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Diffusion of crossbreeding technology in piggery: A case of 'T&D' breed in Eastern region of India

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The paper throws light on the genesis and diffusion of a new breed of pig developed and propagated in India. The breed named 'T&D' was developed by crossing and continuous selection of Tamworth with local indigenous (Desi) pig which is distinctively black in colour. The extent of dissemination of the technology was assessed through random selection and interviewing 240 farmers across four states of India. It was interesting to see color as a trait significantly influencing the choice of farmers especially among the tribal communities. The 'T&D' pig innovation has spread beyond its place of origin to distant places especially in Eastern and North eastern parts of India, where pork consumption is comparatively very high. The study revealed that due to desired innovation attributes like relative advantage, observability, cultural compatibility and trialability, there was faster rate of adoption of 'T&D pig'. Favourable impact of adoption of 'T&D' pig innovation was observed in terms of guarantying farmers price premium, mitigating marketing uncertainty, reducing drudgery and compatibility with existing farming system.

Key words: Diffusion, adoption, crossbred pigs, India.

INTRODUCTION

Developing countries of Asia and Africa have witnessed unprecedented economic growth and increase in real per capita income in last two decades. These two key factors have resulted in increased consumption led demand of livestock products. Although, increase in consumption of food products of animal origin has been most prominent for milk and milk products, recent trends in dietary patterns suggest that consumption of meat is increasing albeit from a low base. The rise in meat consumption has

primarily been overshadowed by poultry meat consumption. However, among livestock species an important but understated change has been observed in case of consumption of pig meat and pork products. During the past three decades, per-capita consumption of pig meat has increased at a rate of 1.40% per annum as against 0.48 and 0.20% growth rate observed in case of bovine and ovine (sheep and goat) meat, respectively (Bardhan, 2007). Though, pig husbandry in India has

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Abbreviations: 'T&D', Tamworth and *desi* (Local); **KVK**, Krishi Vigyan Kendra; **DAH**, department of animal husbandry; **GDP**, gross domestic product.

been considered as an occupation for scheduled tribes and other economically backward classes, status regarding livestock ownership at national level suggests that pig production is an economic activity dominated by marginal and smallholders (NSSO, 2003). The growth in domestic demand for pork, thus, presents a potential for increased smallholder income and for poverty alleviation among rural households.

Local/indigenous pigs constitute the bulk of pig population in India with poor growth rate and productivity and are reared under extensive and scavenging system and to a lesser extent in a semi-intensive system under subsistence farming, with few or no inputs. Average meat yield of pigs in India is 35 kg/animal, which is about 55% less than the corresponding value of world average (FAO, 2011). An important development in India's livestock production system including piggery has been the introduction of high-producing exotic germplasm to improve the productivity of indigenous stock (Birthal and Taneja, 2006). A plethora of studies have highlighted the impact and consequences of crossbreeding in dairy sector (Rao et al., 1995; Patil and Udo, 1997; Samdup, 1997; Staal et al., 2005; Patil, 2006). However, there exists a black box regarding pattern of adoption and diffusion process of crossbreeding technologies in piggery; relative importance of various factors associated with adoption and various channels and factors involved in diffusion. Adoption and diffusion studies assume critical importance, as they provide crucial inputs to policy makers in increasing the efficiency of dissemination process of technologies, and also ensuring their effective uptake by the farmers.

The present study is an attempt to address specific crossbreeding technology, viz. 'T&D' pig, which is black colour pig obtained by crossing exotic pig 'Tamworth' with 'local Pig'. The 'T&D' pig has faster growth rate, better reproductive performance, higher disease resistance and better adaptability at farmers' door. The profitability of 'T&D' breeds over traditional breeds has been established in several earlier studies (Verma, 2003; Mahto, 2008). This breed has been developed in Agricultural University at Ranchi, Jharkhand State of India and promoted in native and adjoining States, viz. Bihar, West Bengal, Madhya Pradesh and North Eastern States, for enhancing sustainable livestock production with both environmental and socio-economic benefits. The specific objectives of the study were to assess the adoption pattern of 'T&D' pig innovation and its diffusion in the study area, identify the factors influencing adoption of 'T&D' pig and analyze the socio-economic consequences associated with 'T&D' pig adoption.

