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Evaluation of black gram varieties using crowd source citizen science under northern hilly climatic condition of Chhattisgarh

Satyapal Singh, Deepak Sharma, JC Rana and SP Ahlawat

Abstract
Crowd sourced citizen science is an emerging approach in plant sciences. The triadic comparison of technologies (tricot) approach has been successfully utilized by demand-led breeding programmes to identify varieties for dissemination suited to specific geographic and climatic regions. An important feature of this approach is the independent way in which farmers individually evaluate the varieties on their own farms as "citizen scientists." In this study, we adopted this approach farmer experimentation for climate adaptation with triadic comparisons of technologies (tricot) to evaluate the native/local and improved black gram varieties in Northern hilly region of Chhattisgarh state. Specifically interested in evaluation of major phenotypic and quality parameters. Overall performance of Teliya Urad was highest and best than others relative varieties in his set/group followed by Indira urad and Hara Urad. Teliya Urad variety of black gram is native of Jhabua Madhya Pradesh. It is introduced in the project activity as sharing of variety. Many farmers demanding and preferring this variety than other variety due to very shined and contrast seed coat with high yield (747.93 Kg/ha.) and taste.

Keywords: Black gram, citizen science, climmob, native varieties, tricot, surguja

1. Introduction
Chhattisgarh is endowed with rich and diverse forest resources area constitutes 44% of the total geographical area of the state. The State is geographically situated between 170 46' to 240 5' North Latitude and 800 15' E to 840 20' East Longitude. The total geographical area is around 137898 Sq. kms of which 34% is cultivable land area. It is ideally positioned to act as the nerve center of the entire region. Chhattisgarh has an amazing variety of food production systems. It is one of the places on the earth to have a remembered history of an enormous diversity of food resources. These food resources are included many varieties of germplasm, a wide range of millets and other dry land crops, pulses, oilseeds, fruits, edible flowers, tubers mushrooms and other forest gathered foods. Many of these are dependent upon access to close proximity of the forests.

In agriculture, the local environmental conditions determine to a large degree which technological solutions are the most suitable. In dry soils, for example, drought-resistant crop varieties will outperform other varieties, but in wet soils these same varieties may do worse than most. Not only drought, but an entire range of problems including excessive heat, floods, new pests and diseases tend to intensify under climate change. This multitude of limiting factors requires multiple technological solutions, tested in diverse environments. Black gram is resistant to adverse climatic conditions and fixes atmospheric nitrogen in the soil, enhancing soil fertility. The major constraints for achieving higher yield are lack of genetic variability, absence of suitable ideotypes for different cropping system, poor harvest index and susceptibility to biotic and abiotic stresses (Vignesh M., *et al*., 2021) [19]. Consideration of genetic diversity existing in a population is the basic requirement for effective improvement programme.

Citizen science is based on the cooperation of citizen scientist or observers (paid or unpaid). Researchers assign microtasks (observations, experiments) that, once completed and gathered, contribute with a great amount of information to science. One of the advantages of citizen science is that agricultural researchers can get access to many environments by crowdsourcing their experiments. As farmers contribute with their time, skills and knowledge to the investigation, researchers are able to do more tests than in a traditional setup also citizen scientists acquire new knowledge, abilities and information useful for future challenges of

their work (de Sousa *et al*. 2021) [2].

Triadic comparison of technologies can help to introduce new varieties, inputs and practices to rural areas, because it empowers farmers to identify the most suitable technologies for the local conditions of their own farm. Tricot is a research methodology that involves many farmers in the testing and/or validation of new and promising technologies, like crop varieties, as 'farmer researchers'. This means: Large numbers of farmers carry out many small and easy trials, instead of a few big trials realized at research stations. The participants provide the observations from their trials to the agricultural research centers, where the data from all mini-trials is merged and analyzed. The research centers then feedback the findings to all participants (Steinke and Van Etten 2016) [11].

2. Materials and Methods

2.1 Study sites

The study was conducted in Surguja and Korea using improved varieties and farmers' native varieties of black gram (*Vigna mungo* L. Hepper) crop available in the different site of the state (Fig. 2). In Chhattisgarh, the study was conducted in the Northern hilly regions during *kharif* 2019. Surguja and Korea districts (Northern Region); Nakna, Dhekidoli Lalati, Taragi and Bataikela (Batauli Block Region); Ghughra, Odari, Kailashpu, Vikrampur, Orgai and Katgodi village (Sonhat block Region of Korea district) is tribal region of the state. Consumption of rice followed by black gram is important in selected areas of Northern hilly region. Study of crowdsourcing trial was taken after baseline survey of project during 2018-2019. We collected different varieties after baseline survey (Singh *et al*. 2021) [10] and conducted mother trials for identification of potential variety for crowdsourcing trials (Fig 1). The entire crowdsourcing experiment conducted under the UN implemented GEF project entitled "Mainstreaming of agricultural biodiversity conservation in agriculture sector to ensure ecosystem services and reduce vulnerability". Project activity supervised by the Bioversity International India office New Delhi.

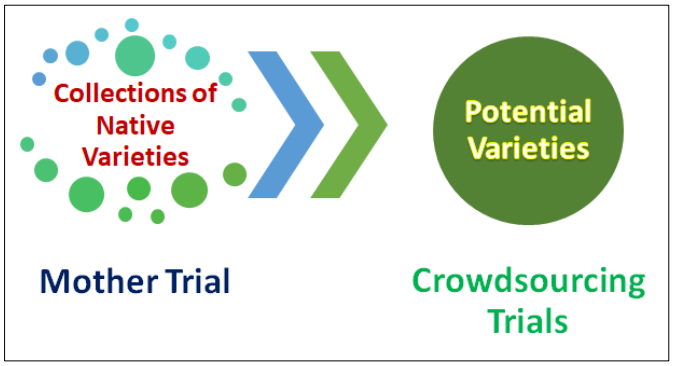


Fig 1: Representation of mother trial and crowdsourcing trial.

