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Determinants, Nutritional Support and Constraints of Crossbred Cattle Adoption: A Case Study of Dairying in Assam#

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ABSTRACT

While studies show that cattle crossbreeding has important role for dairy development, the adoption of crossbred cattle and diffusion of artificial insemination (AI) is found to be at a nascent stage in Assam resulting in the fact that he state has continued to remain as a milk deficit state. Using techniques such as Probit regression, Propensity Score Matching (PSM) and Rank Based Quotient (RBQ) for cross-section data of 245 smallholder dairy farmers distributed in 3 representative districts of Assam, the study examines the constraints of adoption of crossbred cattle along with its contribution to nutritional security in the state. The study finds that factors such as herd-size, knowledge about AI, membership of dairy cooperative society, being beneficiary of government dairy development schemes and milk price significantly influence adoption of crossbred cattle. Furthermore, adoption of crossbred cattle has significant influence on nutritional gain of the people by way of increase in net dairy income/milch animal/day along with enhanced milk and meat consumption. Hence, working on adoption constraints such as higher requirement of feed and fodder by crossbred cattle, higher requirement of care by these animals, difficulty in getting green fodder etc. as perceived by the farmers would incentivize their adoption of the new technology. Overall, the findings of the study advocate for expansion of extension services, strengthening of dairy cooperative society (DCS) network and raising milk price towards diffusion of crossbred cattle.

Keywords: Crossbreeding, Artificial insemination, Dairy cooperative, Assam

JEL: I30, P36, Q13, Q16

I
INTRODUCTION

While India has set its goal for doubling of farmers' income by 2022, there is a growing apprehension on its feasibility by way of intervention in the crop sector through increased investments. Studies, however, have advocated for a better contribution from the livestock sector (Chandrasekhar and Mehrotra, 2016; Singh, 2018). This is due to the fact that the role of dairy sector as one of the important sub-sectors of livestock component has been continuously increasing in the economy in recent years. Milk has grown to be the largest agricultural commodity in quantity terms and its value can be considered to be at par with that of cereals (Birthal and Jumrani, 2017). The expanding market for milk provides increased opportunities for enhancing income and nutritional support for the farming community. However, the sector has confronted with various challenges that need to be overcome. One such challenge is

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addressing the problem of low productivity of the huge indigenous cattle population in situation with declining feed and fodder resources. To raise productivity of the dairy sub-sector, there is a requirement of optimising cattle population in line with the available feed resources. A major policy prescription in this regard is the reduction of low productive indigenous cattle stock through increased proportion of high-yielding crossbred cattle population (Dalal and Pathak, 2010). This may be facilitated through encouraging the farmers to adopt artificial insemination (AI) technology and/or deployment of pure breed exotic bulls of high genetic merit in not so easily accessible areas. This calls for identifying factors influencing crossbred cattle adoption which would be beneficial for diffusing the crossbreeding technology for the interest of experiencing spike in milk production in states like Assam, where the pace of adoption of the crossbred technology has remained rather slow. Furthermore, demonstrating about the likely benefits of crossbred cattle diffusion on the nutritional front through dairy income enhancement and consumption of protein-rich high value commodities to farmers and policy makers would also encourage the level of adoption.

Government of Assam through the Department of Animal Husbandry and Veterinary, has undertaken several extension activities to promote crossbred cattle production through AI technology. Some of such programmes are- RKVY (*Rashtriya Krishi Vikash Yojana*), externally aided (World Bank) projects like ARIAS (Assam Rural Infrastructure and Agricultural Services project) and AACP (Assam Agricultural Competitiveness Project), etc. However, in spite of such efforts, the rate of adoption of crossbred cattle in the state has remained unimpressive.

