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STATUS OF POTATO HUSBANDRY AND FARMER'S SOCIO-ECONOMIC PROFILE IN MOISTURE AND HEAT PRONE KARNATAKA, INDIA

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Hassan district of Karnataka (India) plays an important role of providing processing grade potatoes (*Solanum tuberosum*) during September to December months when there is real dearth of such potatoes in the country. However, shallow soils, low soil carbon, inadequate irrigation water (126% cropping intensity in study area) and heat stress have been bothering farmers of this area for a long time. In addition, severe late blight infestations during recent years have played havoc for potato farmers, dragging average potato productivity in the area to sub seven tonne/ hectare levels. Current study was carried out to analyse socio-economics of potato farmers in Hassan district of Karnataka so that policy makers and development agencies take right decisions towards upliftment of potato farmers of this area. District wise annual compound growth rates (ACGRs) of potato area, production and productivity were estimated for the period during 1999-00 to 2009-10. During this period, potato area in Hassan district expanded at 11.5% ACGR, the corresponding production and productivity figures decelerated by 2 and 12%, respectively. The study of various socio-economic factors revealed that the sampled households were deprived of even the basic household necessities such as food security (33% total and 65% landless labourer respondents), personal water connection (72% respondents) and toilets (68% respondents). Potato contract farming arrangements between potato farmers and the leading contractor, PepsiCo India were also studied. This article recommends enhanced emphasis of Indian government on irrigation development under various rural development schemes and consolidation of land holdings in order to facilitate farm mechanization and improved agricultural profitability.
Keywords: Contract farming, heat stress, moisture stress, processing, socio-economics

INTRODUCTION

India has attained potato (*Solanum tuberosum*) production of 45 million ton from an area equal to 1.9 million hectare during 2012. Now India is the second largest producer of potato after China (85.9 million ton) and has higher productivity (23.7 ton/ ha) than the world average (17.4 ton/ ha) and other top three potato producers *i.e.* China (15.8 ton/ ha), Russian Federation (13.4 ton/ ha) and Ukraine (16.2 ton/ ha) (FAOSTAT, 2013). Strong indigenous potato research and development program having domestic varietal development and seed production system is primarily responsible for this advantage.

Conventionally potato was consumed only as vegetable in India however, during previous decade processing sector has started consuming sizeable proportion of national potato production (Rana and Pandey, 2007; Keijbets, 2008; Rana *et al*., 2009; Rana, 2011). With increasing demand for processed potato products in the country several new processors are entering the industry while almost every established player has either expanded or is in the process of expanding processing capacities. However, procuring processing quality potatoes for running a plant throughout the year is one of the biggest challenges in the country for potato processors. The problem aggravates tremendously if the plant is located in southern or south-western parts of country. During September to December months these plants desperately depend on rainy season crop from plateau region and Hassan district of Karnataka is an important area in this regard.

Irrigation is very important determinant of yield especially for a crop like potato that has higher water requirement. About 79.5% agricultural crops in Hassan district of Karnataka are grown under un-irrigated and rain fed conditions (http://cgwb.gov.in/district_profile/karnataka/hassan_brouchure.pdf). Surface water and ground water are the major sources of irrigation in the district (Fig. 1 and 2). Although higher proportion of potato was cultivated by the respondent farmers on irrigated land in the district yet due to insufficient quantity of irrigation water, during intermittent failure of rains, the crop was severely affected by the moisture stress. Heat stress, shallow soils, low soil carbon, low water holding capacity of soils and rising trend of late blight severity were some other factors responsible for very low potato productivity in the area.

Global warming and climate change have been seen as the serious impending threats to the agriculture in Indian sub-continent in general and potato in particular, in the future (Hijmans, 2003; Lal *et al*., 2008; Rana *et al*., 2011; Shakoor *et al*., 2011 and Imran *et al*., 2013). 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. Karnataka has been estimated to face the highest decline in potato production by 2020 and 2050 (19.7%; 44.9%, respectively). Gujarat (18.2%; 31.8%); Maharashtra (13.0%; 24.6%) and Madhya Pradesh (9.7%; 16.6%) are other important potato producing states likely to be negatively affected by global warming during the years 2020 and 2050 (Singh *et al*., 2008).