Crowdsourcing trial of Black gram commonly known as 'Urad' was set up with 6 varieties involving 10 farmers in selected core villages as per package generated with ClimMob application (Van Etten *et al*. 2019) [4]. Each farmer was provided with three varieties to set four-line experiment of each variety on $12m^2$ plot. In all 10 farmers setup 30 experimental plots. Farmers trail was laid in four rows for each variety. Detail of each farmer trails were recorded on farmer record book provided by Bioversity International. Data collected of each farmer was filled in excel sheet generated with Climmob application for the crop. Data sheet of each crop was uploaded in the Climmob for the project created of the crop. Data was analyzed with Climmob application and report for each crop was generated. DIVA GIS 7.5 application tool was used to generate geographical map and rainfall pattern of the target site under the project (Fig. 2 & 3). Crowdsourcing data were collected from the farmers field and analyzed by ClimMob version 2 application.

2.2 ClimMob

The primary goal of ClimMob is to help farmers adapt to variable and changing climates. ClimMob was created as part of Bioversity International's research in the CGIAR Research Programme on Climate Change, Agriculture, and Food Security (CCAFS). It serves to prepare and analyze citizen science experiments in which a large number of farmers observe and compare different technological options under a wide range environmental condition (Van Etten 2011) [17].

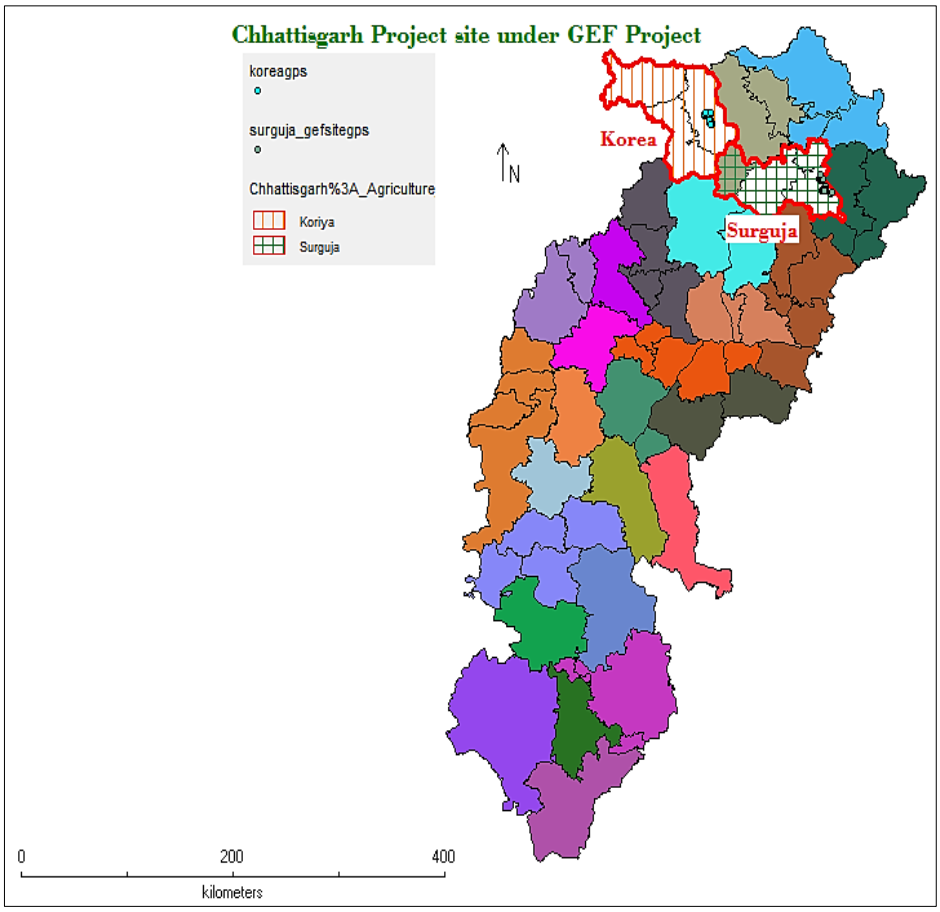


Fig 2: Study sites under GEF Project.

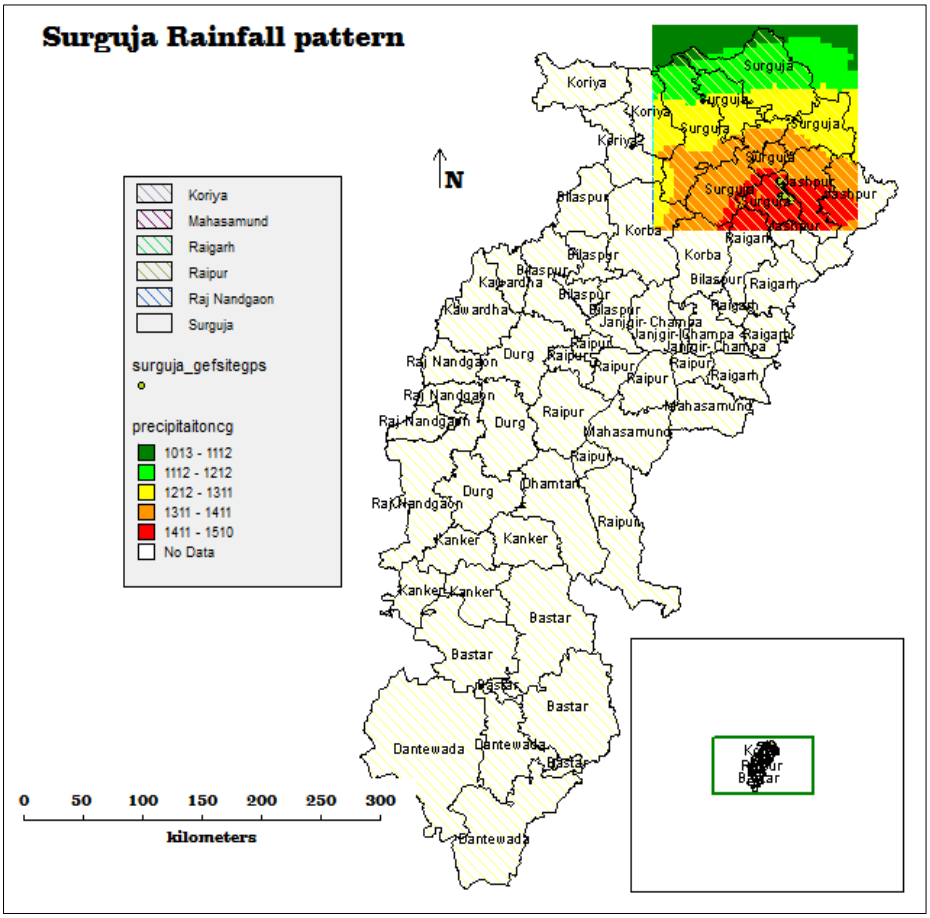


Fig 3: Rainfall pattern of the study sites.

