



Gender responsive participatory varietal selection for sustainable seed potato systems in Assam, India

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Acronyms

AAU	Assam Agriculture University
APART	Assam Agribusiness and Rural Transformation project
ARIASS	Assam Rural Infrastructure and Agricultural Services Society
ATMA	Agricultural Technology Management Agency
CIP	International Potato Center
CPRI	Central Potato Research Institute
DoH&FP	Directorate of Horticulture and Food Processing
FPOs	Farmer production organizations
KVK	Krishi Vigyan Kendra
PVS	Participatory varietal selection
SI	Sustainable intensification

Executive summary

In order to identify the most suitable potato varieties in Assam, participatory varietal selection (PVS) trials were conducted in three districts in 2018-2019, as part of the five-year CIP-APART potato value-chain program running from 2018 to 2023. The objective of this PVS is to introduce new potato clones that are resistant to late blight and viruses with short duration and end-user-preferred traits that are conducive to rice-based cropping systems in the lowland tropics. After a rigorous selection process with the involvement of stakeholders including farmers, consumers, traders, researchers, and extension agents, the most suitable clones will be identified and released as cultivars with the help of the state release committee. The clones will be multiplied locally in pest- and disease-free areas suitable for seed production and made available to the farming community.

In the first year (2018-19), we have used varieties that are available within India (Group 1) along with locally preferred dominant varieties as control. These group 1 varieties are released by the Central Potato Research Institute (CPRI) in Shimla. We have used these varieties in our initial years of testing in Barpeta, Nagaon, and Sonitpur in collaboration with Krishi Vigyan Kendra (KVK). Group 2 clones are imported to India from the International Potato Center (CIP). They are derived from the lowland tropics virus-resistant (LTVR) population. From the third year onwards, we will test group 2 clones along with group 1 varieties in the PVS trials across Assam.

This report presents the results of the PVSs implemented in 2018. A total of 116 people participated in the PVSs at the flowering stage and 139 people participated at the harvesting stages. Gender-responsive approaches were employed to facilitate women's active participation. More than 50% of participants were women, and gender-segregated group discussions were held to create a comfortable environment for women to speak in public.

The findings have shown that female and male farmers have some common criteria about preferred traits, such as taste, size (medium), shape (oval) and color (yellow skin and creamy flesh). Women considered criteria from culinary perspectives, such as preferring shallower eyes to save preparation time and reduce waste and preferring potatoes with shorter cooking times. In contrast, men's criteria focused on potato production and selling such as preferring potatoes of medium size and ones with many eyes that are suitable for seed potatoes. Market value was also important for men while taste was more important than market value for women. These results are closely associated with gender roles in Assam, and consistent with findings from potato PVSs across different regions of the world. Overall, Kufri Chipsona-3 was the most preferred variety by both male and female farmers. Its taste, shape and color matched farmers' preferences and overall it grew well in three locations in both mother and baby trials.

There are some challenges in this PVS. The yield of the baby trial fields varied from one farmer to another. This may be associated with individual farmers' experiences, knowledge and interests. There are some farmers, including a female farmer, whose yield was above the average in Assam. Those farmers can be trained as trainers for other farmers. Overall, performance of the baby trials were much better than the mother trials, because, most of the KVK staffs are not trained in potato agronomy. Therefore, substantial capacity-building efforts are needed to train people in KVK, in integrated pest and disease control, seed production and post-harvest activities. In the concluding section, we provide five key recommendations for appropriate potato variety selection and how best to provide support to sustain those varieties in Assam.

1. Introduction

Potatoes are the third most important food crop worldwide after rice and wheat (FAOSTAT, 2017). Assam ranks very low in potato productivity (9.92 t ha^{-1}) compared to the national average of 21.5 t ha^{-1} , in spite of having a production volume of 1.1 million tonnes with an area of 108143 ha (DoH-GOI, 2018). The major impediment in Assam is the lack of quality seeds and infrastructure facilities for irrigation. Hence, most farmers in Assam grow potatoes with inferior seeds under rain-fed conditions, which often result in low yields. India needs 70 MT of potato seeds per 2.6 million ha with a productivity of 27 t ha^{-1} to meet seed requirements by 2030 (Singh et al., 2016). Most farmers use their own saved seeds and cut tubers to reduce the seed consumption rate. The current seed replacement rate is less than 1%, with seed provided by a few local seed producers adding to seed from other states. If seed is used over several generations, it becomes severely degenerated by viral diseases and results in reduced crop yield. Hence, lack of quality seed is one major constraint faced by farmers in Assam and an important factor contributing to low crop productivity.

Therefore, with the objective of introducing new, improved potato cultivars to Assam and subsequently making those varieties' seeds available by upscaling the preferred clones in a 'clean environment', a farmer's participatory varietal selection (PVS) approach was carried out in the different agro-climatic zones of Assam to identify the best-suited cultivars in Assam that carry farmers' preferred traits to enhance the adoption rate. The nice thing of PVS is that it will help spread preferred varieties to the informal farmer networks if these varieties are indeed robust and can adapt to predominant local management practices (de Haan, personal communication). The involvement of both female and male farmers, consumers, and stakeholders in PVS is essential. It enriches the selection process by considering a variety for its preferences, perspectives, and selection criteria in environments with different contexts and socioeconomic backgrounds. In particular, understanding the real needs of female farmers is important for improving the adoption rate (Daniel et al., 2006) as well as reducing women's labour and time burdens (Quisumbing & Pandolfelli, 2010). Furthermore, through participation, farmers and other stakeholders gain more knowledge about new varieties, which facilitates earlier adoption through improved access to best-bet clones (Klawitter et al., 2009). PVS aims to obtain systematic feedback about the breeding program based on end-user-desired key traits, features, and preferences, to improve the distribution of genetic material based on end-user assessment and finally to increase efficiency in the breeding process by increasing the likelihood of end-user adoption and diffusion, and reducing the time required for variety release (currently 3-5 years). We apply a gender-sensitive PVS approach, and we include women in all the decision-making processes of PVS (de Haan et al., 2019).