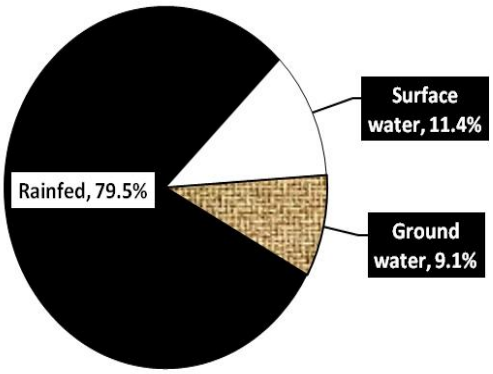

Figure 1. Irrigation status in Hassan district of Karnataka

Source: Central Ground Water Board, Ministry of Water Resources, Government of India

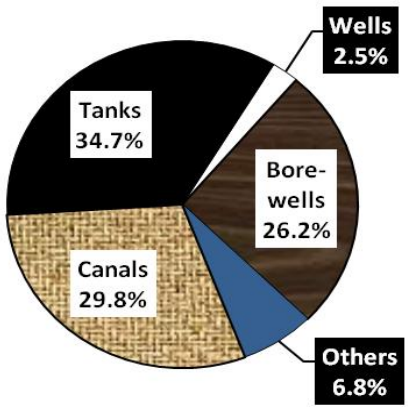

Figure 2. Source wise proportion of irrigation in Hassan district of Karnataka

Source: Central Ground Water Board, Ministry of Water Resources, Government of India

Ill effects of global warming are not restricted to just rise in temperature, by the year 2050, areas with water stress will double due to climatic change (Bates *et al*., 2008). Technological interventions have been worked out and suggested to deal with this problem using options related to agronomical (Hassanpanah and Benam, 2007; Minhas *et al.*, 2011), modelling (Govindakrishnan *et al.*, 2011) and breeding (Levy and Veilleux, 2007; Schafleitner *et al.*, 2007; Haverkort and Verhagen, 2008; Hassanpanah, 2010; Minhas *et al.*, 2011; Sharma *et al*., 2011; Rana *et al*., 2013a) levels.

In order to understand crop husbandry practices and socio-economics of the potato farmers, a joint survey by International Potato Centre, New Delhi, and Central Potato Research Institute, Shimla, was carried out in Hassan district of Karnataka during August and September months of 2009.

MATERIALS AND METHODS

Hassan being the leading supplier of processing quality potatoes during September to December months and the largest potato producing district in Karnataka along with being highly prone to moisture stress was purposively selected for this study. Potato cultivation in this district is carried out in rainy season (May to September; called *kharif* season in India). Potato produce of Hassan is in high demand due to its appropriateness for processing and dearth of processing quality potato in the country at this time. Taking into consideration the national importance of *kharif* potato in Karnataka and its declining yield trends the current study was targeted at understanding socio-economic determinant of potato farming in the state based on two year primary data *i.e.* year 2008 and 2009.

Hassan is situated on the Deccan plateau. The district was stratified into areas of plain and hilly topography. One cluster from each stratum was included as sample block. Potato contract farming is very important determinant substantially affecting crop husbandry in the study area (Singh *et al*., 2011). PepsiCo was the well established corporate contractor involved in potato contract farming and its activities were concentrated in Arsikere block which falls under stratum of plain area. Since contract farming is expected to govern future trend of potato cultivation in the study area therefore, Arsikere block and adjoining villages of Hassan block were purposively selected as a cluster out of plain areas of the district. Belur block was randomly selected from potato growing hill blocks of Hassan district, hence this block and its adjoining potato growing villages were selected as cluster out of hilly areas. Three potato growing villages from each selected block were randomly selected as sub-clusters for this study. The selected villages that constituted sub-clusters (including areas of adjoining villages) were Hannovar, Hallanhalli and Chigatihalli in plain stratum and Chilkur, Sankenhalli and Kartikere in hilly stratum of the district. Block and village wise potato growing necessary details were obtained from the office of District Horticulture Officer, Hassan, Government of Karnataka. The number of respondents in various categories from plain and hilly clusters was selected employing probability proportional to number of farmers in a particular category.

