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Short Communication

What drives the adoption of fodder innovation(s) in a smallholder dairy production system? Evidence from a cross-sectional study of dairy farmers in India

¿Qué impulsa la adopción de nuevas opciones forrajeras en un sistema de producción de leche a pequeña escala? Evidencia de un estudio transversal entre productores de leche en India

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Abstract

The study in India involving 384 households found that 42.7% of dairy farmers adopted new forage varieties when varieties were released. The farmer's resources, their caste, access to markets for milk and price received for milk had positive effects on the decision to adopt. Management of farms by women-headed households had negative effects on the adoption decision. Increased forage yield and ease of propagation and establishment were important reasons for adoption of varieties, e.g. the relative advantage of pearl millet × Napier grass (*Cenchrus americanus* × C. *purpureus*) vs. hedge lucerne (*Desmanthus virgatus*). Thus, researchers need to address these issues when developing new germplasm, if farmers are to readily adopt new varieties, especially in the case of resource-poor farmers.

Keywords: Forage attributes; surveys; smallholder dairying; tropical forages; variety acceptance.

Resumen

El estudio en India que involucró a 384 hogares encontró que el 42.7% de los productores de leche adoptaron nuevas variedades de forrajes cuando se liberaron. Los recursos del agricultor, su casta, el acceso a los mercados de la leche y el precio recibido por la leche tuvieron efectos positivos en la decisión de adoptar. Las mujeres enfrentaron más dificultades para adoptar las nuevas opciones forrajeras en sus fincas. El aumento del rendimiento del forraje y la facilidad de propagación y establecimiento fueron razones importantes para la adopción de variedades, p.ej. la ventaja relativa del mijo perla × pasto elefante (*Cenchrus americanus* × *C. purpureus*) frente al frijolillo (*Desmanthus virgatus*). Por lo tanto, los investigadores deben abordar estos problemas al desarrollar nuevo germoplasma, para que los agricultores adopten fácilmente nuevas variedades, especialmente en el caso de agricultores de escasos recursos.

Palabras clave: Aceptación de variedad; atributos del forraje; encuestas; forrajes tropicales; lechería en pequeña escala.

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Introduction

Attributes (characteristics) of an innovation are considered to be drivers of its adoption or rejection by end-users, explaining 49–87% of the variance in adoption (Rogers 2003). These attributes include: relative advantage over the existing technology; compatibility with values, lifestyle and needs; ease of use; trialability on a small scale; and results/benefits and risk/uncertainty easily seen; these attributes influence the decision to adopt or not (Rogers 2003; Trope and Liberman 2003; Castaño et al. 2008). Socio-demographic factors also impact on decisions to adopt (Arts et al. 2011). These inferences are based mainly on adoption of consumer goods, such as durable goods, fast-moving consumer goods, fashion etc. and have been used to modify and design innovations and/or reposition them in the market. However, research on factors driving adoption of improved fodder varieties by smallholder dairy-farmers, who account for 90% of milk produced and are associated with 80 million rural households in India, is limited.

Since 1970, various stakeholders have made attempts to enhance productivity of dairy animals through improvement in feed and fodder resources, inter alia. These innovations encompassed: enrichment of crop residues; promotion of concentrate feeding; and fodder cultivation. However, livestock are still under-nourished and there is an estimated 35.6% deficit of green fodder in India (Indian Grass and Fodder Research Institute 2013). Furthermore, for the year 2025, Singh et al. (2013) predicted the deficit to increase to 65% for green fodder and 25% for dry fodder (residues of cereal and pulse crops). This scenario holds good for Tamil Nadu state, a tropical region and one of the leading milk-producing states of India. For a substantial period, various stakeholders, including Tamil Nadu Agricultural University (TNAU), have been addressing the shortage of feed resources and between 1976 and 2019 TNAU released 22 fodder varieties/hybrids (Table 1).

Mean annual yields of pearl millet × Napier, multi-cut sorghum and hedge lucerne are 80, 49 and 20 tonnes dry matter (DM)/hectare, respectively, while the nearest competitor, single-cut sorghum, yields about 10 tonnes DM/ha. From 2010 onwards, Animal Husbandry Department of Tamil Nadu intensively promoted and propagated perennial forage germplasm, namely: pearl millet × Napier, multi-cut forage sorghum and hedge lucerne as mixed fodder crops/individual crops through various incentive programs across the state (Government of Tamil Nadu 2018). Continuous efforts of the various stakeholders resulted in an increase in forage cropping. A micro-study by Thirunavukkarasu et al. (2014) reported that the area under pearl millet × Napier had increased from 0.01 ha to 0.08 ha during the period 2001–2011 at an individual household level. Thirunavukkarasu et al. (2011a; 2011b) reported wide variation in availability of green fodder and deficits of dry fodder across the state. To provide base data for planning future fodder development programs, a deeper understanding of the socio-demographic factors which affect adoption of new forage varieties was needed. We conducted a study of dairy farmers to clarify the situation.

Table 1. Major fodder varieties developed in Tamil Nadu Agriculture University between 1976 and 2019.