Earlier studies have found that farmers have various potato trait preferences according to their gender, socio-economic status and culinary culture. For example, in Ecuador, blight resistance, early maturity and yields were very important traits for men while women pay particular attention to culinary aspects such as flesh color, texture and cooking time (Daniel et al., 2006). Similarly, in Bolivia, women selected some clones with specific traits such as shallow eyes and ease of peeling, while men did not choose those clones (Gabriel et al., 2004). In the drought-prone areas of Ethiopia, on the other hand, household food insecurity is a great concern for women who manage everyday meals for their children. Therefore, women prefer varieties with a slow tuber-bulking rate that enable them to fill food security gaps. In contrast, men are interested in market demands to increase their incomes as they are responsible for earning cash (Kolech et al., 2015). In Peru, the preferred size (small-medium) of the seed tubers was very important for poorer farmers because, unlike more well-off

farmers, they cannot invest heavily in seed tubers. Before this study, breeders were focusing on varieties with resistance to diseases and pests and were not aware of tuber size as an important criterion (Zimmerer, 2002). However, in Peru the traits sought after are highly variable by sub-region. Since 2000 more than 7 varieties have been released using the mother and baby trial design (de Haan, personal communication). Thus, PVS approaches have helped illuminate important selection criteria that were overlooked in past variety development efforts. It can guide the deployment of advanced clones, based on documented end-user preference traits (de Haan, personal communication).

In India, participatory plant breeding (PPB) studies were conducted for rice varieties. There are great similarities with the above studies of gender differences in potato preferences in Latin America. For example, women prefer rice varieties with a good taste for home consumption purposes while men prefer hybrid ones (high yielding) for selling purposes (Meher et al., 2017), which shows that researchers need to pay more attention to other attributes beside yield potentials. In a patriarchal society where gender norms are restricted, women's participation in PVS is a challenge. For example, women have limited experiences in participating in research activities. They may not be familiar with the technical vocabulary used in PVS or they may be focusing on details regarding specific traits (Gabriel et al., 2004). For this reason, the mother and baby trial ranking exercise are very simple and can be used easily by illiterate farmers as well (de Haan et al., 2019). In India, women's participation is culturally difficult; in some areas, women do not participate in farming at all (Courtois et al., 2001). In their studies in Uttar Pradesh, Paris and her colleagues (2007) explain that women have various restrictions that prevent them from participating in PVS such as the perception that land is owned by men, the cultural norm that women do not participate in farming or farm experiments, a lack of self-confidence that their opinions as women are important and can influence breeders and time constraints due to their many other responsibilities. Farmers need to be compensated for their fields and time. For example, through the distribution of seed after the participatory evaluations.

This PVS study is based on these earlier studies and their results. We have established nine trials across three locations in Assam: Barpeta, Nagaon, and Sonitpur, involving KVKs and farmers' fields. Of the nine trials, three were planted on-station in KVKs, they are known as 'mother trials'. A mother trial is developed within the study area (experimental field station), following a randomised complete block design (RCBD) and is managed by a researcher or agricultural technician. Each mother trial should have at least three replications. The remaining six trials were planted under farmers' field conditions situated close to the on-station mother trials. These trials are under farmer-managed conditions and are known as 'baby trials'. They are individual trials in farmers' fields located near the mother trial, where it is possible to assess variations under the farmers' management and the environment they face, while still monitored by researchers. Every baby trial is a repetition of the conditions in the mother trial. Baby trials are different from mother trials because they generally consist of a single replicate, and are 100% managed by the farmers themselves. The underlying assumption is that clones have to be able to perform under typical farmer management practices in order to become an acceptable, adopted and easily spread variety. Mother trials are different from baby trials because they have multiple replicates, are managed by a technician, include an agronomic management package that accompanies the clones under selection and in some cases can be installed on research stations. Trials begin with the assumption that clones best show their true genetic potential under optimal crop management conditions.

We will introduce 13 new improved clones under PVS from our CIP-headquarters in Lima, Peru to Assam in 2020 along with 17 elite clones from CPRI. In total we will evaluate 30 clones in Assam. These clones will be assessed for three consecutive years from 2020 to 2022 in different agro-climatic zones to identify the best-fit

clones with end-user-preferred traits. At the end of the fourth year, two or three new, improved clones will be identified and released as new varieties in Assam, and these cultivar seeds will be multiplied locally and made available to the farmers. The structure of this report is as follows: Section 2, describes local research contexts including local perceptions of potatoes, popular potato dishes, and popular potato varieties in Assam. Section 3 describes gender-integrated PVS methods. Section 4 focuses on results including local women's and men's selection criteria determining 'good' potato plants and 'good' potatoes, which were an entry point for identifying gendered trait preferences. Section 5 discusses similarities and differences in trait preferences for men and women. The final section concludes with key recommendations.