MATERIALS AND METHODS

Sampling

The study employed a combination of multistage random and purposive sampling technique to select the ultimate sampling units.

'T&D' pig was developed at Birsa Agricultural University, Ranchi, Jharkhand in 1989 and gradually spread within the Jharkhand State (23° 23' N and 85° 23' E) and in adjoining States, viz. West Bengal (23° 14' N and 87° 07' E), Bihar (42° 49' N and 85° 01' E) and Chhattisgarh (22° 53' N and 84° 12' E). One district was selected from each State, viz. Ranchi district from Jharkhand, Bankura district from West Bengal, Jashpur district from Chhattisgarh and Gaya district from Bihar. These districts were selected on account of having highest concentration of pig farmers among all the districts in the respective States. Most of the farmers in these selected districts were tribals and pork consumption was comparably very high among these communities. Surveys for the study were purposely targeted at farmers who own pigs. Only those farmers were considered who were engaged in pig husbandry for a minimum period of 5 years so as to have proper and reliable response on different variables. A semi-structured questionnaire was administered to 60 randomly selected farmers in each State, thus, making a sample size of 240 farmers.

Data

The socioeconomic variables selected were farm experience, education, communication profile, landholding, size of pig stock, income generation from piggery, economic motivation for rearing pigs, attributes of innovation, need perception, constraints in piggery and degree of adoption of improved pig husbandry practices.

Descriptive analyses

Descriptive statistics in the form of means and proportions were used to analyse farm and farmer-specific characteristics and information pertaining to different aspects regarding adoption of 'T&D' pig innovation.

Explaining likelihood of adoption of 'T&D' pig

Binary Choice Regression model (Logit) was formulated in an attempt to explain the factors influencing adoption of 'T&D' pig. Logit analysis is a mathematical modelling approach which describes the relationship of one or several explanatory variables (X 's) to a binary response variable (Y) coded to take the value of 1 or 0 for success or failure, respectively. The dependent variable in this study was dichotomous in nature (dependent variable assumes a value of 1 in case a respondent has adopted 'T&D' pig and 0 if the respondent has not adopted). The Logit model is of the form:

$$P_i = \frac{1}{(1 + e^{z_i})}$$

Where, P_i is the probability that the dependent variable assumes a value of 1

$$1 - P_i = 1 - \frac{1}{(1 + e^{z_i})}$$

is the probability that the dependent variable assumes a value of 0, where

$$Z_i = \alpha + \sum \beta_i X_i$$

$$\text{Odd's Ratio (OR)} = \frac{P_i}{1 - P_i} = e^{Z_i}$$

Taking log on both sides,

$$\ln \frac{P_i}{1 - P_i} = Z_i = \alpha + \sum \beta_i X_i + e_i$$

Where X_i is a vector of independent variables and β_i 's are the coefficients to be estimated. These coefficients represent change in log of odds of T & D pig innovation adoption. A positive estimated coefficient implies an increase in likelihood that the respondent will be adopter of 'T&D' pig with a unit increase in the concerned explanatory variable. e^{β} gives the Odd's Ratio associated with change in independent variable. The Odd's Ratio means the ratio of probability of happening of an event to probability of not happening of that event. The odds are expressed as single number to the ratio to 1. Odds of 2, for example, mean that likelihood of adoption of 'T&D' pig is twice that of non-adoption. The above econometric model was estimated using the iterative Maximum Likelihood Estimation (MLE) procedure due to the nonlinearity of the logistic regression model.

RESULTS AND DISCUSSION

Profile of pig farmers

Table 1 elicits the socioeconomic profile of pig farmers surveyed in the study area. Vast majority of pig farmers surveyed in this study belonged to Scheduled Castes/Scheduled Tribe caste category (81%). Religion-wise profiling of the respondents revealed that highest proportion of pig farmers in all the states except Bihar belonged to Sarna religion of tribes (38% in Jharkhand, 53% in West Bengal and 45% in Chhattisgarh). There are as many as 30 different tribes in this region (<http://tribes-of-jharkhand.blogspot.in/>). In Bihar, Hinduism was the predominant religion as 90% of the pig farmers belonged to this religion in the State. Findings regarding education of respondents revealed good educational status in all the four states as highest proportions of pig farmers in these states were educated up to high school level (38%).

