



Identification of short cycle, heat-tolerant potato (*Solanum tuberosum*) clones for the semi-arid agro-ecology*

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Potato (*Solanum tuberosum* L.) being native to the Andean Region is well adapted to cool and temperate climates. Out of 34.4 million tonnes, about 31 million tonnes of Indian potatoes are produced in the subtropical lowlands during winter under short day conditions (FAO 2009). Potato fits well in a multiple cropping pattern due to its short duration, flexibility of planting and harvesting nature along with its high commercial value. High temperature during crop growth restricts the adaptation of potatoes to early planting conditions of the North-Western plains and Peninsular India (Luthra *et al.* 2006). Considering prediction of global warming over the next 60 years, Hijmans (2003) expected worldwide yield reduction for potato in the range of 18–32% without adaptation in production methods, or 9–18% with adaptation in terms of planting time and use of heat-tolerant varieties. The optimum temperature for haulm growth is about 25°C. The minimum night temperature plays a crucial role during tuberization in potato and largely determines whether plants will tuberize or not. For most varieties, tuberization is inhibited at night temperatures above 20°C with complete inhibition above 25°C. Optimum temperatures for tuber formation are widely regarded as being in the range of 10–17°C (Levy and Veilleux 2007). Pandey *et al.* (2005) have also reported that day length

and temperatures are the most important factors affecting tuber initiation phase in potato. High temperatures during tuber maturation may obstruct with the onset of tuber dormancy, shorten its rest phase, or even release the inhibition of tuber buds, resulting in pre-harvesting sprouting (Levy and Veilleux 2007). Exposure of potato plants to heat stress alters the hormonal balance in the plants and results in partitioning of the most of assimilated carbon in favour of above ground vegetative parts against tuber development. Periods of high soil temperatures during tuber development adversely affect both tuber yield and starch content (Wang *et al.* 2003). Ninety-three respondents from different rural backgrounds, viz. non-farmers, non-potato growers (farmers who have not grown potato continuously for last two years, i.e. 2007–08 and 2008–09) and various categories of potato growers, i.e. marginal (potato area <1 ha), small (potato area 1ha to <2 ha), medium (potato area 2 ha to <4 ha) and large (potato area > 4 ha) in a baseline study in Gujarat revealed that a large proportion of farmers desired attributes of high temperature resistance, early bulking, high yield and processing quality in new varieties (Rana *et al.* 2010). The present study was undertaken to develop 80 day heat tolerant potato varieties, to improve food security and to increase processing from its current level of about 2% to 20% by 2020 to address risks associated with occasional over production of potatoes.

Thirty-five advanced clones received from the International Potato Center, Lima were multiplied at the Central Potato Research Institute Campus, Modipuram, Meerut, India (29° 4' N and 76° 46' E; 237 m above sea level), in the aphid-free crop period during crop season 2008–09. Nine promising clones selected initially at the Central potato Research Institute Campus, Modipuram were supplied to Potato Research Station, Deesa for testing in the hot-arid agro-ecology at the Agriculture Research Station, Ladol, of the Sardar Kushinagar Dantiwada Agricultural University (SDAU) located at 23° 37' N, 72° 43' E and 118 masl in Gujarat State during winter season in 2009–10 and 2010–11. The weather of Ladol is

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characterized by higher night and day temperatures. The daily maximum and minimum temperatures and relative humidity were recorded during the crop season. The mean weekly temperature and humidity are presented in Fig 1. Popular Indian varieties Kufri Badshah, Kufri Surya and Kufri Lauvkar were used as controls. The trial was planted on 20th October in 2009 and 2010 respectively, one month earlier than the normal planting time for the region, in order to observe tuberization during relatively higher temperatures. The sprouted tubers were planted at 60 cm × 20 cm spacing in randomized block design having three replications each of 2.0 × 2.4 m² size. Recommended cultural practices of the region were applied. The experimental clones and control varieties were dehaulmed after 80 days of planting and the potatoes were harvested after 10 days of hardening of tuber skin. Marketable tuber yield (>20 g size tubers) and total tuber yield were recorded at harvest. Tuber dry matter content was estimated by oven-drying 50 g cut tubers from a composite sample from the all 3 replications of each entry at a constant temperature of 80°C. Chip colour was recorded visually on a scale of 1–10 on freshly prepared chips fried in oil at 180°C. According to the scale developed by the Central Potato Research Institute, Shimla, chip colour scores of 1 to 3 are considered suitable for processing. The hunter colour (dL value) of the chips was estimated by putting crushed chips under a hunter colour scorer where 0 represents dark colour and 100 represents light colour. A hunter colour value of chips >58 is considered acceptable for processing. The data were statistically analyzed by statistical software IRRISTAT (1999). Day and night temperatures were estimated using the Went's equation (1957).

