Indian Journal of Agricultural Sciences **87** (11): 1559–64, November 2017/Article

Participatory evaluation of advanced potato (*Solanum tuberosum*) clones for water stress tolerance

SUSHMA ARYA[1], SANJAY RAWAL[2], S K LUTHRA[3], NEERAJ SHARMA[4], V K GUPTA[5] and M S KADIAN[6]

International Potato Centre (CIP), South West and Central Asia Region, New Delhi 110 012

Received: 24 March 2017; Accepted:12 June 2017

ABSTRACT

An attempt was made to introduce potato (*Solanum tuberosum* L.) in hot arid water scarce zone of Western Rajasthan, India. Eight CIP-bred potato clones were evaluated along with two controls, viz. Kufri Pukhraj and Kufri Surya on farmer's field at Jodhpur, Rajasthan under normal and moderate water stress regime during three winter crop seasons (2012-15). Pooled analysis revealed that CIP clone 397006.18 (34.0 tonnes/ha) out yielded Kufri Pukhraj (26.8 tonnes/ha) and Kufri Surya (20.2 tonnes/ha) for marketable tuber yield. This clone maintained yield under normal and deficit irrigation and attained 26.9% higher marketable yield under normal irrigations, which further improved by 31.3% under deficit water stress regime over the best control Kufri Pukhraj. This clone recorded highest tuber dry matter content (22.7%), statistically superior to both control Kufri Pukhraj (17.9%) and Kufri Surya (21.4%). Clone 397006.18 had highest mean drought tolerance index value (1.16) and least total weight loss under normal irrigation (4.9%) and water stress conditions (8.6%) up to 60 days of storage. Preference yield analysis by potato growers showed that they liked this clone most and its overall acceptability was fairly better for all organo-leptic traits. Results of field study and participatory varietal selection indicated that clone 397006.18 performed better for tuber productivity under deficit water management, exhibited drought tolerance traits and achieved overall acceptance by the farmers in Western Rajasthan.

Key words: Arid region, Drought tolerance, Organoleptic traits, Participatory variety selection, Potato, Tuber yield

Potato (*Solanum tuberosum* L.) is key crop for food and nutritional security in India. Future challenges in technological developments of this crop are much more complex than before for achieving the set targets of 2050. The country envisage requirement of 125 million tonnes of potatoes from increased area of 3.62 million ha with enhanced productivity of 34.5 tonnes/ha. To increase acreage, non-traditional areas are needed to be explored where several biotic and abiotic stresses should be addressed before commercial cultivation (CPRI 2015). Within domain of abiotic stresses, water is going to be important factor for crop raising as evident from current pace of climate change globally. International Potato Centre (CIP) has already set strategic objective of developing agile (robust varieties having desirable traits that can fit into currently available growing window) potato varieties for South Asian region (CIP 2013). Selection of appropriate locally adapted clones should be the strategy under global as well as regional climate change scenario as abiotic and biotic stresses would put more pressure on yield of potato (Levy *et al.* 2013).

Major potato growing regions of India like northern sub-tropical plains, western region, central and southern plateau are facing the shortage of irrigation water. Growth attributes are significantly lowered by reduced water supply in potato crop. Thus, overall crop yield is expected to reduce and in such situations development of drought tolerant varieties is essential. Although potato is sensitive to water deficit regime and depicts adverse symptoms quickly at various growth stages, but, variations in drought tolerance capability has been noticed in some genetic lines of potato (Cabello *et al.* 2013). Identification of drought tolerant genotypes for yield maintenance and breeding purposes is need of hour to increase drought tolerance of the 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). However, the identified

[1]Potato Scientist (e mail: s.arya@cgiar.org), CIP, New Delhi. [2]Principal Scientist (e mail: srawalcpri@gmail.com), [3]Principal Scientist (e mail: skluthra@hotmail.com), CPRI Campus, Modipuram. [4]Scientist (e mail: n.sharma@cgiar.org), Bioversity International, New Delhi. [5]Principal Scientist (e mail: vijaigupt@gmail.com), CPRI Campus, Modipuram. [6]Lowland Potato Leader (e mail: m.kadian@cgiar.org), CIP, New Delhi.

promising clones should also meet regional requirements and preferences of potato growers and consumers. Hence, the approach of participatory varietal selection (PVS) is increasingly being adopted by researchers. This process facilitates selection of most suitable clones liked by stakeholders as per their needs (Semagn *et al*. 2015).

