

KUFRI THAR-2: A NEW DROUGHT TOLERANT TABLE POTATO VARIETY

SK Luthra^{1*}, Sanjay Rawal¹, VK Gupta¹, Bandana¹, Vinod Kumar², Vinay Bhardwaj², BP Singh², Neeraj Sharma³, MS Kadian³, Sushma Arya³ and Merideth Bonierbale⁴

ABSTRACT: Kufri Thar-2 is a drought tolerant table potato variety suitable for cultivation in drought prone areas in Uttar Pradesh, Rajasthan, Haryana and Chhattisgarh. It is an exotic clone CIP397006.18 (CP4175) descendant of cross CIP92.119 × CIP88.052 developed at International Potato Center, Lima, Peru. Its plants are medium and vigorous with resistance to late blight. It is a water use efficient variety with high drought tolerance index (1.08) and comparatively lower water requirement (74 litre/kg of potatoes under water stress conditions). The variety produces attractive, light yellow, ovoid tubers with shallow eyes and light yellow flesh, possess 20-21% tuber dry matter and has very good keeping quality. It has ability to produce up to 30 t/ha under less water (<20%) availability and 35 t/ha under normal irrigation regime.

KEYWORDS: Kufri Thar-2, drought tolerance, water use efficiency, drought prone areas, table potato variety

INTRODUCTION

Potato is susceptible to drought due to shallow root system, low capacity of recuperation and poor soil water extraction. Drought is a considered production constraint of potato worldwide as it decreases plant growth (Deblonde and Ledent, 2001), tuber set (Lynch and Tai, 1989), tuber number (Eiasu *et al.*, 2007), size of tubers (Schafleitner *et al.*, 2007), tuber yield (Rawal *et al.*, 2014) and loss of tuber quality (Mackerron *et al.*, 1988). The magnitude of drought effects depends on timing, duration and severity of the stress. Insufficient water supply may occur almost anywhere, where potatoes are grown. In sub-tropical plains of India, where potato production is only possible with irrigation, short periods of drought often arise because of inadequate irrigation techniques or shortage of water. Therefore, identification of drought tolerant genotypes for yield maintenance and breeding purposes is now a priority for improving drought

tolerance of potato crop, saving irrigation water, and ensuring yield and food security in changing scenario of global climate and growing demand of water (Luthra *et al.*, 2011; Luthra *et al.*, 2018). To extend the potato cultivation in non-traditional and drought prone areas, drought tolerant variety Kufri Thar-2 has been developed and released for sustainable productivity and ensuring income of farmers.

BACKGROUND

The clone CIP397006.18 (CP4175) developed at International Potato Center (CIP), Lima Peru in 1997 was brought to India in 2008 under ICAR-CIP collaborative programme on potato crop improvement. The clone CIP397006.18 is descendant of cross CIP389468.3 × 88.052 (**Fig. 1**). In India, the advanced clone was evaluated under normal and reduced water regime at Modipuram (2011-2012 and 2012-13) and Jodhpur (2012-13, 2013-14 and 2014-15) and

¹ICAR-Central Potato Research Institute, Regional Station, Modipuram, Meerut-250110, UP, India

²ICAR-Central Potato Research Institute, Shimla-171001, HP, India

³International Potato Center, South West and Central Asia Region, New Delhi 110 012, India

⁴International Potato Center, Avenida La Molina 1895, La Molina, Apartado Postal 1558, Lima, Peru

*Corresponding author: skluthra@hotmail.com

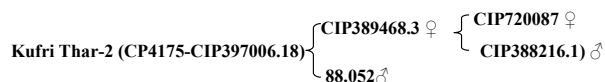


Fig. 1. Pedigree of Kufri Thar-2

based on its superior performance, it was introduced and evaluated in AICRP following procedure as described by Luthra *et al.*, 2020. Under AICRP (Potato), CP4175 was evaluated under normal and reduced water regime at Hisar, Faizabad, Kota, Raipur and Deesa during 2017-18 and 2018-19. The data were analyzed following standard statistical procedures as described by Gomez and Gomez (1984) using the software Windostat 8.5 (Ameerpet, Hyderabad, India). Drought tolerance index (DTI) was calculated using formulae suggested by Hassanpanah (2010), $DTI = Y_{pt} \times Y_{st} / (Y_p)^2$, where, Y_{st} is yield of cultivar under moisture stress conditions, Y_{pt} is yield of cultivar under irrigated conditions and Y_p is mean yield of all cultivars under irrigated conditions.

