Quantification of trait preference by farmers for post rainy sorghum and pearl millet using conjoint analysis

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Abstract

Conjoint analysis technique was used to quantify the varietal attributes preferred by farmers, for two important dry land crops, i.e., post rainy season sorghum and pearl millet. The attributes considered include grain yield, fodder palatability, crop duration, grain size, grain shape and grain color. The data for the study was generated using a structured questionnaire administered on farm households in Sholapur district of Maharashtra for post rainy season sorghum and Jodhpur district of Rajasthan for pearl millet. The utility index developed in this study provides a framework for evaluating farmers' preferences for improved seed of sorghum and pearl millet.

CONTENTS

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INTRODUCTION

Researchers are interested in knowing the attributes of crop varieties that are important to farmers to enable hassle free adoption. Thus it is very important for researchers to be able to design their crop varieties based on preferred traits and position them to achieve a commercially successful product.

All Individuals including farmers in their decision making process evaluate the benefits and costs of competing products before a final choice is made. This process is a complex one. In many instances farmers' varietal preferences are ignored or considered through subjective evaluations that lead to rejection or non-adoption of crop varieties on a large scale.

This is because farmers use judgments, impressions, evaluation of all competing variety attributes and market demand before they make their final choice on the variety to grow. In this process, farmers combine (integrate) information about different determinant attributes of a crop to form overall impressions of product profiles, a process that conjoint analysis is built upon, and is known as information integration theory (IIT). IIT has three stages, which includes valuation, (psychophysical judgment formation) integration, and response formation. The final choice is the one that provides the farmer with the highest level of total utility. The utility index provides a framework for evaluating farmers' preferences for an improved seed or technology in agriculture. Varietal selection based on such utility index stands better chance of adoption and up scaling on a large scale.

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This study was carried out on two important dryland crops, i.e., post rainy season sorghum and pearl millet. Post rainy (rabi) season sorghum is mainly grown on residual soil moisture and is prized for its grain quality and fodder. The area under post-rainy season sorghum in India is around 5.7 million ha producing approximately 3 million tons of sorghum grain. This has a critical impact on the livelihood of about 5 million farm households. The most severe droughts (25% of seasons) were when stress began before flowering and resulted in failure of grain production in most cases, although biomass production was not affected so severely.

India is the largest` producer of pearl millet in Asia, both in terms of area (about 9 million ha) and production (8.3 million tons). The crop is mainly grown under low rainfall regimes as it is drought tolerant. Its grain and fodder are the staples for humans and cattle in the major growing areas of the country.

The present study is undertaken to quantify the varietal attributes preferred by farmers for post rainy sorghum and pearl millet using conjoint analysis technique. With this knowledge, researchers can focus on the most important features of seeds and design a variety that is most likely to gain acceptance of the target buyers. Further the utility attributes derived from the analysis is used to simulate preferences for new improved cultivars for both the crops that will identify the most preferred variety. The present study would thus help in in screening new improved cultivars of these crops for preferred attributes and over all preference.

REVIEW OF LITERATURE

Kouadio, et al., 2003, estimated the preferences of farmers for cattle traits in southern Burkina Faso using conjoint analysis, a survey-based system for measuring preferences for multiple-attribute goods. Here the technique is used in the context of a West African country where literacy is low, where cattle perform multiple functions, where low-input management is the norm, and where cattle are exposed to a number of tropical diseases and other environmental stresses. The results reflect the production practices of the region, suggesting that important traits in developing breed improvement programs should include disease resistance, fitness for traction and reproductive performance. Beef and milk production are less important traits. The study shows the potential usefulness of conjoint analysis for quantifying preferences in less developed countries for livestock and for the wide variety of other multiple-attribute goods. One implication is that conjoint analysis provides a quantitative methodology that helps make diverse livelihood strategies more operational. Distinguishing differences in preferences between groups of respondents in connection with specific agro-ecological zones and production systems can be used to promote conservation-through-use of breeds at risk of extinction.

Horna, Melinda and Matthias von Oppen, 2005, in their study examined farmers' preferences for seed of new rice varieties and their willingness to pay for seed-related information in villages of Nigeria and Benin. Conjoint analysis was used to estimate the structure of farmers' preferences for rice seed given a set of alternatives. Farmers are considered to be consumers of seed as a production input, preferring one variety over another based on the utility they obtain from its attributes, which depends on their own social and economic characteristics, including whether or not they sell rice. Contingent methods are used to elicit preferences and willingness to pay (WTP) for rice seed. The marginal values of attributes, with and without information about the seed, are estimated with an ordered probit regression. WTP for information is derived from the analysis of WTP for rice seed. They averred that the results have implications for the best way to finance research and extension services in the areas of intervention, particularly for new rice varieties.

Mafuru, Norman and Fox, 2007, evaluated quality attributes of sorghum ugali based on different varieties in order to determine marketing potential relating to the different improved sorghum varieties. A total of 231 consumers, randomly selected from urban and rural areas participated in a food panel to evaluate ugali prepared from five sorghum varieties (three improved, two local). Conjoint analysis was used to determine consumer perceptions of the variety attributes, while a logistic model was applied to determine preference ranking of different varieties. The results indicated that the color and taste of sorghum ugali were the most important criteria used by consumers to evaluate the quality ugali. The study results indicated that sorghum ugali with white/khaki color and the majority of panel participants preferred neutral or slightly sweet taste. Consumers from rural and urban areas accepted two improved varieties; only consumers from rural areas accepted the remaining variety.

Asrat et al.2009, using a choice experiment approach, they investigate Ethiopian farmers' crop variety preferences, estimate the mean willingness to pay for each crop variety attribute, and identify household specific and institutional factors that govern the preferences. They found that environmental adaptability and yield stability are important attributes for farmers' choice of crop varieties. Farmers are willing to forgo some income or output in order to obtain a more stable and environmentally adaptable crop variety. Among other things, household resource endowments (particularly land holdings and livestock assets), years of farming experience, and contact with extension services are the major factors causing household heterogeneity of crop variety preferences.

Adane et al, 2012 Conducted conjoint analysis to elicit farmers' opinions on management attributes that they believed to affect yield and quality of potato. The study involved interviewing 324 farmers who grew seed potato in Jeldu and Welmera districts. The results showed that management attributes, such as storage method, hoeing combined with hill size; fertilizer rate (FR) and fungicide application (FA) frequency had larger effect on seed yield and quality than seed source, seed size, sprouting method, tillage frequency, and planting date. In both districts, using diffused light storage (DLS); hoeing twice, combined with big hills; and using recommended FR, combined with two FAs had significant positive effects on yield and quality of seed potato. In both districts, if all farmers switched to the best management attribute levels, potential increases in seed yield would be about two times the actual seed yield produced in 2010. The results suggest that it is possible to design better methods to produce seed potato compared with methods that farmers currently use.

METHODOLOGY

Conjoint Analysis

Conjoint analysis is a technique for estimating the value people place on the attributes or features that define products in this study a crop variety. The goal of conjoint survey is to derive specific values of the predefined attributes that post rainy season sorghum and pearl millet producers consider when making a purchase decisions of seeds. With this knowledge, researchers can focus on the most important features of seeds and design a variety that is most likely to gain acceptance of the target buyers.