Main purpose of introducing PVS for potato crop is to cut short the cycle of release of desirable varieties and enhance their adoption rate. In the existing system, it takes 10-12 years to release a new variety and in several cases, the adoption rate is poor due to limited involvement of farmers. PVS helps to know the preferences of stakeholder which determines the adoption after varietal release. PVS has become popular in some of the countries for various crops and in India also main emphasis is on evaluating the new clones for their yield, appearance, texture and taste based on organoleptic tests (Gupta *et al*. 2015). Rajasthan is hot and dry area where potato production is very low due to paucity of water. Although, climate favours high yield of potato as in the state of Gujarat, but due to lack of suitable variety and lack of technological awareness, potato is still grown by few farmers for self-consumption only. Hence, there is a great scope of increasing the area under potato. This study was an attempt to introduce potato to the hot arid zone of Western India.

MATERIALS AND METHODS

Eight CIP-bred potato clones, viz. 392745.7, 392780.1, 397006.18, 399101.1, 301029.18, 380583.8, 388972.22, 391580.30 were evaluated along with two cultivars Kufri Pukhraj (early bulking) and Kufri Surya (heat tolerant) at farmer's field in village Mansagar, district Jodhpur, Rajasthan (26º 17'12'' N, 73º 01'48'' E, 235 m asl) under moderate water stress during three winter crop seasons (2012-13, 2013-14 and 2014-15). Water table in this region is deep (approx. 260 m) and farmers have to pay a lot for power that increases cost of cultivation. The soil of experimental site was sandy with neutral pH (7.12), low organic carbon content (0.29%), available nitrogen (241.1 kg/ha), available potassium (121 kg/ha) and medium in available phosphorous (22.6 kg/ha). Maximum and minimum mean monthly temperatures during the potato growing season ranged between 24.0-32.3ºC and 9.2-15.9ºC, respectively. Rainfall was negligible in crop period except for during 2012-13 (32.9 mm), while this region had better bright sun shine hours in range of 7.3-9.0 (Table 1). 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. Sprouted seed tubers of 40-45 mm size were planted in the first fortnight of November at 60 cm × 20 cm distance in a plot size of 4.8 m × 1.2 m. Approximately, 50 mm of water (50 l/m^3) was applied in each irrigation through conventional ridge and furrow method. Two irrigations were applied during emergence phase and one after earthing up (25 days) in both the treatments. Water was applied in normal treatment at 10 days interval after earthing up, whereas water was applied twice at 50 and 70 days in deficit irrigation. In normal treatment, irrigation was terminated 10 days before dehaulming. Space of 2.4 m was kept between and around the treatments to avoid border effect. Uniform fertilizer dose of 90, 34.4 and 104 kg/ha of N, P and K, respectively, was applied at planting and 90 kg/ha of nitrogen was applied at earthing up. Recommended schedule of herbicide, fungicide and insecticide application for potato crop was followed for maintaining proper crop growth. Crop was dehaulmed at 90 days after planting and harvested 15 days later after tuber skin maturity. Growth parameters were recorded at scheduled intervals, while total and marketable (> 20 g) tuber yield and 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 80ºC until constant weight is achieved in forced hot air draft oven. Drought tolerance index (DTI) was calculated using formula suggested by Hassanpanah (2010). All recorded data was pooled and analysed using statistical software IRRISTAT (1999).

Produce of eight CIP genotypes from field study were evaluated against two check varieties (Kufri Pukhraj and Kufri Surya) in PVS exercise at the experimental site during February 2014 and 2015 just after harvesting. Fifty participants (15-20 females and 30-35 males) of different age groups and background were involved to evaluate the tuber yield under water stress treatments. Basic rules of evaluation were explained to all persons (Paris *et al*. 2011). Main criteria were yield, tuber shape, skin colour and depth of eyes etc. Information of each person was recorded on evaluation form and everybody evaluated individually without speaking with others. Harvested potato clones/ varieties were clearly identified with a number written on

Table 1 Mean monthly climate data of Jodhpur (Rajasthan)