Jini (2008) and Kumar (2012) had also reported that tribal community has good level of education. Pandey (1996) on the other hand reported that tribals have low literacy rate. Fifty-three percent of the farmers across all the States had 31 to 45 years of experience in pig farming which is considered as high experience level. Crop cultivation was the primary occupation for majority of the pig farmers (65%) while animal husbandry was the main source of income for only 12% of households. Animal husbandry was pursued mainly as a subsidiary occupation by majority of respondents (84%).

Subsistence nature of crop farming was revealed by the preponderance of marginal farmers (66%) followed by landless (17%) and large land holders (4%) (Table 2). Highest proportion of respondents in all the states owned small herd size (up to 3 animals) in all the States (80% in

Jharkhand, 83% in West Bengal, 82% in Chhattisgarh and 87% in Bihar).

Size of pig stock and reasons for pig keeping

Majority of the pig farmers (65%) had small size of pig stock while 24% owned medium size pig stocks followed by large size of pig stock (11%) (Table 3). Overall, average size of pig stock was 14 in Jharkhand, 10 each in West Bengal and Chhattisgarh and 8 in Bihar.

Across all States, source of extra income and cultural and religious reasons were reported as the most important reasons for rearing pigs by the highest proportion of pig farmers (82%) while 62% pig farmers reared pigs as their main source of income (Table 4). Source of employment and utilization of waste materials were reported as reasons for keeping pigs by relatively lesser proportion of respondents (40% and 38%, respectively). The findings are in line with the results of Mahli (2004) and Jini (2008).

Source of information about 'T&D' pigs

Table 5 presents the findings regarding sources from which the pig farmers obtained information about 'T&D' pigs. Pooled data from all the four States revealed that majority of farmers obtained information on 'T&D' pig through personal localite channels viz. relatives (85%), fellow farmers (82%), neighbors (76%), village leaders (61%) and friends (61%). On the other hand, relatively lesser proportions of farmers received information about 'T&D' pig through personal cosmopolite channel, viz. Agricultural University/Krishi Vigyan Kendra (KVK) personnel (48%), Department of Animal Husbandry officials (49%) and pig grower society (14%). *Gram Sewak* (61%) was the only personal cosmopolite channel through which relatively higher proportion of farmers (61%) received information about 'T&D' pig. Since 'T&D' breed was developed in the State Agricultural University in Jharkhand, Pig Grower Society, Agricultural University and its associated Farm Science Centers played a major role in promotion of new breed. Higher proportion of respondents obtained information from Department of Animal Husbandry in Bihar (50%) and Chhattisgarh (58%) while State Agricultural University and associated institutes (28 and 17%, respectively) were the major source of information.

Pooled data from all the four States revealed that majority of farmers obtained information on 'T&D' pig through personal localite channels followed by personal cosmopolite channels. This indicates that cosmopolite channels are relatively more important at the knowledge stage and localite channels are relatively more important at the persuasion stage. Cosmopolite communication channel are those linking an individual with source

Table 1. Distribution of sample households on the basis of their socio-economic characteristics.

Category	Jharkhand		West Bengal		Chhattisgarh		Bihar		Pooled	
	f	%	f	%	F	%	f	%	f	%
Caste										
SC	05	8.3	12	20.0	07	11.7	44	73.4	68	28.3
ST	37	61.7	42	70.0	45	75.0	02	03.3	126	52.5
OBC	10	16.7	04	06.7	05	08.3	09	15.0	28	11.7
General	08	13.3	02	03.3	03	05.0	05	08.3	18	07.5
Religion										
Hindu	23	38.0	18	30.0	15	25.0	54	90.0	110	45.8
Christian	15	25.0	10	16.7	18	30.0	4	06.7	47	19.6
Sarna	22	36.7	32	53.3	27	45.0	2	03.3	83	34.6
Education										
Illiterate	00	00	00	00	00	00	00	00	00	00
Primary	00	00	08	13.3	10	16.7	17	28.3	35	14.6
Middle	13	21.7	18	30.0	15	25.0	12	20.0	58	24.2
High School	27	45.0	25	41.7	22	36.7	18	30.0	92	38.3
Intermediate	12	20.0	06	10.0	09	15.0	10	16.7	37	15.4
Graduate and above	08	13.3	03	05.0	04	6.6	03	05.0	18	07.5
Farm experience										
< 30 years	18	30.0	15	25.0	21	35.0	19	31.7	72	40.0
31-45 years	39	65.0	40	66.7	36	06.0	37	61.7	152	53.2
> 45 years	03	05.0	05	08.3	03	05.0	04	06.7	15	06.8
Annual household income										
Low (< Rs. 50, 000)	10	16.7	09	15.0	12	20.0	22	36.7	53	22.1
Medium (Rs. 50, 000-Rs. 60, 000)	42	70.0	45	75.0	43	71.7	35	58.3	165	68.7
High (> Rs. 60, 000)	08	13.3	06	10.0	05	08.3	03	05.0	22	09.2
Occupation (Primary)										
Crop Cultivation	38	63.3	32	53.3	48	80.0	38	63.3	156	65.0
Animal Husbandry	12	20.0	04	06.7	05	08.3	07	11.7	28	11.6
Agricultural Labour	00	00	19	31.7	00	00	08	13.3	27	11.3
Non-agricultural Labour	03	05.0	00	00	01	01.7	02	03.3	06	02.5
Trade and Commerce	03	05.0	02	03.3	02	03.3	03	05.0	10	04.2