The respondents were selected from various backgrounds *viz*., non-farmers, non-potato growers (farmers who have not grown potato continuously for last two years *i.e.* 2008-09 and 2009-10) and various categories of potato growers *i.e.* marginal (potato area ≤1 ha), small (potato area >1 ha to ≤2 ha), medium (potato area >2 ha). Large category of potato growers (≥4 ha) was considered but due to less number of respondents (only 2) it was merged with medium category. Category wise details of number of sample households are given in Table 1. To conserve time and financial resources *vis-a-vis* the study objectives, the number of non-potato growers and landless agricultural labourers was intentionally kept less. However, the overall estimates were derived using population proportion in respective category as weight shown in the table. Figures 3 and 4 provide better understanding of population distribution among various categories. Interview schedule was designed to fulfil the survey requirements. Farmers' data were collected using personal interview technique. In addition to personal interviews, focus-group discussions were also carried out.

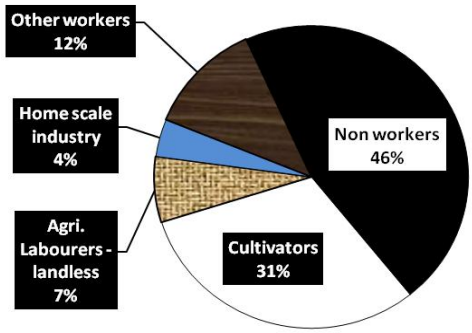

Figure 3. Occupational pattern in Hassan district of Karnataka

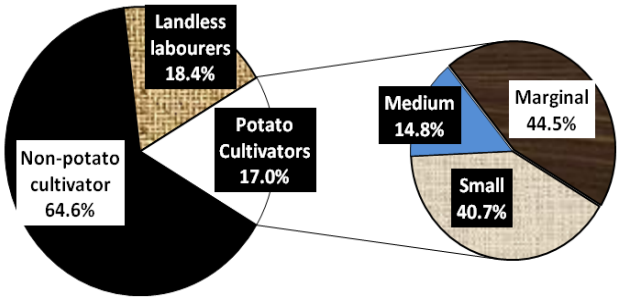

Figure 4. Distribution of farming family in Hassan district of Karnataka

Data were tabulated and analyzed using simple mathematical and statistical techniques such as averages and percentages. District wise Annual Compound Growth Rates (ACGRs) of potato area, production and productivity were estimated (1999-20 to 2009-10) and used to describe growth scenario among different districts of Karnataka. District wise potato area, production and productivity data were obtained online from Directorate of Economics and Statistics, Ministry of Agriculture, Government of India. Corresponding ACGRs for Karnataka state and national level were also computed. Following procedure was adopted to estimate the ACGRs:

$$Y_t = Y_o(1+r)^t$$

$$\text{or } \ln Y_t = \ln Y_0 + \ln(1+r)t$$

$$\text{or } Y_t = A + B*t \qquad [A = \ln Y_0 \text{ and } B = \ln(1+r)]$$

$$r = \exp(B) - 1$$

Here r = Annual compound growth rate (ACGR); exp = Exponential value; ln = Natural log; t = Time period in years for which ACGRs are calculated.

For assessing independence of responses among various farm size categories and contract farming categories of potato farmers, t tests for comparison of 'several population means' and 'two population means' were used.

RESULTS AND DISCUSSION

***Status of potato in Karnataka*:** Karnataka shares 4.1 and 1.4% of national potato area and production, respectively. Even on productivity front the state compares very poorly (<7 tonne/ hectare) to the national average (18.81 tonne/ ha; during 2009-10). Hassan is the most important potato producing district of Karnataka which contributes about 56% of potato area and more than 20% of potato production to the state (Table 2). However, lower proportion of potato production compared to the area under crop in this district presents very grim picture. For securing better control over raw material (processing grade potatoes) during lean period of September and December months, large potato processors like PepsiCo have established contract farming operations in these districts.

In order to have representation of all years' figures of potato area, production and productivity, ACGRs were also computed over 1999-00 to 2009-10 (Table 3). ACGRs indicate that potato production in the Hassan district and Karnataka state are primarily held by the large expansion in respective potato areas on account of better product prices due to off-season production and suitability for processing. The potato productivity ACGRs in Hassan and Karnataka showed negative 12 and 7% growth during this period. The overall potato production of the state and the country varied at an ACGR of 1.83 and 3.25%, respectively over this period.