Month	2012-13					2013-14					2014-15				
	Air temperature (°C)			Rain fall (mm)	BSS (hr)	Air temperature (°C)			Rain fall (mm)	BSS (hr)	Air temperature (°C)			Rain fall (mm)	BSS (hr)
	Max.	Min.	Mean			Max.	Min.	Mean			Max.	Min.	Mean		
November	31.3	14.1	22.7	0.0	9.0	30.0	15.2	22.6	0.0	8.7	32.3	15.9	24.1	0.4	8.4
December	26.8	11.6	19.2	0.0	8.3	26.1	10.4	18.2	0.0	8.3	26.4	10.8	18.6	0.0	8.3
January	24.0	9.2	16.6	32.9	8.5	23.4	9.9	16.7	0.0	7.3	24.1	10.2	17.2	0.2	7.4
February	26.5	14.2	20.3	19.3	8.2	27.0	12.2	19.6	0.1	8.0	29.7	14.2	21.9	0.1	9.0

Max., maximum; Min., minimum; BSS, bright sun shine hour a piece of cardboard. Clone/variety's real name was kept hidden in order to prevent pre-conceived opinions. Each participant was asked to rank three best clones according to his/her preference. They were made to walk around harvested lots and observed tubers of each clone to select three best clones. They were encouraged to make a personal choice. Ample time and clarity was imparted to each participant in selecting the clones/varieties. Each participant was given 6 grains where men had gram grain and women had beans grain. Each participant was supposed to keep 3 grains for the best selected genotype in the bowl kept in front of the heaps of potato, 2 grains for the second best selected clone/variety, 1 grain for the third best selected clone/variety. Data were pooled and analysed for taking out the inferences.

Participatory organoleptic analysis

The analysis was done immediately after the harvesting to record stakeholder's preference for appearance of tuber, taste and texture during PVS exercise at the experimental site in February 2014 and 2015. Fifty participants (15-20 females and 30-35 males) of different age groups and background were involved to evaluate the produce of eight CIP clones and two check varieties. Basic methodology was explained to members of the panels. From fresh harvest, 25 potato tubers of each genotype were kept in a netted poly bag for boiling. Each bag had a tag of registration number of clone/variety to maintain the identity. Whole potatoes (five) of each genotype were placed on a plate and clearly identified by the registration number. Further bite size tuber pieces of same clone were kept on same plate without salt, spices or flavouring compound. This test was performed with 6-7 panels consisting of a maximum of 8 members of both sexes. Each panelist's information was recorded on evaluation form to record the observations in reference to appearance, taste and texture of each clone/variety. Every panelist evaluated individually without discussion with other panelists. She or he evaluated clone by clone and washed her/his mouth with potable water before moving on to the next sample. Data were pooled and analyzed for further interpretation. Organoleptic evaluation was based on three main characteristics, viz. appearance (excellent, fair, poor) referred to visual aspect that how much boiled potatoes of a genotype were appealing to eyes when presented on plates; taste (excellent, fair, poor) referred to the panelists experience at the moment of savouring boiled tuber dices from each clone/variety; texture (mealy = floury, intermediate, soggy = watery) was the feel of tuber flesh in mouth and directly related to dry matter that the potatoes possessed.

RESULTS AND DISCUSSION

Productivity of promising clones

Total and marketable tuber yield (tonnes/ha), and their stability under water stress is most important trait for evaluating the potato genotypes. Pooled analysis revealed that CIP clone 397006.18 (34.0 tonnes/ha) out yielded the control Kufri Pukhraj (26.8 t/ha) and Kufri Surya (20.2 t/ha) in terms of mean marketable yield, and similar trend was found for total tuber productivity (Table 2). Most promising

Table 2 Mean marketable and total tuber yield (t/ha), and tuber dry matter content (%) of potato genotypes under different irrigation regimes (2012-15) at Jodhpur

Clones/varieties	Tuber yield						Tuber dry matter content		
	Marketable			Total					
	I1	I2	Mean	I1	I2	Mean	I1	I2	Mean
392745.7	26.7	17.7	22.2	28.3	19.3	23.8	19.5	20.1	19.8
392780.1	24.9	18.3	21.6	27.0	19.9	23.4	20.7	21.7	21.2
397006.18	37.9	30.2	34.0	38.7	31.3	35.0	21.9	23.5	22.7
399101.1	32.1	21.9	27.0	34.3	24.0	29.1	19.8	20.9	20.3
301029.18	30.8	21.0	25.9	32.3	22.4	27.3	21.6	23.2	22.4
380583.8	28.7	22.8	25.7	30.2	24.7	27.4	19.5	20.9	20.2
388972.22	28.6	22.2	25.4	29.6	23.6	26.6	21.4	20.9	21.1
391580.30	23.9	16.7	20.3	25.1	17.9	21.5	20.4	21.5	20.9
Kufri Pukhraj	30.7	23.0	26.8	32.8	24.9	28.8	17.6	18.3	17.9
Kufri Surya	23.2	17.3	20.2	24.7	18.5	21.6	21.0	21.8	21.4
Mean	28.7	21.1	24.9	30.3	22.7	26.5	20.3	21.3	20.8
LSD (P= 0.05)									
Irrigation (I)		1.72			1.75			0.71	
Clone/variety (C)		3.94			4.17			0.87	
Interaction I × C		5.35			5.28			NS	