Table 1. Contd.

Service	04	06.7	03	05.0	04	06.7	02	03.3	13	05.4
Occupation (Secondary)										
Crop Cultivation	02	03.3	03	05.0	02	03.3	02	03.3	09	03.7
Animal Husbandry	52	86.7	48	80.0	52	86.7	49	81.7	201	83.7
Agricultural Labour	03	05.0	04	06.7	02	03.3	04	06.7	13	05.4
Non-agricultural Labour	02	03.3	03	05.0	03	05.0	02	03.3	10	04.2
Trade and Commerce	01	01.7	02	03.3	01	01.7	03	05.0	07	02.9
Service	00	00	00	00	00	00	00	00	00	00

Table 2. Distribution of sample households on the basis of their farm characteristics.

Category	Jharkhand		West Bengal		Chhattisgarh		Bihar		Pooled	
	f	%	f	%	F	%	F	%	f	%
Size of landholding										
Landless (No land)	06	10.0	22	36.7	04	06.7	08	13.3	40	16.7
Marginal (0.1-2.5 acres)	43	71.6	28	46.7	43	71.6	44	73.4	158	65.8
Small (2.6-5.0 acres)	04	06.7	06	10.0	06	10.0	05	08.3	21	08.7
Medium (5.1-10.0 acres)	04	06.7	02	03.3	03	05.0	02	03.3	11	04.6
Large (>10 acres)	03	05.0	02	03.3	04	06.7	01	01.7	10	04.2
Mean±SE	2.06±0.26		1.41±0.30		2.05±0.32		1.40±0.25		1.73±0.14	
Herd Size										
Small (<3 animals)	48	80.00	50	83.3	49	81.7	52	86.7	199	82.9
Medium (4-6 animals)	12	20.00	10	16.7	11	18.3	08	13.3	41	17.1
Large (>6 animals)	00	00	00	00	00	00	00	00	00	00
Mean±SE	2.90±0.16		2.50±0.10		2.80±0.13		2.93±0.13		2.78±0.07	

Table 3. Distribution of sample households according to the size of pig stock.

Category	Jharkhand		West Bengal		Chhattisgarh		Bihar		Pooled	
	f	%	f	%	F	%	F	%	f	%
Small (<10 pigs)	32	53.4	43	71.7	37	61.7	44	73.3	156	65.0
Medium (11-15 pigs)	17	28.3	12	20.0	15	25.0	14	23.3	58	24.2
Large (>15 pigs)	11	18.3	05	08.3	08	13.3	02	03.3	26	10.8
Total	60	100	60	100	60	100	60	100	240	100
Mean±SE	13.98±1.44		10.26±0.79		9.76±0.81		8.35±0.68		10.58±0.50	

Table 4. Distribution of respondents according to rationale for pig farming.

Reason for pig farming	Jharkhand		West Bengal		Chhattisgarh		Bihar		Pooled	
	f	%	f	%	F	%	F	%	f	%
Main source of income	32	53.3	45	75.0	50	83.3	38	63.3	165	68.7
For extra income	49	81.7	52	86.7	45	75.0	50	83.3	196	81.7
To utilize waste	15	25.0	25	41.7	30	50.0	21	35.0	91	27.9
For employment	18	30.0	28	46.7	26	43.3	23	38.3	95	39.6
Cultural and religious reasons	45	80.0	52	86.7	55	91.7	41	68.3	196	81.7
Own consumption	20	33.3	24	40.0	27	45.0	18	30.0	89	37.1

Table 5. Distribution of respondents according to their source of information for 'T&D' pig innovation.

