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Sorghum participatory varietal selection: a citizen science approach with tribal farmer communities in India

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Abstract

The Triadic Comparison of Technologies (tricot) approach is a citizen science methodology with a high potential to improve the development of context specific crop varieties and accelerate their adoption among smallholder farmers. We evaluated this methodology with 200 tribal farmers from the Adilabad District (Telangana, India) to select dual-purpose sorghum varieties. Farmers were asked to rank the tested varieties from best to worst for traits such as pest- and disease resistance, grain yield, and general appreciation. Specific statistical methods for ranking data were used to determine farmers' variety preference. We extended the tricot methodology by evaluating the influence of socio-economic background, environment, management practices, and culture on the varietal selection process. Cultural values were measured using an adapted version of Hofstede's Cultural Dimensions Scale. In parallel we performed an on-station experiment with sorghum breeders to evaluate the same varieties using the tricot approach. The results showed that farmers and breeders agreed about the most appreciated variety, but that the farmers' selection was influenced by factors like soil quality, management practices, and cultural values.

Introduction

Despite considerable efforts to accelerate adoption of improved varieties among smallholders, the success rates remain low (Kabunga et al. 2012; Dhehibi et al. 2018). The inadequacies between broadly adapted varieties and the specific environmental- and socio-economic context experienced by farmers from developing countries, is often mentioned as one of the main causes of this problem (Abakemal et al. 2013; Dhehibi et al. 2018; Ceccarelli, 2017). The Triadic Comparisons of Technologies (tricot) approach, developed by Van Etten et al. (2018), can be seen as an effort to simplify the design of on-ground farmer experiments. This methodology makes it easier to integrate the farmer's opinion regarding the selection of agricultural technologies (e.g. improved varieties) and to develop more context specific solutions. Since 2017, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and the Centre for Collective Development (CCD) have supported tribal farmer communities in India to identify dual-purpose sorghum varieties for human- and animal nutrition, adapted to their specific needs (Anbazhagan et al. 2022). The application of the tricot approach gave us a unique opportunity to evaluate this methodology for sorghum selection in this specific context, to compare it with breeder decisions, and to determine the drivers of farmer choices.

Material and Methods

We performed our tricot experiment in a population of 200 farmers coming from 20 villages from the Adilabad District (Telangana, India). Each farmer blindly evaluated three sorghum varieties out of a set of

six. The selected varieties included three improved varieties selected at the national level (CSV22, CSV26, and CSV29), two regionally selected varieties (Phule Chitra and Phule Revati), and a local landrace (Keslapur), used as reference. After growing the varieties according to their own management practices, the farmers were asked to rank the varieties (best, middle, worst) with respect to drought tolerance, pest- and disease resistance, grain yield and -quality, stover yield and -quality, and general appreciation. We extended the tricot approach by monitoring environment (soil type and -quality), management practices (e.g. fertilisation), farming type (e.g. access to technology), socio-economic background (capital, demographics), and cultural values of the farmers, to determine their influence on the selection process. Cultural values were measured using an adapted version of Hofstede's Cultural Dimensions Scale (Hofstede, 1980), which consists of six dimensions measuring power distance, individualism, uncertainty avoidance, masculinity, long-term vs. short-term orientation, and indulgence vs. restraint. In parallel we performed an on-station experiment with sorghum breeders, using the same tricot approach to evaluate the same varieties on a set of 45 plots (3x15). We performed statistical analysis using the Plackett-Luce model (Turner et al. 2020) to estimate the varieties' worth based on farmer- and breeder ranking data. We also modelled the probability of choosing a certain variety after the experiment, using a logistic regression including up to five covariates.

Results and Discussion

The analysed data allowed us to: a) compare the farmers' and breeders' ranking; b) determine the influence of covariates on the farmer's choice; and c) identify the main features explaining the choice of a variety at the end of the experiment.

Ranking assessment for varietal selection

Table 1 shows the log transformed probability for each tested variety to be selected by the farmers (F) or the breeders (B). The results show that both farmers and breeders generally gave higher scores to the improved varieties (CSV lines). CSV29 received the highest ranking from both groups for stover yield, grain yield, and general appreciation. Even if the evaluations were performed in different location and settings, the results suggest a general agreement about the superiority of the nationally selected lines (CSVs) compared to the regionally selected lines and the landrace (Keslapur).

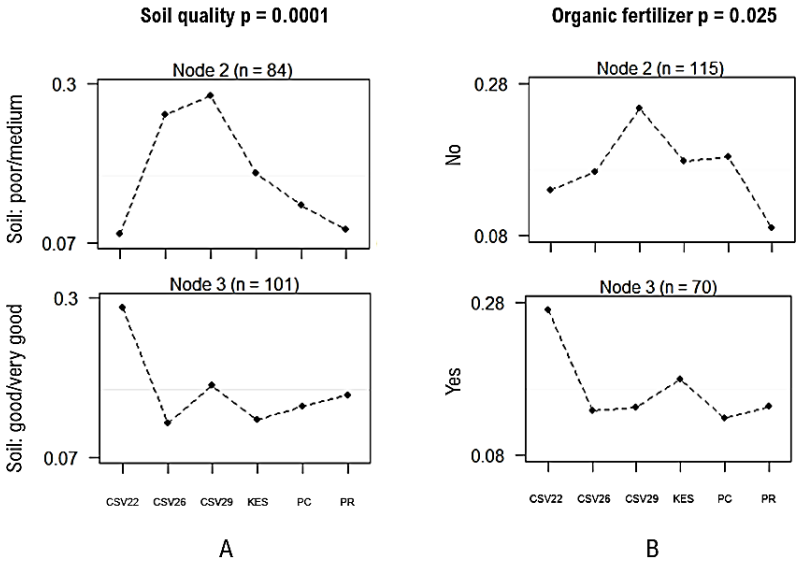
Table 1. Estimation coefficient for selection of tested varieties.