Conjoint Analysis is a research technique used to measure the trade-offs between attributes people make in choosing between products. It is also used to predict their choices for future products and services. Conjoint Analysis assumes that a product can be “broken down” into its component attributes. For example, a plant variety has attributes such as high yield, stover quality, grain size and shape, and grain color. . Using Conjoint Analysis, the value that individuals place on any product is equivalent to the sum of the utility they derive from all the attributes making up a product. Further, it assumes that the preference for a product and the likelihood to purchase it is in proportion to the utility an individual gains from the product. There are three phases in the analysis of conjoint data: collection of trade-off data through a survey, statistical analysis of the data, and simulation.

For purposes of this methodological description, imagine that you are researching perceptions of farmers of post rainy season sorghum and pearl millet. Conjoint analysis evaluates product attributes in a very practical and real life way. Traditional survey approaches ask respondents to estimate how much value they place on each attribute. This is a very difficult task for any person to tell, much less someone who doesn't spend much time thinking about the most important features of products such as crop variety. Conjoint analysis, on the other hand, attempts to break the task into a series of choices or ratings. These choices or ratings, when taken together, allow us to compute the relative importance of each of the attributes studied. Instead of "stated importance", conjoint analysis uses "derived importance" values for each attribute or feature.

Another advantage of conjoint analysis is the ability to use the results to develop market simulation models that can be used well into the future or evaluate existing products or varieties. Markets continue to change as new varieties enter; new varieties are introduced, etc. With traditional research approaches, every time a major change takes place in the market, a new survey needs to be conducted to find out how people feel about the changes and how it will affect their purchases. With conjoint analysis, the new product or changes to existing products can be incorporated into the simulation model to obtain predictions of how buyers will respond to the changes. In most markets, these models can maintain their accuracy for two or three years before you need to conduct a mini-version of the original study to determine if any adjustments must be made to the model.

Depending upon the type of conjoint survey conducted, statistical methods like ordinary least squares regression, weighted least squares regression, and logit analysis are used to translate respondents' answers into importance values or utilities. Conjoint analysis has been used by academics and professional researchers during the past 25 years. The actual values obtained by these statistical methods are not important, only the relative values or relationships between each of the attributes are needed. The goal of this analysis is to evaluate the responses in a manner that reveals the underlying value they consciously or sub-consciously place on each attribute. It is known that any rational farmer will prefer yield levels of 1.5 tons to 1.0 tons per hectare if all other things are equal (quality, features, etc.). What we do not know about each farmer is his or her level of sensitivity to the yield difference. A farmer who always chooses variety with better stover quality over variety with average stover quality, regardless of yield level, obviously places more value on stover quality than yield level. Conjoint analysis allows us to compute the relative value between these options and all other options considered in the research design.

Basic Steps to Conducting Conjoint Analysis

1. Determine which varietal attributes or features are most important to the farmer /consumer.
2. Determine which data collection methodology will be used to select respondents and how the data will be collected.
3. Determine which conjoint methodology will best fit the research problem.
4. Create an experimental design which will allow the calculation of main effects and key interactions between the attributes and their respective levels being studied, potential interactions between attributes should also be considered.
5. After pre-testing your attribute list and survey instrument, begin collecting data from the target market.
6. Calculate the utilities for each respondent or for groups of respondents.
7. Create a market simulation model. This allows you to predict the impact of changes in existing products and the introduction of new products on the market.

Attributes and Levels

Expertise, intuition and qualitative research are needed to develop the list of key attributes for any product. It is critical to have a carefully thought out list of attributes. Too many attributes can greatly increase the burden on the respondent and therefore reduce the accuracy of the response. Too few attributes can result in critical information missing from the model.

In addition to developing the attributes, you must also consider the individual levels within each attribute. For an attribute like yield, the attribute levels would be specific points like 2 to 3 metric tons per hectare, 1 to 2 metric tons and less than 1 metric ton per hectare. For discontinuous attributes like color, the attribute levels might be yellow, grey and white. Once again, the researcher must find a balance between too many and too few options.

Attribute levels must encompass all of the products that exist or you expect to achieve within the near future through research. For continuous variables like yield, 2 or 4 levels can cover the market from low yield to high yield. For discontinuous attributes, 3 to 5 levels are typically specified so some sacrifices may have to be made to eliminate the least desirable or least important options.

If an option is not included in the conjoint survey and it does not fall within the boundaries of any two-attribute levels that are specified, you will not have any information on how respondents react to that attribute level. Without this missing piece of information, the importance of that attribute or attribute level relative to all of the other items in the survey is unknown and cannot be accounted for in the simulation model. The attributes considered in the study have been identified based on discussion with the plant breeders, agronomists, economists, sociologists and other scientists working on the crop at ICRISAT, Hyderabad.

Yield is an important attribute that all farmers will target as it would have a bearing on the commercial viability of the product. Currently the best performance on the farmers' field is 2 metric tons per hectare. Hence it was taken as the upper limit. Dairying is an important activity in the dry tracts, hence farmers growing post rainy season sorghum and pearl millet would use the crop residue or stover as fodder and this would in turn enhance the milk yield and the overall farm income. Since both post rainy sorghum and pearl millet are essentially dryland crops, drought tolerance would be a minimum requirement. Days to maturation is deemed to be an important attribute as the most severe droughts (25% of seasons) were when stress began before flowering results in failure of grain setting in most cases, although biomass production was not affected so severely. Ideally they would prefer to have moisture till 65 days so that flowering is complete. Grain size is considered important as from marketing point of view as it fetches a higher price. Grain color and grain shape are obviously market parameters that the producer concentrates on in order to get better market acceptance (Table 1&2).

Table 1: Attributes for post rainy season sorghum

Post rainy season sorghum Attributes	Levels
Yield	> 2 tons per hectare
	1 to 2 tons per hectare
	< 1 ton per hectare
Stover	Sweet and palatable
	Average palatability
Plant Colour	Pigmented
	Tan
Drought Tolerance	High
	Medium
Maturation of crop (Flowering)	60 to 65 days
	65 to 72 days
Grain Size	Large (25 gm/1000)
	Medium (10 gm/1000)
	Small (<8 gm/1000)
Grain Colour	Yellow
	White

Table 2: Attributes for pearl millet

Pearl Millet Attributes	Levels
Yield	2.5 to 3 metric tons per hectare
	1 to 1.5 metric tons per hectare
	< 1 ton per hectare
Stover	sweet and Palatable
	Average palatability
Drought Tolerance	High
	Low
Maturation of crop (Flowering)	60 to 65 days
	65 to 72 days
Grain Size	Large (20 gm/1000)
	Medium (7.5 to 15 gm/1000)
	Small (<5 gm/1000)
Grain Color	Grey
	White
Grain Shape	Obviate
	Globular
	Hexagonal

Preferences and Utility

Utility, which is subjective and unique to each individual, is the conceptual basis for measuring consumer demand in economic theory. Economic theory states that utility is interpreted as a numerical measurement of the satisfaction derived from the consumption of alternative bundles of commodities. In recent years, the theory of consumer utility has gone beyond the traditional economic theory of consumer demand. According to Lancaster's model of consumer behavior, the theory of preferences states that goods are valued for the attributes they possess, and that differentiated products are merely different bundles of attributes. The importance score was also calculated for each attribute.

Importance Scores

The importance score for factor of attribute 'i' is

Importance = 100 x RANGE of utilities of 'I' / Σ of all utility ranges.

where RANGE i is the highest minus lowest utility for factor i. The importance for each factor is calculated separately for each subject, and these are then averaged for all the farmers.