Based on its performance over the years/ locations at Modipuram, Faizabad, Hisar, Raipur and Jodhpur, CP4175 have been recommended for released by 37th Group Meeting of AICRP (Potato) held during 3-4 September, 2019 at JNKV, Jabalpur, Madhya Pradesh for five agro-climatic zone *viz.*, Middle Gangetic Plains Region (Zone 4, Uttar Pradesh), Upper Gangetic Plains Region (Zone 5, Uttar Pradesh), Trans-Ganga Plains Region (Zone 6, Haryana), Eastern Plateau and Hills (Zone 7, Chhattisgarh) and Western Dry Region (Zone 14, Rajasthan). The clone CP4175 named as Kufri Thar-2 has been notified in October, 2020 by Central Sub-Committee on Crop Standards Notification and Release of Varieties for Horticultural Crops, Ministry of Agriculture, Department of Agriculture and Co-operation, Government of India, New Delhi.

VARIETAL DESCRIPTION

Plant

Plant: Medium, plant canopy semi-compact, stem thick, predominantly green, red brown lightly scattered throughout, wings poorly developed and straight.

Foliage: Grey green, leaves intermediate, leaf width medium, leaflets ovate-lanceolate, leaflet coalescence absent, anthocyanin colouration of rachis, mid rib green, anthocyanin colouration of mid rib at base.

Inflorescence

Flowering: Profuse (**Fig. 2**), inflorescence medium, floral stalk green with medium anthocyanin colouration, floral stalk-pedicle articulation clearly visible and located above the middle, calyx medium coloured, corolla white, white acumen, corolla shape semi-stellate, anther yellow, anther cone normally developed, stylar length longer in



Fig. 2. Morphological characteristics of Kufri Thar-2: Leaf, flowers, sprout and tuber

comparison to stamen column and stigma bi-lobed.

Tuber

Size: Tuber number (7-8), ovoid shape, skin light yellow, shallow eyes, flesh light yellow and texture mealy.

Sprout

Red purple, spherical, pubescence at sprout base is weak, sprout tip closed.

YIELD PERFORMANCE

Primary evaluation trial at Modipuram (Uttar Pradesh)

At Modipuram, CP4175 (51.4, 40.3 and 36.4 t/ha) produced 49, 25 and 29% higher total tuber yield than Kufri Bahar (34.8, 32.2 and 28.6 t/ha) under normal irrigation, mild and severe water deficit conditions respectively (Table 1). It showed advantage of 16% over Kufri Pukhraj under normal irrigation at 90 days, however exhibited at par total tuber yield under mild and severe water deficit conditions. The clone CP4175 (49.5 t/ha and 34.4 t/ha) produced nearly 96% and 95% marketable tubers as compared to 92% and 89% in Kufri Bahar (32.0 and 32.2 t/ha) and 96% and 98% in Kufri Pukhraj (42.5 t/ha and 36.1 t/ha) under normal and severe water deficit respectively.

Primary evaluation trial at Jodhpur (Rajasthan)

At Jodhpur, CP4175 (38.7 & 31.3 t/ha) produced 18 and 26% higher total tuber yield than Kufri Pukhraj under normal irrigation and mild water deficit conditions, respectively at 90 days (Table 1). CP4175 (37.9 and 30.2 t/ha) produced nearly 98% and 96% marketable tubers as compared to 94 and 92% in Kufri Pukhraj (30.7 and 23.0 t/ha) under normal and mild water deficit regime.

