



## Tackling moisture stress with drought-tolerant potato (*Solanum tuberosum*) varieties: Perception of Karnataka farmers

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### ABSTRACT

Karnataka plays an imperative role of supplying processing grade potatoes to Indian processing industry during September and December months when there is dearth of raw material. Heat and moisture stress aggravate existing grim potato husbandry outlook due to shallow and carbon deficit soils, small and fragmented land holdings, and resource paucity of farmers in the area. Lack of technological support may prove to be a threat to sustainability of potato farming and growth of Indian potato processing industry. With this objective into consideration, current study was undertaken under the broader project “Enhanced Food and Income Security in South West and Central Asia through Potato Varieties with Improved Tolerance to Abiotic Stress”. Farmers’ opinions on yield enhancing attributes on their farms, good and bad characters of the existing potato varieties and reasons for the abandonment potato varieties were collected and analyzed. Priority indices of farmers’ opinion on desirable attributes were computed and based on these indices top ten attributes were listed and supplied to the crop improvement team of the project. The research paper also describes some important areas where development agencies need to act sooner than later for ensuring welfare of potato farmers and crop in the area.

**Key words:** Abandonment of varieties, Drought and heat tolerance, Farmers’ perception, Karnataka, Potato varieties

Karnataka is an important potato state of India. This importance comes from quality of the produce of this state rather than the quantity (1.7% of production from 4.2% of national potato area) which is suitable for processing into potato chips. Indian potato processing industry started its noticeable growth and experienced rapid growth only in the last decade (Rana and Pandey 2007, Keijbets 2008, Rana *et al.* 2009 and Rana 2011). During the months of September and December there is real dearth of processing grade potatoes in the country and Karnataka plays an important role of bridging this demand and supply gap. Hassan being the largest potato producing district of the state and a supplier of processing grade potatoes for sustaining potato processing

revolution in the country was in media attention due to tremendous economic losses to its potato growers in the recent past. Severe late blight infestation was the principal and additional reason that aggravated the already grim farming situation in the area due to shallow and carbon deficit soils, inadequate irrigation water during intermittent failure of rains and heat stress.

However, rising average temperature due to global warming is posing serious threat to potato farming in the state (Lal *et al.* 2008, Rana *et al.* 2011). Temperature is estimated to rise by 1, 3 and 5 °C during potato growing season in India by the year 2020, 2050 and 2080, respectively. Indian potato production is estimated to decline by 9.6 and 16.1% in year 2020 and 2050, respectively (Singh *et al.* 2008). Karnataka has been estimated to face the highest decline in potato production by 2020 and 2050 (19.7%, 44.9%) followed by Gujarat (18.2%, 31.8%), Maharashtra (13.0%, 24.6%) and Madhya Pradesh (9.7%, 16.6%) as some of the other important potato producing states. Rising temperature is likely to inflict water stress and by the year 2050, areas with moisture stress are estimated to double (Bates *et al.* 2008).

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Table 2 Sampling details (Number of respondents)

Particulars	Cultivators					Non-potato	Land less agricultural labourers	All
	Potato growers				All			
	Marginal	Small	Medium	All				
<i>Stratum/ Village wise</i>								
<i>Plain stratum</i>								
Hannovar	3	8	5	16	4	20	5	25
Hallanhalli	7	6	2	15	4	19	3	22
Chagatihalli	8	6	3	17	2	19	5	24
Sub-total	18	20	10	48	10	58	13	71
<i>Hill stratum</i>								
Chilkur	7	4	0	11	4	15	1	16
Sankenhalli	6	4	1	11	3	14	2	16
Kartikere	5	5	1	11	2	13	2	15
Sub-total	18	13	2	33	9	42	5	47
<i>Contract farming wise</i>								
Contract	6	16	7	29		29		29
Non-contract	30	17	5	52	19	71	18	89
Total	36	33	12	81	19	100	18	118
Population# (%)				17.04	64.57	81.61	18.40	100.00

# Source: Census of India, 2001 and office of the District Horticulture Officer, Hassan.

@ Marginal = potato area up to 1 ha; small = having potato area more than 1 ha and up to 2 ha and medium = having potato area more than 2 ha.

