour, chemical fertilizers and harvesting cost. In case of marginal farmers the shares of chemical fertilizer and family wages were almost the same as other category farmers. On an average planting material cost accounted for about 25.38 per cent followed by hired labour cost (21.31%) in the sucker propagated banana cultivation.

Table 3: Input costs and their share in total input costs in sucker propagated banana cultivation (₹/ha)

Particulars	Marginal	Small	Semi Medium	Medium and large	
Family Wages	9500(10.37)	6117(6.83)	4000 (4.56)	6000(6.47)	4291(4.92)
Hired Wages	19100(20.85)	19294(21.55)	17924(20.44)	19675(21.23)	18571(21.31)
Machinery charges	8650 (9.44)	8647 (9.65)	7575 (8.64)	5100 (5.50)	7318 (8.40)
Planting material	21600(23.58)	19323(21.58)	22985(26.21)	21537(23.24)	22104 (25.38)
FYM	3000 (3.27)	2911 (3.25)	2920 (3.33)	3070 (3.31)	2955 (3.39)
Chemical Fertilizers	9375(10.23)	12417(13.87)	9816(11.19)	15065 (16.25)	12719 (14.60)
Plant protection chemical	3750(4.09)	3823 (4.27)	3451 (3.93)	4750 (5.12)	3791 (4.35)
Propping	6500 (7.09)	5800 (6.47)	7643 (8.71)	6578 (7.09)	5987 (6.87)
Harvesting	8900 (9.71)	8790 (9.81)	8752 (9.98)	7895 (8.52)	6889 (7.91)
Others	1200 (1.31)	2400 (2.68)	2598 (2.96)	2985 (3.22)	2456 (2.82)
Total input costs	91575	89522	87664	92655	87081
Depreciation	3800	4419	3874	3650	3176
Interest on fixed assets	8000	8517	12908	12620	18221
Rental value	25000	25000	25000	25000	25000

Note: Figure in parenthesis indicates the percentage to total cost.

Table 4 explains the cost and return details of TCB growers. Total cost (cost C3) was highest in case of semi-medium category of farmers (221658 ₹/ha) followed by small farmers (211634 ₹/ha). This is due to the higher usage of inputs and hired machineries by small and marginal farmers. Yield was almost same in all category of farmers. Gross returns was highest in medium and large category of farmers followed by small farmers. Farm Business Income was highest in the case of marginal farmers as compared to other category of farmers. Net income over cost C_2 and C_3were maximum in marginal category of farmers, except net income over cost C_2 where medium and large farmers position is slightly higher (303795 ₹/ha).In a nut shell as the farm size increased the net income decreased in tissue culture banana.

Table 4: Costs and returns in tissue culture banana cultivation (₹/ha)

Particulars	Marginal	Small	Semi medium	Medium and large	All
Yield (Bunch/ha)	2920	2923	2931	2933	2929
Cost A	149874	159092	159902	156698	157210
Cost B_1	158072	170458	171407	163532	167123
Cost B_2	168489	190458	199324	189469	190298
CostC_1	160147	172395	173591	165482	169168
CostC_2	170564	192395	201507	191419	192342
CostC_3	187620	211634	221658	210561	211576
Gross Returns	463333	467727	469104	469277	468732
Farm Business Income	313459	308635	309202	312579	311523
Family Labour Income	294844	277269	269780	279808	278435
Net Income over Cost C_1	303186	295332	295513	303795	299565
Net Income over Cost C_2	292769	275332	267597	277858	276391
Net Income over Cost C_3	275713	256093	247446	258716	257157

Table 5 depicted the cost and returns of sucker propagated banana cultivation. Yield was highest in the case of marginal farmers followed by semi medium farmers. Cost C_2 was highest in case of medium and large farmers. Again marginal farmers were reaping the maximum gross return of ₹ 386000 among all categories. When it comes to the net return over various costs, marginal and small category of farmers benefited more with highest net income over cost C_2. In total sucker propagated banana yielded 215877 ₹/ha against 257157 ₹/ha in tissue culture banana cultivation.

Table 5: Cost and returns of sucker propagated banana cultivation (₹/ha)

Particulars	Marginal	Small	Semi medium	Medium and large	All
Yield (Bunch/ha)	2900	2705	2724	2716	2798
Cost A	116625	110007	107778	107437	110418
Cost B_1	124125	118363	126106	117437	125506
Cost B_2	130375	127807	140974	137437	139628
CostC_1	126500	120674	128485	123437	127930
CostC_2	132750	130118	143353	143437	142052
CostC_3	145037	143306	162660	157781	156257
Gross Returns	386000	365294	364186	365583	372134
Farm Business Income	269375	255287	256408	258146	261716
Family Labour Income	255625	237487	223212	228146	232506
Net Income over Cost C_1	259500	244620	235701	242146	244204
Net Income over Cost C_2	253250	235176	220833	222146	230082
Net Income over Cost C_3	240963	221988	201526	207802	215877

The elasticities of production of banana derived by fitting the cob-Douglas production function under tissue culture and sucker propagated are presented in table 6. Planting material, human labour, plant protection chemicals, machine and bullock labour were having a positive and significant impact on the productivity of tissue culture banana production. Surprisingly, irrigation and chemical fertilizers did not impact the yield significantly. Yield response was maximum towards the use of plant protection chemicals. In case of sucker propagated banana irrigation and chemical fertilizer components were coming as significant variables and the

response of chemical fertilizer component is negative with a magnitude of 1.27.

Table 6: Production function estimates for banana cultivation by using tissue culture and sucker propagated plantlets.