In the two successive seasons, out of nine clones three selected CIP clones, viz. CIP 301029.18, CIP 388972.22 and CIP 393708.31 gave 56.0, 50.7 and 55.6 tonnes/ha total tuber

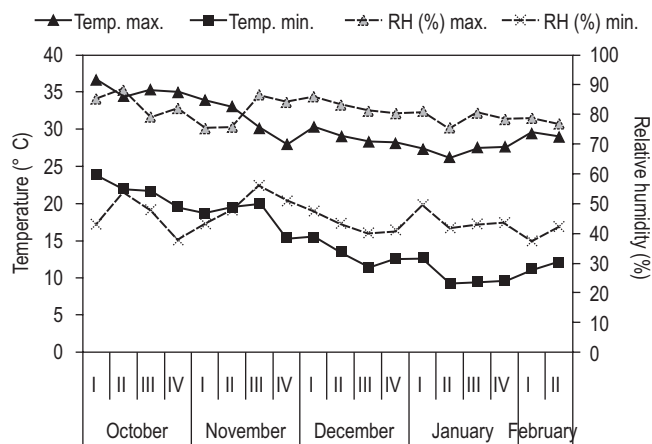


Fig 1 Mean weekly minimum and maximum temperatures and relative humidity (%) recorded at ARS, Ladol during potato crop season

yield, respectively, which were 19.6%, 11.3% and 19.0, respectively higher than the best heat tolerant control Kufri Surya (45.0 tonnes/ha). The results revealed that three clones were superior to Kufri Surya which has distinct advantage of at least 2°C for tuberization over the existing variety Kufri Chandramukhi reported by Minhas *et al.* (2011). These three clones also produced greater yield than most popular table purpose local control Kufri Badshah. Luthra *et al.* (2010) also screened genotypes which produced higher yield than the local varieties under warm climate. The average marketable tuber yield (>20 g size tubers) of two years of the three clones varied between 52.6 and 49.3 tonnes/ha compared to 45.4 and 33.4 tonnes/ha of the three control varieties (Table 1). Marketable tuber yield is an important trait for selecting a new variety in view of fetching the best remunerative price of table potatoes and for processing. The

Table 1 Performance of advanced potato clones at ARS Ladol, Gujarat during 2009–10 and 2010–11 crop seasons

Clone/variety	Total tuber yield (tonnes/ha)			Marketable tuber yield (tonnes/ha)		
	Year 1	Year 2	Mean	Year 1	Year 2	Mean
CIP 301029.18	49.7	62.4	56.0	45.5	59.7	52.6
CIP 380583.8	23.2	45.2	34.2	21.0	42.9	31.9
CIP 381381.13	17.4	42.4	29.9	14.9	39.1	27.0
CIP 388972.22	49.4	52.1	50.7	48.1	50.6	49.3
CIP 391580.30	20.6	38.9	29.8	18.9	37.2	28.1
CIP 392781.1	31.6	44.3	38.0	30.5	41.7	36.1
CIP 393536.13	27.8	42.0	34.9	26.3	39.8	33.1
CIP 393617.1	31.3	50.7	41.0	29.0	46.8	37.9
CIP 393708.31	47.3	63.8	55.6	43.5	61.6	52.6
Kufri Badshah	41.7	53.0	47.3	40.2	50.7	45.4
Kufri Lauvkar	31.2	38.9	35.0	29.6	37.2	33.4
Kufri Surya	42.7	47.4	45.0	41.7	45.9	43.8
CD 5%	4.4	3.1		3.2	3.13	

Marketable yield: >20 g, Year 1: 2009–10; Year 2: 2010–2011

two years results clearly revealed that the three selected clones were superior to the control varieties in production when evaluated under higher temperatures in Gujarat. The results revealed that the farmers in this region can obtain economic yields in 80 days by planting these clones one month earlier than the normal planting season and can earn more money by selling fresh produce at premium price at a time when there are no fresh potatoes in the local markets.

Farmers need varieties which can be stored in country stores for a longer period. The potato prices at harvesting time are generally low therefore, farmers prefer to keep the produce in heap or in rustic stores until prices increase. Tuber dry matter is one of the key characteristics determining value-addition through processing raw potatoes into chips and French fries. Tuber dry matter content higher than 21% is desirable for obtaining good quality potato processed products (Marwaha *et al.* 2008). The mean percent tuber dry matter of clones and varieties ranged from 16.6% to 22.1% (Table 2). The clones found superior in tuber yield also produced higher dry matter than controls. The tuber dry weight was highest in CIP 301029.18 (22.1%), followed by CIP 393708.31 (20.8%). The experimental clones had higher dry matter content than Kufri Lauvkar which is mainly used for processing purpose in Gujarat, indicating a promising future for the new selected clones for the processing industry of our country.