	Keslapur		**CSV22**		**CSV26**		**CSV29**		**Phule Chitra**		**Phule Revati**	
	F	*B*	*F*	*B*	*F*	*B*	*F*	*B*	*F*	*B*	*F*	*B*
P&d resistance	0	0	0.51*	0.29	0.58**	0.64	0.28	0.65	0.12	1.36	0.09	0.57
Drought tolerance	0	0	-0.02	0.4	-0.13	0.66	0.13	1.01	-0.11	1.85*	-0.44*	0.38
Stover yield	0	0	0.11	2.05*	0.26	1.49	0.47*	2.06*	0.04	1.02	-0.2	1
Stover quality	0	0	0.37	-0.7	0.68**	0.62	0.56**	-0.69	0.15	1.62	0.05	-0.49
Grain yield	0	0	0.07	1.1	0.3	1.05	0.55*	4.16*	0.12	0.5	-0.07	0.73
Grain quality	0	0	0.13	-0,46	0.14	0.08	0.39	0.03	-0.06	-0.25	-0.09	-0.17
General appreciation	0	0	0.08	0.4	0.3	1.83	0.64**	2.75**	-0.12	1.42	-0.2	0.18

Covariates

We determined the influence of covariates using Plackett-Luce trees, which consist of finding partition of the data with significantly different variety preference scores, given the covariate. A significant ($p = 0.001$) estimated effect was found for soil quality as shown in figure 1A. It can be observed that farmers who classified the soil quality of their tricot plot as poor or medium, preferred CSV29 and CSV26. Contrarily, these two varieties were less appreciated by farmers who described the quality of their soil as good or very good. Once the soil quality increased, the results indicate that farmers showed a much higher preference for CSV22. These outcomes suggest that CSV29 and CSV26 are more suitable for less nutritious soils, while CSV22 thrives in soils that are fertile.

Figure 1. Placket-Luce trees for soil quality (A) and use of organic fertilizer (B)



Further analysis showed a significant (p = 0.025) effect of organic fertilizer on varietal selection (figure 1B). Farmers who do not use organic fertilizers in general, mostly preferred CSV29, while farmers who do use organic fertilizers showed a strong preference for CSV22. These results are in line with the outcome of soil quality as a covariate, which indicates that CSV29 gives good results in less fertile soils, while CSV22 is more interesting to the farmers when cultivated in good quality soils.

Best predictors for variety choice

A forward logistic regression was performed to identify the five best predictors of choosing a certain sorghum variety at the end of the experiment. The most interesting result to emerge from the data is that it shows the importance of the farmers' cultural values in predicting which variety they will choose. Farmers who received a higher score on Hofstede's dimension of masculinity (more emphasis on competition, less on compassion and equal chances) were more likely to choose CSV22. This outcome, together with the other predictors that describe farmers with more means and agricultural inputs, characterize a type of farmer that is more willing to invest and compete with others. Additionally, farmers who showed less uncertainty avoidance and a more short-term orientation while answering the questions about cultural values, often selected CSV29. Farmers who selected this variety have generally less means and inputs, a larger household and therefore tend to rely on quick decisions and solutions. Keslapur, the local landrace, was mostly preferred by female farmers who in general scored higher for long-term orientation on the Hofstede scale. This landrace has been preferred in Adilabad for a long time, which could also indicate a tendency to preserve their traditional crops in the area, despite the availability of newer varieties with a possible higher agronomic- or economic performance.

Table 2. Five best predictors for variety choice

Rank	CSV22	CSV26	CSV29	Keslapur	Phule Chitra	Phule Revati
1.	Used fertilizer during Tricot	Has crop insurance	Less pesticides during Tricot	Mostly female farmers	Less use of informal credits	Less indulgence
2.	Higher masculinity	Does not use org. pesticides	Less uncertainty avoidance	Irrigated more during Tricot	More weeding during Tricot	More use of informal credits
3.	Access to chem. pesticides	Marital status: single	Less access to chem. pesticides	Does not use org. pesticides	Larger exp. surface	Older farmers
4.	Access to org. pesticides	Larger exp. surface	Short-term orientation	Marital status: single	Grown for hh consumption	More access to chem. pesticides
5.	Smaller exp. surface	Less used for fodder	Larger household size	Long-term orientation	High seed exchange	Mostly male farmers

Conclusions and Outlook

This study has shown that the tricot approach can be a valuable method for sorghum varietal selection among tribal farmer communities in India. The citizen science component made it possible for the farmers to actively participate and provide input and feedback during almost all stages of the project. Therefore, their personal experiences and opinions played a central role in our research, which enabled them to identify sorghum varieties that meet their specific needs, while considering the highly diverse context of farmer communities in the district. The similarity of results between farmers and breeders indicate that breeders can make selection choices that are in line with farmers' needs. However, as we noticed with the effect of soil quality and organic fertilization, the on-ground variety performance is modulated by local conditions and practices that are mostly under farmers' influence. The importance of the cultural values for the ultimate choice of a specific variety also emphasizes the large variety of factors influencing farmer decisions. Therefore, to increase adoption of improved varieties among highly diverse populations, future policies and breeding programs should include their target groups as much as possible in the selection process and take into account their local practices and cultural background.

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