2. Research contexts

2.1 Local perceptions of potatoes and popular potato dishes in Assam

Potatoes are an integral part of Assamese diets, typically consumed every day in each hot meal. Many women and some men do not distinguish potatoes by variety, as there are usually only one or two varieties available in local markets in rural areas. Also, seed potatoes are not well-distributed in rural areas, and farmers use whatever varieties of table potatoes are available in local food markets as seeds. According to their perceptions, potatoes can be divided into two groups: normal-sized potatoes and baby potatoes. Baby potatoes are grown in home gardens for home consumption. Female farmers generally prefer baby potatoes as they are tastier and their cooking time is shorter than normal potatoes. There are a few varieties of baby potatoes with varied shapes and colors of skin and flesh, and both men and women farmers know local names for these baby potatoes. Seed potatoes for baby potatoes are locally sustained. Farmers also grow one or perhaps a few varieties of normal potatoes, which are used for both consumption and sale. Photos 1 below shows potatoes available in Assam.



Photos 1: Assamese local baby potatoes (left) and normal-sized potatoes in the market (right) Photo credit: N. Kawarazuka

There are various Assamese potato dishes such as Assamese mashed potato, potato and lentil curry, baby potato stir fry and Thali (a set meal in which potato dishes are central). Skins are usually peeled except for baby potatoes. Like most states of India, Assam uses a lot of spices in potato dishes. Potatoes are usually boiled or stir fried. Varieties of baby potatoes are each used for particular dishes with particular cooking methods while normal-sized potatoes are used for many different dishes regardless of variety.

2.2 Potato varieties available in Assam

The local landraces in Assam are Rongpuria, Nainital, S-1, Khaesia, and Kokhraj. The most prominent table-purpose cultivars in Assam are Kufri Jyoti and Kufri Pukhraj and in some pockets of Nagaon district in Assam a few farmers grow Lady Rosetta, a processing variety, largely preferred by processing industries due to its high dry matter content and storability. The commonly available potato varieties in Assam are listed in Table 1. Among the landraces, Rongpuria is cultivated widely in Assam. These landrace potatoes occupy around 20-25% of the cultivable area in Assam. However, these landraces are poor in yield and often carry viral loads that spread from infected plants to healthy ones through active and passive transmission (including aphids and whiteflies). Hence, preserving these landraces and clearing them of viruses is very important. Farmers get a market price of Rs 25-30 per kg for local potatoes, but the table-purpose varieties only fetch a market price of Rs 8-10 per kg. Preservation of existing potato biodiversity is important to establish links between smallholder farmers who cultivate potato landraces and the larger market. Efforts are being taken to clean local potato landraces from viruses in collaboration with Assam Agricultural University and the virology lab at the CIP headquarters.

Table 1: Potato varieties available in Assam

Variety	Maturation time	Duration (days)	Average national productivity (t ha ⁻¹)	Type	Characteristics
Kufri Jyoti	Medium	90-100	25	Dual (Table and Processing)	White skin tubers, moderately resistant to late blight, day neutral, wide adaptability both in hills and plains
Kufri Pukhraj	Early	70-80	35	Table	Yellow skin tubers, early bulker, poor storage quality
Kufri Megha	Medium	90-100	25	Table	White skin tubers, resistant to late blight, good taste and texture
Kufri Surya	Medium	90-100	35	Dual (Table and Processing)	White skin tubers, heat tolerant and good processing quality
Kufri Sinduri	Late	110-120	40	Table	Red skin tubers, susceptible to late blight, suitable for low inputs
Kufri Chandramukhi	Early	70-90	25	Dual (Table and Processing)	White skin tubers, susceptible to late blight, attractive tubers, suitable for processing
Rongpuria	Early	70-90	7	Table	Local landraces usually grown in the backyards as home garden. Due to their taste and shape (small tubers), it usually fetches 3 to 4 times the market price of other table-purpose potatoes
Nainital	Early	70-90	7	Table	
S-1	Early	70-90	7	Table	
Khaesia	Early	70-90	7	Table	
Kokhraj	Early	70-90	7	Table	

Availability of good-quality seeds for these improved potato varieties in Assam is very scarce. Traders bring these cultivars primarily from neighboring states as well as from Punjab. But very few farmers in Assam are actually involved in potato seed production as they usually have agreements with private seed companies, who in turn supply seeds to the farmers. Through a telephone conversation with one of the farmers in the Gingia region, where most potatoes are cultivated, we were able to collect the seed availability of the two important popular varieties. This farmer produces every year about 20 MT of potato seeds, out of which he produces 15 MT of Kufri Jyoti and about 5 MT of Kufri Pukhraj.

2.3 Gender roles and norms in potato production and their potential implications for potato trait preferences

Like many parts of the world, in Assam women and men play different roles in potato production, which shape different potato trait preferences in men and women. Prior to this PVS, a qualitative study on understanding gender roles in potato farming was conducted in five districts in Assam (Kawarazuka & Goswami, 2019). Here, we describe five examples of gender roles and norms in relation to the potato value-chain and discuss how these gender roles and norms can create different trait preferences between men and women.

First, women usually engage in specific activities in potato farming such as planting, weeding and harvesting. Women usually do not spray fungicide and pesticide, and they hardly interact with male agricultural input suppliers. Women are therefore not very familiar with names of pests and diseases. In this respect, women need more time to understand the concepts of pest- and disease-resistant varieties and their benefits, while men tend to have a great interest in pest- and disease-resistant varieties as men are responsible for controlling pest and diseases.

Second, in some areas of Assam, it is usually men who go to sell and/or buy potatoes in local markets. Men are therefore more familiar with market value and seasonal price changes. This may be associated with men's greater interests in potato varieties with higher prices.

