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On-farm Evaluation of Improved Potato (*Solanum tuberosum* L.) Varieties through Frontline Demonstrations in the Indo-Burma Plains of Manipur, India

K. Lily Rangnamei[1], Arati Ningombam[2], Ngursangzuala Sailo[3], P. Janani[3], Damitre Lytan[4], Lydia Zimik[1], E. Lireni Kikon[5] and Rishikesh Salam[2]

[1]KVK-Imphal West, ICAR RC for NEH Region, Lamphelpat, Manipur (795 004), India
[2]ICAR Research Complex for NEH Region, Manipur Centre, Lamphelpat, Manipur (795 004), India
[3]ICAR-CPRI Regional Station, Shillong, Meghalaya (793 009), India
[4]Dept. of Entomology, Nagaland University, Medziphema Campus, Nagaland (797106), India
[5]ICAR-KVK Dimapur, ICAR Research Complex for NEH Region, Medziphema, Nagaland (797 106), India

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Corresponding arati.ning@gmail.com

0000-0003-1422-9693

ABSTRACT

The experiment was conducted during December, 2022–23 and 2023–2024 at four different locations to study varietal performance in the Indo-Burma plains of Manipur. Frontline demonstrations (FLD) of four high-yielding potato varieties, Kufri Chipsona-1, Kufri Pukhraj, Kufri Girdhari, and Kufri Kanchan, were conducted in farmers' fields at four locations, i.e., Haorong Sabal, Kwasiphai, Mayang Langjing, and Phumlou, in the Imphal West district of Manipur. Across the demonstrations, Kufri Girdhari recorded the highest plant height, while Kufri Pukhraj produced the maximum number of stems per plant and the highest tuber weight per hill. Kufri Kanchan showed the highest performance in terms of tubers per hill, number of tubers per m^2 and tuber weight per m^2. It also recorded the highest total and marketable tuber yields. Kufri Chipsona-1 produced the highest number of small-sized tubers, whereas medium-sized tubers were most abundant in Kufri Pukhraj. Overall, Kufri Kanchan produced the highest total tuber yield, marketable tuber yield, and number of large-sized tubers. From the demonstrations, it was found that potato varieties Kufri Kanchan, Kufri Pukhraj and Kufri Girdhari performed well under the agro–climatic conditions of Imphal West district, Manipur. These varieties were recommended for large-scale production and horizontal area expansion to enhance productivity and improve farmers' income and livelihood.

KEYWORDS: Potato, FLD, K. Chipsona, K. Pukhraj, K. Girdhari, K. Kanchan

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1. INTRODUCTION

Potato (*Solanum tuberosum* L.) is the world's fourth most important food crop, playing a crucial role in global food security. Potato is a short-duration crop with high yield per unit input (Mijena et al., 2022). Globally, potatoes were cultivated on approximately 16.8 million ha, producing about 383 million metric tonnes in 2023 (Anonymous, 2023). India is the second-largest potato-producing country after China, and potato cultivation extends across diverse agro-ecological regions. Variety, seed quality, crop duration, planting geometry and crop management practices strongly influence potato productivity (Kumar et al., 2023; Sadawarti et al., 2023). In the North Eastern Region (NER), potato is an important crop cultivated across diverse agroecological conditions. However, potato productivity in the NER remains lower than the national average, indicating a considerable regional yield gap (Kharumnuid et al., 2023; Sailo et al., 2024). This lower productivity is attributed to the use of locally available, low-yielding varieties and to inadequate knowledge of improved varieties, crop production, and protection technologies (Debbarma et al., 2023a; Kharumnuid et al., 2023; Singh and Jahanara, 2024). Quality seed is an important factor because potato is vegetatively propagated and seed tubers constitute a major component of cultivation costs (~40–50% of production cost). In contrast, poor-quality seed can adversely affect crop establishment, disease incidence and yield (Sadawarti et al., 2023). The North-Eastern Himalayan region holds significant potential for potato cultivation, and adopting sustainable farming paradigms is essential for achieving long-term food security and development goals in the region (Das et al., 2025).