I_1, normal irrigation; I_2, moderate water stress; NS, non-significant trend was that this clone was able to maintain yield under normal and deficit irrigation. CIP clone 397006.18 could attain 26.9% higher mean marketable yield under normal irrigaiton, which further improved by 31.3% under deficit water stress regime in comparison to best control Kufri Pukhraj. Analogous outcome was observed for mean total tuber yield and total yield in water stress treatment. Increase of water stress declined marketable (26.4%) and total tuber yield (25.1%) significantly and all the genotypes were affected by shortage of irrigation water. Some of the genotypes like 391580.30 exhibited yield losses to the tune of 30.1% under water stress. As far as behavior of different genotypes under varied soil moisture is concerned, it might differ due to variations in metabolic activities within the plant governed further by several genes. Water stress induced yield decline is primarily influenced by its negative impact on crop growth traits, tuber initiation and bulking, and finally hastened senescence of potato crop (Hassan *et al.* 2002). Reduction in tuber number and their bulking was supposed to be the main cause for yield reduction among genotypes with variation in soil moisture (Hasasanpanah 2010) and this phenomenon could be mainly attributed to variations in enzymatic activities, which are ultimately governed by expression or suppression of genes under normal and deficit soil water regime (Schafleitner *et al.* 2007). He reported that some of the genes were able to maintain their activity under drought and thus few potato clones were able to maintain the productivity through their expression. Similar findings were also testified by Levy *et al.* (2013).

Tuber dry matter content

Pooled analysis of three years indicated significant variation in tuber dry matter content (%) among different clones and control cultivars, and deficit water availability to crop also affected it markedly (Table 2). CIP clone 397006.18 recorded the highest tuber dry matter (22.7%) remaining at par with genotype 301029.18 (22.4%) and statistically superior to both control Kufri Pukhraj (17.9%) and Kufri Surya (21.4%). Tuber dry matter content increased significantly under water deficit regime as compared to normal irrigation. Sharma *et al.* (2011) also found increase in tuber dry matter content of potatoes under water deficit regime.

Water stress tolerance

Drought tolerance index (DTI) is an indicator of sustained productivity under adverse conditions of lower soil water availability and genotype 397006.18 attained highest mean DTI value (1.16) under water stress regime (Fig 1). Its performance was superior to all CIP clones and both the controls Kufri Pukhraj (0.80) and Kufri Surya (0.50). Hassanpanah (2010) reported similar findings while evaluating potato cultivars against water deficit stress under *in vitro* and *in vivo* conditions and he found this index quite useful in explaining results on the basis of agronomic yields. Cabello *et al.* (2013) also concluded that apart from other indices DTI is a good measurement of production potential

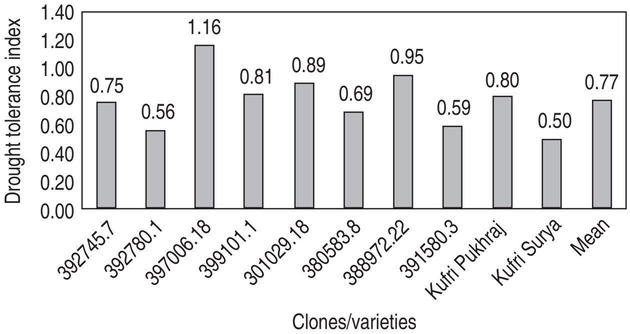

Fig 1 Mean drought tolerance index of potato genotypes during 2012-15 at Jodhpur (Rajasthan)

of a genotype under soil moisture stress conditions for proving it to be stress tolerant.