Multi-location testing under AICRP

In AICRP, replicated yield trials (90 days) along with suitable controls were conducted during 2017-18 and 2018-19 at five locations namely Hisar (Haryana), Faizabad (Uttar Pradesh), Kota (Rajasthan), Raipur (Chhatisgarh) and Deesa (Gujarat). CP4175 performed well at three locations namely Hisar, Faizabad and Raipur and results are described below-

Hisar: CP4175 (34 and 36 t/ha) reflected its superiority by margin of 13 and 27% for total tuber yield over Kufri Bahar (30 and 28 t/ha) under normal and severe water deficit conditions, respectively (Table 2).

Faizabad: CP4175 (29 and 32 t/ha) exhibited its superiority by margin of 5 and 11%

Table 1: Total tuber yield of CP4175 under different irrigation regime at Modipuram (mean of 2011-12 and 2012-13) and Jodhpur (mean of 2012-13, 2013-14 and 2014-15)

Location	Modipuram				Jodhpur		
	CP4175	Kufri Bahar	Kufri Pukhraj	CD _{0.05}	CP4175	Kufri Pukhraj	CD _{0.05}
I ₁ Normal irrigation	51.40	34.50	44.40	NS	38.70	32.80	NS
% Yield ±	-	49.00	15.80	-	-	18.00	-
I ₂ Mild water deficit	40.30	32.20	41.50	NS	31.30	24.90	NS
% Yield ±	-	25.15	-2.24	-	-	25.70	-
I ₃ Severe water deficit	36.40	28.30	36.70	NS	-	-	-
% Yield ±	-	28.60	-0.80	-	-	-	-

*Approximately 50 mm water (measured by Parshall flume) in each irrigation,

Modipuram: where I₁ is normal irrigation (five irrigations), I₂ is mild water deficit (three irrigations) and I₃ is severe water deficit (two irrigations).

Jodhpur: where I₁ is normal irrigation (eight irrigations) and I₂ is mild water deficit (five irrigations, 37.5% lower than the normal).

Table 2: Mean total tuber yield of CP4175 under different irrigation regimes in primary screening (2012-13, 2013-14 & 2014-15) and in AICRP trials (2017-18 & 2018-19) at 90 days

Location	Irrigation regime	CP4175	Controls	CD0.05
Modipuram*	I ₁ Normal irrigation	51.4	34.5	NS
Jodhpur**	I ₁ Normal irrigation#	38.7	32.8	NS
Hisar*	I ₁ Normal irrigation	33.9	30.0	4.69
Faizabad***	I ₁ Normal irrigation	29.4	28.0	NS
Raipur**	I ₁ Normal irrigation	19.3	15.8	NS
Mean		34.5	28.2	
% Yield ±		-	21.27	
Modipuram*	I ₃ Severe water deficit	36.4	28.3	NS
Jodhpur**	I ₂ Mild water deficit#	31.3	24.9	NS
Hisar*	I ₃ Severe water deficit	35.5	27.9	4.69
Faizabad***	I ₃ Severe water deficit	31.9	28.8	NS
Raipur**	I ₃ Severe water deficit	13.9	12.4	NS
Mean		29.8	24.5	
% Yield ±		-	21.63	

Controls: *Kufri Bahar (Modipuram and Hisar), **Kufri Pukhraj (Jodhpur and Raipur), ***Kufri Sindhuri (Faizabad); #Approximately 50 mm water in each irrigation.

Modipuram: where I₁ is normal irrigation (five irrigations), I₂ is mild water deficit (three irrigations) and I₃ is severe water deficit (two irrigations).

Jodhpur: where I₁ is normal irrigation (eight irrigations) and I₂ is mild water deficit (five irrigations, 37.5% lower than the normal).

AICRP: I₁ is normal irrigation (six irrigations) and I₃ is severe water deficit (four irrigations to save 33% irrigation water applied up to 50-60 days).

for total tuber yield over Kufri Sindhuri (28 and 29 t/ha) under normal and severe water deficit conditions, respectively (Table 2).