There may be various underlying constraints that farmers may perceive to hinder adoption of crossbreeding technology. Ranking of the constraints according to their severity is, therefore, important so that policy prescription can be made to address them on priority basis to increase the rate of adoption of the technology. For this, constraints that farmers may perceive to negatively influence their adoption decision of crossbred cattle are to be identified. Additionally, it is also important to identify the factors determining the adoption of crossbred cattle stock (AI borne) and to demonstrate the likely nutritional gain of adopting high-yielding crossbred cattle at farm household level. The present study is undertaken to systematically address all these issues on a selected group of representative dairy farmers in the state. To be specific, the paper makes an attempt to find out answers to questions such as (i) What are the factors influencing crossbred cattle adoption in Assam? and (ii) What is the impact of crossbred cattle adoption on the net dairy income and consumption of high value commodities for the farm households?

The rest of the paper is organised as follows. Section II is devoted to description of the materials and methods used for carrying out the study. While section III reports and discusses the results of the analysis, Section IV concludes the paper by summarising the findings of the study. It also suggests a few policies for addressing the issue of slower adoption of AI technology in the dairy sector in Assam.

II

MATERIALS AND METHODS

2.1 *Data*

The study is based on primary data collected from 245 smallholder dairy farmers from three districts in the state. The three districts considered for the study are - Barpeta from Lower Brahmaputra Valley Zone, Sonitpur from North Bank Plains zone and Karbi Anglong from the Hills zone. For collection of primary data, multistage sampling technique has been followed to make the sample representative of the dairy farming scenario in the state. The districts were, in the first stage, stratified in terms of high, medium and low density of crossbred cattle population, following which one sample district was randomly selected from each stratum. In the process, three districts, namely, Barpeta Sonitpur and Karbi Anglong were selected from high, medium and low stratum respectively. In the second stage, two community development blocks (CDBs) were selected from each of these three districts considering that these CDBs are non-contiguous to one another. Also, care had been taken to ensure that one CDB had relatively high density of crossbred cattle population compared to the other. Well informed sources such as District Veterinary Officer (DVO) and doctors of block veterinary dispensary were consulted to arrive at the final decision on the selection of CDB. This was followed by random selection of three non-contiguous villages from each of the CDBs in the third stage. In the last stage, two separate lists of farmers (adopter and non-adopter of crossbred cattle) were prepared for each village at the premise of the village headman through discussion with the concerned veterinary field assistant (VFA), *Gopal Mitra* (a private AI worker deployed in a cluster of villages with limited access to VFAs) and a few leading farmers of the village. Finally, 30 per cent farmers were interviewed with a structured questionnaire from both the lists constituting a total of 245 dairy farmers (137 adopters and 108 non-adopters). The location map of the surveyed blocks is given in Figure 1.

2.2 *Methods*

Depending on the objectives of the study, different methods are applied in the process of carrying out the study.

(1) For identifying the factors influencing adoption of crossbred cattle by the sample farmer households, Probit model has been used. A farmer's decision on adoption of ~~ng~~ crossbred cattle depends on the following criterion function (Zavale *et al*., 2005),