Weight losses during storage

Keeping quality of all genotypes was recorded under Jodhpur conditions at room temperature up to 60 days (Table 3). A wide range of variation was observed among the CIP genotypes and control varieties for physiological, rotted and total tuber weight loss (%). Minimum physiological and rotted tuber weight loss was recorded in CIP clone 397006.18 under normal irrigation (4.9%) and water stress conditions (8.6%). This genotype proved the best among all clones or control varieties. Clone 380583.8 showed the highest physiological weight loss, while genotype 391580.30 had maximum rotted tuber loss under normal irrigation. Under deficit irrigation, clone 392745.7 revealed the highest weight loss in both categories. Physiological weight losses depended on dormancy period of a genotype, periderm thickness and lenticel density on tuber surface. Variations of plant growth

Table 3 Weight loss in potato genotypes under normal and water stress conditions 60 days after harvest during 2012-15 at Jodhpur (Rajasthan)

Clones/ varieties	Mean weight loss (%)					
	Normal irrigation			Water stress		
	Physio-logical	Rottage	Total	Physio-logical	Rottage	Total
392745.7	7.8	11.9	19.7	14.8	19.2	34.0
392780.1	5.7	7.8	13.5	7.0	10.8	17.8
397006.18	3.9	1.0	4.9	5.5	3.1	8.6
399101.1	5.6	7.0	12.6	6.9	7.6	14.5
301029.18	5.6	6.0	11.6	5.8	7.5	13.3
380583.8	10.5	12.0	22.5	8.8	12.9	21.7
388972.22	8.6	9.0	17.6	9.3	5.7	15.0
391580.30	7.8	16.5	24.3	5.9	7.5	13.4
Kufri Pukhraj	6.9	6.8	13.7	7.9	9.6	17.5
Kufri Surya	4.3	4.7	9.0	6.5	6.2	12.7
Mean	6.7	8.3	15.0	7.8	9.0	16.8

Table 4 Mean participatory preference of potato growers for potato genotypes (2013-15)

Clones/ varieties	Participatory preference	Appearance			Taste			Texture		
		Exc.	Fair	Poor	Exc.	Fair	Poor	Exc.	Fair	Poor
392745.7	37	16.3	9.6	3.3	13.6	11.3	4.3	13.0	13.0	3.3
392780.1	4	6.0	13.6	9.3	6.6	12.6	8.3	8.6	15.3	5.0
397006.18	42	19.0	8.0	1.0	11.3	13.3	2.6	12.6	13.0	2.3
399101.1	28	11.6	14.0	4.6	10.0	15.6	4.3	9.3	14.3	4.0
301029.18	18	15.0	10.6	2.6	9.6	15.0	3.0	12.3	13.0	2.6
380583.8	7	10.0	16.6	2.3	8.6	17.0	6.0	11.3	13.6	3.6
388972.22	41	12.3	12.0	4.0	10.3	14.6	3.6	11.6	12.3	4.3
391580.30	4	11.0	17.6	3.0	12.6	15.3	4.6	8.6	14.6	5.3
Kufri Pukhraj	7	10.3	14.0	3.3	8.3	14.3	5.3	9.3	13.3	5.0
Kufri Surya	1	13.6	12.6	2.6	5.3	17.0	4.0	15.6	10.3	2.0
LSD (P=0.05)		5.71	5.78	3.06	6.28	5.91	4.04	5.04	2.93	4.49

Exc., Excellent

regulators and tuber anatomy among genotypes had been observed in several studies. Mentioned traits seemed to affect the evaporative tuber weight losses with different magnitude among clones (Gupta *et al*. 2015).

Participatory varietal selection

Most complex part of study was participatory yield and organoleptic evaluation of genotypes under study as one had to decipher region specific preferences and information about the traits valued by the participants and their initial impression of clones and varieties (Table 5). Preference yield analysis revealed that potato growers (mean of male and female evaluation) had most liking to CIP clone 397006.18 (42) closely followed by genotype 388972.22 (41) and 392745.7 (37). Farmer's decision making depended on their socio-economic conditions and they paid sincere attention to very specific genotypic characters like overall marketable proportion in total yield, appearance, colour of tuber skin and flesh etc. There inference was of utmost importance to the team workers of this experiment (Semagn *et al*. 2015).