Third, women are entirely in charge of cooking. Women have detailed criteria for 'good' potatoes for cooking, such as potatoes with fewer and shallower eyes, smooth skins, appropriate size, boiling time and texture, whereas men generally do not care much.

Fourth, potatoes are stored at home for home consumption for a maximum of three months, and women are in charge of maintaining the storage. In some areas, women keep potatoes in a bamboo basket in the loft of the kitchen where smoke prevents insects, while in other areas, they put potatoes under the bed on the soil or concrete floor. Women therefore tend to care about storability for home consumption.

Fifth, in many parts of Assam, men are the final decision makers in their families and play the role of head of the household. They are also generally the household's land owners. Men tend to have more self-confidence articulating their opinions in public while women do not get much opportunity to do so. Therefore, men's interests and opinions often dominate. There is a need for a comfortable environment for women to speak and share their ideas in public.

Having considered the differences derived from gender roles and norms, PVS events were organized with careful considerations of gender realities.

3. Methods

Plant materials

Five early- to medium-maturing table purpose varieties, Kufri Jyoti, Kufri Pukhraj, Kufri Surya, Kufri Himalini and Kufri Khyati were planted along with a medium- to late-maturing processing variety, Kufri Chipsona-3, in three locations in Assam covering the upper, lower and middle Brahmaputra valleys. Three trials were planted in each location. Kufri Jyoti is a moderately resistant late-blight cultivar with good consumer preference traits and Kufri Surya is a heat-tolerant cultivar. Group 1 varietal characteristics are mentioned in Table 2.

Table 2: List of group 1 varieties used in PVS trials across nine locations in Assam

Group 1 varieties	Duration (days)	Year of release	Tuber characteristics	Other characteristics
Kufri Jyoti	90-100	1968	White-cream, ovoid with shallow eyes and cream flesh	Wide adaptability, early bulker and slow rate of degeneration
Kufri Pukhraj	70-75	1998	Yellow, ovoid with shallow to medium eyes and yellow flesh	Early bulker, suitable for low input ecosystems
Kufri Himalini	90-100	2006	White-cream, ovoid with medium-deep eyes and yellow flesh	Day-neutral
Kufri Surya	80-85	2006	White-cream, oblong with shallow eyes and cream flesh	Heat tolerant, suitable for early planting in plains, tolerant to hopper and mite burn
Kufri Khyati	75-80	2008	White-cream, ovoid with medium-deep eyes and white-cream flesh	Early bulker, suitable for high cropping intensity
Kufri Chipsona-3	110-115	2006	White-cream, ovoid with shallow eyes and white flesh	Easy to cook, texture waxy, flavour mild, free from after-cooking discoloration. High dry matter, low reducing sugars and low phenols. Suitable for making chips and French fries

Experimental design

Six potato cultivars were planted in a mother-and-baby trial design. The mother trial was planted at the research station under the supervision of the researcher with three replications in a randomized complete block design with a spacing of 0.6 m between rows and 0.2 m between plants. Each plot consists of 12 rows with a row length of 15 m, totally we had about 900 plants per plot. Baby trials were planted at farmers' fields under farmer-managed conditions without repetitions. The baby-and-mother trial approach was intended to capture the expression of the genotype under contrasting management conditions.

The number of participants

In each workshop, approximately 40 people participated, including potato growers, rural agricultural work experience (RAWE) students from AAU, agricultural scientists, extension workers, and consumers (Table 3). Slightly more women than men participated in all regions in both mother and baby trials, partly because many men were engaged in activities including farm and market management. All the participants were selected by their respective KVK stations, most of them were engaged in potato cultivation in the nearby clusters. In Sonitpur,

farmers were brought in from Gingia, which is far away from the PVS trial locations. Gingia is one of the major potato-growing regions in Sonitpur; we want to have their opinion heard in the PVS selection process.

Table 3: The numbers of participants from three districts

Trial type	Sonitpur						Barpeta						Nagaon					
	Flowering			Harvesting			Flowering			Harvesting			Flowering			Harvesting		
	M	W	T	M	W	T	M	W	T	M	W	T	M	W	T	M	W	T
Mother	18	25	43	25	25	50	25	15	40	18	21	39	12	21	33	25	25	50
Baby	12	22	34	25	25	50	18	14	32	18	21	39	14	21	35	25	25	50

M – Men; W – Women; T – Total

Selection criteria and methods of evaluation

Selections were made during two important growth stages, vegetative (60-65 days after sowing) and harvest (100-110 days after sowing). Selection criteria and methods of evaluation for different growth stages are presented in Table 4.

Table 4: Selection criteria and methods of evaluation during different crop growth stages

Component	Methods	Evaluation phase	
		Vegetative	Harvest
Collection of selection criteria	Free-listing	Late blight resistance Virus resistance Plant Vigor Cut worm resistance	Skin color Tuber shape Tuber size Number of eyes
Prioritization of selection criteria	Weighted ranking	X	
Ranking of best clones/varieties	Weighted ranking	X	
Standard yield evaluation	Direct observation		X
Organoleptic evaluation	Weighted ranking		X

Selection criteria was free-listed based on gender and the final trait selections were ranked using weighted mean rankings for both vegetative and harvest stages. Six bean kernels were given to female participants, whereas six corn kernels were given to male participants during the selection process. Stakeholders placed 3 kernels inside a bag for the top-ranked varieties or traits, 2 kernels for the second best, and one kernel for the third best and then they left the bags in the field in the respective plots for final selection and ranking. A list of free-listing traits for both vegetative and harvest stages are listed above in Table 4. For all selections, women were asked to go first before men to avoid gender influence. For organoleptic evaluation, taste, texture and appearance of the potato, varieties were evaluated after boiling, and farmers were asked to voice their opinion. For each category, three evaluation scales were considered. An ‘excellent’ score got 5 points, ‘fair’ got 3, and ‘poor’ got 1. The weighted mean ranking of each category was considered for the final selection.