***Socio-economics characteristics of the potato growers*:** Farmers in Hassan district of Karnataka are not prosperous due to the general problems in agriculture such as shallow soil depth, heat stress and unavailability of sufficient irrigation water. In addition, the potato farmers have experienced enhanced and severe late blight infestation

Table 1. Sampling details (Number of respondents)

Particulars	Cultivators						Land less agricultural labourers	All
	Potato growers@				Non-potato	All		
	Marginal	Small	Medium	All				
STRATUM/ VILLAGE WISE								
PLAIN STRATUM								
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
HILL STRATUM								
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
CONTRACT FARMING WISE								
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: 1. 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; 2. Being sampling details, this table has been shared as such or in the modified form in other publications out of the same study.

Table 2. Details of potato area, production and yield in Hassan, Karnataka and India

District	TE average area (ha)			TE average production (t)			TE average yield (t/ha)	
		2009-10#			2009-10#			
	2001-02	Area (ha)	% share@	2001-02	Production (t)	% share@	2001-02	2009-10#
Hassan	13615	39705	2.29	140194	90379	0.29	10.48	2.80
Karnataka	36700	70900	4.10	464033	441200	1.40	12.73	6.14
India	1256333	1731667	100.00	23646000	31450000	100.00	18.83	18.62

TE: Triennium ending year; #: The latest available district wise data from the DES, 2013 (June), was for the year 2009-10; @: in comparison to national average. This Table is taken from Rana *et al.* (2013b).

Table 3. Important ACGRs of potato area, production and productivity in Karnataka during 1999-00 and 2009-10

District/geography	Area	Production	Productivity
Hassan	11.47	-2.01	-12.09
Karnataka	9.52	1.83	-7.02
India	3.90	3.25	-0.62

The district wise data was taken online from the website of DES, 2013 (June). This Table is taken from Rana *et al.* (2013b)

during recent years. In order to understand exact socio-economic profile of potato farmers in the district, information on important indicators was collected (Table 4). Almost all studied indicators depict that economic conditions of potato growers were better than the non-potato growing farmers and the landless labourers were the worst in the lot. Among potato farmers the contract farming adopters had better economic conditions than the non-adopters. Invariably the potato farmers with larger holdings were enjoying better socio-economic conditions compared to those with the smaller holdings. The difference in various socio-economic indicators of wellbeing among or between the farm categories was found statistically significant in most of the studied attributes. Smaller holdings resulting into poverty have also been reported from other countries with similar socio-economic conditions (Hafeez *et al.*, 2011).

***Poverty indicators*:** Food security is principal concern of large proportion of people and governments in the Indian

Table 4. Average inventory of household assets and standard of living

Particulars	Potato growers						Non-potato growers	Total Growers	Landless	Overall
	Farm size			Contract farming		All Potato growers				
	Marginal	Small	Medium	Adopter	Non-adopter					
Motorcycle (No.)***@@	0.36	0.42	0.83	0.66	0.35	0.46	0.32	0.35	0.00	0.28
House condition (1-5)#*	2.83	2.87	3.75	3.04	2.96	2.99	2.63	2.71	1.61	2.58
Food security (%)**@@	69.44	79.38	89.00	89.29	69.23	76.25	73.68	74.22	35.29	67.07
Water connection (%)*	44.12	38.71	50.00	46.43	40.82	42.86	31.58	33.93	0.00	27.69
Electrification (%)	97.22	96.88	100.00	98.08	96.43	97.50	84.21	86.99	88.89	87.34
Sanitation (%)										
Flush toilet*	8.33	3.13	16.67	7.69	7.14	7.50	-	6.06	0.00	5.98
Temporary toilet	30.56	34.82	33.33	34.62	28.57	32.50	21.05	30.30	0.00	25.64
Open field*	61.11	62.50	50.00	57.69	64.29	60.00	78.95	63.64	100.00	68.38
School type of children										
Government*	77.27	68.18	57.14	67.65	76.47	70.59	88.89	85.07	100.00	87.82
Private**@	22.73	31.82	42.86	32.35	23.53	29.41	11.11	14.93	0.00	12.18
TV (%)**@@	41.67	46.88	66.67	64.29	38.46	47.50	31.58	34.90	5.88	29.57
Landline (%)	22.22	18.75	25.00	21.43	21.15	21.25	15.79	16.93	5.88	14.90
Mobile (%)*	75.00	77.42	91.67	82.14	76.47	78.48	52.63	58.02	64.71	59.26