Note: Being strategically important processing quality potato producing area contract farming is very important determinant affecting nature and future of crop cultivation in the study area.

Potato farmers of Hassan and many other places affected by heat and moisture stress are in immediate need of technological intervention to sustain their livelihood. Developing heat and drought tolerant potato varieties for such farmers can save the latter's families from distress and economic destitution (Sharma *et al.* 2011). Considering these objectives a GTZ funded project "Enhanced Food and Income Security in SWCA through Potato Varieties with Improved Tolerance to Abiotic Stress" was initiated in SWCA countries during 2008. The current study is a part of this bigger project which targets assessment of potato farmers' opinion on presence of various characters in the varieties to be released in their area in the future.

Karnataka is an important potato producing state which fills the demand supply gap of processing potato in the country during September and December months. Hassan district of the state is leading potato producer and an important destination for processing potato procurement teams of the leading potato processing companies. However, severe late blight infestation and consequent deterioration in financial health of the potato farmers in this area is real cause of concern as more and more potato farmers are losing interest in potato crop. Hassan being prone to heat and moisture stresses was purposively selected for this study. One cluster each from hilly and plain strata of the district was selected and out of each cluster three villages were selected using

simple random sampling (Table 1). For broader objectives of the study respondents were selected from various backgrounds, viz. non-farmers, non-potato growers and potato growers. Interview schedule was designed to fulfil the survey requirements and farmers' data were collected using personal interview technique during August and September 2009.

Data so collected were analyzed with the help of appropriate mathematical and statistical techniques. In order to study the independence of individual responses among various farm size categories and contract farming categories of the potato farmers, t tests for comparison of 'several population means' and 'two population means' were used.

*Yield enhancing attributes:* Farmers' responses on seventeen possible yield enhancing attributes of potato were taken and analysed. These yield enhancing factors were selected based on the past survey experiences of team members in similar conditions. All sampled potato farmers of all size categories believe that there was potential of increasing potato yields at their farms. Cent per cent potato growing respondents believed that late blight resistant potato varieties can increase their potato yield (Table 3). Adequate availability of crop loan was perceived by about 95% farmers as very important factor for potato yield enhancing. High yielding potato varieties and better agricultural extension services were elicited as important factors having potential of increasing potato yields at farmers' fields by more than

Table 2 Farmers' perception on potato yield enhancing attributes (% multiple responses)

Attributes	Potato growers					All
	Farm size			Contract farming		
	Marginal	Small	Medium	Adopter	Non-adopter	
Late blight resistant varieties	100.00	100.00	100.00	100.00	100.00	100.00
Adequate availability of crop loan	92.86	95.65	100.00	94.74	95.62	95.24
High yielding potato varieties	93.75	93.55	100.00	96.43	93.62	94.67
Better Agril Extension Services@	97.15	93.44	85.69	86.52	98.08	93.94
Provision of subsidised inputs**@@	92.45	87.50	66.67	70.67	93.94	86.20
Drought tolerant varieties*@@@	93.33	84.00	70.00	64.05	97.20	85.70
Soil amelioration**@@@	97.60	68.10	60.50	61.10	91.66	80.43
Sufficient irrigation water***@@@	96.00	67.20	48.00	42.00	97.00	77.23
Water saving technology@	82.40	71.40	70.08	65.40	81.24	75.75
High dose of fertilizer**@@	80.95	69.50	55.00	50.00	79.41	70.66
Proper weed control***@@@	87.50	58.82	25.00	37.50	92.31	62.07
Heat tolerant varieties@@@	45.45	42.11	33.33	25.00	58.82	42.42
Availability of cheaper machinery	37.50	40.00	33.33	37.50	39.48	38.33
Adequate availability of fertilizers@	30.33	29.82	20.33	19.17	33.33	28.45
Adequate availability of pesticides*@	33.33	25.07	18.33	17.45	33.33	27.70
Management of other diseases	22.00	18.60	22.00	19.20	21.40	20.60
Proper insect pest control	20.40	18.50	15.00	17.60	19.00	18.50

Application of t test indicated statistically different response levels among potato farm size categories at \*10%; \*\*5%; and \*\*\*1% level of significance and between contract farming categories at @ 10%; @@ 5%; and @@@ 1% level of significance.