Variable	Tissue culture		Sucker propagated	
	Coefficients	Standard Error	Coefficients	Standard Error
Intercept	-1.51	0.21	1.58	1.12
Planting material	0.10***	0.03	-0.08	0.10
Human labour	0.28***	0.05	0.05	0.310
Machine and bullock labour	0.30***	0.04	0.31	0.317
Irrigation	-0.01	0.03	1.55***	0.451
Plant protection chemicals	0.35***	0.05	0.40	0.416
Chemical fertilizers	-0.01	0.03	-1.27**	0.55
R^2	0.8		0.81	

Note: *, ** and *** represents significance at 10, 5 and 1 per cent levels, respectively

Table 7 showed the difference in net returns between adopter and non-adopter farmers. Adopter farmers were found earning 16.7 per cent higher income than non-adopter farmer. Even though the Absolute figures were higher in marginal category of farmers, the per cent variation in the net income was highest in the category of medium and large farmers. With increase in farm size, the variation in income between the adopter and non-adopter categories were also found to be increasing.

Table 7: Difference in net returns of tissue culture technology and sucker propagated banana.

Particulars	Marginal	Small	Semi medium	Medium and large	All
Adopter	292769	275332	267597	277858	276391
Non adopter	253250	235176	220833	222146	230082
% Variation	13.4	14.5	17.4	20.0	16.7

Using frontier production function the technical efficiencies were calculated for each farms. The results show that under TC adopter category, 77.7 per cent of the farmers were under 95-100 per cent efficiency category followed by 9.5 per cent farmers in less than 75 category. Among non-adopters 43 per cent were under 85-90 category followed by 13.5 per cent in 80-85.

On an average, technical efficiency in case of adopter category was 0.94 and that of non-adopter category was 0.86.Under TCB growing farmers, technical efficiency was found to be higher in case of semi medium category of farmers, followed by small category.

In all categories of farmers most of the farms were under 95-100 per cent efficiency range. Among small category 16.6 per cent farmers were in less than 75 per cent efficiency category. The technical efficiency of marginal farmers were comparatively less among all adopters.

Table 8: Distribution of sample farmers in banana cultivation according to technical efficiency level

Efficiency (%)	Adopter (%)	Non adopter (%)
95-100	77.7	8.1
90-95	7.9	27
85-90	1.6	43.2
80-85	3.1	13.5
75>	9.5	8.1
Average	0.94	0.86

Table 9: Categorization of TCB growing farms based on the efficiency levels

Efficiency (%)	Marginal (%)	Small (%)	Semi medium (%)	Medium and large (%)
95-100	66	75	85.7	77.7
90-95	25	8.3	0	5.5
85-90	0	0	4.7	0
80-85	0	0	4.7	5.5
75>	8.3	16.6	4.7	11.1
Average	0.92	0.95	0.96	0.94

Constraints in tissue culture banana cultivation

Tissue culture banana cultivation in the region faced various kinds of constraints. An attempt is made to capture the major constraints faced using Garett ranking, and the results are presented in the Table 10.The risk due to abiotic factors like wind and drought were identified the farmers as the most important constraint for adoption of tissue culture banana in the region. This received the highest score of 87 Since the region is highly vulnerable to these threats. This was followed by the factors like quality of inputs including, planting material. The quality of planting material is the key factor in a biotechnological intervention like tissue culture, and in most of the cases the quality wasfound to be inferior. In addition to this, the high cost of plant lets and lack of insurance benefits also affectedthe adoption of tissue culture banana cultivation. Other factors restricting the adoption of the technology include the lack of reliable markets and storage facilities in the region, and shortage of labour.

Table 10: Constraints in tissue culture banana production

Constraint	Score	Rank
Risk due to abiotic factors(wind, drought)	87	I
Lack of availability of good quality plantlets and inputs	79	II
High price of plantlets	77	III
Insurance benefits	76	IV
Reliable market facility	72	V
Storage facilities	69	VI
shortage of labour	59	VII

CONCLUSION

It can be concluded that, the adopters of tissue culture technology were young and educated farmers, who had better land holding and household income. Cost and

return in tissue culture banana showed that the total cost (cost C_3) was highest in the category of semi-medium farmers followed by small farmers. Farm Business Income was found to be highest in the case of marginal farmers. Net income over cost C_2 and C_3 was maximum in marginal category of farmers, except net income over cost C_2in which, medium and large farmers position was slightly higher (303795 ₹/ha). As compared to the sucker propagated banana, tissue culture banana yielded higher in terms of weight. Planting material, human labour, plant protection chemicals, machine and bullock labour had a positive and significant impact on the yield of tissue culture banana. The effect of irrigation and chemical fertilizers on yield was found to be insignificant. One unit increase in planting material enhances the tissue culture banana production by 0.107 units. Similarly, a unit increase in human labour,bullock and machine labour, and plant protection chemicals increase the yield by 0.289, 0.308 and 0.351 units respectively. Frontier technical efficiency analysis revealed that average technical efficiency level of adopters was 0.94 and for non-adopter it was 0.86. Among adopters, major share of farmers were highly efficient, which indicated the potential of those farmers to attain maximum desirable physical output. This again indicated the adequate and timely application of better package of practices with quality inputs. Among different category of farmers, semi medium farmers hold the first position followed by small farmers. In small farmer category, 17 percent of the farmers fell under the range of less than 75 percent. The efficiency level of marginal farmers were found to be least compared to the other category of farmers. The risk due to wind, drought and other abiotic factors was identified as the major constraint in the adoption of tissue culture banana in the region, followed by quality and cost of planting material, poor insurance coverage, marketing and storage facilities.

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