4. Results

4.1 Gender differences in selection criteria for “good” potato plants

What does a ‘good’ potato plant look like for women and men? During the PVS at the flowering stage, women and men had separate group discussions. Women and men use different language to describe their preferences and there are considerable knowledge gaps between women and men. While men use the names of pests and diseases to describe their criteria for ‘good’ plants, women generally describe them with symptoms in very simple words. Women also needed more time to communicate with researchers. After free-listing what ‘good’ potato plants mean for women, researchers helped to group their observations according to two associated categories: pests/diseases and plant vigorousness. Table 5 shows women’s descriptions of good and bad potato plants.

Table 5: Women’s descriptions of good and bad potato plants in Barpeta

	‘good’ potato plants	‘bad’ potato plants
Descriptions associated with pest and diseases	Plants with many leaves Plants with dark green colored leaves	Plants with few leaves Plants with yellowish/whitish leaves Leaves with spots Affected by Hur Puk (blue insect) on leaves Affected by Kumali (Mole cricket)
Descriptions associated with plant vigorousness	Plants with bigger leaves Plants with medium-sized height	Short plants Tall plants

After the free-listing of their ‘good’ plant criteria, men and women separately discussed their priority criteria (Table 6).

Table 6: Men’s and women’s priority criteria for good potato plants

Men	Women
Late blight resistance	Plants less affected by diseases and pests Plants which are strong against sunlight Medium height (which may be associated with higher yields)
Plant vigorousness	
Virus resistance	
Heat tolerance	
Cold tolerance	
Cutworm resistance	
Plant height	
Green skin	
Aphid resistance	

Based on those criteria and priorities from women and men, three selection criteria were identified as common priorities for both women and men: plant vigorousness, late blight resistance and virus resistance. Symptoms of late blight and virus infections were explained in local terms so that the women could clearly understand differences in those two criteria.

4.2 Trait preferences at the flowering stage

Having identified selection criteria at the flowering stage, voting for trait preferences was carried out in the mother and baby trial fields in three districts. The common variations observed between the mother and baby trials in terms of differences in the management practices were presented in the table 7. In the mother trial,

farmers named virus resistance as the most important trait, whereas in the baby trials, farmers selected late blight resistance as the most important trait (Table 8). The crop stages were different in both trials: baby trials were planted a week or two later than the mother trials (Table 7). There were no significant differences in the preferences of women and men. The best clones were selected during the flowering stage, the list of the best clones across the three locations are presented in Table 9. Again, there were no significant differences in the preferences of women and men. Overall, in all three locations of the mother and baby trials, Kufri Chipsona-3 was preferred, followed by Kufri Surya. Kufri Chipsona-3 is a processing variety with high dry matter content suitable for making chips. The only drawback of this variety is its medium to long crop duration, which is often undesirable in Assam due to the short cropping window prior to rice cultivation. Assam needs short duration (75-80 days) varieties with late blight and virus resistance. Kufri Surya is a heat-tolerant variety with short crop duration that fits very well into the rice (sali)-potato-rice (boro) cropping system. It has a great potential in Assam as it was ranked the second preference by both men and women (Table 9). Across all three locations female farmers preferred Kufri Surya after Kufri Chipsona-3 (Table 9). There are slight differences in preference by location: in Barpeta, farmers also preferred Kufri Himalini, whereas in Sonitpur and Nagaon, farmers preferred Kufri Khyati along with Kufri Chipsona-3 and Kufri Surya.

Table 7: Common variations observed between the mother and baby trials across different geographies of Assam

Operations	Mother trial	Baby trial
Field preparation	Not up to the mark	Well prepared
Planting time	On-time planting	Late planting by a week or two
Planting distance	0.6 m between rows and 0.2 m between plants	0.55 m between rows and 0.2-0.25 m between plants
Fertilizer dose	Recommended dose	Recommended dose
Pesticide use	Ridomil and Rogor was sprayed to control the late blight and white fly population	Farmers sprayed latest chemicals like sectin, melody duo, curzate to control late blight
Intercultural operations (weeding and earthing up)	Not managed so well	Regular roughing and other intercultural operations were followed
Harvest	Early to on-time harvest	On-time harvest

Table 8: Ranking of preferred traits based on the number of kernels that each trait received during flowering stage

Trial	Traits	Men	Women	Global	Rank
Mother trial	Late blight resistance	104	100	204	II
	Virus resistance	122	136	258	I
	Plant vigour	64	74	138	III
Baby trial	Late blight resistance	136	128	264	I
	Virus resistance	142	120	262	II
	Plant vigour	54	146	200	III

Table 9: Selection of best clones during flowering stage

Varieties	Mother trial				Baby trial			
	Men	Women	Global	Rank	Men	Women	Global	Rank
Kufri Chipsona-3	91	98	189	I	137	123	260	I
Kufri Khyati	17	27	44	V	23	55	78	III
Kufri Surya	29	41	70	II	77	103	180	II
Kufri Himalini	31	26	57	IV	24	51	75	IV
Kufri Jyoti	18	11	29	VI	39	34	73	V
Kufri Pukhraj	28	32	60	III	24	25	49	VI

4.3 Selection criteria for 'good' potatoes

There are some gender differences in potato trait preferences. Men tend to think of criteria from a producer perspective while women consider criteria from a culinary perspective. Below, Tables 10 and 11 show the list of criteria and reasons mentioned by women and men in Barpeta.