Cluster Analysis

Cluster analysis is a multivariate technique that classifies respondents based on selected variables. It classifies respondents, products so that each respondent is very similar to the others in the cluster with respect to some predetermined selection criterion or variable. The resulting clusters show high within-cluster homogeneity and high between-cluster heterogeneity. Cluster analysis classifies a set of observations into two or more mutually exclusive *unknown* groups based on combinations of interval variables. The purpose of cluster analysis is to discover a system of organizing observations, usually people, into groups, where members of the groups share properties in common.

There are two types of clustering

1. Hierarchical clustering
2. K mean-clustering

Hierarchical clustering allows users to select a definition of distance, then select a linking method for forming clusters, then determine how many clusters best suit the data. In k-means clustering the researcher specifies the number of clusters in advance, and then calculates how to assign cases to the K clusters. K-means clustering is much less computer-intensive and is therefore sometimes preferred when datasets are very large. Finally, two-step clustering creates pre-clusters, and then it clusters the pre-clusters.

Measuring Similarity and Distance

Distance: The first step in cluster analysis is establishment of the similarity or distance matrix. This matrix is a table in which both the rows and columns are the units of analysis and the cell entries are a measure of similarity or distance for any pair of cases. There are a variety of different measures of inter-observation distances and inter-cluster distances to use as criteria when merging nearest clusters into broader groups or when considering the relation of a point to a cluster. The most common used one is the Euclidean distance.

Euclidean distance is the most common measure - a given pair of cases is plotted on two variables, which form the x and y axes. It is the geometric distance in the multidimensional space. It is computed as: distance (x,y) = $\sqrt{\sum_i (x_i - y_i)^2}$

Profiling the cluster solution

The profiling stage involves describing the characteristics of each cluster to explain how they differ on relevant dimensions. Data on demographic characteristics, psychographic profiles, and consumption patterns could be used to profile the clusters. Profile analysis focuses not on what directly determines the clusters but the characteristics of the clusters after they have been identified.

For this study the importance scores of each of the traits being studied, viz. stover, plant colour, drought tolerance, maturation of crop (Flowering), grain Size and grain color were the variables selected for clustering and the respondent farmers were categorized into the respective clusters and their profiles characterized based on household size, age of the head of household, experience (Years), dryland area (irrigated area), income (Rs), main product and livestock income.

Data and Sampling

Data collection involves the collection from a sample of 75 individuals / households at the minimum. The issues of data collection for this study were the orthogonal design of cards that were developed which then were administered to the respondents. The data collection was structured to meet the requirements of analysis using conjoint analysis. The aim is to present to respondents various attribute combinations i.e., product profiles that facilitate effective preference evaluation. Presentations can either be in a written or pictorial format. In this study a pictorial card was developed and they were asked to rank it from 1 to 18. Two hold out cards were also inserted to check the accuracy of response.

The Solapur district in western Maharashtra was selected as the study area for the varietal attributes preferred by farmers for the post rainy sorghum. The district is prone to erratic rainfall with infertile and fragile soils. About 58% of the gross cropped area under post-rainy season sorghum in Maharashtra is in the district of Solapur (GOI 2009). A sample of 100 farmers growing post rainy season sorghum were selected to administer the survey. Data was collected with the help of a pre-tested questionnaire that included data on their socio-economic characteristics together with technical details about the crops and varieties grown, extension support and their effectiveness, preferred varieties of post rainy season sorghum and the binding constraints to sorghum cultivation along with attribute preferences were collected from farmers in 6 villages of Solapur district during the month of July 2013 (Table 3).

Table 3: Sample villages and sample size sorghum, Maharashtra

Villages Sholapur district	Sample size (farmers/ households
Mandrup	14
Bandrakote	16
Kumbhari	25
Nimbargi	9
Valsang	18
Vinchur	18
Total	**100**

Likewise a sample of 100 farmers growing pearl millet in 7 villages (Table 4) of Jodhpur district of Rajasthan was selected to study the varietal attributes preferred by farmers for pearl millet.

Table 4: Sample villages and sample size for pearl millet, Rajasthan

Village Jodhpur District	Sample size
Sawant Ka kuan	9
Mahalna	38
Kasti	12
Jointra	10
Rathi ki Dhani	1
Purkhawas	6
Lunawas Khara	24
Total	**100**

Market Simulation

Market simulation consists of describing each market varietal profile in terms of its attributes, adding up the respondent's value for all of varieties' attributes and using this information to determine the relative value of each variety to each respondent. Further, based on the results the existing varieties and those in the stage of development were evaluated through a simulation process.

Varieties which contain those attribute levels for which the farmer respondents have higher utility values produce a higher degree of acceptance likelihood. Acceptance likelihood is calculated by adding up the sums of the attribute level utilities.

Through market simulation, a "base case" is specified which contains selected attribute levels across all product attributes. Simulations can be run to determine the sensitivity of a respondent's likelihood of acceptance to modifications on each attribute.

Each product used in the simulation is assigned a probability p_i for each product 'i ''. The probabilities are all computed based on the predicted score for that simulated product. The probabilities are computed as follows: Probabilities are averaged across respondents for the grouped simulation results. For the BTL (Bradley-Terry-Luce) and Logit methods, only subjects having all positive probabilities are used for the calculation.

The output from the above analysis gives the predicted probabilities of choosing each of the simulation cases as the most preferred one, under three different probability-of-choice models. The maximum utility model determines the probability as the number of respondents predicted to choose the profile divided by the total number of respondents. For each respondent, the predicted choice is simply the profile with the largest total utility. The BTL (Bradley-Terry-Luce) model determines the probability as the ratio of a profile's utility to that for all simulation profiles, averaged across all respondents. The logit model is similar to BTL but uses the natural log of the utilities instead of the utilities across the 100 subjects in this study.

RESULTS AND DISCUSSION

Sorghum

The farming practices, constraints in production, extension support and socio-economic background have been documented in this section for post rainy season sorghum. A list of the varieties grown currently by the farmers reveals that Maldandi is the most popular variety grown in the area accounting for about 73 percent of the farmers (Table 5). This is followed by Dagadi (9%) and Chitra (3%)

Table 5: Important sorghum varieties grown in the study area

Variety	No of farmers	Percent (%)
Maldandi	73	72.28
Dagadi	9	8.91
Dagadi , Maldandi	5	4.95
Chitra	3	2.97
Vasuda	2	1.98
Phule Vasudha	2	1.98
Phule Chitra,	1	0.99
Suvarna	1	0.99
Yashoda	1	0.99
M351 , Chitra	1	0.99
Mahabeej	1	0.99
Phule Yashoda	1	0.99
Jute	1	0.99
Grand Total	**101**	**100**

With regard to the sourcing of post rainy season sorghum seed by the farmer, Table 6 reveals that about 66 percent of the farmers use their own seeds. This is not a very healthy practice from the point of view of crop improvement. The other important sources of seed are the Agri-clinics and Government agencies. This does not augur well for seed replacement for obtaining a healthy crop and farmers should be encouraged to replace their seeds periodically. This is an issue that the extension agencies should try to correct.

Table 6: Source of post rainy season sorghum seeds

Source	No	Percent (%)
Agricultural Clinic	17	16.83
Farmers Own Seed	67	66.34
Farmers Own Seed , Agricultural Clinic	1	0.99
Government Agency	12	11.88
Input Dealer	1	0.99
Input Shop/ Agricultural Clinic	1	0.99
Mahabheej	2	1.98
Grand Total	**101**	**100.00**

The farmers grew a variety of crops in their dry lands in the study villages. Post rainy season sorghum was the most predominant crop grown by as much as 87 percent of the farmers (Table 7). The other important crops grown in the region are groundnut and pigeonpea as a pure crop but their importance can be gauged by the fact that each crop is grown by less than 5 percent of the farmers, testifying to the overwhelming presence of sorghum.