ClimMob software assigns a limited number of items (typically 3 crop varieties or agricultural practices) to each farmer, who will compare their performance. Each farmer gets a different combination of items drawn from a much larger set of items. Comparisons of this kind are thought to be a very reliable way to obtain data from human observers (Martin 2004) [5]. Once the results of the microtasks have been collected, *ClimMob* builds an image of the whole set of assigned objects, combining all observations. *ClimMob* not only reconstructs the overall ordering of items, but also takes into account differences and similarities between observers and the conditions under which they observe. It assigns similar observers to groups that each corresponds to a different preference profile. Groups are created on the basis of variables such as the characteristics of the plot, geography, age, gender etc.

ClimMob uses a recently published statistical method to analyze ranking data (Strobl *et al*. 2011) [12]. It automatically generates analytical reports, as well as individualized information sheets for each participant. *ClimMob* will hopefully help many agricultural researchers to start using crowdsourcing approaches in order to accelerate climate change adaptation. Complementary to the micro talks performed by the farmers, a detailed environmental monitoring is performed, using new, cheap sensors (Mittra *et al*. 2013) [6], makes it possible to compare across sites and predict crop variety performance for new places.

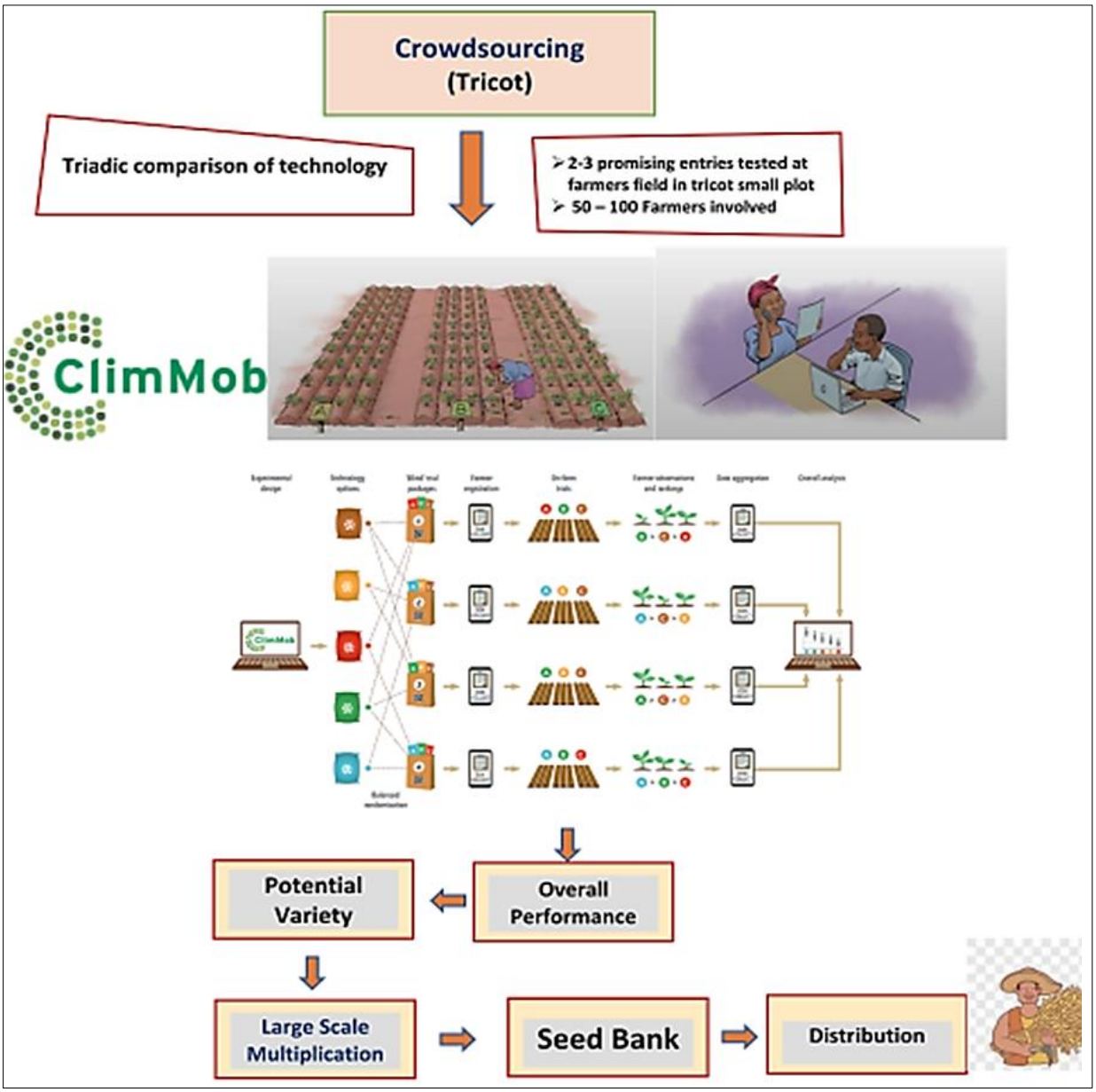


Fig 4: Crowdsourcing approach demonstration.