Raipur: Though the yield levels were quite low at Raipur, even CP4175 (19 and 14 t/ha) exhibited its superiority by margin of 22 and 12% for total tuber yield over Kufri Pukhraj (16 and 12 t/ha) under normal and severe water deficit conditions, respectively (Table 2).

Overall performance of Kufri Thar-2

The pooled results of 5 locations, revealed superiority of CP4175 (35 and 30 t/ha) by a margin of 21 and 22% for total tuber yield over controls (28 and 25 t/ha) under normal and severe water deficit conditions, respectively (Table 2).

Tuber dry matter

In primary screening at Modipuram (2011-12 & 2012-13), CP4175 possessed higher tuber dry matter (19, 20, 22%) as compared to Kufri Bahar (19, 19 and 20%) and Kufri Pukhraj (17, 16 and 17%) under normal, mild and severe water deficit (Table 3). In primary screening at Jodhpur (2012-13, 2013-14 & 2014-15), CP4175 possessed higher tuber dry matter (22 & 24) as compared to Kufri Pukhraj (18 and 18%) under normal and mild water deficit (Table 3).

Keeping quality

CP4175 possesses long tuber dormancy period (>8 weeks), comparatively less weight loss, rotting, sprout weight and firm tuber appearance after 75 days of on-farm storage (Table 4), therefore adjudged to be of good

Table 3: Tuber dry matter content of CP4175 under different irrigation regimes at Modipuram (mean of 2011-12 and 2012-13) and Jodhpur (mean of 2012-13, 2013-14 and 2014-15)

Location	Modipuram				Jodhpur			
	Irrigation regime*	CP4175	Kufri Bahar	Kufri Pukhraj	CD _{0.05}	CP4175	Kufri Pukhraj	CD _{0.05}
I ₁ Normal irrigation		19.0	18.5	16.8	NS	21.9	17.6	NS
I ₂ Mild water deficit		20.1	18.6	16.4	NS	23.5	18.3	NS
I ₃ Severe water deficit		21.6	19.7	17.4	NS	-	-	-

Table 4: Keeping quality of CP4175 during 2012-13, 2013-14, 2014-15 at Modipuram

Genotypes	Dormancy (<or> than 6 weeks)	% Sprouting		% Weight loss at 75 days			
		At 45 days	At 75 days	Sprout	Rottage (weight basis)	Physiological	Total
CP4175	>8 weeks	60.52	100.00	0.15	0.99	14.54	15.69
Kufri Bahar	< 6 weeks	99.60	98.59	1.22	3.83	16.09	21.14
Kufri Pukhraj	> 6 weeks	71.35	98.22	0.33	0.57	14.88	16.13

Temperature: Minimum: 17-28°C, Maximum: 26-40°C, Relative humidity: Minimum: 18-53%, Maximum: 43-82%

keeper. CP4175 clearly showed very good keeping quality by virtue of having less physiological and total weight loss (15 and 16%) as compared to Kufri Bahar (16 & 21%) under ambient room temperature at Modipuram. It possessed at par keeping quality with Kufri Surya known to be very good keeper. At Jodhpur, CP4175 (5 and 9% total weight loss) showed good keeping quality under normal irrigation and mild water deficit conditions as compared to Kufri Pukhraj (14 & 18% total weight loss) and Kufri Surya (9 & 13%) as described in table 5. Thus very good keeping quality of CP4175 will benefit small/marginal farmers who are unable to store potato in cold store and have to either store potatoes through traditional methods at their farm for short term (up to 75 days) or then sell their produce in the market.

Usage

The clone CP4175 is table potato variety suitable for planting in drought prone areas as main season crop. (Luthra *et al.*, 2020). It produces attractive light yellow, ovoid tubers with shallow eyes and light yellow flesh. The shallow eyes lead to less peeling losses. The tubers of CP4175, seldom exhibits external/internal defects and are not susceptible to skin damage at harvest. It is easy to cook (15-20 minutes) and cooked/boiled potatoes are free from discolouration. It possesses pleasant flavour, mealy texture and good organoleptic taste. The desirable tuber characters, good keeping and culinary quality of CP4175 will favour its acceptance.