Fodder	Year of release	Purpose
Hedge lucerne (*Desmanthus virgatus*)	1976; 2019	Introduced as a perennial multi-cut crop to meet the protein requirements and minimize costs of protein supplementation. In 2019 for the first time mutational breeding was carried out and an improved variety was released.
Pearl millet × Napier grass (*Cenchrus americanus* × *C. purpureus*)	1982–2012[1]	To replace cereal-based green crop residue; to reduce grazing dependence; and as a perennial fodder. Five varieties released.
Multi-cut fodder sorghum (*Sorghum bicolor* × *S. sudanense*)	2001–2014[1]	To replace single-cut sorghum as perennial green and dry fodder. Two varieties released.
Guinea grass (*Panicum maximum, now Megathyrsus maximus*)	1993–2009[1]	Introduced as a perennial multi-cut crop; shade-tolerant. Three varieties released.
Lucerne (*Medicago sativa*)	1980–2013[1]	Early-maturing leguminous fodder crop. Two varieties released.
Cowpea (*Vigna unguiculata*)	1986–2004[1]	Introduced as leguminous fodder crop; resistant to root-rot and cowpea yellow mosaic virus. Two varieties released.

[1]Periodic releases of improved varieties/hybrids with higher yields and better attributes.

Material and Methods

A sample of 384 dairy-farming households, proportionally representing different farming systems of Tamil Nadu, were selected using stratified multi-stage random sampling (D. Thirunavukkarasu unpublished data). The selected farmers were interviewed regarding their status in relation to adoption of new forage varieties and socio-demographic factors were recorded. During the course of interviewing, fodder adoption status, membership in farmers' collectives, caste and gender role were captured at a categorical level and other socio-demographic factors were measured at a continuous level. For the purpose of triangulation of the collected data, to improve understanding and obtain additional information, 'focus group' discussions were organized in villages. In this exercise, participants, including farmers (both female and male) and the village-level animal health service providers, identified the reasons for planting or not planting new varieties.

To understand the socio-demographic differences between adopters and non-adopters, the chi square (for categorical variables) and Mann-Whitney U test (for continuous variables) were used taking account of nature of variables and non-normal distribution of data. Binary logistic regression was used to understand the causal factors that promote adoption of new varieties along with descriptive statistics. In performing binary logistic regressions, if a farmer adopted any of the promoted fodders, the farm was coded as 1, with 0 for non-adopters. The binary logit model was as follows:

Fodder adoption status = $\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + [...] + \beta_n x_n$
where:
x_1, x_2, x_3 [...] x_n represent independent variables;
β_0 = constant;
β_1, β_2 are logistic variables;
regression coefficients (estimates)
Adoption status = 0, (adoption ≤0)
Adoption status = 1, (adoption >0).
The above statistical analysis was carried out using Statistical Package for Social Sciences and spread sheets at stat-help.com/spreadsheets.html

Results and Discussion

Mean age of respondents was 46 years, while land holdings were marginal (20% of respondents were landless) for sustaining their family needs. Respondents were mostly (58% of households) the third lowest caste in the Indian hierarchy ('caste' is a social stratification prevailing in India). Fifty-three percent of respondents belonged to the rural middle economic class and owned 1–3 adult dairy animals, producing around 10 L milk/day/household. Family women operated more than one-third of the farms (35%) on their own with occasional support of men, while remaining farms were operated by men or men plus women. Fifty-eight percent of respondents reared dairy animals primarily, to supply their household needs, with any surplus sold as market milk. The majority (53.1%) of farmers were members of farmers' collectives (farmers' producer organizations). About 40% of farmers were able to market milk through either co-operative dairies or privately-owned dairy processors; 19.3% of households had provisions to market milk through both co-operatives and private processors; 25.5% were able to market milk only through a milk vendor; and the remainder had no marketing opportunities. On average farmers produced 3,613 L milk annually, for which they received 22 INR/L (1 USD = 75 INR). These farmers access mass media and mass contact programs (exhibitions, campaigns, etc.) to obtain information. In addition, farmers interact with the extension system (propagators of livestock-related innovations), including veterinarians, para-veterinarians and other associated stakeholders at village level.

The data indicated that 42.7% of the dairy-farming households have adopted at least 1 or more improved fodder varieties promoted through the Animal Husbandry Department and others. Adopters and non-adopters differed significantly in terms of land holdings and animal numbers, socio-economic class, reasons for dairying, gender role, caste, milk production, access to markets, price received for milk, availability of mass media and extension agency contact but differences were not necessarily influential in terms of adoption of new varieties. On average households cultivated 0.1 ha (range 0–1 ha) of fodder on their own or leased land. Among the adopting farmers (164 farmers), 87.8, 22.0 and 1.2 % of farmers planted pearl millet × Napier, multi-cut fodder sorghum and hedge lucerne, respectively. Of the total cultivated area devoted to fodder production, pearl millet × Napier accounted for 64.8% and fodder sorghum 35.2%, with very little under hedge lucerne.

