EVALUATION OF ADVANCED POTATO CLONES FOR DROUGHT TOLERANCE IN ARID ZONE IN RAJASTHAN, INDIA

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India needs to extend potato cultivation to non-traditional areas for meeting hefty target of producing 125 million t potatoes by 2050 (Singh *et al*., 2014). However, most non-traditional potato growing areas both in lowland and plateau regions suffer from heat and drought stresses and the situation is expected to further aggravate in the future. Potato growers in these areas perceive heat and drought tolerant varieties as potent tool to tackle the impending threat of climate change and global warming (Rana *et al*., 2011; 2013; 2014). Potato is a cool season crop and requires optimum soil moisture throughout its growing period and its productivity is hampered to a great extent in absence of these favorable conditions (Cabello *et al*., 2013). Exploitation of the gene pool is required for identifying and evaluating clones suitable for drought tolerance. Genotype-specific differences have been reported in potato for tuber productivity and quality under combined environment of drought and heat stresses (Ahn *et al*., 2004). Efforts are under way to breed and screen potato clones for adaptation to adverse agro-ecologies in a collaborative endeavor of the Central Potato Research Institute and the International Potato Center (CIP).

A site was selected near Jodhpur, Rajasthan (26° 17′12′′ N, 73° 01′48′′ E, 235 meters above sea level) to evaluate the advanced CIP-bred clones under moderate water stress conditions during 2012-13 crop season. This was an attempt to introduce the potato crop to the hot arid zone of Western India, where water is scarce for field crops, livestock and human beings. Soils of the experimental site were sandy plain with neutral pH (7.05), low organic carbon content (0.31%), available nitrogen (243.6 kg/ha), available potassium (119 kg/ha) and medium available phosphorous (21.4 kg/ha). Maximum and minimum temperatures during the potato growing season ranged between 16.2-32.2°C and 5.6-18.4°C, respectively. Total rainfall of 32.9 mm was recorded on two occasions *i.e.* 2.4 mm on 17 January and 30.5 mm on 18 January 2013 during the crop period.

Eight CIP-bred potato clones (V_1 = 392745.7, V_2 = 392780.1, V_3 = 397006.18, V_4 = 399101.1, V_5 = 301029.18, V_6 = 380583.8, V_7 = 388972.22, V_8 = 391580.30) were evaluated along with two

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control varieties Kufri Pukhraj (early bulking) and Kufri Surya (heat tolerant). Sprouted seed tubers of 40-45 mm size were planted on 5 November 2012 at 60 × 20 cm distance in a plot size of 4.8 × 1.2 m^2. The field experiment was laid out in strip plot design with two irrigation regimes: I_1 = Normal Irrigation (eight irrigations) and I_2 = Deficit irrigation (five irrigations) as horizontal factor and ten clones/ varieties as vertical factor. Approximately, 50 mm of water (50 l/m^3) was applied in each irrigation by means of conventional ridge and furrow method. In both the treatments, two irrigations during emergence phase and one irrigation after earthing up were given. After that, in normal treatment, water was applied at 10 days interval, whereas in deficit irrigation, water was applied at 50 and 70 days. In normal treatment irrigation was terminated 10 days before dehaulming. There was 2.4 m wide space between and around the treatments to avoid any effect of border soil moisture. Uniform fertilizer dose of 90, 34.4 and 104 kg/ha of N, P, K, respectively, was applied at planting and 90 kg/ha of nitrogen in the form of urea was applied at earthing up time at 25 days after planting. Recommended schedule of herbicide, fungicide and insecticide applications for potato crop was followed for maintaining proper crop growth. The crop was dehaulmed after 90 days of planting and harvested 15 days later after hardening of tuber skin.

The growth parameters were recorded at scheduled intervals, while total and marketable (> 20 g tuber size) and tuber number were recorded at harvesting. Tuber dry matter content (TDMC) was estimated by drying a representative sample (50 g) of chopped tuber pieces drawn from three marketable sized tubers from each treatment at 80°C until constant weight is achieved in forced hot air draft oven. Drought tolerance index (DTI) and susceptibility index (DSI) were calculated using formulae presented by Hassanpanah (2010). Stakeholder's preference for CIP genotype's appearance of flesh, taste and texture (organoleptic traits) was appraised during participatory varietal selection at the experimental site on 20 February 2014 just after harvesting. Fifty participants (14 females and 36 males) of different age group and background evaluated eight CIP clones and two check varieties by observing and tasting boiled tubers, and provided their feedback in a schedule adopted by International Potato Center.