Table 7: Crops grown under rainfed or dryland crops in Sholapur district

Crop	Number	Percentage (%)
R. Sorghum	81	87.10
Groundnut	4	4.30
Pigeonpea	3	3.23
K. Sorghum , Pigeonpea	2	2.15
Maize	1	1.08
R.Sorghum , Sugarcane	1	1.08
Safflower , Sorghum	1	1.08
Grand Total	**93**	**100**

In irrigated areas sugarcane is the most important crop grown by 59 percent of the farmers. The other important irrigated crops grown are chilly, vegetables and wheat. .

The important constraints faced by the famers in the study area are documented in Table 8. Farmers were asked the frequency of each constraint and the degree of impact. The impact has been measured on a hedonic scale which ranges from 1 for mild to 5 for severe. The constraints are related to moisture stress, yield variability, labour scarcity, marketing problems, high cost of production, poor quality of inputs and input and credit availability. Moisture stress was a universal problem indicated by almost all the farmers which has high impact as well. The next in importance was yield variability related to moisture stress followed by labour scarcity. Labour scarcity could indirectly be related to moisture stress which leads to out migration resulting in labour shortage. But the impact factor of labour shortage is moderate (2.86) compared to moisture stress and yield variability. High cost of production was another major constraint with an impact factor of 3. Input availability and credit availability were the other problems facing the farmers of the region.

Table 8: Production concerns of the farmers growing post rainy season Sorghum

Problems	Incidence (%)	Impact
Moisture Stress	98.02	4.70
Yield Variability	67.33	3.37
Labour scarcity	42.57	2.86
Marketing problems	3.96	2.75
Fodder shortage	3.96	2.00
High cost of production	18.81	2.95
Poor Input Quality	4.95	2.00
Input Availability	6.93	2.86
Credit Availability	6.93	2.00

Note: Impact has been scored on a hedonic scale ranging from 1 for mild to 5 for severe.

To promote modern technology, extension is an important component. Government extension agencies were the most important source of technology knowhow, followed by fellow farmers' advice in terms of coverage (Table 9). The farmers visualized the media as the most effective source of extension support (2.54) followed by Government extension (2.38).

Table 9: Sources of extension support

Agency	Coverage (%)	Effectiveness
Government Extension	52.48	2.38
Private Extension	31.68	1.97
Fellow Farmer	47.52	1.85
Media	27.72	2.54
Experience	41.58	1.24
Dealers	0.99	2.00

Note: Impact has been scored on a hedonic scale ranging from 1 for mild to 5 for severe.

A cursory look of the socioeconomic profile of the sample farmers, presented in Table 10, reveals that on an average they had studied up to the 8^{th} Standard, owned about 3.65 acres and had an experience of 29 years in farming.

Table 10: Socio economic background of the growers

Attribute	Total
Educational (Years)	7.92
Farm size (Acres)	3.65
Experience (Years)	28.58

Farmers Preference for Varietal Traits of Post Rainy Season Sorghum

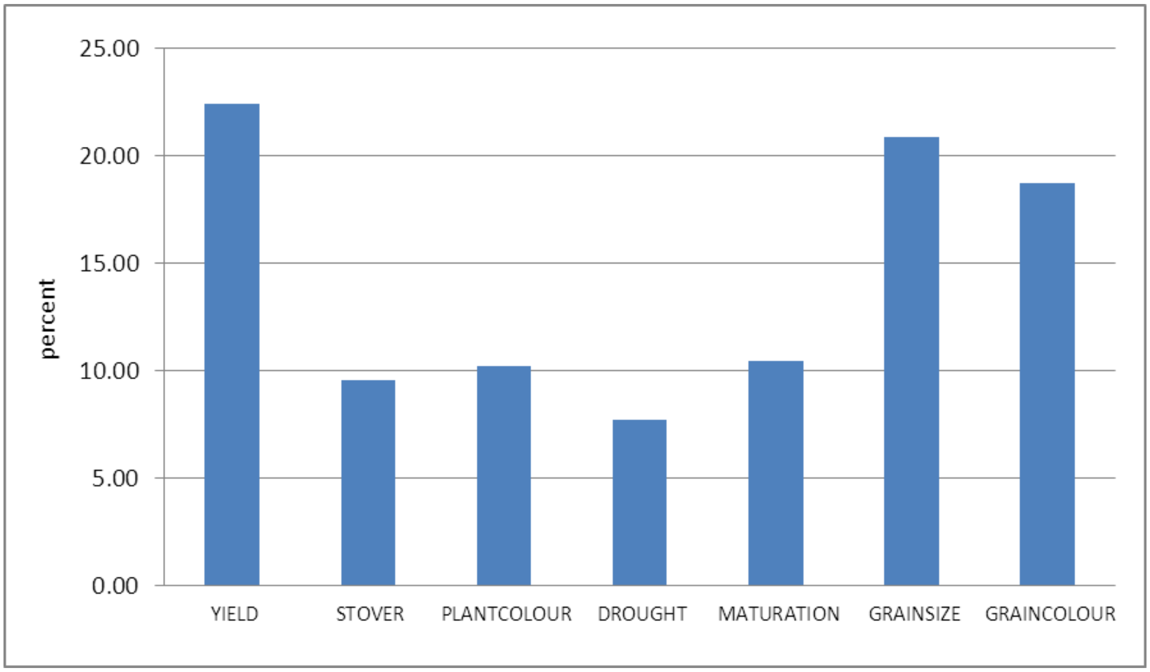
The famers growing post rainy sorghum were asked to indicate their preference with regard to crop yield, stover quality, plant color, drought tolerance, time taken to maturation, (as early maturation will help the crop to withstand late season drought), grain size and grain color. The first five parameters are the production parameters while the latter two are market parameters. The importance assigned by the sorghum farmer to each attribute is estimated using conjoint analysis. The utility derived by the farmer from the attributes of post rainy season sorghum are presented in Table 11. The importance index / score is depicted in Fig 1. Perusal of the figure reveals that farmers in the study area assigned the highest importance to yield (22.42%), followed by grain size (20.85%) and grain color (18.71%). The other traits like stover quality, maturation and plant colour had an importance value of around 10 percent each. Drought tolerance is taken as given in the sorghum crop in general and hence the farmers did not specifically look for this attribute in the variety.