Manipur lies in the Indo-Burma region and has considerable potential for potato cultivation because of its diverse topography and agro-climatic conditions. Potato is cultivated mainly during winter (November to February/March) in the plains, whereas cultivation in the hills extends from February/March to June/July (Luthra et al., 2025). Potato is an important vegetable crop in Manipur and locally adapted cultivars such as 'Aberchaibi' and 'Amubi' are traditionally cultivated and utilised by local communities (Lokendrajit et al., 2013). It is widely used in the preparation of traditional dishes such as *eromba, kangsoi, and kangou,* as well as in fish and chicken curries. Potatoes are commonly cultivated in kitchen gardens and farmers' fields, primarily for household consumption and for supply to local markets. Although the Kufri Jyoti variety is very popular among farmers, its high susceptibility to late blight has limited productivity and constrained farmers' ability to meet market demand (Anil et al., 2024). Evaluating the performance of improved potato varieties in different agro-climatic zones is essential for maximising yield and adaptation (Bekele, 2018). Varietal selection is a critical factor for successful potato cultivation because potato cultivars differ in maturity, tuber characteristics, yield potential, disease response and adaptability to specific agro-climatic conditions (Pradel et al., 2019). Therefore, evaluation of improved varieties for their adaptability, productivity and overall performance under farmers' field conditions is essential. Frontline Demonstrations (FLDs) provide an effective approach for evaluating and demonstrating improved technologies directly in farmers' fields, facilitating wider dissemination and adoption of these technologies (Ezung et al., 2024). Several improved potato varieties developed by ICAR-Central Potato Research Institute, Shimla, have been evaluated and promoted for different agro-ecological regions of India. However, information on their performance under farmers' field conditions in the Indo-Burma plains of Manipur remains limited. Therefore, the present study was undertaken using FLDs to evaluate improved potato varieties under farmers' field conditions and assess their growth, tuber yield, and economic returns, to identify promising varieties with better adaptability and productivity, and to generate location-specific evidence to strengthen potato production and technology dissemination in the Indo-Burma plains of Manipur.

2. MATERIALS AND METHODS

The experiment was conducted during December, 2022–23 and 2023–2024 at four different locations to study varietal performance in the Indo-Burma plains of Manipur. A frontline demonstration of high-yielding potato varieties, viz., Kufri Chipsona-1, Kufri Pukhraj, Kufri Girdhari, and Kufri Kanchan, was conducted in farmers' fields at four locations, i.e., Haorong Sabal, Kwasiphai, Mayang Langjing, and Phumlou, in Imphal West district, Manipur (Figure 1). Table 1 presents the agronomic characteristics and optimum yield performance of these

Figure 1: Frontline demonstration (FLD) of improved potato varieties in farmers' fields of Imphal West, Manipur, showing crop establishment, performance, and harvested tubers

Table 1: Agronomic characteristics and yield performance of potato varieties

Varieties	Year of release	Duration (days)	Average yield (t ha^{-1})	Agronomic characteristics
Kufri Chipsona-1	1998	90–110	30–35	Processing variety and suitable for chips and French fries, resistant to late blight
Kufri Pukhraj	1998	70–90	35–40	Moderately resistant to late blight, early bulker and requires low input
Kufri Kanchan	1999	120–140	25–30	Red skin, moderately resistant to late blight disease
Kufri Girdhari	2008	120–140	30–35	High-yielding, highly resistant to late blight disease

potato varieties. Farmers followed a package of practices, and data were collected from a one-metre-sized bed in the field, with the mean calculated. All collected data were subjected to statistical analysis using one-way analysis of variance (ANOVA) with a randomised block design (RBD), as described by Gomez and Gomez (1984). The data were subjected to statistical analysis using Fisher's method of analysis of variance (ANOVA) with four treatments and four replications. Further, differences between treatments were analysed using ANOVA at a significance level of 0.05. After conducting the "F-test", the homogeneity of variances between different treatments was tested using Duncan's Multiple Range Test (DMRT) as given by Duncan (1955) to find out the significant differences between mean values.