Plant emergence varied significantly among clones/varieties (70.1-84.0%). Clone 397006.18 attained 83.3% mean emergence remaining comparable to both the controls Kufri Pukhraj (84.0%) and Kufri Surya (81.3%). The lowest emergence was recorded in 391580.30 (70.1%) among CIP clones (data not shown). Stem number per plant varied distinctly among studied genotypes and between irrigation regimes though moisture stress was not prevailing at the time of observation. Clone 397006.18 recorded mean stem number (2.94), which were comparable to one of the controls *viz*. Kufri Surya (2.94) and statistically lower than Kufri Pukhraj (3.78). Maximum stem number were observed in clone 392780.1 (4.00), whereas, 388972.22 (2.61) had the lowest stem number **(Table 1)**. Compound leaf number per plant differed significant among clones/varieties. Water stress also tended to depress leaf number with progress in crop age. At 60 days, clone 397006.18 had 32.6 mean compound leaves per plant, which were comparable to control cv. Kufri Pukhraj (38.7) and significantly better than in Kufri Surya (26.3) which incidentally also had the lowest number. At this stage, water stress influenced leaf number negatively, but statistical differences were not prominent. At all the stages of observations, clones/varieties differed significantly for

Table 1. Mean performance* of CIP clones and varieties for growth, yield and processing traits.

Clones/varieties	Stem No.[@]	Leaf No.[$]	Height[&]	Yield[*]	Number[#]	DM[##]
392745.7	2.78	33.6	31.0	29.1	6.82	16.7
392780.1	4.00	37.2	22.7	24.4	5.13	19.8
397006.18	2.94	32.6	34.8	35.4	4.19	20.5
399101.1	3.83	35.0	26.9	29.1	5.59	18.1
301029.18	3.39	39.2	24.9	31.5	5.29	21.2
380583.8	2.94	34.5	30.1	28.0	5.96	17.8
388972.22	2.61	29.5	32.3	30.8	4.97	20.6
391580.30	3.94	34.7	30.0	19.1	4.28	18.5
Kufri Pukhraj	3.78	38.7	23.2	33.3	5.56	15.7
Kufri Surya	2.94	26.3	20.9	24.0	4.77	19.7
Statistics	CD (0.05)	CD (0.05)	CD (0.05)	CD (0.05)	CD (0.05)	CD (0.05)
Irrigation (I)	0.31	NS	1.49	1.60	0.30	NS
Clone/ variety (C)	0.69	6.62	4.97	4.38	0.90	0.53
Interaction I C	NS	NS	NS	5.09	0.95	0.66

*Mean performance under both the irrigation regimes, [@] = stem number per plant at 45 days of planting (DAP), [$] = leaf number per plant at 60 DAP, [&] = plant height (cm) at 60 DAP, * = tuber yield (t/ha) at 90 DAP, [#] = tuber number per plant at 90 DAP, [##] = tuber dry matter (%) at 90 DAP

plant height and water stress reduced this attribute drastically. CIP clone 397006.18 had significantly better mean plant height at all the stages of growth as compared to both the varieties and clones. This clone recorded maximum plant height (34.8 cm) at 60 days and control cv. Kufri Surya had the lowest plant height (20.9 cm) among all genotypes. Increase of water stress significantly decreased plant height at every stage of observation. Growth attributes of the potato plant may vary among various genotypes due to their genetic makeup and drought might also influence these differently (Sharma *et al.*, 2011). Ayas and Korukcu (2010) while working on water management under deficit conditions also found positive linear relationship between amount of irrigation water and plant height, number of leaves and stems per plant, and other growth parameters.

Tuber number per plant varied significantly among CIP clones and the controls. Genotype 397006.18 had lower mean tuber number (4.19), which was comparable to control variety Kufri Surya (4.77) while Kufri Pukhraj recorded significantly higher total tuber number (5.56) in comparison to this genotype. Highest tuber numbers (6.82) were observed in clone 392745.7. Normal and deficit irrigation levels resulted in 5.95 and 4.56 tubers/ plant, respectively. A similar trend was observed for mini tuber production by Hassanpanah (2010) among varieties with varied moisture amounts under both *in vitro* and *in vivo* conditions. Reduction in tuber number may be mainly controlled by enzymatic activities governed by expression or suppression of genes under soil moisture deficit (Schafleitner *et al.*, 2007). CIP clones had great variation in tuber productivity. Clone 397006.18 had highest mean tuber yield (35.4 t/ha) among all genotypes **(Table 1)**, which was significantly better than several clones and also one of the controls *viz*. Kufri Surya (24.0) and was at par with another control variety Kufri Pukhraj (33.3). This clone achieved maximum and significantly higher tuber yield (31.0 t/ ha) among all genotypes under the moderate water stress treatment. Schafleitner *et al.* (2007) observed variations in tuber productivity of different clones associated with activation of certain genes under drought conditions where some genotypes were able to maintain yields. Maximum tuber dry matter (TDMC) 21.2% was recorded in CIP clone 301029.18. Although Ayas and Korukcu (2010) recorded a negative linear relationship for TDMC with the amount of irrigation water applied. The deficit irrigation treatment did not influence this trait under Jodhpur conditions.