Table 11: Utilities attributes of post rainy season sorghum for the Farmer

Attributes	Utility	Levels
Yield	1.1832	> 2 tons per ha
	-0.4121	1 to 2 tons per ha
	-0.771	< 1 ton per ha
Stover	0.6597	Sweet and palatable
	-0.6597	Average palatability
Plant Colour	0.1163	Pigmented
	-0.1163	Tan
Drought Tolerance	0.3552	High
	-0.4552	Medium
Maturation of crop	0.3515	60 to 65 days
	-0.3515	65 to 72 days
Grain Size	0.6716	Large (10 gm/1000)
	-0.2603	Medium (8 gm/1000)
	-0.4113	Small (< 5 gm/1000)
Grain Colour	-0.1535	Yellow
	0.8428	White
Constant	8.0747	
Pearsons R	0.67	
Kendall's Tau	0.39	

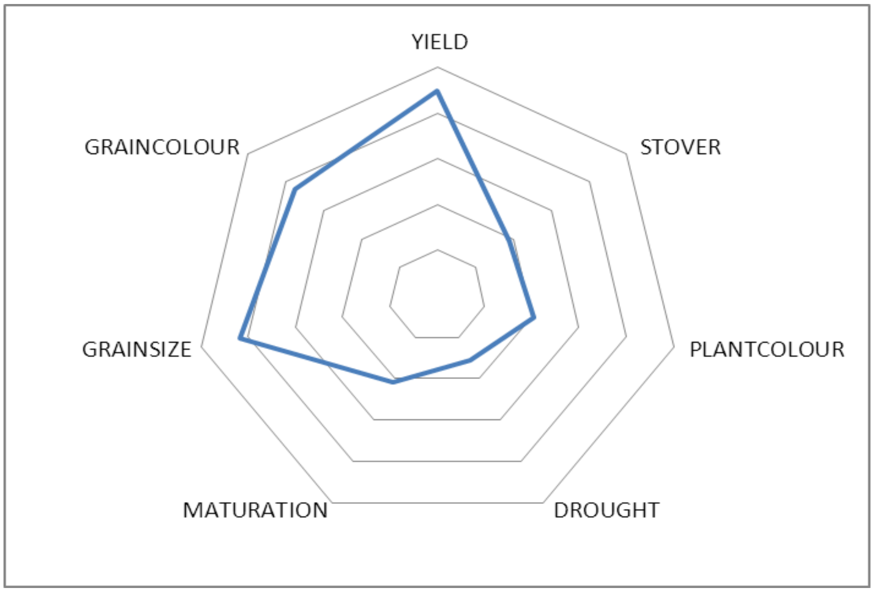
Among the attributes yield was the most important and yield level of over 2 tons per hectare was desired by the farmers. For grain size, large grain size was preferred with a grain weight of over 10 gm. per 1000 grains and in this the white colored grain was preferred to enhance the look of the cooked "rotis". Large grain size was preferred because it increased the grain weight and reduced the chaff percentage. Early maturation of less than 65 days helped the crop to withstand late drought and is also able to withstand moisture stress during the late season. The farmers preferred a plant with green stalk over tan and a variety that can withstand drought. Sweet and palatable fodder was also a desired trait in the variety as it had a very high utility score of 0.6597 which was next only to grain yield levels of 2 tons / ha and more (1.1832), grain colour (0.8428) and grain size (0.6716) (Table 11).

Fig 1: Importance attached to selected varietal traits of stay green post rainy season sorghum by farmers in Maharashtra



The preference for a variety cannot be generalized as it is quite likely there will be different requirements among various groups of farmers. The figure 2 confirms the earlier results and shows that the farmers require varieties with high yield of over 2 tons per hectare, white and bold grain of over 10 gm. per 1000 seeds. Cluster analysis was carried out on the preferred traits of the farmers to form homogeneous groups based on their preferences. However the varietal preferences for sorghum were fairly uniform across all groups of farms and hence separate groups were not found.

Fig 2: Preference chart of post rainy season sorghum farmers



Simulations

Some of the existing varieties including new varieties recently sown on farmers' fields have been included in the simulations in the backdrop of the values attached to the attributes by the post rainy season sorghum farmers. The findings give the predicted probabilities of choosing each of the simulation cases as the most preferred one, under three different probability-of-choice models discussed in the methodology section. . The results are presented in Table 12 for the seven varieties listed in the table across the 100 subjects in this study.

Table 12: Post rainy season sorghum simulation results

Serial No.	Variety	Max Utility	BTL	Logit
1	Dagadi	11.56	12.50	8.43
2	M-35-1 (Maldandi)	18.81	13.39	19.89
3	Parbhani Moti	9.90	15.21	12.04
4	Parbhani Jyoti	43.89	17.42	37.47
5	Akola Kranti	0.99	14.22	4.80
6	Phule Chitra	9.90	15.21	12.04
7	Phule Yashoda	4.95	12.06	5.33

From the results it appears that Parbhani Jyoti is the most popular of the simulated varieties as about 44 percent of the sample farmers would prefer it. This is followed by M-35-1 (Maldandi) with a maximum utility of 19 percent. In addition to these two varieties Dagadi and Phule Chitra should meet with good demand. Akola Kranti and Phule Yashoda do not have attributes that meet farmers demand.

Pearl millet

Pearl millet is grown extensively in the dry tracts of the arid and semi-arid regions of the country on account of its ability to withstand conditions of moisture stress due to low and erratic rainfall and poor soils. The crop is grown both for its grain and fodder value and is a staple for the people living in these regions. Pearl millet is by far the most preferred crop in rainfed conditions while *moong* and *moth* (from green gram family*) were* other crops of some importance.

Among the preferred varieties of pearl millet in the study area, HHB 67 improved was the most popular with almost 70 percent of the farmers growing it. The next in importance was RHB 177, with a patronage of 21 percent of the famers (Table 13).

Table 13: Pearl millet varieties grown in Jodhpur, Rajasthan

Variety	Total
HHBI 67	70
Pioneer	2
Proagro	1
RHB 121	6
RHB 177	21
Grand Total	**100**

The important crops grown in the irrigated tracts are Cumin Cotton and wheat (10.71%). The problems faced by the pearl millet farmers will give inkling on their requirement with respect to crop technology. Of the problems encountered moisture stress was the top in the list with a high impact of 4.70 out of 5. Lack of credit facilities, yield variability and non-availability of suitable pearl millet varieties in the region were the other major problems faced by the pearl millet farmers. Poor marketing facilities, lack of fodder and inadequate labour were also in the list of problems faced by the pearl millet farmers (Table 14).

Table 14: Production and marketing constraints faced by the pearl millet farmers

Constraints	Total
Moisture Stress	4.70
Lack of credit facilities	3.50
Yield Variability	3.06
Lack of proper varieties for region	2.88
Fodder availability	2.75
Poor marketing	2.51
Labour availability	2.41
Lack of proper extension service	2.30
High cost of inputs	2.28
Poor quality of inputs	2.19
Lack of availability of inputs	2.03

The major sources of extension support for the pearl millet farmers in the study area documented in Table 15, Where the Government agencies were the largest followed by fellow farmers, media and input dealers. However Private extension, though limited in its use, was perceived to have the highest impact as evidenced by an impact score of 3.75 (Table 15). Demonstrations and field visits also had a high impact while fellow farmers had a low impact in extension. Government extension service was only moderate with an impact score of 2.81.

Table 15: Extension support

Data	Coverage (%)	Effectiveness
Govt Extension	93	2.81
Pvt. Ext	32	3.75
Fellow Farmers	90	2.28
Media	94	2.55
Input Dealers	67	3.34
Demonstrations	11	3.36
Field Visit	20	3.55

The sources of income derived by the farmers presented in Table 16 reveals that about 37 percent of their gross income was derived from labour wages, followed by agricultural income (28.97%), Non- agricultural income (13.34%) and other income (12.63%).