$$Y_i^* = \propto Z_i + \mu_i \qquad \ldots. (1)$$

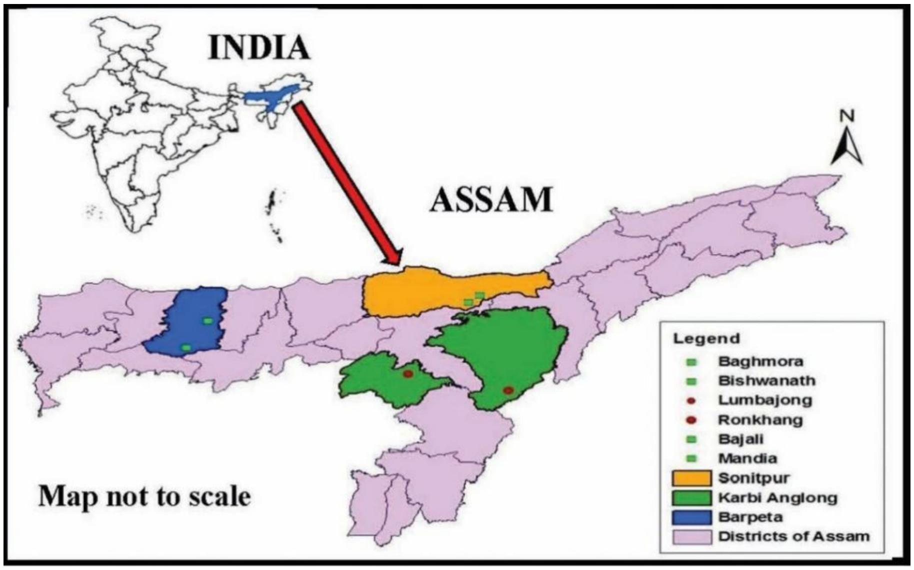


Figure 1. Location map of the surveyed blocks

where Y_i^* is an underlying index reflecting the difference between the utility of adopting and not adopting crossbred cattle, $\propto$ is a vector of parameters to be estimated, Z_i is a vector of exogenous variables explaining crossbred cattle adoption, and μ_i is normally distributed disturbance term. Given the dairy farmers' assessment, when Y_i^* crosses the threshold value, 0, we observe the farmer adopting AI borne crossbred cattle. In actual scenario, Y_i^* is unobservable; the observable counterpart is Y_i, which is defined by

$Y_i = 1$ if $Y_i^*>0$ (Household 'i' rearing crossbred cattle), and $Y_i = 0$ otherwise.

In the case of normal distribution, the model to estimate the probability of observing a farmer rearing AI borne crossbred cattle can be stated as

$$P(Y_i = 1/x) = \varphi\ (x'\beta) = \int_{-\infty}^{x'\beta} \exp\left(\frac{-z^2}{2}\right) dz \qquad \text{....(2)}$$

where,

P is the binary indicator for i[th] household to rear crossbred cattle;

x is the K by 1 vector of the explanatory variables;

z is the standard normal variable (normally and independently distributed); and

β is the K by 1 vector of the coefficients to be estimated.

(2) Following Rosenbaum and Rubin (1985), Heckman *et al*. (1997) and Caliendo and Kopeinig (2005) suggest that propensity score matching (PSM) method based on conditional independence assumption (CIA) can address the problem of selection bias by conditioning on the observable covariates by way of pairing each adopter farmer

with one or more non-member farmers with similar observed characteristics. Furthermore, PSM is grounded on the assumption of overlap or common support underlying that propensity scores of members and non-members remain in the same domain. Finally, PSM needs to fulfill the balancing property, i.e., covariate means of adopter and non-adopters should be the same after matching (Mojo *et al.*, 2017).

Satisfying the above assumptions, we calculate the average treatment effect on the treated (ATT), i.e., the impact of crossbred cattle adoption on income and nutritional indicators of our interest. The ATT is computed as follows:

$$ATT = E(Y_1 - Y_0 /A_i = 1) = E(Y_1/A_i = 1) - E(Y_0/A_i = 1) \quad \text{.... (3)}$$

where, Y_1 and Y_0 are the dairy income and nutritional indicators of dairy production system in Assam at their treated and untreated conditions, respectively; and A_i is an indicator variable denoting crossbred cattle adoption status. Common matching algorithms such as nearest neighbour matching (NNM), kernel based matching (KBM) and radius matching (RM) are used to estimate ATT after controlling treatment and control groups.