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; #: 1=very bad, 2=bad, 3=average, 4=good and 5=very good

sub-continent (Amir *et al*., 2013; Singh and Rana, 2013) The resource scarcity of the sampled farmers is depicted by the fact that only 35% of landless labourers had food security compared to 74% in case of all farmers. Just 32 and 43% of non-potato growers and potato growers, respectively, had water connection in their houses. The state of electrification was better in the area compared to other socio-economic indicators. The state of availability of toilets in the sampled households was pathetic as all landless labourers were using open fields for toilets while less than 40% farmers had toilets in their households. Very high proportion of toilets was temporary in nature without proper flushing system that may lead to diseases and infections. More than 52 and 68% potato farmers and non-potato farmers didn't possess television sets in their houses, while about 42% of farmers were without mobile phones. Due to nature of their job, landless labourers were having mobile phones (65%) in higher proportion than the farmers. Direct relation between smaller holdings or landlessness to food insecurity and hindrance of agricultural technology transfer due to lack of possession of electronic equipments by farm families have been reported by Bashir *et al.* (2012) and Muhammad *et al*. (2012).

***Land use pattern*:** On an average the respondent potato farmers were using 60% of cultivated land for potato growing (Table 5).This proportion ranged between 42% on marginal farms to 74% on small farms. Proportion of potato area in total cultivated land on contract farms (with PepsiCo) was about 35% higher compared to non-contract farms. Overall 76% of land was irrigated and 87% potato crop in the study area was irrigated. However, the irrigation was not sufficient and the crop was exposed to moisture stress due to intermittent failure of rains. The cropping intensity varied from 117% (non-potato farmers) to 160% in case of small potato growers.

***Crop wise area*:** At present potato was the crop grown on the highest proportion of cropped land among potato growers except marginal category who put slightly more area under maize than potato (Table 6). It is worth mentioning here that due to sever late blight infestation during 2008 potato profitability was adversely affected which led to drastic decrease in potato area during 2009. The non-potato farmers put highest cropped area under maize followed by other crops (including groundnut, pulses and other oilseeds), *ragi* (finger millet) and ginger.

Table 5. Land use pattern of sampled households (Land in ha)

Particulars	Potato growers						Non-potato growers	All Growers
	Farm size			Contract farming		All potato growers		
	Marginal	Small	Medium	Adopter	Non-adopter			
Cultivated land (owned)								
1. Irrigated	0.919	1.429	4.180	2.072	1.352	1.611	0.838	1.000
2. Rain fed	0.473	0.368	0.405	0.279	0.498	0.421	0.494	0.478
Cultivated land (rented in irrigated)	0.069	0.036	0.170	0.113	0.049	0.069	0.045	0.049
Self cultivated land								
1. Irrigated	0.963	1.465	4.350	2.185	1.384	1.671	0.890	1.052
2. Rain fed	0.445	0.368	0.405	0.251	0.494	0.409	0.441	0.433
Potato land irrigated	0.469	1.202	2.699	1.712	0.757	1.097	0.000	0.231
Potato land rain fed	0.146	0.158	0.235	0.028	0.243	0.166	0.000	0.036
Total Potato land	0.615	1.360	2.934	1.740	0.996	1.263	0.000	0.263
Uncultivated land	0.053	0.000	0.000	0.028	0.020	0.024	0.045	0.040
Total cultivated land holding	1.457	1.833	4.755	2.465	1.898	2.100	1.376	1.526
Cropping intensity (%)	141.660	160.23	144.440	153.140	146.260	148.950	117.370	126.210

Table 6. Average area under different crops (ha)