Table 16: Income from various sources

Sources	Average (Rs/annum)	Percentage
Agriculture Income (Rs)	30670	28.97
Dairy Income (Rs)	3549	3.35
Other Livestock Income (Rs)	4421	4.18
Non Agrl. income (Rs)	14120	13.34
Labour Income (Rs)	39220	37.04
Other income	13370	12.63

Farmers Preference for Varietal Traits of Pearl Millet

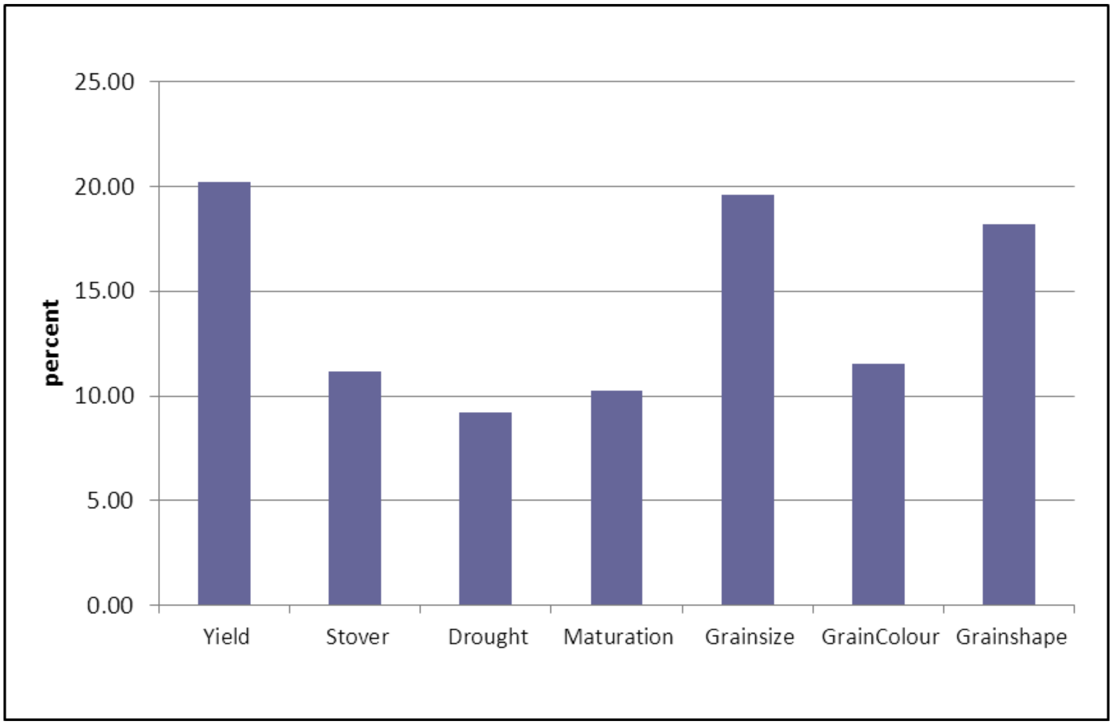
Like for sorghum an attempt has been made to quantify the features/ traits of pearl millet preferred by the farmers. The important varietal traits of pearl millet were identified in consultation with the pearl millet scientists of ICRISAT. The varietal traits identified were yield, stover quality, drought tolerance, ear head maturation duration, grain size, grain color and grain shape. Within each varietal trait the important levels were identified and conjoint analysis carried out on data from a sample of 100 farmers. The specific importance of the levels of each trait is measured in terms of utilities. This is presented in Table 17. When it comes to yield, the farmers derive the highest utility from an yield level of 2.5 to 3 metric tons per hectare. They prefer a medium grain size of around 7.5 gm/ 1000 grain with a utility score of 0.3042, as well as a grain which is obviate in shape. Unlike in sorghum they preferred a variety that produced grain of grey colour and they wanted the stover to be sweet and palatable. The model yielded a Kendall's tau and Parsons R of 0.68 and 0.90, respectively, which were significant testifying to the significance of the results.

The result of the conjoint analysis is presented in Figure 3. From the figure it is clear that pearl millet farmers are primarily interested in yield levels and grain size with importance indices of around 20 percent each. Grain shape, grain color and stover quality were next in order of importance with values of 18 percent, 12 percent and 11 percent respectively. Drought tolerance and maturation time were not considered important as it is perhaps taken for granted that pearl millet is inherently tolerant to moisture stress conditions.

Table 17: Utilities of post rainy season sorghum attributes to the farmer

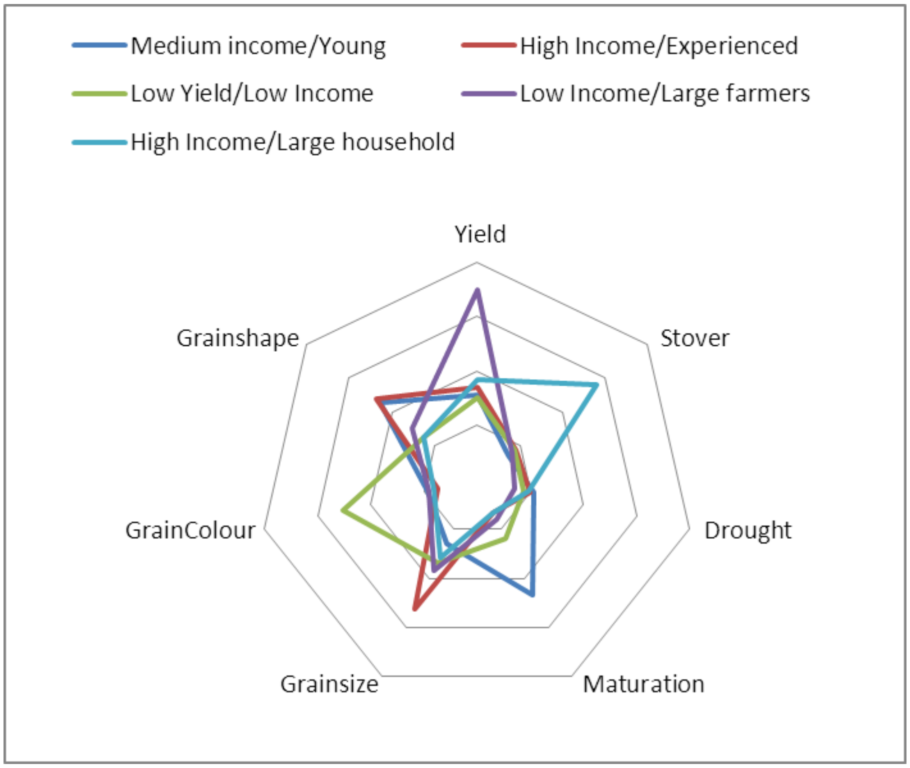
Trait	Utility	Levels
Yield	0.2067	2.5 to 3 metric tons per ha
	0.1117	1 to 1.5 metric tons per ha
	-0.3183	< 1 ton per ha
Stover	0.2388	sweet and Palatable
	-0.2388	Average palatability
Drought Tolerance	-0.0163	High
	0.0163	Low
Maturation of crop	0.015	60 to 65 days
	-0.015	65 to 72 days
Grain Size	-0.2133	Large (12 gm/1000)
	0.3042	Medium (7.5 gm/1000)
	-0.0908	Small (<5 gm/1000)
Grain Color	0.085	Grey
	-0.085	White
Grain Shape	0.1167	Obviate
	-0.0408	Globular
	-0.0758	Hexagonal
Constant	8.4725	
Parsons R	0.903	
Kendall's Tau	0.667	

Fig 3: Importance attached to selected varietal traits of pearl millet by farmers in Rajasthan



Variation in varietal preferences for farmers growing pearl millet were examined by clustering (employing cluster analysis) on the attributes of the varieties, viz., yield, stover palatability, grain size and grain colour. The cluster procedure grouped the farmers into 5 clusters. Profiling the socio economic characteristics of the farmers' o on the five clusters the following groups were identified: 1) young farmers with medium income 2) High income and experienced farmers 3) farms with Low yield and low income 4) large farmers with Low income and 5) High income large household farmers. The preference for the varietal traits for pearl millet differed for each group as shown in Figure 4.