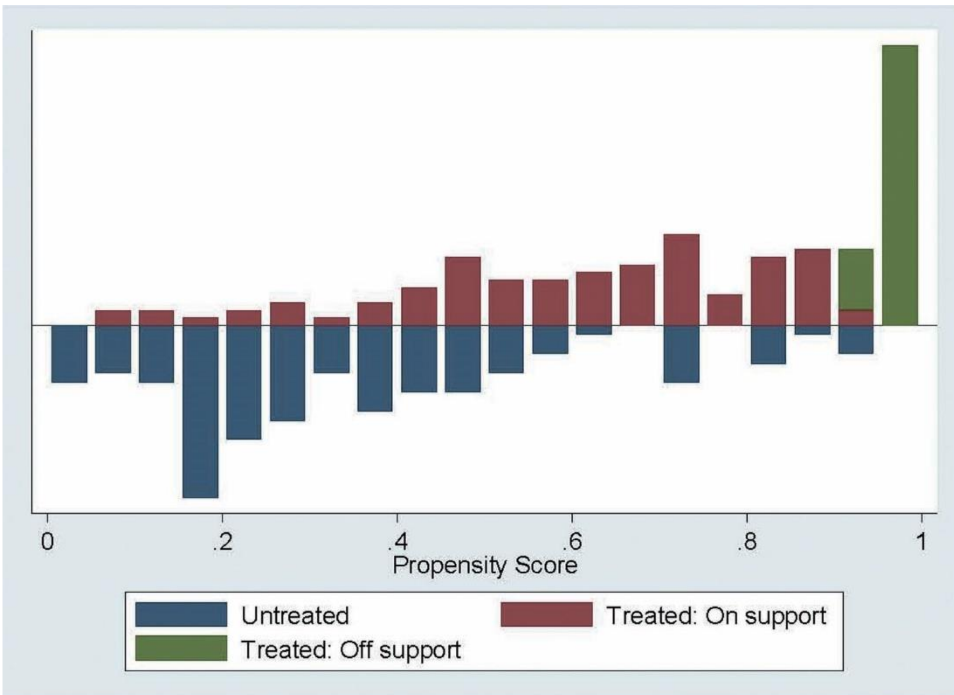
PSM requires to fulfill the balancing property and the same is found in the following way in the context of the study. As indicated in Table 1, the Pseudo-R^2 before matching was 32.9 per cent, which gets reduced to 1.6 – 2.5 per cent post matching. Again, the *p*-values of the likelihood ratio tests (joint significance of covariates) were significant and never rejected before matching, is rejected after matching. The standardised mean difference for the covariates used in the propensity score of around 29.2 per cent prior to matching is reduced to about 4.4-6.8 per cent after matching. This reduces total bias substantially in the range of 76.71 – 84.93 per cent. It is further observed that the number of observations retained after matching are 200 from a total of 245 observations and indicates that the matching process did not result to substantial loss of observations (see Table 1 and graphically in Figure 2).

TABLE 1. INDICATORS OF MATCHING QUALITY PRE AND POST MATCHING

Matching algorithm (1)	Pseudo R^2 before matching (2)	Pseudo R^2 after matching (3)	LR χ^2 (p-value) before matching (4)	LR χ^2 (p-value) after matching (5)	Mean standardised bias before matching (6)	Mean standardised bias after matching (7)	Total per cent bias reduction (8)
NNM[a]	0.329	0.025	110.48 (p=000)***	6.29 (p=0.998)	29.2	6.8	76.71
KBM[b]	0.329	0.018	110.48 (p=000)***	4.70 (p=1.000)	29.2	5.2	82.19
RM[c]	0.329	0.016	110.48 (p=000)***	4.03 (p=1.000)	29.2	4.4	84.93

Source: Author's estimation based on field survey data.

Note: *** Significant at 1 per cent probability level, [a]NNM = five nearest neighbour matching with replacement and on common support, [b]KBM = kernel based matching with band width 0.06 and on common support, [c]RM = radius matching with caliper 0.1 and on common support



Note: "Treated: on support" indicates the observation of high yielding crossbred cattle adoption group that have suitable comparison. "Treated: off support" indicates the observation of high yielding crossbred cattle adoption groups that do not have suitable comparisons.

Figure 2. Distribution of Propensity Scores and Estimation of Common Support for Propensity Scores.

(3) To rank the constraints of adoption of crossbreeding technology 'Rank Based Quotient' (RBQ) technique has been employed. The probable constraints that farmers may be facing for crossbreeding technology adoption were listed in the questionnaire after an iterative process of pilot surveys. Farmers were asked about their perceived constraints as severe and were recorded and later they were reminded of the remaining listed constraints and asked for their preferred ranking. The criterion followed by the farmers was listed first and later they were asked to rank on the basis of individual priority by giving scores from 1 to 5. The strongly preferred criterion was ranked as 5, followed by 4 as less important and then 3 and so on. After interviewing the farmers, the constraint analysis was done to rank the preferences on the basis of RBQ. Analysis was done for the entire sample households of adopters (137) and non-adopters (108) for ranking the constraints.