90% respondents. Non-contract farmers have statistically mentioned higher concern on this issue as they are deprived of equal extension services.

Provision of subsidised inputs, drought tolerant potato varieties and soil amelioration were the factor which according to more than 80% respondents could enhance potato yield. Smaller and non-contract potato farmers showed statistically higher responses on these issues. According to more than 70% respondents sufficient irrigation water, water saving technologies and higher doses of fertilizers were other attributes that can increase potato yield. Incidentally smaller and non-contract farmers, once again, were statistically more concerned on these issues. Heat tolerant potato varieties were considered a yield enhancing attribute by about 42% potato respondents where non-contract potato farmers are affected to a greater extent. The extent of problem perceived on availability of farm inputs like fertilizers and pesticides was statistically higher in case of smaller and non-contract farmers.

*Desirable and undesirable varietal characters:* As per farmers' elicitation desirable and undesirable characters of existing potato varieties were described. Indices, ranging from 0 to 200, were computed for judging the relative importance of a particular attribute. The desirable and undesirable qualities of Kufri Jyoti were analysed using the said indices (Table 4). Better yield than Atlantic, the other PepsiCo promoted variety grown

in the area, was the most important good quality of Kufri Jyoti on respondents' mind. Other good qualities of this variety in the decreasing order of importance were better skin colour, heat tolerance (better than Atlantic), better late blight tolerance (than FL 1533 and Atlantic) and better taste with desirable texture. However, late blight susceptibility of Kufri Jyoti was its most important bad quality followed by lower yield than FL 1533, late maturity, lower price and bad tuber shape.

Contract farming adopter farmers showed statistically higher concern on lower yield of Atlantic and smaller farmers were happy with the higher yield of Kufri Jyoti. In the same way better skin colour of Kufri Jyoti was a preferred trait by the smaller and non-contract potato farmers. Larger and contract potato farmers had higher score on better late blight tolerance and taste/texture of Kufri Jyoti. Similarly late blight susceptibility bothered more to smaller and non-contract farmers who are less capable and equipped to tackle this challenge. However, lower yield of Kufri Jyoti compared to FL 1533 concerned more to the larger and contract potato farmers. Lower price of Kufri Jyoti was putting contract farmers at greater unease while bad tuber shape of this variety was disliked by the larger potato farmers to a greater extent.

FL 1533 had more good qualities than the bad but its late blight susceptibility was the single bad quality (index score 141) that can make farmers have second thought on its

Table 3 Responses on desirable and undesirable qualities of Kufri Jyoti (indices#)

Attributes	Potato growers					All
	Farm size			Contract farming		
	Marginal	Small	Medium	Adopter	Non-adopter	
<i>Good qualities</i>						
Better yield than Atlantic**@@	106.67	116.00	90.90	126.09	97.67	107.57
Better skin colour***@@@	73.33	36.00	27.27	21.74	67.44	51.51
Heat tolerance	10.00	20.00		13.04	11.63	12.12
Better late blight tolerance**	10.00	8.00	27.27	13.04	11.63	12.12
Tasty and good texture***@@@	3.33	16.00	27.27	30.43	2.32	12.12
<i>Bad qualities</i>						
Late blight susceptibility**@@@	120.59		72.73	48.15	114.89	90.54
Lower yield than FL-1533***@@@	41.18	110.34	81.81	114.81	51.06	74.32
Late maturity**	26.47	44.83	18.18	33.33	31.91	32.43
Lower price@@	35.29	37.93	36.36	37.04	21.28	27.02
Bad tuber shape**	8.82	13.79	36.36	11.11	17.02	14.87