Among the above discussed variables, those which differentiated between adopters and non-adopters were checked for bivariate relationships. Animal numbers and socio-economic class, which had highly significant bivariate correlation with land, caste and annual milk production, were excluded for understanding the role of predictor variables in logit regression. Among the

selected variables, land, milk sale price, annual milk production, market opportunity, gender role and caste explained about 47.3% (Pseudo R2 = 0.473) of the variance in fodder adoption among the farmers (Table 2). Even though many variables differed between adopters and non-adopters, the only ones displaying positive relationships with fodder adoption were: land size, annual milk production and access to milk marketing opportunities (P<0.001), caste (P<0.05) and price received for milk (P<0.10). For one unit changes in acreage of land, liters of annual milk produced and marketing opportunity score (ranged from 0 to 3), the estimated odds of adoption (Odds ratio) are multiplied by 1.3, 1 and 2.876, respectively. Members of the third lowest caste were 2.2 times as likely to adopt as those in the second lowest caste, while gender had a significant negative relationship (P<0.05) with adoption. Women-operated farms were only 0.49 times as likely to adopt fodder innovations as male-operated farms, i.e. women-operated farms were less likely to adopt fodder varieties than farms operated by men only or men and women.

Thus, farmers with better resources (relatively large land holdings) and access to commodity markets (markets plus good milk price), high milk production and higher in caste hierarchy are more likely to adopt new forage varieties. Crossing of Indian-origin Zebu cattle breeds with European origin dairy breeds for increasing milk productivity demanded improved feeding strategies, such as feeding of cultivated fodder. Thus, in tandem, cattle breeding programs and adoption of fodder varieties might have improved milk production. Large landholders have the option to divert some land from cropping to green forage production. Better marketing opportunities in the form of better access to markets and higher milk prices (incentives) act as extrinsic motivational factors for adoption. Even landless farmers had acted to lease land for cultivation of fodder. These findings are in agreement with observations by other researchers that incentives or extrinsic motivational factors drive adoption of innovations (Donkor et al. 2018).

Women-operated farms were less likely to have cultivated fodder than those operated by men only or men plus women. Mobility restriction of women, on account of cultural factors and limited access to transport systems, limits their access to extension services, technological solutions and external inputs, which may limit their adoption of innovations (Theis et al. 2018). Castes that are higher in social stratification tend to adopt fodder innovations more than lower castes, which may be related to limited access to extension services and quality information among the lower castes (Krishna et al. 2019). Nguthi (2007) suggested that an indirect inference for rejection by non-adopters may be a lack of fit with existing livelihood assets, available options and activities for resource-poor farmers. Similarly, poor market access is a disincentive (due to market disparities) to adoption.

At the same time all new varieties of fodder are not uniformly adopted by farmers and group discussion with farmers and others revealed the following facts: While hedge lucerne was released earlier than pearl millet × Napier and multi-cut forage sorghum, the latter 2 are certainly preferred. Biomass yield of pearl millet × Napier is higher (a relative advantage) than that of hedge lucerne, and planting materials (vegetative setts) are readily available through exchange between farmers (less complex). Collection of planting material (seeds) of hedge lucerne is a tedious, laborious process and seed is not readily available. In addition, hedge lucerne seeds need seed treatment prior to sowing to break seed dormancy. Therefore, relative ease of obtaining planting materials, nature of planting material and forage yields are obvious reasons for greater adoption of pearl millet ×Napier and multi-cut sorghum than hedge lucerne.

Table 2. Estimated coefficients of logistic regression for factors influencing adoption of new fodder varieties (n=384).

Variable	Estimated coefficient	Standard error	Odds ratio[1]
Land size	0.246	0.053	1.279***
Price received for milk	0.052	0.031	1.054[#]
Annual milk production	0.000	0.000	1.000***
Access to milk marketing opportunities	1.056	0.162	2.876***
Gender role (women-operated farms coded as 1; otherwise as 0)	-0.705	0.289	0.494*
Caste (lowest ranked in caste hierarchy–Schedule caste coded as 0)			
Most backward caste (second lowest in caste hierarchy coded as 1)	0.408	0.388	1.053
Backward caste (third lowest in caste hierarchy coded as 2)	0.799	0.404	2.223*
Constant	-0.5480	0.910	0.004

Pseudo R^2 = 0.473; Log likelihood = 357.4

***P<0.001; **P<0.01; *P<0.05; [#]P<0.10

[1]Increased odds of adoption from a unit increase in the variable.

Conclusions

Similar to the situation with consumer goods, socio-cultural factors and forage attributes influence the adoption/rejection of new forage varieties. These varieties are more readily adopted by farmers with adequate land, producing larger volumes of milk and with ready access to milk markets paying acceptable milk prices. New forages with higher yields and ease of propagation are also more readily adopted. When developing new germplasm and propagating new varieties, researchers need to consider these issues by focusing on material that does not require complex processes to establish and manage. Extension professionals need to improve access to the extension system and technological inputs by marginalized sections within the dairy-farming community, if all sectors of the community are to take advantage of the new resources, especially resource-poor farmers.

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(Note of the editors: All hyperlinks were verified 15 July 2021).

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