CIP clone 397006.18 had the lowest drought susceptibility index (DSI) of 0.677 among all CIP clones and controls. Similarly the same clone recorded the highest drought tolerance index (DTI) of 1.067 **(Fig. 1)**. These two indices have been found to be good measurements of a genotype's production potential under soil moisture stress conditions (Cabello *et al.*, 2013). Results of participatory varietal selection for organoleptic traits of CIP clones revealed that genotype 397006.18 was overall acceptable for texture and taste, and was ranked 4th position for appearance of flesh and taste, while, its rank for texture was 2nd among all genotypes and varieties. Its performance was better over control varieties for overall organoleptic traits **(Fig. 2)**.

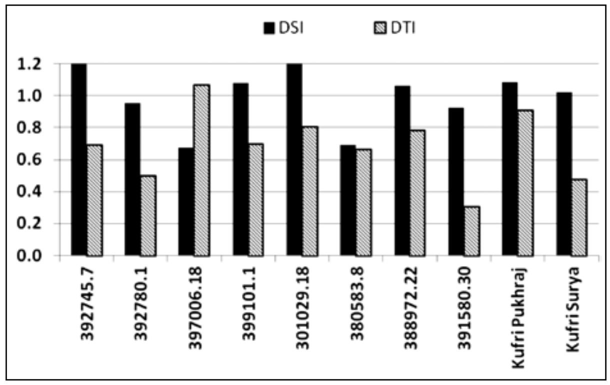

Fig. 1. Drought susceptibility (DSI) and tolerance index (DTI) of clones and varieties.

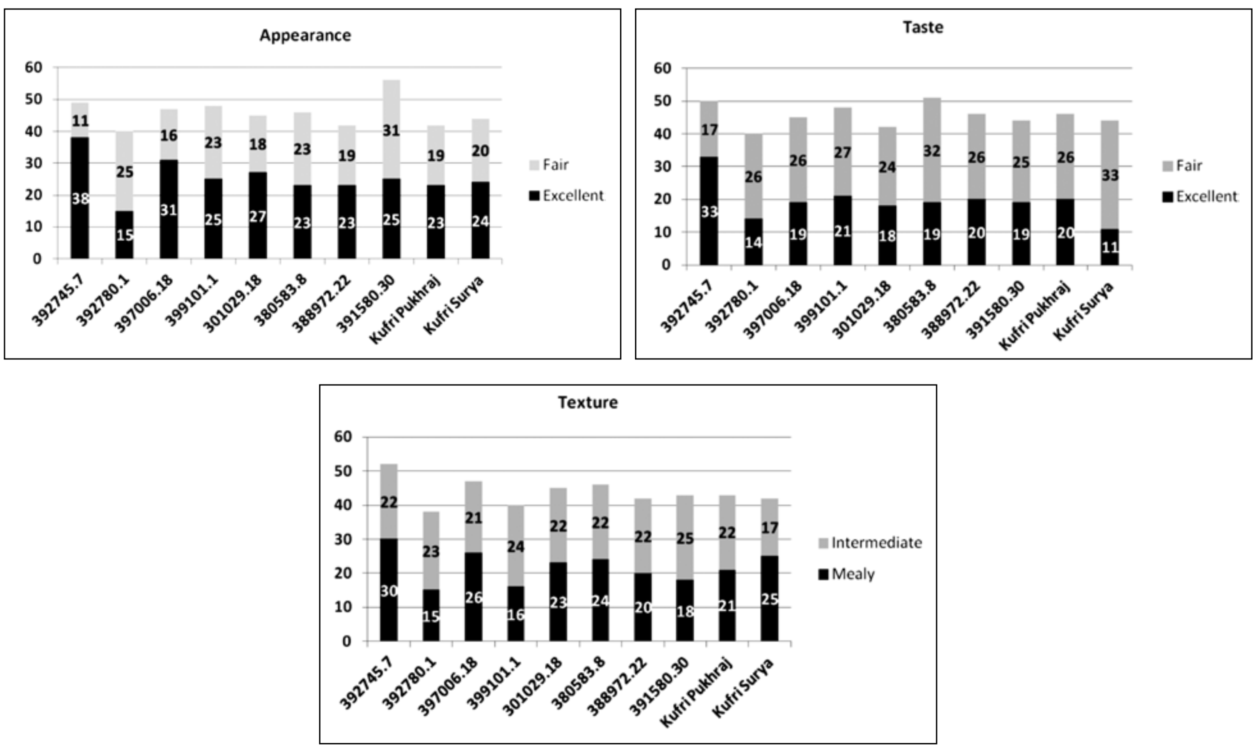

Fig. 2. Stakeholder's preference for CIP genotype's appearance, taste and texture.

Among CIP clones 397006.18 was found promising based upon its overall yield performance, drought tolerance and acceptability of texture and taste.

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