Table 10: Free-listing criteria mentioned by women in Barpeta

Criteria	Reasons
Skin color	Women tend to prefer whitish and light brown skin colors to red ones because the potato conditions are more visible and look healthier. Generally, they are not used to red skin potatoes.
Size	Women prefer medium-sized potatoes as they can be used for multiple purposes (e.g. One big potato may not be enough for one dish but two big potatoes may be too much for one dish. In this respect, a medium size is more useful). Larger potatoes may also be damaged inside but difficult to identify the damage in appearance.
Shape	Oval is preferable because they can be cut into appropriate sizes and are easy to peel.
Eyes	Women prefer potatoes with fewer and shallower eyes to reduce preparation time and minimise waste.
Cooking time	Women would like to have varieties with shorter cooking times as they are spending a lot of time boiling potatoes and fetching firewood.
Flesh color	Creamy yellow is preferable to whitish. It looks tasty and fits with their potato dishes.
Market value	This is less important for women. The quality of potatoes is more important than market value.
Texture	Mealy potatoes with a high dry-matter content are preferred to waxy ones, but potatoes should not break when boiled.
Taste	Taste is very important for women. They prefer a less-sugary and less bitter taste.

Table 11: Free-listing criteria mentioned by men in Barpeta

Criteria	Reasons
Skin color	Men tend to prefer yellowish skin colors than red ones because most of the available potato varieties are yellowish unless the red color skin possess some medicinal properties.
Eyes	Men prefer potatoes with many more eyes with shallow depth because they will have a good plant establishment by getting more stolons. Shallow depth will help faster sprouting.
Size	Medium-size is preferred by men, because it is easy to handle for planting, harvesting and other post-harvest practices like sorting, grading, and packaging.
Flesh color	Creamy yellow is preferred, as it is most familiar. However, consumer preferences will change if other colors of potatoes offer some extra nutritional values or medicinal properties.
Market value	Important for men. Since men handle all the harvest and post-harvest related matters they are very interested in the market value of the produce.
Texture	No very strong preferences, perhaps a slight preference for coarse textured potatoes.
Taste	Taste is very important for men.

Common preferences for both women and men are size (medium), skin color (yellowish), flesh color (creamy) and taste but women and men cite different reasons for their preferences. Women have a strong preference for medium-sized potatoes because they can be cut into several pieces evenly and can be used for many dishes without waste. Men also prefer medium-sized potatoes, but because they think they are more suitable for seed potatoes. There are some conflicting preferences too; for example, women prefer fewer and shallower eyes to save preparation time while men consider many more eyes preferable for planting purpose. Men care about market value while for women, other criteria are more important than market value.

Based on brainstorming discussions, both women and men set their priority traits (Table 12).

Table 12: Priority traits of men and women

Men	Women
Skin color (Yellow)	Taste (Less sugary)
Size (Medium)	Shape (Oval)
Number and depth of eyes (Many and shallow)	Size (Medium)

4.4 Selection of best varieties and organoleptic evaluation at the harvesting stage

Farmers and other stakeholders were involved in the final selection of varieties and organoleptic evaluation after harvest. Farmers' preferences were recorded based on gender regarding skin color, number of eyes on the tuber, depth of the eyes, and size of the potatoes. Kufri Surya was the most preferred variety by the farmers in the baby trials followed by Kufri Chipsona-3 and Kufri Pukhraj. Farmers particularly liked the size and shape of the Kufri Surya variety. In mother trials farmers preferred Kufri Pukhraj followed by Kufri Khyati and Kufri Chipsona-3 (Table 13). There were no gender differences in the results.

Table 13: Preference of varieties during harvesting stage

Varieties	Mother trial				Baby trial			
	Men	Women	Global	Rank	Men	Women	Global	Rank
Kufri Chipsona-3	53	30	83	III	54	52	106	II
Kufri Khyati	64	21	85	II	10	29	39	V
Kufri Surya	17	5	22	V	49	75	124	I
Kufri Himalini	16	2	18	VI	13	20	33	VI
Kufri Jyoti	28	10	38	IV	33	34	67	IV
Kufri Pukhraj	55	50	105	I	37	44	81	III

Across the three regions, Kufri Jyoti yielded well with an average yield of 29.7 t ha⁻¹ followed by Kufri Chipsona-3 (28.3 t ha⁻¹), Kufri Himalini (27.3 t ha⁻¹), Kufri Pukhraj (26.7 t ha⁻¹), Kufri Surya (26.1 t ha⁻¹) and Kufri Khyati (25.9 t ha⁻¹). Kufri Khyati (38.7 t ha⁻¹), and Kufri Pukhraj (38.3 t ha⁻¹) performed very well in Barpeta and Nagaon (Table 14). Kufri Surya (41.2 t ha⁻¹) out yielded all other varieties in Sonitpur, followed by Kufri Chipsona-3 (38.8 t ha⁻¹) (Table 14). For varietal yield comparisons across different geographies, only baby trial data were considered because of the variations in the management of mother trials.