# Indices were calculated assigning weights equal to 2 for 1<sup>st</sup>; 1 for 2<sup>nd</sup> and 3<sup>rd</sup>, and 0.5 for subsequent priority in responses

Application of t test indicated statistically different response levels among potato farm size categories at \*10%; \*\*5%; and \*\*\*1% level of significance and between contract farming categories at @ 10%; @@ 5%; and @@@ 1% level of significance.

adoption (Table 5). The prominent good qualities of this variety are higher yield than Kufri Jyoti followed by its heat tolerance (better than Kufri Jyoti), early maturity, processing quality, higher prices of produce and higher proportion of desirable tuber size. Bad storability of this variety was the other shortcoming on farmers' mind. Higher yield of FL 1533 was more significant for larger potato farmers while early maturity, late blight susceptibility and bad storability

of this variety were weighed more on the minds of smaller potato farmers.

In case of Atlantic, the processing attributes, early maturity, desirable tuber size and higher price of the produce were some desirable qualities considered by the respondents. However, being the most susceptible to late blight, farmers were reluctant to adopt it in spite of PepsiCo's efforts to push the variety in the study area. Its low yield,

Table 4 Responses on desirable and undesirable qualities of FL 1533 and Atlantic (indices#)

Attributes	Potato growers				Atlantic & all potato growers
	FL 1533			All potato growers	
	Marginal	Farm size Small	Medium		
<i>Good qualities</i>					
High yield*	130.00	136.84	150.00	138.46	
Heat tolerant	90.45	85.50	86.68	87.70	
Early maturing***	90.00	42.11	70.00	61.54	76.92
Good for processing	60.00	63.16	60.00	61.54	84.62
Higher price of produce	20.00	26.32	20.00	23.08	36.84
Desirable tuber size	53.33	44.00	54.55	50.00	38.46
<i>Bad qualities</i>					
Late blight susceptible*	160.00	128.57	137.50	140.63	148.42
Bad storability**	40.00	21.43		21.89	
Low yield					84.62
Heat susceptible					53.08
Bland taste and bad texture					15.79

# Indices were calculated assigning weights equal to 2 for 1<sup>st</sup>; 1 for 2<sup>nd</sup> and 3<sup>rd</sup>, and 0.5 for subsequent priorities; Category wise analysis was not carried out due to poor responses within the categories; t test indicated statistically different response levels among potato farm size categories at \*10%; \*\*5%; and \*\*\*1% level of significance

Note: FL 1533 and Atlantic varieties are grown only by the contract farmers of PepsiCo India

Table 5 Varieties abandoned<sup>#</sup> and reasons for abandonment by potato farmers (multiple responses)

Attributes	Potato growers					
	Farm size			Contract farming		All potato growers
	Marginal	Small	Medium	Adopter	Non-adopter	
<i>FL 1533</i>						
Late blight susceptibility	100.00	100.00	100.00		100.00	100.00
<i>Kufri Jyoti</i>						
Lower yield@@	80.00	100.00	100.00	100.00	66.67	95.65
Lower price of the produce**	40.00	23.08	20.00	25.00	33.33	26.09
Late blight susceptibility@	20.00	15.38	20.00	15.00	0.00	13.04
<i>KCM</i>						
Low yield**	100.00	75.00			80.00	80.00
Low price*	60.00	75.00			60.00	60.00
Impure seed***	40.00	25.00	100.00		40.00	40.00

<sup>#</sup>Kufri Jyoti, Kufri Chandramukhi and FL 1533 potato varieties were abandoned by 60, 25 and 15% of respondents; t test indicated statistically different response levels among potato farm size categories at \*10%; \*\*5%; and \*\*\*1% level of significance and between contract farming categories at @10% and @@5% level of significance.

heat susceptibility and bland taste with bad texture for table purpose consumption were other bad qualities of this variety in farmers' mind.