Source	Jharkhand		West Bengal		Chhattisgarh		Bihar		Pooled	
	f	%	f	%	F	%	F	%	f	%
Personal localite channel										
Neighbour	41	68.3	47	78.3	45	75.0	49	81.7	182	75.8
Relatives	49	81.7	51	85.0	55	91.7	50	83.3	205	85.4
Village leader	35	58.3	42	70.0	30	50.0	39	65.0	146	60.8
Fellow farmer	50	83.3	52	86.7	48	80.0	46	76.7	196	81.7
Friends	31	51.7	36	60.0	42	70.0	38	63.3	147	61.2
Personal cosmopolite channel										
Agricultural University/KVK personnel	47	78.3	40	66.7	10	16.7	17	28.3	114	47.5
DAH officials	28	46.7	25	41.7	35	58.3	30	50.0	118	49.2
Gram Sewak	32	53.3	38	63.3	36	60.0	40	66.7	146	60.8
Pig Grower Society Personnel	34	56.7	00	00	00	00	00	00	34	14.2

outside the social system

Reasons for adopting T&D pigs

Farmers' motivation to convert from traditional (local pig) to 'T&D' pig (crossbred) farming were categorized into farming related motivation, financial motivation, personal motivation and general concerns motivation (Table 6). Majority of the farmers (91.70%) reported low yield problem (litter size) with traditional piggery followed by problems relating to husbandry and technical aspects (78%) and animal health problems (65%) under farming related motivation to adopt 'T&D' pig innovation. Under financial motivation category, need for solving existing financial problems (88%) was the reason for adopting 'T&D' pig innovation by highest proportion of farmers followed by need for cost saving (81.70%) and securing future of farm (72%). It was interesting to note that majority of the farmers (91.25%) reported black colour of 'T&D' pigs as the reason for its adoption, followed by cultural reasons (76.25%), custom reasons (69.20%), religious reasons (63.75%) and ancestral or traditional reasons (57.10%) under the personal motivation category

of 'T&D' pig innovation adoption. All the sample farmers reported that meat quality had motivated them to adopt 'T&D' pig, while 86% of the farmers were motivated to adopt 'T&D' pig for self employment reasons. Environmental concerns and (75.00%) and stewardship (71.25%) were the reasons for adoption of 'T&D' pig under general concerns motivations.

Characteristics of different adopter categories of 'T&D' innovation

The 'T&D' pig adopters were categorized into five adopter categories (Rogers, 2003) by using mean and standard deviation, viz. innovators (2.50%), early adopters (13.75%), early majority (33.7%), late majority (31.70%) and laggards (18.30%). The detailed characteristics of each adopter categories are depicted in Table 7. Innovator farmers adopted 'T&D' pig early in the study area due to more contact with research personnel of Birsa Agricultural University, Ranchi and also accessed 'T&D' piglets free from scientists of Birsa Agricultural University as on trial basis. Further, few farmers had good interaction with the personnel of KVK, Bankura

Table 6. Distribution of respondents on the basis of motivation to convert from traditional to 'T&D' pig farming.