RBQ as a problem identification technique is represented by the following mathematical notations:

$$RBQ = \sum_{j=1}^{n} \frac{fi\ (n+1)*100}{N*n}, \qquad \ldots.(4)$$

where, N = Total number of farmers; n = Total number of ranks (since there is five ranks, so n = 5); i = Total rank for which RBQ is calculated (for a particular problem); f = Number of farmers reporting the rank i (for the problem).

III

RESULTS AND DISCUSSION: DETERMINANTS AND IMPACT OF CROSSBRED CATTLE ADOPTION

3.1 *Descriptive Statistics*

The mean difference tests for various farm characteristics that may influence adoption of crossbred cattle show that adopters are more educated as compared to non-adopters by 2.81 more years of schooling and have lesser distance to all-weather road by 121.77 metres. Furthermore, treatment group is likely to have higher herd size of 7.16 cattle heads against the herd size of 5.39 cattle heads of non-adopter group. The likelihood of access to credit and membership of dairy cooperative society for the adopters of crossbred cattle is larger vis-à-vis the non-adopters. 'Number of years since first knew about AI' has been taken as a proxy for access to extension services. It indicates that adopters have better and advance information about AI over the non-adopter counterparts which can be considered as synonymous with having better access to extension services. It also appears that adopter households are more likely to be the beneficiaries of government dairy development programmes (such as free distribution of fodder seeds and distribution of subsidised concentrates under RKVY). The average price of milk is considered as proxy for availability of better marketing facility in the farmer's locality. It indicates better and remunerative marketing facility for the adopters compared to the non-adopters of crossbred cattle (Table 2). For all other variables (i.e., age of household head, family size, off-farm income, distance to market and years of farming), the mean differences between the two groups are not statistically significant.

3.2 *Probit Estimates of Determinants of Crossbred Cattle Adoption*

The results of Probit estimates are presented in Table 3. The highly significant values of LR Chi^2 and Pseudo R^2 show that the model is a good fit. The log likelihood ratio is -112.86 and the model correctly predicts 78.70 per cent of adopters and 79.56 per cent of non-adopters. Probit estimation results indicate that most of the variables are in line with the expected sign. Some of the important variables such as herd size, number of years since knowing about artificial insemination (AI), membership of dairy co-operative society (DCS), beneficiary of government dairy development programme, and price of milk sold are found to significantly and positively influence adoption of

TABLE 2. DESCRIPTIVE STATISTICS FOR EXPLANATORY VARIABLES (MEAN)

	Treatment (N=137)		Control (N=108)		*t*-test (2-tailed)
Explanatory variables (1)	Mean (2)	Std. error (3)	Mean (4)	Std. error (5)	Difference (6)
Age of the household head (years)	50.671	1.100	49.778	1.167	0.894
Education of the household head (number of years in school)	7.489	0.404	4.676	0.413	4.813***
Family size (number of family members)	5.722	0.203	6.139	0.257	-0.416
Off-farm income (1=yes; 0=otherwise)	0.620	0.042	0.556	0.048	0.065
Distance to market (km)	2.853	0.136	3.148	0.161	-0.295
Distance to all-weather road (metre)	350.00	33.283	471.768	35.902	-121.767**
Herd size (number of cattle)	7.161	0.736	5.389	0.357	1.772**
Access to credit (1=yes; 0=otherwise)	0.212	0.035	0.111	0.030	0.100**
Number of years since first knew about AI technology (years)	13.459	0.747	7.852	0.570	5.608***
Membership of dairy cooperative society (1=yes; 0=otherwise)	0.459	0.043	0.111	0.030	0.349***
Beneficiary of govt. dairy development programme (1=yes; 0=otherwise)	0.328	0.040	0.028	0.016	0.300***
Having saving/ bank account (1=yes; 0=otherwise)	0.854	0.030	0.648	0.046	0.206***
Price of milk sold (Rs/litre)	34.993	0.644	31.370	1.319	3.622***
Years of farming (years)	27.540	1.274	27.194	1.396	0.346
District dummies					
Sonitpur (1=yes; 0=otherwise)	0.314	0.040	0.361	0.046	-0.047
KarbiAnglong (1=yes; 0=otherwise)	0.292	0.039	0.287	0.044	0.005