The tricot approach was used (Van Etten *et al*., 2019) [4] to study consumer preferences. This trial was supported by the *ClimMob* digital platform (http://climmob.net/) (Van Etten *et al*. 2020) [3], which streamlines the process. The objective of the study was shared with community leaders who also coordinated and interpreted in the local languages to ensure every participant understood the aims of the study. Potential participants who consented to being part of the study and having evidence photographs taken, with possibility of being published for research purposes only, signed up to participate. Sets of three genotypes from the site-specific sets of genotypes were allocated randomly to participants as

incomplete blocks, maintaining balance by assigning roughly equal frequencies of each genotype, where possible. In Korea, some varieties were slightly underrepresented as they were in short supply from the demonstration trials. They were however included for comparative purposes quality attributes. Genotypes in each incomplete block were labeled as A, B, and C and presented anonymously to prevent bias in the evaluation (De Sousa *et al*. 2021 and Turner *et al*. 2020) [1]. Each participant evaluated their assigned set choosing the genotype which, according to their opinion, had the best and the worst characteristic for a given trait. The middle-ranking genotype is inferred from the answers on the best and worst, leading to a complete ranking of each set (incomplete block) of three varieties.

2.3 Bradley-Terry tree

Bradley-Terry tree figure for each combination of the explanatory variables chosen. The figure gives a visual representation of how the groups were formed and their preference profiles. At the Bradley-Terry Tree figure, the values at the bottom rectangles (called terminal nodes) are the worth of the items. Worth rescales the scores to sum to one, for each group (node) that has been identified. It represents the degree of success of each item in the group. Each node represents a group of observers, and has a corresponding relative estimation figure and table next to the Bradley-Terry tree. The relative estimation figure gives an idea of the best and worst item in the corresponding node (Strobl *et al*. 2011) [12].

3. Results and Discussion

3.1 Mother trial performance of black gram varieties

Mother & Baby trials are designed to facilitate conversations among farmers, extension, and researchers. This is essential in order to develop, assess, and test various agronomic practices in a manner that incorporates diverse farmer priorities, and can evaluate performance across a range of management practices and edaphic conditions in a quantifiable and repeatable manner. It has been used most widely in participatory plant breeding, as a systematic approach to incorporate farmer assessment of crop varieties (and for participatory plant breeding approaches that involve farmer evaluation of early generation germplasm (Witcombe *et al*., 2005) [20].

Table 1: Yield performance of Black gram varieties in mother trials.

S. No.	Name of variety	AMBIKAPUR		KOREA		Mean Kg/ha
		KVK	Nakna	KVK	Ghughra	
1	Indira Urad	814.75	879.4	789.41	816.33	824.97
2	Teliya Urad	661.44	821.32	718.32	790.65	747.93
3	Deshi Bhura Urad	642.39	712.50	738.53	531.20	656.15
4	Nar Urad	613.98	654.77	582.45	523.08	593.57
5	Hara Urad	573.45	623.42	513.76	619.33	582.49
6	Karani Urad	487.53	541.23	534.63	587.14	537.63
	Grand Mean	632.26	705.44	646.18	644.62	657.12
	Max	814.75	879.40	789.41	816.33	824.97
	Min	487.53	541.23	513.76	523.08	537.63
	Standard Error	44.35	51.64	47.71	52.41	44.84
	CD (p=0.05)	113.99	132.74	122.64	134.71	115.25
	CV (%)	17.18	17.93	18.09	19.91	16.71

Mother trial result carried out at farmers field as well as KVK farms. Indira Urad showed highest yielder 824.97 kg./ha. across the four location *viz*. Krishi vigyan kendra Ambikapur, Village-Nakna, Krishi vigyan kendra Korea and Village: Ghughra under the mother trial followed by Teliya urad (747.93 kg./ha.), Deshi Bhura Urad (656.15 kg./ha.), Nar Urad (593.57 kg./ha.), Hara Urad (582.49 kg./ha.), Karani Urad (537.63 kg./ha.). Indira urad is improved variety of Chhattisgarh state (Sahu and Shrivastav 2019) and Teliya urad is a landrace of Jhabua Madhya Pradesh were performed high yield across the four locations (Table 1).

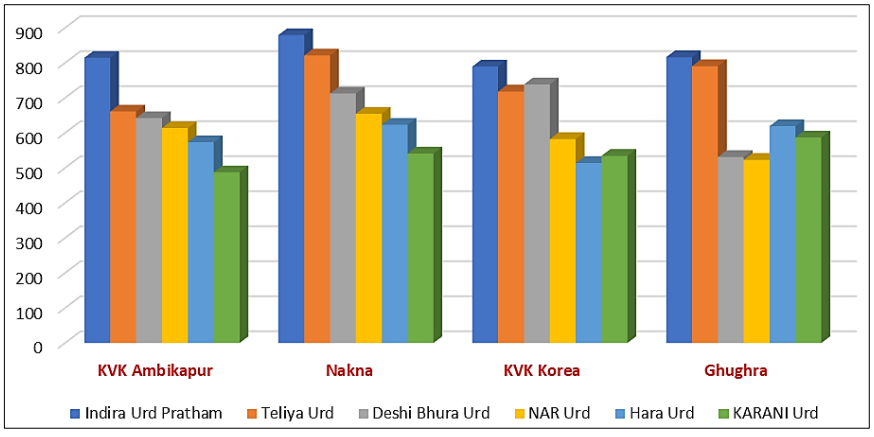


Fig 5: Yield performance of Black gram varieties in mother trial.

3.2 Crowdsourcing trial of black gram varieties

Crowd sourced citizen science supports the identification of promising genotypes in a first analysis, we aggregated the results from the 6 black gram tested genotypes, and the group of 100 total participants from the two target sites from field testing trials (Figure 1 & 2). In Surguja, Teliya urad highest estimation score 1.79 for germination followed by Indira urd and Deshi bhura urad (Toppo *et al*. 2020) [14]. Vigor character highly estimated for Indira urd followed by Deshi bhura urad. Hara urad performed highest estimation 0.16 for plant architecture of the plant followed by Deshi bhura urad. Nar urad showed faster maturity estimation 2.15 followed by estimation of Indira urad 0.98 and Teliya urad estimation 0.42. Insect resistance estimation highly showed by Nar urad 44.83 followed by Indira Urad 22.71, Hara Urad 22.29, Teliya urad 21.87 and Disease resistance estimation of Indira Urad 1.83 showed highest followed by Hara Urad 0.59, Teliya Urad 0.36.

Table 2: Estimation value for each combination of the explanatory variables.