Table 5: Keeping quality of CP4175 (mean of 2012-13, 2013-14 & 2014-15) at Jodhpur

Genotypes	Weight loss (%) at 60 days of storage					
	Normal irrigation			Mild water deficit		
	Physiological	Rottage	Total	Physiological	Rottage	Total
CP4175	3.9	1.0	4.9	5.5	3.1	8.6
Kufri Pukhraj	6.9	6.8	13.7	7.9	9.6	17.5
Kufri Surya	4.3	4.7	9.1	6.5	6.2	12.7

Late blight resistance

The clone CP4175 showed high resistance to late blight at Modipuram and Kufri (Table 6). It possessed comparatively low AUDPC (114) and lesion area 2.9 cm²) as compared to Kufri Bahar (905, 8.89) and Kufri Pukhraj (572, 4.47). Also, the tubers of this variety seldom exhibit external or internal defects and are not susceptible to skin damage at harvest.

Drought tolerance Index (DTI)

Drought Tolerance Index (DTI) is an agronomic index based upon performance of genotypes under normal and water stress conditions. The clone CP4175 possessed high drought tolerance index (mean 1.08, range 0.87 to 1.18) under water deficit conditions than normal irrigation (mean 0.76; range 0.55 to 0.98) in trials over the years (Table 7).

Field water use efficiency (FWUE)

Field water use efficiency is marketable yield of crop produced per unit of water used in evapotranspiration (Michael, 1978). The field water use efficiency (Table 8) of CP4175 was found high (116 and 180 Kg/ha mm) as compared to controls (93 and 146 Kg/ha mm) under normal irrigation and severe water deficit conditions respectively. It is pertinent to mention that CP4175 showed more than 23% superiority in terms of water use efficiency over controls in trials. Due to high field water use efficiency, CP4175 produced one kg of potatoes by using 74 and 100 l of water under severe water stress and normal irrigation conditions as compared control (88 and 118 l). The results revealed that CP4175 have nearly 16% water saving as compared to controls for production of one kg of potatoes.

Agronomic management

Planting time: Second fortnight of October to first week of November. For seed potatoes, plant the crop in mid-October.

Planting: Seed rate is around 3.5-4 t/ha with seed size tubers (40-60 g). Plant spaced at 20 cm in 60 cm (planting depth: 10-12 cm) rows provides optimum tuber size distribution for

Table 6: Late blight reactions of CP4175 at Modipuram (UP) and Kufri (HP)

Genotypes	Modipuram (2015-16)		Kufri (2015)
	AUDPC	Lesion area (cm ²)	AUDPC
CP4175	114	2.90	200
Kufri Bahar	905	8.89	-
Kufri Jyoti	588	5.70	400
Kufri Pukhraj	572	4.47	-
Kufri Lauvkar	773	7.08	-

Table 7: Drought tolerance index (DTI) of CP4175 based on total tuber yield (t/ha over I₃ severe water deficit (Modipuram-mean of 2011-12 and 2012-13), over I₂ mild water deficit (Jodhpur-mean of 2012-13, 2013-14 and 2014-15) and over I₃ severe water deficit in AICRP trials (2017-18 & 2018-19)

Location	Irrigation regime [#]	CP4175	Controls
Modipuram*	I ₃ Severe water deficit	1.04	0.55
Jodhpur**	I ₂ Mild water deficit ^{##}	1.16	0.80
Hisar*	I ₃ Severe water deficit	1.18	0.82
Faizabad***	I ₃ Severe water deficit	1.14	0.98
Raipur**	I ₃ Severe water deficit	0.87	0.64
Mean		1.08	0.76

Controls: *Kufri Bahar (Modipuram and Hisar), **Kufri Pukhraj (Jodhpur and Raipur), ***Kufri Sindhuri (Faizabad);
[#]Approximately 50 mm water in each irrigation.
^{##}Approximately 50 mm water in each irrigation

Modipuram: where I₁ is normal irrigation (five irrigations), I₂ is mild water deficit (three irrigations) and I₃ is severe water deficit (two irrigations).