3. RESULTS AND DISCUSSION

3.1. Growth and yield attributes

3.1.1. Plant height

A significant difference was observed among the varieties in plant height. Maximum plant height was found in Kufri Girdhari (64.10 cm), which is on par with Kufri Chipsona-1 (62.55 cm), while other scholars also recorded the tallest plant height (Debbarma et al., 2023a), followed by Kufri Pukhraj (54.35 cm). Consistent with the present findings, Eaton et al. (2017) observed significant differences in growth parameters and yield when evaluating modern potato varieties. The shortest plant height was recorded in Kufri Kanchan (47.8 cm) (Table 2). The difference in plant height could be due to genetic variations among the varieties (Asnake et al., 2023). Variations in growth performance among different varieties, as noted in this study, are also supported by Fetene and Adem (2017), who reported distinct growth patterns in released and local potato varieties. While it can vary from one cultivar to another, having more stems per plant also increases the number of tubers per plant, thereby increasing yield (Knowles and Knowles, 2006). Ahmed et al. (2017) observed that potato plant height varied significantly across different sowing dates and varieties. Pathak et al. (2024) reported significantly greater plant height at 60 DAP when planting was advanced by 20 days to 17 October. Mulch application significantly enhanced plant growth relative to unmulched conditions, with paddy straw (5 t ha^{-1}) yielding maximum plant heights of 50.20 and 52.0 cm across the experimental years. Black plastic mulch was statistically comparable to paddy straw mulch. These growth responses may be attributable to improved water and nutrient uptake.

3.1.2. Number of stems plant^{-1}

The number of stems per plant is the most important parameter contributing to the yield potential of potato. The

Table 2: Effect of different varieties of potato on growth and yield attributes

Varieties	Plant height (cm)	No. of stems plant^{-1}	No. of tubers hill^{-1}	Weight of tubers hill^{-1} (g)	No. of tubers m^{-2}	Weight of tubers m^{-2}
Kufri Chipsona-1	62.55	4.85	9.75	297.33	48.75	1438.04
Kufri Pukhraj	54.35	5.0	9.90	369.52	49.50	1962.96
Kufri Girdhari	64.10	3.40	7.90	348.40	39.50	1781.54
Kufri Kanchan	47.80	3.35	10.75	417.70	53.75	2088.30
SEm±	3.83	0.47	0.55	22.92	2.75	131.93
SD	5.41	0.66	0.78	32.41	3.89	186.57
CD (p=0.05)	12.25	1.50	1.76	73.33	8.80	422.06

highest number of stems was recorded in Kufri Pukhraj (5 nos.) followed by Kufri Chipsona-1 (4.85 cm), which are on par with each other as shown in Table 2. The lowest was recorded in Kufri Kanchan (3.35 nos.) The number of stems is influenced by factors such as the genetic diversity of the potato, tuber size, sprouting behaviour, the physiological age of the seed tuber, and storage conditions (Iritani et al., 1972; Getie et al., 2018). Also, varieties with more stems tend to exhibit greater vegetative growth, resulting in more leaves (Zelelew et al., 2016). The number of main stems was positively correlated with tuber number and negatively correlated with individual tuber weight (Das et al., 2021). Gohain et al. (2025) reported that, among different cultivars, an increased number of leaves, shoots per plant, and chlorophyll content at 30, 60, and 90 DAP were observed in Kufri Uday, followed by Kufri Khyati in Nagaland, while the lowest was recorded in Kufri Megha. In their study, Janani et al. (2025) found that Kufri Jyoti had the highest mean number of stems per plant (4.04) followed by Kufri Megha (3.80) and Kufri Giriraj (3.69). However, the Kufri Kanchan had the lowest mean number of stems per plant (3.17), which was on par with Kufri Girdhari (3.35) and Kufri Himalini (3.28).