Fig 4: Preference chart of various groups of pearl millet farmers



The differences in varietal preferences are also presented in Table 18. Perusal of the table reveals that the medium income young farmers (1) indicate a strong preference for early maturation and grain shape. The high income experienced farmers (2) focused on the market parameters like grain size and grain shape. They also attached a lot of importance to high yield. The farmers with low yield and low income (3) attached a great deal of importance to grain size and grain color and perhaps they were producing high quality pearl millet with desirable market characteristics. The low income large farmers (4) obviously attached a high importance to yield with an importance index of 34.83 percent and to some extent on grain size. The high income large households (5) attached the highest importance to stover, perhaps due to livestock rearing and income from livestock. Grain size was another important trait for this group. They also expressed a desire for high yields and large grain size in keeping with their high performance with regard to income and yield. It is significant that this group which derived the highest income from livestock also had a high demand for stover. Thus in pearl millet stover quality is an important requirement where the farmers raised livestock. In general pearl millet farmers desired high yields and medium sized grain size of 7 to 10 gm per 1000 grain and obviate shape

Table 18: Demand for varietal traits of different groups of farmers and their socio-economic profile

Household Data	Income Clusters					
	Medium income /Young	High Income/ Experienced	Low Yield/ Low Income	Low Income/ Large farmers	High Income/ Large household	Grand Total
Household Size	6.71	7.64	6.89	7.35	8.07	7.37
Age of the head of household	42.79	49.76	45.05	47.55	48.86	47.32
Experience (Years)	20.71	24.52	22.32	20.85	21.79	22.45
DryLand area (ha)	5.99	9.44	9.67	11.45	9.22	9.37
Irrigated area (ha)	1.01	1.85	2.47	1.32	2.02	1.77
Income (Rs)	88857	94273	67237	64000	91200	81893
Main Product (100 kgs))	14.29	17.18	14.95	13.80	17.00	15.65
Livestock Income (Rs)	3143	3879	5833	3635	6286	4421
			Trait preference (%)			
Yield	15.66	17.08	15.06	34.83	18.34	20.22
Stover	7.15	8.95	8.84	8.09	27.99	11.17
Drought	10.55	9.89	8.84	7.09	9.62	9.19
Maturation	23.27	6.64	11.83	8.07	6.61	10.24
Grain size	12.86	26.36	16.84	18.50	15.71	19.60
Grain colour	9.44	7.53	25.35	9.06	8.04	11.56
Grain shape	22.72	23.6	12.61	15.21	12.41	18.17

In order to test whether the differences in the varietal preferences were significant or not an ANOVA test was carried out on the preferences, with the cluster number as the group. The results of the analysis are presented in Table 19. A cursory examination of the results reveals that the preferences of each varietal trait presented in the table varied significantly across the clusters.

Table 19: ANOVA to test differences between clusters

Trait		Sum of Squares	df	Mean Square	F	Sig.
Yield	Between Groups	0.5442	4	0.1361	28.71	0.0000
	Error	0.4502	95	0.0047		
	Total	0.9945	99			
Stover	Between Groups	0.4641	4	0.1160	34.31	0.0000
	Error	0.3212	95	0.0034		
	Total	0.7853	99			
Drought	Between Groups	0.0135	4	0.0034	0.83	0.5083
	Error	0.3865	95	0.0041		
	Total	0.4000	99			
Maturation	Between Groups	0.3132	4	0.0783	25.11	0.0000
	Error	0.2962	95	0.0031		
	Total	0.6094	99			
Grain size	Between Groups	0.2526	4	0.0632	10.60	0.0000
	Error	0.5658	95	0.0060		
	Total	0.8184	99			
Grain Colour	Between Groups	0.4513	4	0.1128	34.07	0.0000
	Error	0.3146	95	0.0033		
	Total	0.7659	99			
Grain shape	Between Groups	0.2517	4	0.0629	12.40	0.0000
	Error	0.4822	95	0.0051		
	Total	0.7339	99			

Varietal preference for pearl millet was also carried out by level of constraints indicated by farmers related to moisture stress, yield variability and cost of cultivation. Though there were differences in trait preferences across constraint levels these were not significant (see Appendix).

Simulations

Some of the existing pearl millet varieties have been analysed in the backdrop of the values attached to each of the attributes by the pearl millet farmers. The results are presented in

Table 20 for the five varieties listed in the table. The table gives the predicted probabilities of choosing each of the simulation cases as the most preferred one, under three different probability-of-choice models. From the results it appears that Pioneer 86M86 and RHB 121 are the most popular varieties as of the simulated varieties as about 22 percent of the sample farmers would prefer each . This is followed by HHB 67 Improved and RHB 177 with a maximum utility of 19.50 percent. In addition to this Proagro 9444 should meet with good demand. Thus, all the varieties / hybrids seem to have good value to the farmers.

Table 20: Pearl millet simulation results

Sl No	Variety	Max Utility	BTL	Logit
1	HHB 67 Improved	19.50	20.41	21.08
2	Pioneer 86M86	22.00	19.33	20.49
3	Proagro 9444	17.00	19.67	16.65
4	RHB 121	22.00	20.20	22.41
5	RHB 177	19.50	20.39	19.37

Conclusion

Farmers in their decision to select a particular crop variety will evaluate the traits vested in the variety before a final choice is made. This process is a complex one. Farmers use judgments, impressions, advice and evaluation of all attributes of the variety and market demand of what they produce before they make their final choice. It is therefore important to quantify the value attached to each varietal trait such that a new variety can be promoted that meets the requirement of the farmers. This will give them satisfaction or utility. This utility index developed in this study provides a framework for evaluating farmers' preferences for an improved seed or technology in agriculture.

The present study was carried out on two important dryland crops, i.e., post rainy season sorghum and pearl millet. Post rainy (rabi) season sorghum is mainly grown on residual soil moisture is prized for its grain quality and fodder. Pearl millet is mainly grown under low rainfall regimes as it is drought tolerant. Its grain and fodder are the staples for humans and cattle in the major growing areas of the country. India is the largest` producer of pearl millet in Asia, both in terms of area (about 9 million ha) and production (8.3 million tons).

The study was carried out for post rainy season sorghum in Maharashtra and in Rajasthan for Pearl millet. 100 farmers in each region were selected and data on their preference of crops and varieties were elicited. Further the preference for the varietal traits which encompassed both production and market attributes was analysed using conjoint analysis. The importance score so obtained for each household was subject to K-mean clustering to obtain homogenous groups.

The findings indicate that for sorghum Maldandi was the most popular variety with over 75% of the dryland farmers growing it followed by Dagadi a distant second. Moisture stress, yield variability, labour scarcity and high cost of inputs in that order, were the principal constraints facing post rainy season sorghum production in the study area. High yield, large grain size (over 10 gm/1000 grain) and white grain colour were the most preferred traits that the farmer required. Results from simulation analysis with respect to existing varieties grown by farmers revealed a superior preference for Parbhani Jyoti over even Maldandi and Dagadi varieties which are the ruling varieties. It is thus important to ensure seed availability of this variety and promotion through extension for increasing its adoption.