*Reasons for abandoning varieties:* Varieties that farmer(s) stopped growing and was/were not willing to re-adopt in any case were considered abandoned. Three potato varieties, viz. Kufri Jyoti, Kufri Chandramukhi (KCM) and FL-1533 were abandoned by the respondents. Late blight susceptibility was the sole reason revealed by all respondents who abandoned FL 1533 (Table 6). Lower yield was the most important reason for the abandonment of Kufri Jyoti (96% responses) followed by lower price of the produce and its late blight susceptibility. Lower yield of the variety was more serious concern for contract farmers while smaller sized farmers were more concerned about the lower price received by the produce of this variety. KCM cultivation was stopped by more or less every potato farmer about half a decade ago. Among those who abandoned this variety the highest proportion was for those who feel its yield is very low (80%) followed by its lower price (60%) and unavailability of pure seed (40%). Smaller farmers were more concerned about its low yield while larger farmers took decision of its abandonment under greater influence of the low prices of its produce and unavailability of pure seed for this variety.

*Priorities for breeding future varieties:* After having farmers' detailed elicitation on perceptions regarding potential yield enhancing factors, desirable and undesirable varietal characters, varieties abandoned and reasons for such abandonment; they were asked to express their priorities of attributes in new potato varieties to be developed under the GTZ project. Based on the priority index top ten attributes were selected (Table 7). Late blight resistance was the most important attribute (priority index 104%) desperately expressed by potato farmers. Lower potato productivity in

the area made respondents to demand for higher yield realization in future varieties (priority index 62%). Within the project objectives of breeding potato varieties tolerant to abiotic stresses, respondents put higher priority for drought tolerance (index 44%) than heat tolerance (index 14%). Suitability for processing and early maturity were two other important priorities in the mind of respondents. Potato varieties free from cracking and deformities was also an important consideration for the potato growers of the area. Since this problem is largely supposed to be due to abiotic stresses hence, it may be easy for breeders to address this issue within broader project objective. Large and uniform tuber size, nutrient efficiency and low degeneration rate of seed were some other important factors that farmers like to have in new potato varieties.

Relative per cent importance of various attributes desired in new potato varieties was also calculated. Severe late blight infestation in 2008 and 2009 was definitely responsible for crop devastation leading to pathetically low potato yields in the area. Out of top ten breeding priorities potato farmers gave 32% importance to late blight resistance and 19% to high-yielding potato varieties. Within the project objectives farmers want varieties which are drought and heat tolerant, early maturing and free from cracking and deformities collectively having more than 28% relative importance. Suitability for processing was another important trait farmers (9% importance) want in new potato varieties.

Lack of technical support to the non-contract potato farmers was reflected through a significantly higher priority for having late blight resistant potato variety. However, larger and contract potato farmers wanted a potato variety that should have higher yield potential compared to the existing varieties. Since, smaller and non-contract farmers have less control over the irrigation resources, they showed statistically

Table 6 Priority indices# for breeding new potato varieties (multiple responses)

Top 10 breeding priorities	Category of potato growers					All	% importance
	Farm size			Contract farming			
	Marginal	Small	Medium	Adopter	Non-adopter		
Late blight resistance@@	108.23	97.50	106.66	88.57	112.00	103.59	32.07
Higher yield***@@	42.35	65.00	106.66	80.00	51.20	61.54	19.05
Drought resistance*@@@	52.4	49.94	40.56	32.24	50.99	44.28	13.71
Fit for chips making@	26.85	30.38	26.31	21.43	32.00	28.21	8.73
Early maturing*@	20.66	17.97	10.92	11.43	21.85	18.12	5.61
Free from cracking and deformities	12.86	15.47	20.73	16.29	14.42	15.09	4.67
Heat tolerance	11.31	15.82	19.98	16.57	13.24	14.43	4.47
Large and uniform tubers	16.67	12.50	5.56	14.29	12.67	13.25	4.10
Nutrient efficiency	15.63	11.88	8.35	8.16	15.73	13.02	4.03
Low degeneration rate of seed	11.02	12.96	8.67	4.91	15.11	11.46	3.55

#Indices were calculated assigning weights equal to 2 for 1<sup>st</sup>; 1 for 2<sup>nd</sup> and 3<sup>rd</sup>; and 0.5 for subsequent priorities: t test indicated statistically different response levels among potato farm size categories at \*10% and \*\*\*1% level of significance and between contract farming categories at @10%; @@5%; and @@@1% level of significance.

higher interest in getting drought tolerant potato varieties in the future. As the non-contract farmers are not able to sell their produce as processing grade potatoes hence they showed higher interest in getting a potato variety which is suitable for making potato chips. Due to resource paucity, smaller and non-contract potato farmers wanted early maturing potato variety in order to escape the severe late blight infestation in longer duration crop.