3.1.3. Number of tubers hill^{-1}

The number of tubers per hill was recorded highest in Kufri Kanchan (10.75 nos.), and a significant difference was observed among the varieties. Debbarma et al. (2023b) also recorded a similar result, with 10.86 nos. These similarities in the data may be due to similar environmental conditions in Manipur. The second-highest number of tubers was found in Kufri Pukhraj (9.90), and the lowest in Kufri Girdhari (7.9). It was observed that Kufri Kanchan, Kufri Chipsona-1 and Kufri Pukhraj are on par with each other. Gohain et al. (2025) opined that a higher number of tubers greatly influenced potato yield, and the increase in yield was attributed to the maximum increase in growth parameters. Another probable reason may be interactions between genetic makeup and the environment. These findings are in agreement with Kumar et al. (2022).

3.1.4. Weight of tubers hill^{-1}

It was highly significant among the varieties. The highest weight was recorded in Kufri Kanchan (417.7 g), whereas Choudhary et al. (2025) recorded a tuber weight of 308.96 g per hill. The second-highest weight was observed in Kufri Pukhraj (369.52 g), and the lowest in Kufri Chipsona-1 (297.33 g). Kufri Kanchan was on par with Kufri Pukhraj and Kufri Girdhari. The weight of the tuber per hill strongly influences the total tuber yield, with greater tuber biomass. Genetic variations inherent to each cultivar may have resulted in the observed differences in mean tuber weight. These outcomes align with the findings of Yayeh et al. (2025), who reported substantial variation in average tuber weight among potato genotypes. Furthermore, Binalfew et al. (2015) suggested that tuber size remains a heritable trait.

3.1.5. Number of tubers m^{-2}

The number of tubers/m2 was highest in Kufri Kanchan (53.75 nos.), followed by Kufri Pukhraj (49.50 nos.), and the lowest in Kufri Girdhari (39.50 nos.). A significant difference was observed among the varieties. Kufri Kanchan was on par with Kufri Pukhraj and Kufri Chipsona-1. A higher number of tubers contributed significantly to the increase in total tuber yield. Under the prevailing agro-ecological conditions in Shillong, Meghalaya, Kufri Himalini recorded the highest total tuber count (591.81 thousand ha^{-1}), while Kufri Giriraj had the lowest (464.30 thousand ha^{-1}), followed by Kufri Girdhari (478.97 thousand ha^{-1}) (Janani et al., 2025). Such distinct differences in tuber production across these cultivars can be attributed to multiple factors, including genetic variability (Das et al., 2015; Giri et al., 2023; Thapa et al., 2022), vegetative vigour, stem count per plant (Gebreselassie et al., 2016), environmental factors, and specific cultivation practices (Islam et al., 2020).

3.1.6. Weight of tubers m^{-2}

The weight of tubers/m^2 was highly significant. The maximum weight was recorded in Kufri Kanchan (2088.30 g), followed by Kufri Pukhraj (1962.96 g), and the minimum weight was found in Kufri Chipsona-1 (1438.04 g). It was also found that Kufri Kanchan was on par with Kufri Pukhraj and Kufri Girdhari. The weight of tubers per plot influences the total yield per hectare in potato production.

3.2. Marketable tuber yield (t ha^{-1})

Large and medium-sized tubers significantly affect marketable yield. It is an important parameter that greatly influences the economics of potato production. Enhanced photosynthetic activity and greater assimilate accumulation result in higher marketable tuber yield (Rojoni et al., 2014). Table 3 shows that marketable yield varies significantly among the varieties. The highest marketable yield was observed in Kufri Kanchan (17.83 t ha^{-1}), followed by Kufri Pukhraj (16.1 t ha^{-1}), and the lowest was reported in Kufri Chipsona (11.83 t ha^{-1}). Kufri Kanchan is on par with Kufri Pukhraj and Kufri Girdhari. Under Shillong, Meghalaya conditions, Janani et al. (2025) reported that the highest marketable yield was recorded from Kufri Himalini (10.31 t ha^{-1}), followed by Kufri Giriraj (8.75 t ha^{-1}), Kufri Girdhari (7.49 t ha^{-1}) and Kufri Jyoti (6.94 t ha^{-1}), while Kufri Kanchan recorded the lowest (5.94 t ha^{-1}). Our finding is consistent with the observations of Shankar et al. (2022) and Scavo et al. (2023) that several factors, including genetic variability, agronomic practices, and agro-ecological conditions, influenced variations in marketable tuber yield among varieties.