A	Germination			
Genotype	**Estimation**	**SE**	**Quasi SE**	**Quasi Variance**
Deshi Bhura Urad	0.00	0.00	0.64	0.41
Hara Urad	-0.10	0.89	0.71	0.51
Indira Urad	1.11	1.30	1.02	1.03
Karani Urad	-20.52	5448.64	5448.64	29687723.56
Nar Urad	-1.12	1.22	1.07	1.13
Teliya Urad	1.79	1.46	1.19	1.41
B	**Vigor**			
Deshi Bhura Urad	0.00	0.00	0.79	0.62
Hara Urad	-0.54	0.93	0.82	0.67
Indira Urad	19.26	6150.21	6150.21	37825035.47
Karani Urad	-2.08	1.31	0.91	0.83
Nar Urad	-2.08	1.31	0.91	0.83
Teliya Urad	-2.49	1.54	1.19	1.42
C	**Plant Architecture (Height)**			
Deshi Bhura Urad	0.00	0.00	0.62	0.39
Hara Urad	0.16	0.83	0.71	0.50
Indira Urad	-0.65	1.02	0.72	0.52
Karani Urad	-0.13	0.95	0.71	0.51
Nar Urad	-2.22	1.24	1.04	1.07
Teliya Urad	-0.54	1.07	0.82	0.67
D	**Faster Maturity**			
Deshi Bhura Urad	0.00	0.00	0.65	0.42
Hara Urad	-0.88	0.91	0.80	0.64
Indira Urad	0.98	1.11	0.80	0.64
Karani Urad	-0.61	1.02	0.81	0.65
Nar Urad	2.15	1.29	1.07	1.13
Teliya Urad	0.42	1.13	0.86	0.74
E	**Insect Resistance**			
Deshi Bhura Urad	0.00	0.00	15964.83	254875798.46
Hara Urad	22.29	16919.03	1.28	1.63
Indira Urad	22.71	16919.03	0.96	0.92
Karani Urad	-21.08	16187.74	21223.48	450436086.18
Nar Urad	44.83	27679.07	22143.05	490314542.15
Teliya Urad	21.87	16919.03	0.96	0.92
F	**Disease Resistance**			
Deshi Bhura Urad	0.00	0.00	0.63	0.40
Hara Urad	0.59	0.88	0.70	0.49
Indira Urad	1.83	1.31	1.06	1.11
Karani Urad	-20.17	6112.37	6112.37	37361063.30
Nar Urad	-0.04	1.05	0.84	0.70
Teliya Urad	0.36	1.18	0.93	0.86
G	**Drought Resistance**			
Deshi Bhura Urad	0.00	0.00	0.62	0.39
Hara Urad	0.80	0.89	0.81	0.65
Indira Urad	-1.05	1.07	0.78	0.61
Karani Urad	-0.37	0.95	0.69	0.48
Nar Urad	0.09	0.94	0.70	0.49
Teliya Urad	-2.01	1.34	1.11	1.24
H	**Yield**			
Deshi Bhura Urad	0.00	0.00	0.66	0.43
Hara Urad	0.00	1.00	0.76	0.57
Indira Urad	48.29	106308.65	97477.41	9501845176.56
Karani Urad	-24.43	70516.11	66897.49	4475274172.41
Nar Urad	-48.52	101611.10	92145.16	8490730327.40
Teliya Urad	24.03	70996.40	68138.33	4642831737.13
I	**Value in the Market**			
Deshi Bhura Urad	0.00	0.00	0.84	0.70
Hara Urad	2.36	1.33	1.09	1.18
Indira Urad	1.57	1.36	0.96	0.92
Karani Urad	-1.96	1.40	1.19	1.41
Nar Urad	-1.23	1.24	1.03	1.06
Teliya Urad	1.51	1.39	1.01	1.03
J	**Taste**			

Deshi Bhura Urad	0.00	0.00	0.60	0.35
Hara Urad	-0.31	0.81	0.68	0.46
Indira Urad	-0.97	0.98	0.71	0.50
Karani Urad	0.00	0.91	0.68	0.47
Nar Urad	-0.42	0.91	0.67	0.44
Teliya Urad	-1.16	1.08	0.85	0.72
K	**Overall performance**			
Local Variety	0.00	0.00	0.48	0.23
Deshi Bhura Urad	-0.72	0.78	0.62	0.39
Hara Urad	0.06	0.78	0.62	0.39
Indira Urad	1.96	1.15	1.03	1.07
Karani Urad	-43.29	20630.29	19338.38	373972812.11
Nar Urad	-22.42	14590.28	14097.40	198736583.80
Teliya Urad	2.61	1.36	1.23	1.50

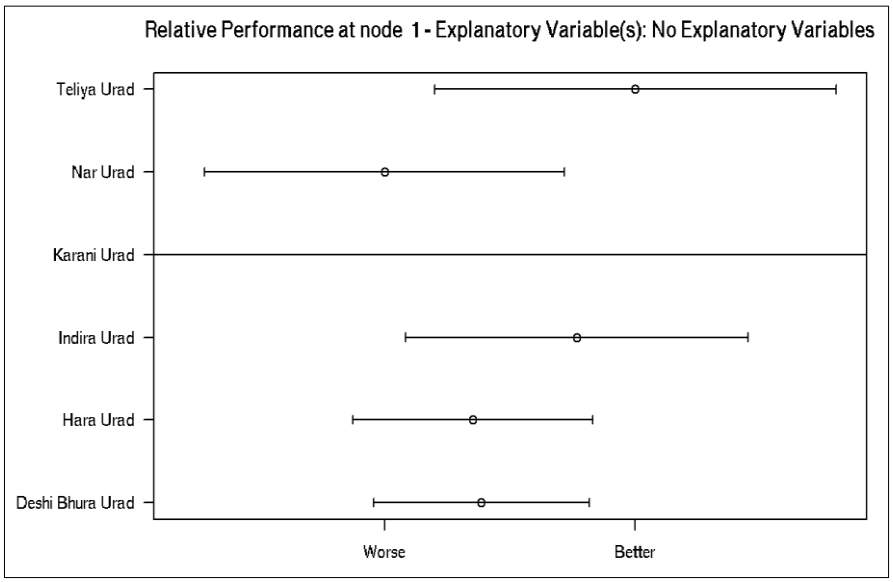
Hara Urad showed highest estimation 0.80 for drought resistance followed by Nar Urad and Deshi Bhura Urad, Yield estimation of Indira Urad showed highest 48.29 followed by Teliya Urad, Hara Urad and Deshi Bhura Urad. Estimation for value in the market highly showed by Hara Urad 2.36, followed by Indira Urad 1.57 and Teliya urad 1.51. Deshi Bhura Urad and Karani Urad showed higher estimation for Taste of the Dal (Table 2).