Motivation	Jharkhand		West Bengal		Chhattisgarh		Bihar		Pooled	
	f	%	F	%	F	%	F	%	f	%
Farming related motivation										
A. Husbandry and technical reasons	50	83.0	48	80.0	52	86.6	38	63.3	188	78.3
B. Animal health problems	42	70.0	38	63.3	40	66.6	36	60.0	156	65.0
C. Yield problem (litter size)	58	96.6	56	93.3	52	86.6	54	90.0	220	91.7
Financial motivation										
A. Solve existing financial problems	56	93.3	52	86.6	50	83.0	54	90.0	212	88.3
B. Secure future of farm	46	76.6	42	70.0	44	73.3	40	66.6	172	71.7
C. Cost saving	52	86.6	50	83.0	48	80.0	46	76.6	196	81.7
D. Premium marketing	58	96.6	54	90.0	50	83.0	52	86.6	214	89.2
Personal motivation										
A. Ancestry/Tradition	30	50.0	40	66.6	42	70.0	25	41.6	137	57.1
B. Choice of black colour pigs	58	96.6	56	93.3	57	95.0	48	80.0	219	91.2
C. Custom reasons	42	70.0	45	75.0	44	73.3	35	58.3	166	69.2
D. Cultural reasons	48	80.0	49	81.6	46	76.6	40	66.6	183	76.2
E. Religious reasons	35	58.3	40	66.6	42	70.0	36	60.0	153	63.7
General concerns										
A. Stewardship	42	70.0	45	75.0	44	73.3	40	66.6	171	71.2
B. Meat quality	60	100.0	60	100.0	60	100.0	60	100.0	240	100.0
C. Rural development	56	93.3	50	83.0	48	80.0	52	86.6	206	85.8
D. Environment	48	80.0	42	70.0	46	76.6	44	73.3	180	75.0

Table 7. Characteristics of adopter categories in 'T&D' pig innovation (N=240).

Characteristic	Innovators n=06	Early adopters n=33	Early majority n=81	Late majority n=76	Laggards n=44
Age	Young to middle	Middle	Middle	Middle	Middle
Education	Above high school	High school	High school	High school	High school
Family size	Small	Small	Medium	Medium	Medium
Herd size	Small	Small	Small	Small	Small
Land size	Marginal to small	Landless	Marginal	Marginal	Marginal
Social participation	High	High	Medium	Low	Low
Extension contact	High	Medium	Medium	Medium	Low
Cosmo-politeness	High	Medium	Medium	Medium	Low
Innovation proneness	High	Medium	Medium	Medium	Medium
Economic motivation	High	Medium	Medium	Low	Medium
Risk orientation	High	High	Medium	Medium	Low

which made them to adopt the innovation. Interestingly, majority of the characteristics of adopter categories were similar to the findings of Rogers (2003).

Time lag in adoption of T & D pigs

A small proportion of farmers first became aware in Jharkhand about 'T&D' pig in the year 1994 (Table 8). Thereafter, awareness spread amongst other farmers

and majority of them (18.30, 21.70 and 25.00%) became aware about the 'T&D' pig by the year 1998, 1999 and 2000, respectively. Most of the farmers (16.70, 18.30 and 30.00%) of West Bengal became aware about the 'T&D' pig in the year 2004, 2005 and 2006, respectively. Majority of the farmers (15.00, 21.70 and 28.30%) of Chhattisgarh first became aware about 'T&D' pig in year 2003, 2004 and 2005, respectively. Majority of the farmers (15.00, 20.00 and 16.70%) of Bihar became aware about the 'T&D' pig innovation in the year 2002,

Table 8. Pattern of adoption of T& D pig innovation.

Adoption year	Jharkhand		West Bengal		Chhattisgarh		Bihar		Pooled		Cumulative No.
	f	%	f	%	f	%	f	%	f	%	
1994	01	01.70							01	00.42	01
1995	01	01.70							01	00.42	02
1996	02	03.30							02	00.83	04
1997	03	05.00							03	01.25	07
1998	04	06.70							04	01.70	11
1999	06	10.00			01	01.70			07	02.90	18
2000	09	15.00			02	03.30	02	3.30	13	05.40	31
2001	12	20.00	01	01.70	02	03.30	02	3.30	17	07.10	48
2002	08	13.30	02	03.30	04	06.70	04	6.70	18	07.50	66
2003	06	10.00	03	05.00	05	08.83	06	10.00	20	08.30	86
2004	03	05.00	06	10.00	07	11.70	07	11.70	23	09.60	109
2005	01	01.70	08	13.3	10	16.70	11	18.30	30	12.50	139
2006			14	23.3	07	11.70	07	11.70	28	11.70	167
2007			07	11.70	06	10.00	05	8.30	18	7.50	185
2008			05	08.30	04	04.70	04	6.70	13	5.40	198
2009			04	06.70	02	3.30	03	5.00	09	3.75	207
2010			03	05.00			01	1.70	04	1.70	211

2003 and 2004, respectively. Overall, awareness to adopt 'T&D' pig was perceived in 1994 (1.25%) and majority of the farmers became aware about T&D pig first during the year 2000 to 2005.