Source: Author’s estimation based on field survey data.
Notes: ** and*** indicate significant at 5 and 1 per cent probability level respectively.

high yielding crossbred cattle (Table 2). Duration of the farm that significantly affects adoption of crossbred cattle is having a negative association with the dependent variable implying that new farms are more responsive towards adoption of crossbred cattle. It is also found from Table 2 that as herd size increases by one cattle head, probability of crossbred cattle adoption increases by 6.19 per cent. Membership of DCS and becoming beneficiary of government dairy development programme have a stronger influence on the adoption of crossbred cattle. This may be due to the enhanced commercial prospect through increased marketing options and reduction of production costs (Bayan, 2018, 2020). It is found that farmers with membership of DCS and availing the services of any government dairy development programme leads to 103.72 and 102.52 per cent higher chances of crossbred cattle adoption respectively. The other two significant variables, ‘price of milk sold’ and ‘years of farming’ imply that with one rupee increase in the price of milk and one additional year increase in completed years of farming, there is an increase in the probability of crossbred cattle adoption by 2.2 per cent and decrease in the probability of crossbred cattle adoption by 2.02 per cent respectively (see Table 3).

TABLE 3. PROBIT ESTIMATION OF DETERMINANTS OF CROSSBRED CATTLE ADOPTION

Variables (1)	Coefficient (2)	Std. error (3)	*p*-value (4)
Age of the household head (years)	0.0137	0.0099	0.169
Education of the household head (number of years in school)	0.030	0.0264	0.255
Family size (numbers of family members)	-0.0087	0.0456	0.849
Off-farm income (1=yes; 0=otherwise)	0.1228	0.2297	0.539
Distance to market (km)	-0.0529	0.0672	0.431
Distance to all-weather road (metre)	-0.00009	0.0002	0.712
Herd size (number of cattle)	0.0619*	0.0325	0.057
Access to credit (1=yes; 0=otherwise)	-0.0028	0.3132	0.993
Number of years since first knew about AI technology (years)	0.0790***	0.0184	0.000
Membership of dairy cooperative society (1=yes; 0=otherwise)	1.0372***	0.3202	0.001
Beneficiary of govt. dairy development programme (1=yes; 0=otherwise)	1.0252***	0.3927	0.009
Having saving/ bank account (1=yes; 0=otherwise)	0.2082	0.2468	0.399
Price of milk sold (Rs/litre)	0.0220**	0.0110	0.046
Years of farming (years)	-0.0202**	0.0089	0.024
District dummies			
Sonitpur (1=yes; 0=otherwise)	-0.9621***	0.3701	0.009
Karbi Anglong (1=yes; 0=otherwise)	0.0199	0.4008	0.960
Constant	-2.4854	0.7502	0.001
LR Chi^2 (20)		110.48***	
Pseudo R^2		0.3286	
Log likelihood		-112.86	
Non-adopters correctly predicted		79.56 per cent	
Adopters correctly predicted		78.70 per cent	
No. of observations		245	

Source: Author's estimation based on field survey data
Notes: ***, ** and * indicate significant at 1, 5 and 10 per cent respectively

In addition to a host of factors influencing adoption of improved cattle, farmers' perception about cattle crossbreeding is important as it favourably affects the diffusion of crossbreeding technology in a state like Assam. The survey posed questions about farmers' perceived constraints and elicited some important findings as discussed below.

3.3 *Estimates of Impact of Crossbred Cattle Adoption*

The estimated treatment effects on the treated using NNM, KBM and RM estimators are shown in Table 4. Different matching estimators such as five nearest neighbour matching and Epanechnikov kernel based matching with bandwidth 0.06

and radius matching with caliper 0.1 have been used to see consistency of the treatment effects. Common support is implemented for all the matching estimators so that the propensity scores distributions for adopters and non-adopters lie in the same domain. The significance of outcome variables (outcome differences of adopters over non-adopters of crossbred cattle) is based on '*z*' value obtained from bootstrapping of standard errors using 50 replications.