Teliya urad was preferred by the farmers among 6 varieties for 10 criteria to estimate at farmers' field. Indira Urad performed highest yield range (0.35-1.91 kg./plot) and Teliya urad yield range (0.51-1.72 kg/plot) followed by Deshi bhura urad (0.43-1.38 kg/plot), Hara Urad (0.35-2.2 kg./plot), Karani urad (0.15-1.18 kg./plot). Highest yield estimated at Ram Prakash Rajwade form for Teliya urad and Karani Urad, Shiv Narayan farm for Indira Urad, Mansai Rajwade farm for Deshi Bhura Urad, Lal Sundar form for Hara Urad respectively (Table 3). Singh *et al*. 2021 [10] suggested that black gram diversity deployment is needed to increase the cultivation area and reduce the dominancy of the few varieties.

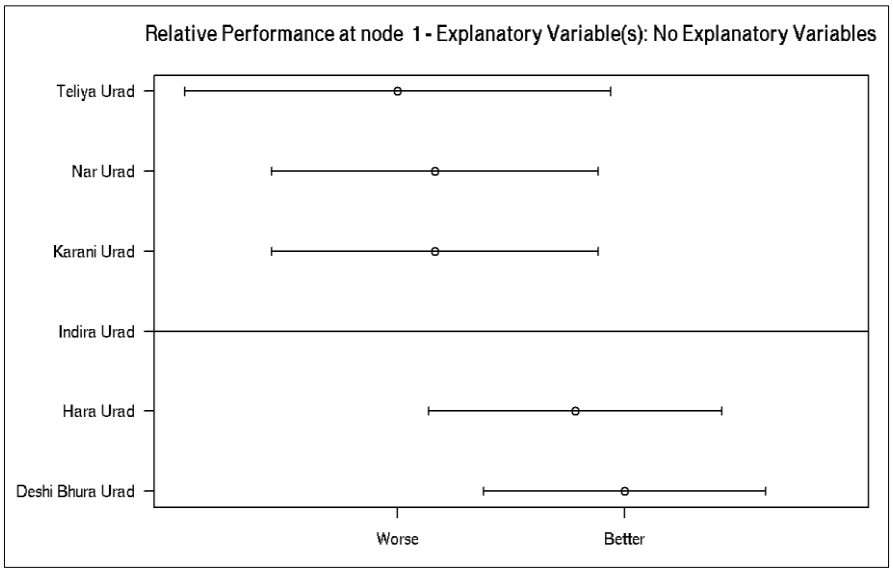
Table 3: Yield performance of Black gram varieties in Crowdsourcing Trial.

Sr.	Farmer Participation	Variety A	Yield (Kg./plot)	Variety B	Yield (Kg./plot)	Variety C	Yield (Kg./plot)
1	Jansai	Karani Urad	0.15	Nar Urad	0.23	Indira Urad	0.45
2	Harinandan	Deshi Bhura Urad	0.43	Hara Urad	0.35	Teliya Urad	0.515
3	Mansai Rajwade	Hara Urad	1.34	Deshi Bhura Urad	1.38	Karani Urad	1.12
4	Shiv Narayan	Teliya Urad	1.41	Indira Urad	1.91	Nar Urad	1.31
5	Ramprakash Rajwade	Nar Urad	1.22	Teliya Urad	1.72	Karani Urad	1.18
6	Ram kumar	Indira Urad	1.87	Deshi Bhura Urad	1.22	Hara Urad	1.46
7	Lal Sundar	Hara Urad	2.2	Teliya Urad	0.51	Indira Urad	0.35
8	Motilal	Nar Urad	1.13	Karani Urad	1.17	Deshi Bhura Urad	1.34
9	Ram kumar Rajwade	Karani Urad	1.18	Indira Urad	1.86	Teliya Urad	1.52
10	Janaki	Deshi Bhura Urad	1.21	Hara Urad	1.38	Nar Urad	1.09

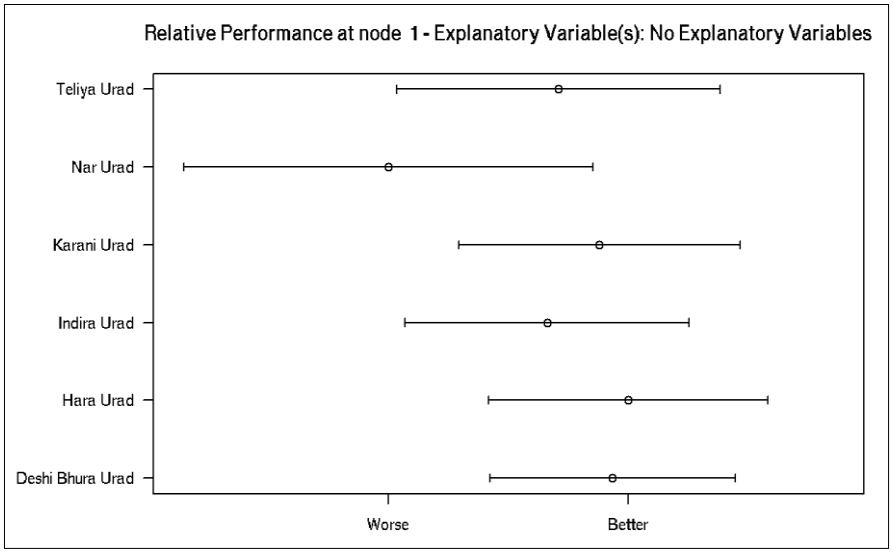
On the basis of this Climmob application report data are presented as given Figure-6. Performance of each variety relative performance at the node only.