Majority of the respondents (35.00%) had high adoption level and 25.0% of respondents had full adoption level of 'T&D' pig innovation (Table 9). However, 17.1% of respondents had partial adoption level and 10.8% of the respondents had low adoption level of innovation. Only 12.1% of the respondents reported non-adoption of 'T&D' pig innovation. The above findings thus depict a high rate of adoption of 'T&D' pig innovation.

The major reason for non-adoption of 'T&D' pig innovation was poor supply of 'T&D' piglets as reported by 80% of non-adopters, followed by expensive investment (72%), and lack in conviction (72%) across all the states under study (Table 10). Discouraging results in trial (47.10%), government substitute (39.20%) and local substitute (38.75%) were other reasons for non adoption of 'T&D' pig innovation.

Sources of procurement of 'T&D' innovation

The T&D pig could be diffused rapidly in these states due to various interventions by the government agencies through various schemes, NGOs, Agricultural University, apart from the breeding policy (mega seed production) supporting T&D pig multiplication and mission mode projects on pigs.

Majority of the respondents (33.75%) identified Agricultural University/KVK pig farm as source for easy

access of 'T&D' piglet, followed by progressive pig farmers (15.0%), relatives (11.25%), neighbours/villager (10.80%) and private farms (10.0%) and government pig farms (10%). Relatively lesser proportion (5%) of respondents procured 'T&D' piglets from middlemen, friends (3%) and pig grower society (2%).

Constraints in 'T&D' pig production

Non-remunerative price for pork emerged as the most important constraint in pig production as reported by all the respondents (Table 11). Lack of financial support for purchase of improved pigs and construction of sty were identified as the next most severe constraints as reported by 98% of pig farmers, followed by high cost of concentrate mixture (95%), lack of subsidies on purchase of improved pigs (93%), procedural complications in getting support from banks (88%), non-availability of veterinary services (78%) and high cost of vaccines and medicines (70%).

Factors influencing adoption of 'T&D' pig innovation (Logit results)

The results of the logit analysis revealed significant and positive influence of education ($P < 0.05$), extension contact ($P < 0.05$), cosmopolitaness source ($P < 0.05$), innovation proneness ($P < 0.05$) and farm experience ($P < 0.01$) on likelihood of adoption of 'T&D' pig technology (Table 12). Size of land holding ($P < 0.05$), annual

Table 9. Constraints perceived by pig farmers in adoption of piggery development intervention.

Constraint	Respondents		
	f	%	Rank
Non remunerative price for pork	240	100.00	I
Lack of financial support for construction of sty	234	97.50	II
Lack of subsidies on purchase of improved T&D pigs	228	95.00	III
High cost of concentrate mixture	222	92.50	IV
Procedural complications in getting support from banks	210	87.50	V
Non- availability of veterinary services	185	77.80	VI
Cost of vaccines and modern medicines are high	168	70.00	VII
Lack of irrigation facilities for fodder production	160	66.70	VIII
Lack of transportation of pigs to other market places	156	65.00	IX
Lack of market facilities	137	57.08	X
Lack of guidance about the management of improved pigs	108	45.00	XI
Charging exorbitant amount by veterinarian treat/ vaccinate pigs	80	33.00	XII
Distant location of veterinary hospital	72	30.00	XIII
Inadequate input supply	60	25.00	XIV

Table 10. Binary logit estimates for factors affecting 'T&D' pig innovation.

Variable	Coefficient	S.E.	Wald χ^2	P-Value	Odds ratio
Constant	3.863	1.857	4.326	0.038**	47.606
Age	-0.912	0.882	1.069	0.301	0.402
Education	1.354	0.535	6.410	0.011**	3.871
Land holding	0.510	0.564	0.818	0.366	1.665
Size of pig stock	-1.186	0.779	2.318	0.128	0.305
Farming experiences	-1.402	0.825	2.888	0.089*	0.246
Economic motivation	-0.265	1.069	0.061	0.804	0.767
Scientific orientation	0.285	0.822	0.120	0.729	1.329
Risk orientation	0.396	1.082	0.134	0.714	1.486
Extension contact	1.375	1.098	1.568	0.010**	3.957
Mass media Exposure	-0.515	1.105	0.217	0.641	0.597
Cosmopolitaness source	2.227	1.103	4.079	0.043**	9.274
Localitiness source	-0.958	0.979	0.958	0.328	0.384
Innovation proneness	-2.163	1.089	3.948	0.047*	0.115