TABLE 4. ESTIMATION OF ATT: IMPACT OF CROSSBRED CATTLE ADOPTION ON NET DAIRY INCOME AND CONSUMPTION OF HIGH VALUE COMMODITIES

	NNM (5)	KBM (0.06)	RM (0.1)
Outcome variables		ATT (Income in Rs.)	
(1)	(2)	(3)	(4)
Net dairy income#/milch cattle/day	42.06***	42.14***	42.21***
	(7.07)	(7.62)	(8.13)
Milk consumption (PC daily)	105.87***	109.55***	106.17***
	(4.71)	(3.76)	(3.85)
Fish consumption (PC daily)	5.37	5.79	4.53
	(0.77)	(0.82)	(0.67)
Meat consumption (PC daily)	8.40*	7.09*	6.51*
	(1.75)	(1.73)	(1.91)
Vegetable consumption (PC daily)	-1.23	11.45	-0.26
	(0.02)	(0.27)	(0.00)
Fruit consumption (PC daily)	2.07	1.03	-0.74
	(0.36)	(0.20)	(0.13)

Source: Authors' estimation based on field survey data;

Note: #Net dairy income is calculated as: gross value from milk and milk product sale + imputed value of domestically consumed milk minus the paid out cost; Figures in parentheses indicate bootstrapped z value using 50 replications;* and ***indicate significant at 10 and 1 per cent probability level respectively; NNM (5) = five nearest neighbour matching with replacement and common support, KBM (0.06) = kernel based matching with bandwidth 0.06 and common support, RM (0.1) = radius matching with caliper 0.1 and common support

The average treatment effects on the treated after adoption of high yielding crossbred cattle for average per capita daily consumption of high value food commodities indicate a positive and significant increase for net dairy income/milch cattle/day and consumption of milk and meat. The significant increase (*p*-value = 0.000) in net dairy income per milch cattle per day after adoption of crossbred cattle is estimated in the range of Rs. 42.06 to Rs. 42.21. Adopter households are found to have higher average per capita daily consumption by a range of 105.87 to 109.55 grams of milk and milk products and 6.51 to 8.40 grams of meat. The differences in average fish consumption between similar pairs of households belonging to different technological status (adopters and non-adopters of cattle crossbreeding) are positive but found to be statistically non-significant. Moreover, the changes in per capita daily consumption of vegetables and fruits are found to be positive for specific matching estimators only (KBM for vegetable consumption and NNM and KBM for fruit consumption)

These findings are consistent with studies on the impact of adoption of agricultural technology such as Hossain *et al.* (2006) in Bangladesh, Kassie *et al*. (2011) in Uganda and Amare *et al*. (2012) in Tanzania.

3.4 *Perceived Constraints about Crossbred Cattle Adoption*

Table 5 presents the ranking of the constraints as perceived by dairy farmers based on RBQ. It has been found that among the various constraints farmers perceive to hinder their adoption of crossbreeding technology, the most severe constraint reported by the sample farmers is the high cost of fodder and concentrate followed by higher requirements of feed and fodder by crossbred cattle. The other constraints hindering the adoption of crossbreeding technology in the order of severity are high overall cost of rearing crossbred cattle, higher requirement of care by crossbred cattle, difficulty in getting green fodder etc. (Table 5). The least severe constraints perceived by the sample farmers is the unavailability of regular milk market (consistent with the observation of ILRI, 2007 in the context of Assam) followed by 'exposure to seasonal flood hampers the rearing of crossbred cattle', favourable attitude towards growing grain and other crops than growing fodder crops, long calving interval of crossbreds etc.