Table 14: Yield performance of Group 1 varieties under PVS in different regions of Assam

Varieties	Barpeta Yield (t ha ⁻¹)			Sonitpur Yield (t ha ⁻¹)			Nagaon Yield (t ha ⁻¹)	
	Mother trial KVK	Kalpna Barman	Prabhat Das	Mother trial KVK	Naren Kalita	Suren Bora	Mother trial KVK	Puwal Nath
Kufri Chipsona-3	22.46	29.44	24.65	20.75	41.50	36.00	16.08	39.45
Kufri Jyoti	19.32	27.22	29.45	12.75	32.17	25.92	16.69	35.97
Kufri Pukhraj	19.88	30.90	34.11	13.75	27.67	34.00	18.87	44.05
Kufri Surya	18.18	29.43	27.24	13.50	39.75	42.58	16.08	28.27
Kufri Himalini	20.55	30.00	30.03	12.00	47.67	31.58	13.46	43.85
Kufri Khyati	21.75	28.89	34.70	14.75	33.92	26.83	17.60	45.58

Organoleptic evaluation was conducted after harvest by boiling the potatoes to determine farmers' preference towards taste, texture, and appearance of the group 1 varieties. The results slightly differed from one trial to another (mother trials to baby trials) due to the differences in the maturity of the potatoes. The results of the organoleptic evaluation are presented in Table 15 and 16. Kufri Chipsona-3 was most preferred both in baby and mother trials across the locations followed by Kufri Surya. Both male and female farmers preferred Kufri Pukhraj in mother trials and Kufri Jyoti in baby trials. Although Kufri Chipsona-3 was preferred across locations for its taste and texture, farmers did not like its appearance after boiling in the baby trial. In this trial, all varieties were cooked in the same way. Due to high dry matter content, Kufri Chipsona-3 appeared to be

overcooked. This could be solved by adjusting the cooking time for each variety. Kufri Surya was preferred across locations because it retained its shape and texture after boiling.

There is little gender difference in taste preferences. Kufri Chipsona-3 was the most preferred variety by both women and men. There is no consistent trend in texture preferences. This may be because the participants had difficulty distinguishing differences or because individual differences in preference are large. For appearance, there is little gender difference as well. As we boiled all varieties together at the same period of time without considering the best cooking time for each potato variety, it is difficult to fairly assess texture and appearance.

Table 15: Organoleptic properties of Group 1 varieties evaluated by participants in mother trial

Group 1 varieties	Taste			Texture			Appearance			Rank
	Women	Men	Global	Women	Men	Global	Women	Men	Global	
Kufri Chipsona-3	90	70	160	81	44	125	75	68	143	I
Kufri Pukhraj	77	70	147	56	58	114	59	56	115	II
Kufri Jyoti	69	52	121	51	40	91	59	48	107	VI
Kufri Himalini	56	68	124	55	48	103	66	52	118	IV
Kufri Khyati	58	48	106	49	42	91	63	62	125	V
Kufri Surya	65	64	129	63	44	107	69	70	139	III

Table 16: Organoleptic properties of group 1 varieties evaluated by participants in baby trials

Group 1 varieties	Taste			Texture			Appearance			Rank
	Women	Men	Global	Women	Men	Global	Women	Men	Global	
Kufri Chipsona-3	86	85	171	74	87	161	54	71	125	I
Kufri Pukhraj	52	44	96	58	60	118	46	64	110	VI
Kufri Jyoti	68	51	119	72	57	129	82	77	159	III
Kufri Himalini	55	75	130	51	70	121	72	79	151	IV
Kufri Khyati	67	68	135	67	62	129	51	44	95	V
Kufri Surya	64	71	135	64	67	131	106	77	183	II

5. Discussion

Overall, we had nine trials in three locations in Assam. Each location had three trials: one mother trial under the KVK research station and two baby trials in the farmers' fields. Mother trials were replicated thrice with a randomised complete block design, whereas baby trials were not replicated and conducted under the farmers' own managed conditions to capture the real genetic potential of the group 1 varieties. We planted six improved potato varieties: Kufri Jyoti, Kufri Pukhraj, Kufri Himalini, Kufri Surya, Kufri Chipsona-3 and Kufri Khyati in Nagaon, Sonitpur, and Barpeta.

One of the major problems of this PVS trial was that the selected varieties were all in different maturity groups (see Tables 1 and 2), and as a result, it was difficult to evaluate all six varieties at the same time. From a biological perspective, some of the medium- to late-maturing varieties such as Kufri Chipsona-3 and Kufri Himalini will not fit into the existing cropping system in Assam because of their late maturity and because they are prone to late blight, as the peak vegetative growth period coincides with the peak late blight onset.

Based on our cross-learning from the participatory workshops across all three locations in two different growth stages, farmers preferred medium-sized and oval-shapes potatoes with skins of a creamy or yellow color. Farmers preferred Kufri Chipsona-3 and Kufri Surya during both the vegetative and harvest stages of selection. Across the regions of Assam, Kufri Jyoti yielded well with an average of yield of 29.7 t ha⁻¹, followed by Kufri Chipsona-3 (28.3 t ha⁻¹), Kufri Himalini (27.3 t ha⁻¹), Kufri Pukhraj (26.7 t ha⁻¹), Kufri Surya (26.1 t ha⁻¹) and Kufri Khyati (25.9 t ha⁻¹).

In the PVS at the flowering stage, there are no large gender differences between the criteria identified by men and women but there are some gender gaps in the level of understanding of pests and diseases. In the studied communities, most women do not participate in spraying for pests. It is therefore very important to take enough time to facilitate discussions based on women's understanding and language during the brainstorming sessions. When women are given enough information and knowledge about pests and diseases including their various symptoms, it seems that there is then no gender difference in preferences or priorities.