-2 log likelihood ratio = 152.031, % Correct Predictions = 89.20, Significant at ***1%, ** 5% and *10% level of significance.

income ($P < 0.05$), scientific orientation ($P < 0.05$) and risk orientation ($P < 0.05$) also exerted significant and positive influence on probability of 'T&D' innovation adoption. On the other hand, size of pig stock ($P < 0.05$), mass media exposure ($P < 0.05$), economic motivation ($P < 0.05$), social participation ($P < 0.05$) and localitiness source ($P < 0.05$) were negatively associated with likelihood of adoption of 'T&D' pig innovation.

The estimated model was used to predict probability of 'T&D' pig adoption across all four states. The probability that a pig farmer will adopt the 'T&D' pig technology was 84%, implying that there was 84 % chance that a pig farmer would adopt 'T&D' pig innovation, all other

things being equal/same.

Perceived benefits of T&D pigs over local breed

The respondents in the study typically received 100% price premium on adoption of 'T&D' pig and increased profitability was another important economic advantage of 'T&D' pig as reported by all the sample pig farmers, followed by reduction in marketing uncertainty (75%) and decreased input cost (72%). Majority of the respondents perceived that adoption of 'T&D' innovation increased their comfort level (75%) and decreased the amount of

time spent on performing farming activities (72%) of farmers. Further, 89% of farmers perceived immediacy of reward from social organizations and government officials as a benefit of adoption of 'T&D' pig innovation. High yielding characteristic of 'T&D' pigs (100%) and sustainability of pig production system with the innovation (86%) were major benefits as perceived by the pig farmers.

Majority of the respondents (76.25%) mentioned their previous experience was compatible with 'T&D' pig farming. Most of the respondents had experience in conventional grazing and kitchen waste based piggery while 18% of pig farmers had practiced it on a small scale before finally implementing in their farms. Majority of the pig farmers used pig during festival, ceremony and marriage (100.00%), *Gram Devta pooja* or *Kuldevi pooja* (77.00%), offering of sacrifice during sowing and harvesting of paddy (64.60%), bride dowry (67.10%), gift to daughters after marriage (65.4%) and exchange of pig among relatives and or kinship (61.70%). Few previous studies (Kosgey et al., 2006; Ndumu et al., 2008) have referred it as less tangible objectives of livestock rearing. Nidup et al. (2011) also stated that, in Bhutanese society, pigs were a very important medium by which social significance was measured. He further depicted that white pigs were unpopular because of practice complexity, since white pigs required good feed, shade, plenty of water and access to wallow.

Farmers' perceived less complexity, high knowledge level of pig farming (83%), confidence in actual 'T&D' pig farming (90%) and high information accessibility (61%). However, there were some disadvantages/disincentives in keeping 'T&D' pigs in terms of obtaining technical skills in rearing 'T&D' pigs (94%), maintenance of detailed records (91%) and difficulty in finding 'T&D' piglets (87%). Interestingly, marketing of 'T&D' pigs was not a major problem as only 37% of farmers reported about difficulty in marketing. In the study area, the adoption of innovation had very good observability which was previously reported by Singh (2009).

Conclusion

'T&D' breed of pig with its black colour has found wide acceptance among tribal communities in Eastern India by fulfilling majority of the favourable attributes and depicts the success of cross breeding in pig husbandry. Interestingly, role of personal localite channels in information dissemination was more prominent than personal cosmopolite channels on account of the breed's successful adaptability and better performance in the existing production system. Though, high yield of 'T&D' pig, low per unit cost of production and black colour were the key reasons for wide adoption, non-remunerative price for pork, lack of financial support in the form of credit and subsidies and lack of adequate supply of 'T&D'

piglets were the potential bottlenecks in diffusion and adoption of innovation. In this context, institutional arrangements and enabling policies are critical for the success in identifying and applying appropriate technologies, improving access to input services and facilitating access to markets in order to translate productivity gains into incomes. Livestock technologies, crossbreeding technologies in particular, like in the case of 'T&D' innovation, have the potential to bring poor livestock keepers out of poverty and also to prevent progressive but vulnerable farmers fall back into the clutches of poverty.

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