### Conclusions

FAO has identified potato as one of the important food crops for fighting food insecurity and poverty in the world (FAO 2008) and India needs to seriously think and act in this direction (Chand *et al.* 2007, Pandey *et al.* 2005). India has shown tremendous growth in potato production and processing during recent years. However Indian processing industry faces severe scarcity of processing quality potatoes during September to December months particularly in the south western parts of the country. Hassan district of Karnataka plays an imperative role of bridging this demand-supply gap in processing grade potatoes. But, the decreasing potato yield and profitability of potato farmers in the study area is a real threat to the sustainability of local potato husbandry and growth of potato processing in the country. The impending heat and moisture stress on account of global warming and climate change have been estimated to further deteriorate potato profitability scenario in the future. Root cause of farmers' problems in this area revolves around poverty, heat, inadequate irrigation water and enhanced late blight infestation in the recent past.

### REFERENCES

Bates B C, Kundzewicz Z W, Wu S and Palutikof J P (Eds). 2008. Climate change and water. Technical Paper. IPCC Secretariat, Geneva.

- Chand R, Raju S S and Pande L M. 2007. Growth crisis in agriculture: severity and options at national and state levels. *Economic and Political Weekly* 42(26): 2 528–33.
- FAO. 2008. New light on a hidden treasure. An end-of-year review (International Year of the Potato-2008). FAO, Rome, p 148.
- DES. 2011. State-wise potato area and production statistics. Directorate of Economics and Statistics, Ministry of Agriculture, Government of India.
- Kadian M S, Luthra S K, Patel N H, Bonierbale M, Singh S V, Sharma, Neeraj, Kumar V, Gopal J and Singh B P. 2012. Identification of short cycle, heat tolerant potato (*Solanum tuberosum*) clones for the semi-arid agro-ecology. *Indian Journal of Agricultural Sciences* (communicated).
- Keijbets M J H. 2008. Potato processing for the consumer: Developments and future challenges. *Potato Research* 51(3): 271–81.
- Lal S S, Govindakrishnan P M, Dua V K, Singh J P and Pandey S K. 2008. Impact assessment of climate change for research priority planning in horticultural crops. CPRI, Shimla, 228 p.
- Pandey S K, Singh S V and Sarkar D. 2005. Potato (*Solanum tuberosum*) for sustaining food and nutrition security in developing world. *Indian Journal of Agricultural Sciences* 75(1): 3–18.
- Rana Rajesh K and Pandey S K. 2007. Processing quality potatoes in India: An analysis of industry's demand. *Processed Food Industry* 10(8): 26–35.
- Rana Rajesh K, Pandey N K, Pandit A, Kumar N R. 2009. Estimation of demand of processed potato products and processing quality potato in Punjab. *Indian Journal of Agricultural Economics* 64(1): 123–32.
- Rana Rajesh K. 2011. The Indian Potato Processing Industry-Global comparison and business prospects. *Outlook on Agriculture* 40(3): 237–43.
- Rana Rajesh K, Sharma, Neeraj, Kadian M S, Girish B H, Arya S, Campilan D, Pandey S K, Carli Carlo, Patel N H and Singh B P. 2011. Perception of Gujarat farmers on heat-tolerant potato varieties. *Potato Journal* 38(2): 121–9.

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

Singh J P, Lal S S, Govindakrishnan P M, Dua V K and Pandey S K. 2008. Climate change and potato production in India. Poster presented in Global Potato Conference – 2008, December 9-12, 2008, New Delhi.