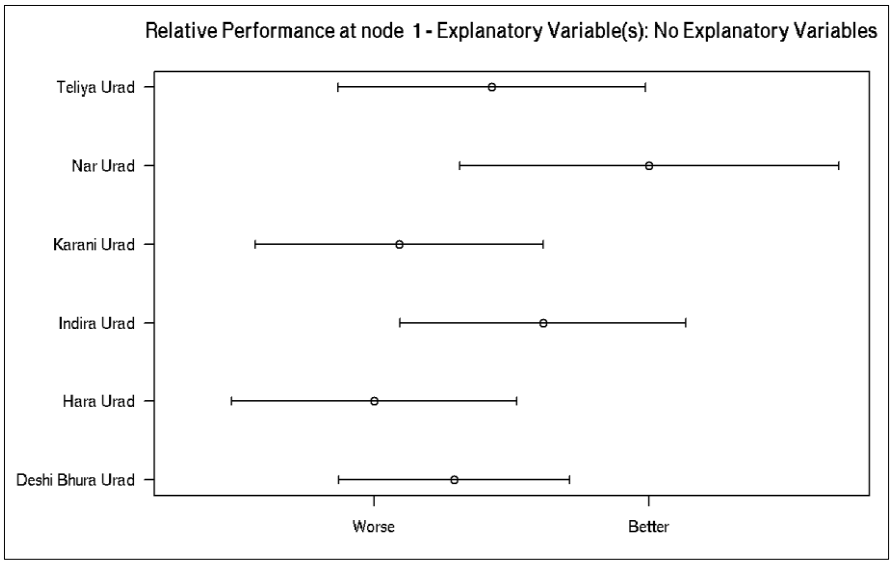
(A) Germination



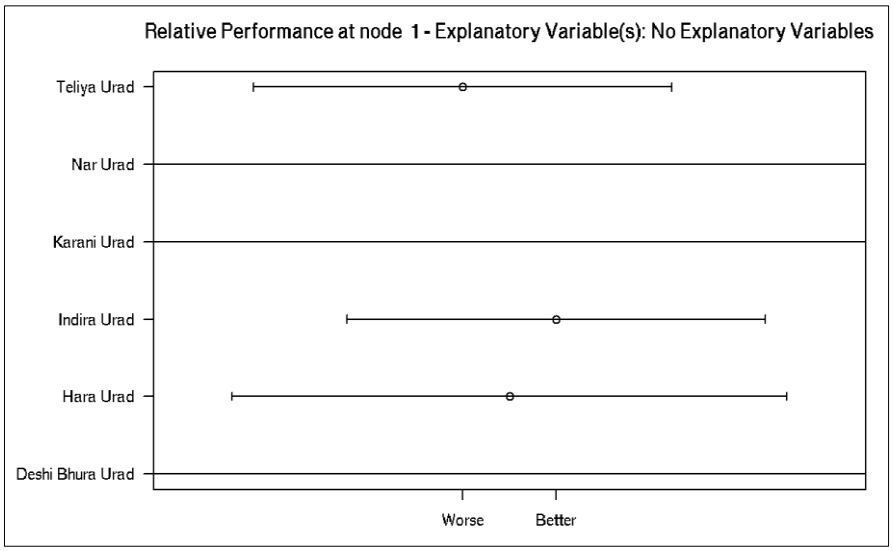
(B) Vigor



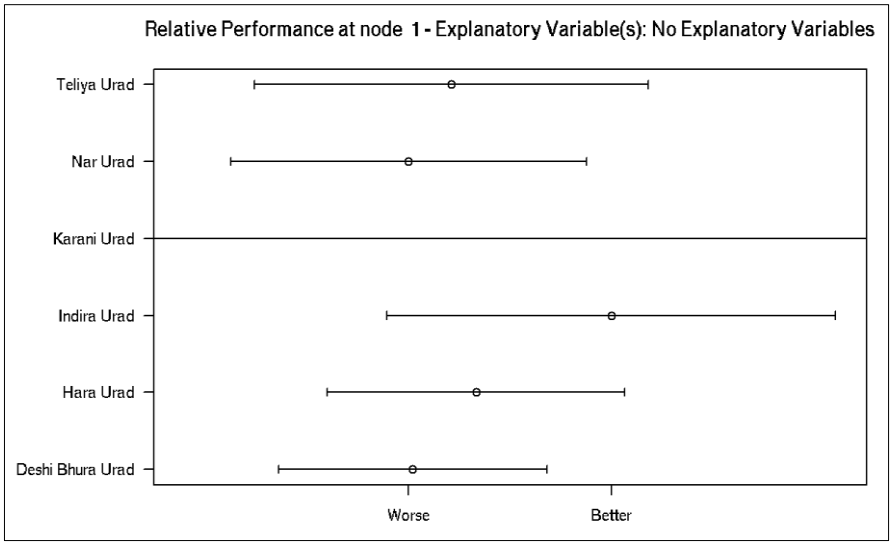
(C) Plant architecture (height)