Organoleptic evaluation

Organoleptic evaluation comprised three components of appearance, taste and texture, and both sexes were involved in clonal valuation (Table 4). Mean of three season data divulged that maximum participants kept CIP clone 397006.18 in excellent category, followed by genotype 392745.7 and 301029.18. For taste, participants allotted third position to CIP clone 397006.18 in excellent category, closely superseded by genotype 392745.7 and 391580.30. The CIP clone 397006.18 attained excellent score for texture, near to best genotype Kufri Surya, while remaining comparable to other clones, viz. 392745.7 and 301029.18. The overall acceptability of new clones was dependent on panelist's importance for yield, appearance, taste and texture, and CIP clone 397006.18 did fairly better for all traits in comparison to other clones or control varieties. This test was very helpful in predicting whether or not farmers are likely to adopt a genotype. Their opinion was unbiased even for local check varieties. Selection of a promising clone was strongly related to participant's decision on its organoleptic acceptance and probable logical decision for future adoption of a genotype for commercial cultivation (Jansky 2008, Ojinnaka and Onwuka 2011, Elnaz *et al*. 2015).

Field study and participatory potato varietal selection for CIP clones demonstrated that CIP genotype 397006.18 had not only performed better for tuber productivity under deficit water management and exhibited drought tolerance traits but also achieved overall acceptance for yield, appearance, texture and taste of potato growers of Rajasthan.

REFERENCES

Cabello R, Monneveux P, Mendiburu F D and Bonierbale M. 2013. Comparison of yield based drought tolerance indices in improved varieties, genetic stocks and landraces of potato (*Solanum tuberosum* L.) *Euphytica* **193**: 147–56.

CIP. 2013. CIP strategy and corporate plan: research, innovation and impact, 2014-2023. International Potato Centre, Lima, Peru, pp 19–21.

CPRI. 2015. Vision: 2050 (www.cpri.ernet.in). Central Potato Research Institute, Shimla, Himachal Pradesh, 33 p.

Elnaz T A, Orang E and Simin A. 2015. Organoleptic evaluation of potato after using pre- drying, slices dimensions and *Psyllium* seed hydrocolloid- coating. *International Journal of Farming and Allied Sciences* **4**: 606–9.

Gupta V K, Luthra S K and Singh B P. 2015. Storage behaviour and cooking quality of Indian potato varieties. *Journal of Food Sciences and Technology* **52**: 4863–73.

Hassan A A, Sarkar A A, Ali M H and Karim N N. 2002. Effect of deficit irrigation at different growth stages on the yield of potato. *Pakistan Journal of Biological Sciences* **5**: 128–34.

Hassanpanah D. 2010. Evaluation of potato advanced cultivars against water deficit stress under *in vitro* and *in vivo* condition. *Biotechnology* **9**: 164–9.

IRRISTAT. 1999. Windows version 4.0. Biometrics unit, IRRI, Los Banos, Philippines.

Jansky S H. 2008. Genotypic and environmental contributions to baked potato flavour. *American Journal of Potato Research*

85: 455–65.

Levy D, Coleman W K and Veilleux R E. 2013. Adaptation of potato to water shortage, irrigation management and enhancement of tolerance to drought and salinity. *American Journal of Potato Research* **90**: 186–206.

Luthra S K, Gupta V K and Rawal S. 2011. MS/6-1947: An early bulking drought tolerant advance stage hybrid. *CPRI Newsletter* **44**: 1–2.

Ojinnaka M C and Onwuka G I. 2011. Organoleptic assessment of the performance of some cultivars of *Ipomoea batatas* in the development of selected snack products. *Pakistan Journal of Nutrition* **10**: 935–9.

Paris T R, Manzanilla D, Tatlonghari G, Labios R, Cueno A and Villanueva D. 2011. Guide to participatory varietal selection for submergence tolerant rice. International Rice Research Institute, Los Banos, Philippines and The Ministry of Foreign Affairs, Japan, p 111.

Schafleitner R, Gutierrez R, Espino R, Gaudin A, Perez J, Martinez M, Dominguez A, Tincopa L, Alvarado C, Numberto G and Bonierbale M. 2007. Field screening for variation of drought tolerance in *Solanum tuberosum* L. by agronomical, physiological and genetic analysis. *Potato Research* **50:** 71–85.

Semagn A K, Donald H, Keith P, Walter D J, Fentahun M T and David W. 2015. Identification of farmer priorities in potato production through participatory variety selection. *American Journal of Potato Research* **92**: 648–61.

Sharma N, Kumar P, Kadian M S, Pandey S K, Singh S V and Luthra S K. 2011. Performance of potato (*Solanum tuberosum* L.) clones under water stress. *Indian Journal of Agricultural Sciences* **81**: 825–9.