For pearl millet HHB 67 improved was the most popular variety followed by RHB 177. Among the constraints documented moisture stress, lack of credit and high yield variability were the principal problems faced by the farmers. For pearl millet in general farmers desired high yields and medium sized grain size of 7 to 10 gm per 1000 grain and Obviate shape. However the requirement of varietal traits of pearl millet was not uniform across farms and differed socio economic status of the farmers. . In the simulation exercise related to existing varieties grown by farmers it was found that Pioneer 86M86, RHB 121 and HHB 67 improved had a strong chance of performing well in the region given the variety preferences of the farmers growing pearl millet in Rajasthan.

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Appendix:

Pearl millet varietal preference by constraints

The varietal preferences of farmers with different levels of constraints have been analyzed and the results reported here. Farmers facing acute moisture stress have a slightly lower focus on yield compared to the other groups and demonstrate a higher preference for grain size and grain shape and also on stover perhaps to fall back on livestock enterprises as an insurance against crop failures. From Appendix Table 1 it is clear that for pearl millet across moisture levels grain characteristics were important and in places where moisture stress was the least the farmers showed a strong preference for high yielding varieties.

Appendix Table 1: Preference of traits of farmers who experience moisture stress

Preferences	Levels of Moisture Stress				
	1	2	4	5	Overall
Yield	24.72	14.55	23.30	19.98	20.25
Stover	5.58	7.35	5.40	11.93	11.25
Drought	6.74	17.90	7.28	9.28	9.25
Maturation	9.90	2.65	7.20	10.63	10.29
Grain size	22.00	20.00	30.00	19.09	19.70
Grain colour	12.32	10.60	5.00	11.83	11.55
Grain shape	19.00	23.30	23.63	17.42	17.87

Note: Impact of the problem has been scored on a hedonic scale ranging from 1 for low to 5 for high.

The attribute preferences for farmers who expressed that yield variability is a serious problem, the results indicate that where yield variability was the most acute, the famers demonstrated a high preference for grain shape. In places where yield variability was the least the farmers showed a strong preference for high yielding varieties followed by strong grain characteristics like grain size, and grain color (Appendix Table 2).

Appendix Table 2: Preference of varietal traits based on yield variability

Preferences	Levels of Yield variability (%)					
	1	2	3	4	5	Overall
Yield	19.09	24.49	21.75	20.37	18.80	21.29
Stover	12.09	7.98	10.20	11.26	3.90	10.26
Drought	8.06	8.92	10.06	9.37	1.55	9.08
Maturation	9.66	7.55	9.06	10.89	8.15	9.59
Grain size	18.75	21.54	18.82	20.34	20.00	20.00
Grain colour	15.08	11.12	9.78	11.08	6.20	11.09
Grain shape	15.73	19.00	20.12	16.91	40.35	18.64

Note: Impact the problem has been scored on a hedonic scale ranging from 1 for low to 5 for high.

In a monetized economy in which agriculture is no exception, high cost of inputs is a serious problem expressed by the pearl millet farmers. From the results four levels of costs were identified based on the intensity of the problem. Where input cost were very high the farmers wanted varieties with very high yield to offset the effect of costs. The requirement of high yield tapered off when the problem of cost was not severe (Appendix Table 3). Overall in pearl millet fodder quality was of lesser importance when compared to post rainy season sorghum.

Appendix Table 3: Preference of varietal traits based on cost of inputs

Preferences	Levels of cost of inputs				
	1	2	3	4	Overall
Yield	18.67	18.81	23.33	29.15	20.22
Stover	10.73	10.67	9.81	9.10	11.17
Drought	7.98	8.57	9.55	2.70	9.19
Maturation	16.83	11.51	10.74	2.90	10.24
Grain size	16.67	20.00	22.50	20.00	19.60
Grain Colour	9.95	10.72	8.66	11.25	11.56
Grain shape	18.38	19.59	16.59	26.95	18.17

Note: Impact the problem has been scored on a hedonic scale ranging from 1 for low to 5 for high.

An ANOVA carried out to test whether the varietal preferences vary significantly across levels of each constraints yielded non-significant F values. This indicates that the apparent differences between levels are not significant. See Appendix Table 4.

Appendix Table 4: ANOVA to test differences in preferences for pearl millet based on level of constraints

Traits		Moisture stress					Yield variability					Cost of inputs					Market Variability				
		Sum of Squares	df	Mean Square	F	Sig.	Sum of Squares	df	Mean Square	F	Sig.	Sum of Squares	df	Mean Square	F	Sig.	Sum of Squares	df	Mean Square	F	Sig.
Yield	Between Groups	0.02	3	0.01	0.68	0.57	0.02	4	0.01	0.44	0.78	0.02	3	0.01	0.61	0.61	0.03	4	0.01	0.86	0.49
	Within Groups	0.97	95	0.01			0.78	64	0.01			0.77	70	0.01			0.58	60	0.01		
	Total	0.99	98				0.80	68				0.79	73				0.61	64			
Stover	Between Groups	0.04	3	0.01	1.57	0.20	0.02	4	0.01	0.82	0.52	0.04	3	0.01	1.51	0.22	0.03	4	0.01	0.76	0.55
	Within Groups	0.74	95	0.01			0.40	64	0.01			0.59	70	0.01			0.53	60	0.01		
	Total	0.78	98				0.42	68				0.62	73				0.56	64			
Drought	Between Groups	0.02	3	0.01	1.66	0.18	0.01	4	0.00	0.93	0.45	0.00	3	0.00	0.08	0.97	0.03	4	0.01	2.06	0.10
	Within Groups	0.38	95	0.00			0.24	64	0.00			0.33	70	0.00			0.19	60	0.00		
	Total	0.40	98				0.26	68				0.33	73				0.22	64			
Maturation	Between Groups	0.02	3	0.01	0.89	0.45	0.01	4	0.00	0.55	0.70	0.02	3	0.01	1.04	0.38	0.02	4	0.01	0.76	0.56
	Within Groups	0.59	95	0.01			0.32	64	0.01			0.48	70	0.01			0.45	60	0.01		
	Total	0.61	98				0.34	68				0.50	73				0.47	64			
Grain size	Between Groups	0.05	3	0.02	2.01	0.12	0.01	4	0.00	0.23	0.92	0.03	3	0.01	1.26	0.30	0.02	4	0.01	0.68	0.61
	Within Groups	0.76	95	0.01			0.49	64	0.01			0.54	70	0.01			0.50	60	0.01		
	Total	0.81	98				0.50	68				0.57	73				0.53	64			
Grain Colour	Between Groups	0.02	3	0.01	0.78	0.51	0.02	4	0.01	0.77	0.55	0.01	3	0.00	0.47	0.70	0.02	4	0.01	0.78	0.54
	Within Groups	0.75	95	0.01			0.43	64	0.01			0.55	70	0.01			0.43	60	0.01		
	Total	0.77	98				0.45	68				0.56	73				0.45	64			
Grain shape	Between Groups	0.02	3	0.01	1.10	0.35	0.11	4	0.03	4.30	0.00	0.01	3	0.00	0.66	0.58	0.02	4	0.01	0.86	0.50
	Within Groups	0.62	95	0.01			0.42	64	0.01			0.50	70	0.01			0.40	60	0.01		
	Total	0.64	98				0.54	68				0.52	73				0.42	64			