On the other hand, there are some gender differences in preferences in potato traits. Women's preferences are associated with cooking, while men's preferences are closely associated with their interests in planting and selling. This is more or less consistent with earlier studies of PVS in potatoes (Gabriel et al., 2004; Daniel, 2006) although in the studied communities, market value was not highly ranked by both men and women. Farmers' preferences confirm that both men and women do not necessarily prioritise biological criteria developed by breeders such as high yield, indicating the significance of involving farmers in variety development.

There were some limitations in this study. This was the first trial and we had various challenges to our methods. For example, maintaining the mother trials was difficult due to a lack of experience with difficult soil conditions. There was also a significant gap in the timing of planting of the mother trial and its baby trials, resulting in different maturity levels during the PVS field studies. In potato tasting events, we did not consider appropriate cooking time for each variety which may affect farmers' choices regarding texture and appearance.

Gender was an important analytical lens in this study. Inviting women was not very difficult but many women seemed to have little confidence in their ability to voice their opinions in public, and therefore special consideration and support was needed to facilitate their active participation. We also found that this trial was a

powerful means of empowering women as their voices were heard and respected by researchers and fellow male farmers. There was one widowed female farmer who participated in a baby trial and her field was maintained better than other male participants. We could increase the number of female participants in trials next year. There are significant differences in the social and economic status of women in the studied communities, however, this time we could not include other analytical angles beside gender, such as caste and socio-economic status, due to our limited experiences interacting with people in the studied communities. We are continuing the PVS trials next year in all seven districts of Assam to make a broader impact and make the best clones and varieties available to poor farmers. Forthcoming studies will be built on our experience of this first study and we will continue to improve our methods.

6. Key Recommendations

In this concluding section, we propose five key recommendations for appropriate potato variety selection and providing support for sustaining those varieties in Assam. First, among the six tested varieties, there is no perfect one that fits well with all farmers' preferred traits, climate conditions and cropping systems. Kufri Chipsona-3 was the most preferred variety by both male and female farmers at both flowering and harvesting stages. In particular, its taste, shape and color matched farmers' preferences and overall it grew well in all three locations in both mother and baby trials. Although this variety was developed for a processing purpose, it has potential for home consumption as table potatoes, as its taste (the most important criteria for women) is good and it meets some other important criteria for farmers. For processing purposes, however, there is a need to facilitate the existing seed systems through existing farmers' network (farmer producer organizations) with assured buy-back agreements. Kufuri Surya was also very promising as it is very close to meeting farmers' criteria and is already available in Assam. However, its productivity was relatively low in baby trials and some technical assistance is needed to improve it.

Second, farmers' preferred traits such as taste, medium size, oval shape, yellow skin, and shallow eyes should be considered in future variety selection in Assam. Although researchers tend to focus on other criteria such as yield and resistance to late blight and viruses, this study showed that yield was not necessarily the farmers' top criteria. In order to promote varieties that meet farmers' needs, farmers' criteria should be valued.

Third, the yield of the baby trial fields varied from one farmer to another. This may be associated with individual farmers' experience, knowledge and interests. There are some farmers including a female farmer whose yield was above average for Assam. They could become farming leaders who can train other farmers.

Fourth, substantial capacity-building efforts are needed to train people in KVK and focused groups of farmer clusters on all aspects of potato cultivation, seed production, and post-harvest activities. There is a large gap in understanding the critical stages of potato growth periods and their requirements based on local soil and prevailing climatic conditions.

Lastly, this study included gender in the analysis of trait preferences. Some of the women's gender-specific trait preferences are often overlooked by male breeders' criteria and therefore inviting women as well as men to contribute opens up opportunities for breeders to identify different criteria that reflect farmers' real needs and interests. Women are, however, still less visible in field experiments in Assam and continuous encouragement and support for women's active participation are required.

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Photos



Photos 2: Brainstorming session with stakeholders for ranking of selection traits during harvest stage in mother trial at Sonitpur-KVK, Assam, India. (left) CIP-team with the PVS beneficiary, Prabhat Das in Barpeta district. (center) Distributing the group 1 varieties among stakeholders for organoleptic evaluation with the help of AAU students at Sonitpur-KVK, Assam, India. (right)



Photos 3: Farmers showing the harvested tubers of Kufri Pukhraj from Puwal Nath's field at Nagaon, Assam, India. (left) Flowering stage PVS workshop at Nagaon-KVK, Assam, India. (center) Harvesting stage PVS workshop at the Puwal Nath's field in Nagaon. Ashfeeka Islam explaining the selection procedures to the stakeholders. (right)



Photos 4: Organoleptic evaluation at Barpeta district baby trial at Prabhat Das's residence. Students from Bajali college helping in scoring the evaluation parameters. (left) Organoleptic evaluation at the Nagaon baby trial at Puwal Nath's field. Ashfeeka Islam and Gunin Roy helping in scoring the cooking parameters. (center) Organoleptic evaluation at the Sonitpur baby trial at Suren Bora's residence. AAU students getting ready for the participatory evaluation with farmers. (right)



Photos 5: Organoleptic evaluation at the Sonitpur baby trial at Mr. Suren Bora's residence. AAU students recording the farmers evaluation data. (left) Organoleptic evaluation at the Sonitpur KVK. AAU students getting ready for the participatory evaluation with farmers. (center)



Photos 6: Organoleptic evaluation at the Sonitpur-KVK. AAU students helping in scoring the cooking parameters like taste, texture, and appearance.(left) PVS harvest stage workshop at Sonitpur-KVK.(right)

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