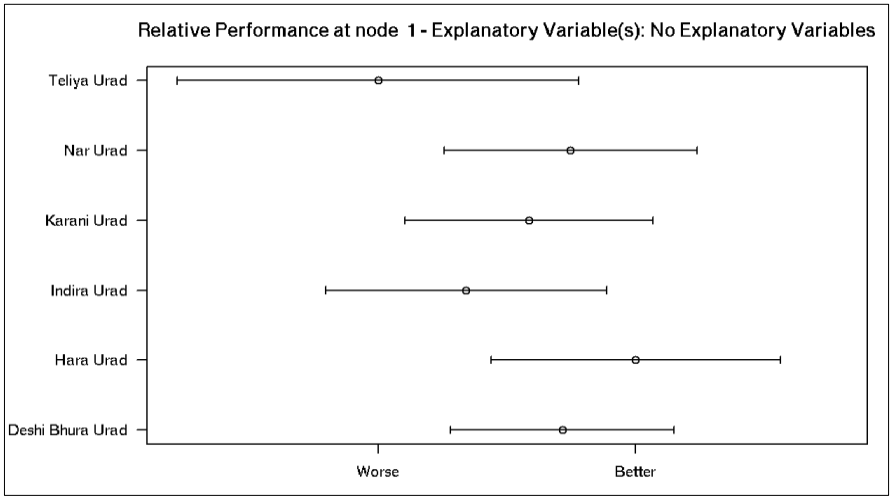
(D) Faster maturity



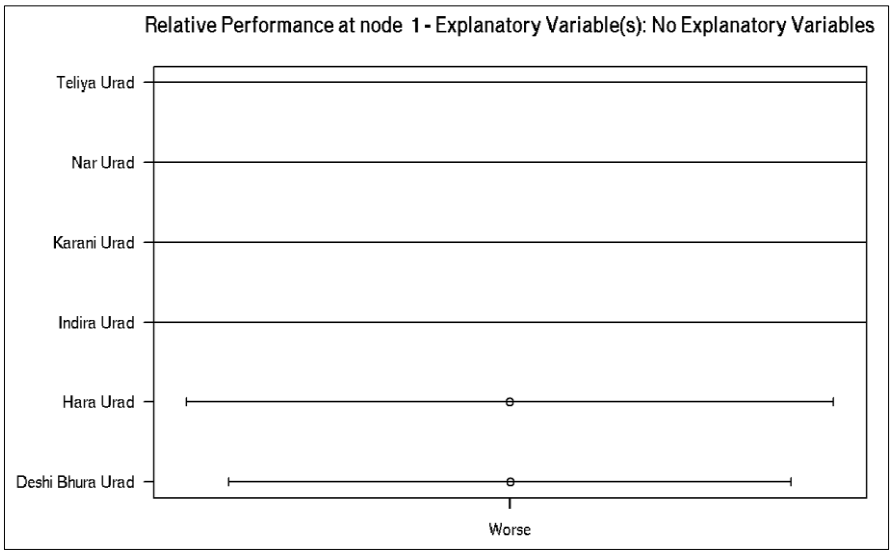
(E) Pest resistance



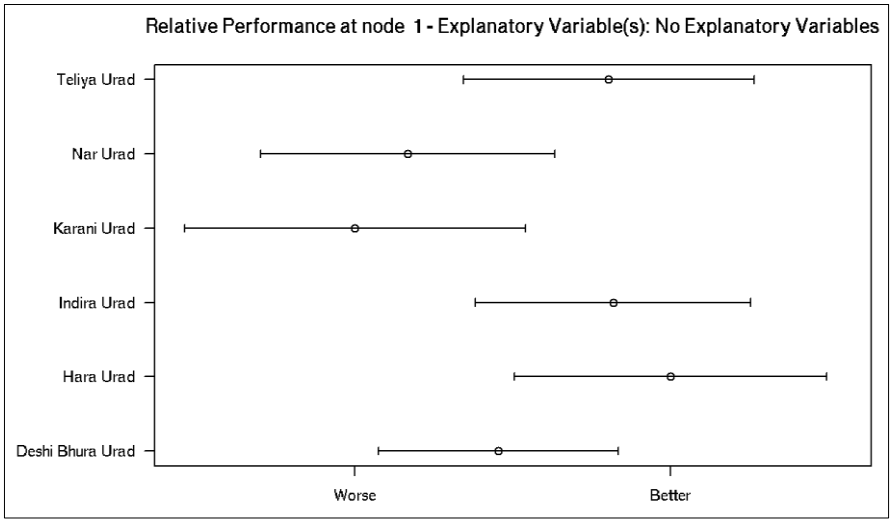
(F) Disease resistance



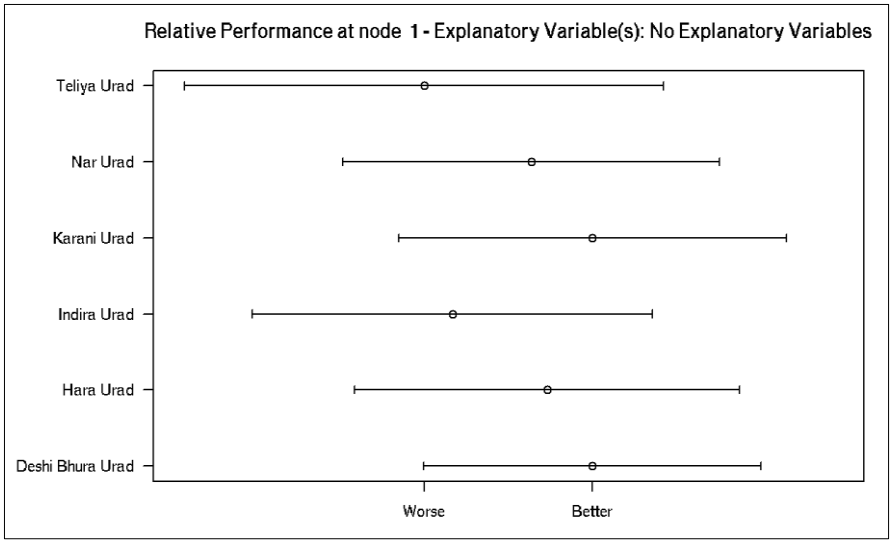
(G) Drought resistance



(H) Yield



(I) Value in the market



(J) Taste

Fig 6: Result for Overall performance and other characters of the variety (10 Participants) Bars indicate 95% confidence intervals.

3.3 Overall performance

Teliya Urad performance overall is highest and best than others relatively followed by Indira urad and Hara Urad. Teliya Urad variety of black gram is a native of Jhabua

Madhya Pradesh. It is introduced in the project activity as sharing of variety. Therefore, many farmers demanding and preferring this variety than other variety. Tricot methodology proved through Climmob crowdsourcing trials. Van Etten *et al*. 2016 [11] suggested that the local variety refers to the different local varieties that farmers grow themselves to which they compare the three introduced varieties. The small variation is remarkable because the local variety is different for each farmer.

4. Conclusion

Overall performance of Teliya Urad was highest and best than others relative varieties in his set/group followed by Indira urad and Hara Urad. Teliya Urad variety of black gram is native of Jhabua Madhya Pradesh. It is introduced in the project activity as sharing of variety to another project partner. Many farmers demanding and preferring this variety than other variety due to very shined and contrast seed coat. Tricot methodology also proved by climmob crowdsourcing trials. Across all trials, we had positive feedback on overall satisfaction with the trial from farmers, expressing their desire to participate in new rounds of trials. Triadic comparison of technologies can help to introduce new varieties, inputs and practices to rural areas, because it empowers farmers to identify the most suitable technologies for the local conditions of their own farm.

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