Table 3: Effect of different varieties of potato on yield attributes

Varieties	Marketable yield (t ha^{-1}) (M+L)	Total Tuber yield (t ha^{-1}) (S+M+L)	Net return (₹ ha^{-1})	BCR
Kufri Chipsona-1	11.83	14.24	83910	1.54
Kufri Pukhraj	16.10	19.60	166910	2.07
Kufri Girdhari	15.63	17.81	162310	2.07
Kufri Kanchan	17.83	20.88	201510	2.29
SEm±	1.08	1.44	-	-
SD	1.53	2.04	-	-
CD (p=0.05)	3.45	4.61	-	-

3.3. Total tuber yield (t ha^{-1})

Total tuber yield varied significantly among the varieties, with the highest yield recorded in Kufri Kanchan (20.88 t ha^{-1}), followed by Kufri Pukhraj (19.60 t ha ¹) and Kufri Girdhari (17.81 t ha ¹), while the lowest was in Kufri Chipsona-1 (14.24 t ha ¹). Kufri Kanchan was also on par with Kufri Pukhraj and Kufri Girdhari. Earlier studies on the total tuber yield of Kufri Kanchan showed considerable variation: Das et al. (2021) recorded 18.42 t ha^{-1}, Debbarma et al. (2023b) reported 17.61 t ha^{-1}, Ezung et al. (2024) observed 23.5 t ha^{-1}, while Janani et al. (2025) reported a comparatively lower yield of 10.13 t ha^{-1} and Choudhary et al. (2025) reported a higher yield of 24.63 t ha^{-1}. These differences in tuber yield reported by various authors may be due to agro-climatic conditions, crop management practices, seed tuber quality, soil fertility status, biotic and abiotic stresses, and genotype × environment interaction.

3.4. Economic analysis

From the yield obtained, it was found that Kufri Kanchan gives the highest net return of ₹ 201510 ha^{-1} and a BCR of 2.29, followed by Kufri Pukhraj and Kufri Girdhari with net returns of ₹ 166910 and ₹ 162310 and BCRs of 2.07 for both varieties (Table 3). In contrast, Kufri Chipsona -1 exhibited the lowest net return and BCR values. These results highlighted the relative efficiency and profitability of potato varieties for farmers. In their study, Janani et al. (2025) highlighted the importance of varietal selection for achieving profitable organic potato production in Shillong, Meghalaya. Their economic analysis revealed that Kufri Himalini offered the highest net returns and BCR of ₹ 436914 ha^{-1} and 1.53, respectively, followed by Kufri Giriraj, yielding net returns of ₹ 340972 ha^{-1} along with a BCR of 1.20. Next, Kufri Girdhari generated net returns of ₹ 311114 per hectare, resulting in a BCR of 1.12, while Kufri Megha produced net returns of ₹ 304815 ha^{-1}, with a BCR of 1.07. Conversely, Kufri Kanchan and Kufri Jyoti exhibited the lowest net returns and BCR values. They concluded that marketable tuber yield is the most important parameter in potato production and directly influences the economics.

4. CONCLUSION

The adoption of modern cultivation practices resulted in an 82.11% increase in productivity compared with traditional methods in Assam. Expanding potato cultivation and profitability in Northeast India requires high-yielding, regionally suitable varieties and accessible, improved scientific practices. Field demonstrations showed that Kufri Kanchan performed best in the Manipur valley, yielding higher production, better economic returns, and alignment with local preferences for red-skinned potatoes. Consequently, Kufri Kanchan, along with Kufri Pukhraj and Kufri Girdhari, can be recommended for widespread cultivation across Manipur.

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