The mean chip colour score ranged from 2.5 (CIP 380583.8) to 6.0 (CIP 381381.13 (Table 2). The chip colour score of the three high yielding advanced clones namely CIP 301029.18, CIP 388972.22 and CIP 393708.31 were recorded 4.0, 4.0 and 4.6, respectively and was at par with varieties indicated the possible utilization of selected clones for processing into French fries. Chip colour was objectively assessed by taking dL value through hunter colour meter. In the present investigation, the hunter colour ranged from 42.9 (CIP 381381.13) to 59.3(CIP 391580.30). The hunter colour score of selected high yielding clones was lower than the controls, but was near acceptable range (>58.0). This present observation on processing qualities of the clones was recorded at 80 days after dehaulming and can improve much better if harvested at natural senescence like normal practice adopted by farmers for producing the processing potatoes. The harvesting at natural senescence gives maximum dry matter. But one of the main objectives of present study was to identify early bulking heat tolerant varieties for semi-arid ecology, therefore, the clones and varieties were dehaumed at 80 days after planting.

Tuber shape and skin colour play vital role for location-specific adoption of new potato varieties released in India. Except for Kufri Jyoti, which is widely accepted in different agro-ecologies, the other varieties have specific niches for different reasons and one of them is tuber shape and colour. Tuber characters beside tuber yield and dry matter were considered important criteria while selecting the clones.

Table 2 Performance of advanced potato clones at Ladol, Gujarat during 2009–10 and 2010–11

Clone/variety	Tuber dry matter (%)			Chip colour score			Hunter colour			Skin colour	Tuber shape	Eye depth	Flesh colour
	Year 1	Year 2	Mean	Year 1	Year 2	Mean	Year 1	Year 2	Mean				
CIP 301029.18	21.9	22.3	22.1	4.0	4.0	4.0	57.1	49.1	53.1	Yellow	Oval	Shallow	Light yellow
CIP 380583.8	17.0	17.2	17.1	2.0	3.0	2.5	64.2	51.6	57.9	Yellow	Oval	Shallow	Light yellow
CIP 381381.13	16.7	17.5	17.1	5.0	7.0	6.0	46.9	38.8	42.9	Yellow	Oval	Shallow	Light yellow
CIP 388972.22	19.1	21.1	20.1	3.0	5.00	4.0	62.1	53.5	57.8	White	Oval	Shallow	White
CIP 391580.30	17.2	19.8	18.5	2.1	4.00	3.1	65.4	53.2	59.3	Yellow	Oval	Shallow	Yellow
CIP 392781.1	19.3	17.8	18.5	4.7	4.20	4.5	60.4	49.8	55.1	Yellow	Oval	Shallow	Light yellow
CIP 393536.13	21.9	19.4	20.6	2.0	4.30	3.2	65.4	46.0	55.7	Yellow	Oval	Medium deep	Light yellow
CIP 393617.1	17.5	17.8	17.6	4.7	5.50	5.1	53.1	40.7	46.9	White	Oval	Shallow	White
CIP 393708.31	20.7	21.0	20.8	4.7	4.50	4.6	60.9	43.3	52.1	Yellow	Oblong	Shallow	Cream
Kufri Badshah	16.7	16.4	16.6	5.5	6.00	5.8	62.1	47.4	54.8	White	Oval	Shallow	White
Kufri Lauvkar	18.9	17.7	18.3	3.8	4.00	3.9	65.1	54.7	59.9	White	Round	Medium deep	White
Kufri Surya	16.6	18.7	17.7	3.0	5.30	4.2	52.7	46.5	49.6	Light yellow	Oval	Shallow	Light yellow

Chip colour: Acceptable range 1-3; hunter colour: acceptable >58; Year 1: 2009–10; Year 2: 2010–11



Fig 2 Promising heat-tolerant clones introduced for multilocation testing

Tuber skin colour, eye depth, tuber shape and flesh colour were recorded at harvest (Table 2). All three high yielding advanced clones produced acceptable shape and colour of the tubers. Clones, CIP 301029.18 and CIP 388972.22 produced oval shape tubers suitable for both table purpose and making chips by processing industries. The oblong shape tubers of clone CIP 393708.31 are ideal for processing as French fries.

The three clones CIP 301029.18, CIP 388972.22 and CIP 393708.31 (Fig 2) produced significantly higher total and marketable tuber yields than the heat tolerant variety Kufri Surya and popular varieties Kufri Badshah and Kufri Lauvkar in the warm early winter season of Gujarat have been admitted to the region-specific variety testing scheme of the All India Coordinated Research Project for Potato. The clones that were superior in tuber yield also had higher dry matter contents than the control varieties.

SUMMARY

Advanced potato (*Solanum tuberosum* L.) clones developed by the International Potato Center (CIP), Lima and locally grown varieties were evaluated for agronomic performance in winter season under short-day conditions at the Agricultural Research Station (ARS), Ladol, Gujarat during the 2009–11. Ladol, selected for screening of the clones has higher mean night and day temperatures during potato crop seasons compared to other potato growing areas in India. Out of nine advanced clones CIP 301029.18, CIP 388972.22 and CIP 393708.31 had significantly higher yield of marketable tuber at the tune of 52.6, 49.3 and 52.6 tonnes/ha, respectively, along with desirable tuber shape, size, colour and more than 20% dry matter. Whereas, CIP 388972.22 was found suitable for processing as fried chips based on its hunter colour quality.

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