TABLE 5. ADOPTION OF CROSSBRED CATTLE AND FARMER'S PERCEPTION ON CONSTRAINTS

Sl. No. (1)	Perceived Constraints (2)	RBQ Score (3)	Rank (4)
1)	Poor conception rate i.e., poor results of AI	70.29	16
2)	Too much repeat breeding through AI	66.78	19
3)	Long calving interval	50.53	28
4)	Non availability of semen at AI centre	58.53	24
5)	Non Availability of Inseminator round the clock	51.35	27
6)	Lack of pregnancy diagnostic (PD) facility	64.24	20
7)	Lack of progeny tested bull	71.18	14
8)	Lack of AI centre in the vicinity	56.65	25
9)	Inadequate knowledge of AI	70.45	15
10)	High cost of AI	74.94	10
11)	Natural Service is favourable than AI	59.35	22
12)	Crossbreds require higher amount of feed and fodder	84.65	2
13)	Lack of knowledge on treatment of poor quality roughages	75.67	9
14)	Fodder and concentrate cost is much higher	85.14	1
15)	Lack of common grazing field	67.51	17
16)	Lack of knowledge on balanced feeding	76.49	8
17)	Getting green fodder is much difficult now a days	77.96	5
18)	Favourable attitude towards growing grain and other crops than growing fodder crops	50.53	29
19)	Lack of knowledge of recommended management practices	77.06	6
20)	Unavailability of veterinary facilities nearby	62.12	21
21)	Unavailability of regular milk market	38.45	31
22)	Poor extension support	73.63	12
23)	Lack of institutional credit facility	74.86	11
24)	Distant location of AI centre	58.61	23
25)	Crossbred cattle are susceptible to disease	76.82	7
26)	Crossbred cattle require comparatively more care in rearing	82.04	4
27)	Crossbred cattle cannot tolerate high temperature	66.94	18
28)	Overall cost of rearing crossbred cattle is very high	83.10	3
29)	AI results to more male calves	54.86	26
30)	It is uneconomical to rear crossbreds due to poor drought capacity of crossbred male	72.24	13
31)	Exposure to seasonal flood hampers the rearing of crossbred cattle	45.79	30

Source: Author's estimation based on field survey data.

IV

CONCLUSION

The study has employed Probit estimation and RBQ techniques respectively for identifying factors influencing adoption of crossbred cattle and ranking constraints according to their severity as perceived by dairy farmers in three representative districts in Assam. From the results of probit regression, it is clear that herd size, knowledge about AI, membership of dairy co-operative society (DCS), availing support under government schemes, and price of milk are significantly important factors for encouraging farmers to adopt crossbred cattle. As there is significant increase (*p*-value = 0.000) in net dairy income per milch cattle per day after adoption of crossbred cattle, estimated in the range of Rs. 42.06 to Rs. 42.21, crossbreeding indicates a positive influence in raising income of the adopter households. Furthermore, as adopter households are found to have higher average per capita daily consumption of milk and milk products by a range of 105.87 to 109.55 grams and of meat by 6.51 to 8.40 grams, adoption of crossbred cattle technology seems to have ensured nutritional support to the dairy farming community with crossbred cattle adoption. The findings of adoption determinants suggest expansion of extension services, strengthening of DCS network and raising of the price of milk (in both DCS and wet markets) to diffuse crossbreeding technology. RBQ ranks constraints such as high cost of fodder and concentrate and higher requirements of feed and fodder by crossbred cattle as severe followed by other constraints such as higher requirement of care by crossbred cattle, difficulty in getting green fodder etc. in the less severe category. The least important constraints as reported by the dairy farmers are unavailability of regular milk market, exposure to seasonal flood, favourable attitude towards growing grain and other crops than growing fodder crops and long calving interval of crossbreds, etc. The farmers' perceived constraints advocate for active government intervention on feed and fodder scenario in the state. Moreover, certain negative perception of farmers about crossbreeding could also be reversed by pro-active extension support in the state. Thus, while adoption of crossbred cattle technology has shown empirical evidence of contributing towards increase in dairy income and nutritional security of the dairy farmers in Assam, the state government needs to ensure proper ambience for adoption by taking a slew of suitable policies in this regard.

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