Jodhpur: where I₁ is normal irrigation (eight irrigations) and I₂ is mild water deficit (five irrigations, 37.5% lower than the normal).
AICRP: I₁ is normal irrigation (six irrigations) and I₃ is severe water deficit (four irrigations to save 33% irrigation water applied up to 50-60 days).

Table 8: Field water use efficiency and water requirement (liter) to produce one Kg of potato*

Irrigation regime	FWUE Kg/ha mm		Water requirement (l)	
	CP4175	Controls	CP4175	Controls
Normal irrigation	115.5	93.2	99.6	118.3
Severe water deficit	179.1	145.6	73.5	87.6

*Calculated from means of trials based on actual irrigations done excluding pre-planting irrigation and precipitation if any.

production of desirable tuber size for seed or table potatoes.

Manure and fertilizer: Apply 10-15 t/ha FYM at the time of planting. For seed crop, dose of 175, 80, 100 kg/ha of nitrogen, phosphorous and potassium, respectively is recommended, where half of N and full P₂O₅ and K₂O is applied at planting and remaining half N is given at earthing-up. For ware crop, apply 180 kg N, 80 kg P₂O₅ and 100 kg K₂O/ha. Nitrogen is best applied in two split doses, 90 kg at the time of planting and 90 kg at the time of earthing up. Nutrient management should be done as per soil test data and regional recommendations for optimum productivity of this variety.

Irrigation: Pre-sowing irrigation is recommended for uniform emergence otherwise first irrigation should be given 4-6 day after planting. Post-planting irrigations is recommended at 7-10 day's interval in sandy loam soil and 10-12 days in heavy soil under normal water availability. One third of water can be saved under water scarce conditions by skipping one to two irrigations. Germination, stolon formation and tuber bulking are critical stages for moisture. Local recommended irrigations schedules may be followed.

Plant protection measures: For management of cutworms, white grubs, beetles and leaf eating caterpillars, apply cartap hydrochloride 4G @20 kg/ha during earthing-up. It will also take care of sucking pest like leaf hopper and aphids. For seed crop to manage white flies and aphid vectors, place yellow sticky traps (15x30 cm² size) just above the canopy height @ 60 traps/ha at equidistance from each other for mass trapping of white flies/aphids. Seed treatment with imidacloprid (200SL) @ 0.04% (4 ml/10 l) for 10 minutes before planting. First spray with imidacloprid (200SL) @ 0.03% (3 ml/10 l of water) at 85% crop

emergence. Second spray with thiamethoxam (25 WG) @ 0.05% (5 gm/10 l of water) after 10-15 days of first spray. For control of late blight, prophylactic spray with mancozeb or propineb or chlorothalonil @ 0.2% (20 gm/10 l of water) followed by need based application of cymoxanil + mancozeb or dimethomorph + mancozeb or fenamidone + mancozeb @ 0.3% (30 gm/10 l of water is required).

ADAPTABILITY

Kufri Thar-2 has performed well in primary screening trials at Modipuram (Uttar Pradesh) and Jodhpur (Rajasthan) and multi-location trials conducted at Hisar (Haryana), Faizabad (Uttar Pradesh) and Raipur (Chhattisgarh) under AICRP. Thus, the variety has been recommended for cultivation in for cultivation in Haryana, Uttar Pradesh, Chhattisgarh and Rajasthan. It has ability to produce up to 30 t/ha under less water (<20%) availability and 35 t/ha under normal irrigation regime. The variety produces attractive, light yellow, ovoid tubers with shallow eyes and light yellow flesh, possess 20-21% tuber dry matter and very good keeping quality. The cultivation of Kufri Thar-2 in drought prone non-traditional areas would help in meeting the consumer demand of fresh potatoes in the targeted areas and thus enabling the farmers to grow the potatoes as profitable enterprise.

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