Crops	Potato growers						Non-potato growers	All growers
	Farm size			Contract farming		All potato growers		
	Marginal	Small	Medium	Adopter	Non-adopter			
Maize	0.672	0.724	1.906	1.004	0.805	0.874	0.680	0.720
Ginger	0.008	0.024	0.000	0.004	0.020	0.012	0.065	0.053
Wheat	0.024	0.182	0.607	0.490	0.000	0.174	0.000	0.036
Potato	0.627	1.360	2.934	1.740	1.004	1.267	0.000	0.263
Vegetable	0.057	0.000	0.069	0.028	0.040	0.036	0.000	0.008
Ragi	0.389	0.538	0.692	0.364	0.567	0.494	0.360	0.389
Fodder	0.016	0.000	0.000	0.020	0.000	0.008	0.000	0.000
Other	0.271	0.109	0.660	0.125	0.340	0.263	0.510	0.457
Total cropped area	2.064	2.937	6.868	3.775	2.776	3.128	1.615	1.926

***Potato contract farming*:** Hassan district being strategically very important for potato processors like PepsiCo and ITC, contract farming was well established form of potato cultivation here. ITC being new player was still establishing itself in the area however, PepsiCo was a well established player and all contract potato farmer respondents for this survey were from PepsiCo which started operations in this area during 2003. Very high proportion of contract farmers was satisfied with their contract farming experiences with PepsiCo (Table 7). While the non-contract potato farmers reduced area under Kufri Jyoti (non PepsiCo variety) by more than 8% during 2009, PepsiCo contract farmers increased average area under contract farming by 7.5%. Rejection of produce has been the largest source of conflict between contract farmers and corporate partners in India. About one tenth of potato produced under contract farming was rejected by PepsiCo on the ground of unacceptable size (96%) and late blight infected tubers (4%). Rejection rate gradually decreased as the size of potato holding increased due to better grading by larger farmers. However, provision of quality inputs at door steps of poor and small farmers and timely transfer of technical knowledge was the biggest positive of contract farming. Effect of improved technology on farm income and production of small farmers have also been reported from other developing countries (Adisa *et al*., 2013)

***Soil health awareness*:** Soil conditions in Hassan are not ideal for very good crop husbandry. Farmers of this area pay very high attention to maintain soil health to sustain productivity. More proportion of adopters of potato contract farming opted for testing of their soils than the non-adopters of potato contract farming (Table 8). The proportion of non potato growers undertaking soil testing was less than one fifth of the potato growers. Since incorporation of farm yard manure (FYM) to the soil is a common practice in the area, about 69% potato and 67% non-potato respondents were attempting carbon sequestration in this mode. Very large proportion of potato respondents (58%) perceived no change

Table 7. Contract Farming (Responses from Contract Farmers)

Particulars	Farm size			All Adopters
Experience	**Marginal**	**Small**	**Medium**	
Good	80.00	100.00	100.00	96.30
Bad	20.00	0.00	0.00	3.70
Area under contract farming (ha)				
2008-09	0.708	1.226	2.833	1.837
2009-10	0.708	1.295	3.238	1.975
Quantity produced (t/ha)				
2008-09	7.58	11.27	11.29	9.02
2009-10	5.46	5.76	7.34	5.46
Rejected (%)	11.98	11.53	8.12	10.11
Reason of rejection (%)				
Odd size	100.00	91.67	100.00	95.83
Late Blight affected tubers	0.00	8.33	0.00	4.17

Table 8. Soil health awareness indicator

Particulars	Potato growers						Non-potato growers	All growers
	Farm size			Contract farming		All potato growers		
	Marginal	**Small**	**Medium**	**Adopter**	**Non-adopter**			
Soil testing index (0-1)*@@	0.222	0.375	0.250	0.393	0.130	0.288	0.053	0.102
Carbon sequestration (FYM)*	0.722	0.545	0.833	0.621	0.692	0.667	0.263	0.347
Soil amelioration*@@	0.139	0.273	0.167	0.345	0.115	0.198	0.053	0.083
Reduction in water holding capacity (% responses)*	40.00	41.38	60.00	37.50	46.00	39.51	26.32	29.07
Change in soil texture and structure# (% responses)								
Better	31.30	34.50	40.00	29.17	36.17	33.80	66.67	59.81
Same	62.50	58.60	40.00	66.67	53.19	57.75	22.20	29.67
Worse	6.20	6.88	20.00	4.17	10.64	8.45	11.10	10.55

#:over last 10 years

in their soil texture and/ or structure. However the proportion of potato respondents perceiving betterment in soil texture/ structure (34%) was much higher than those who felt deterioration (8%) over last 10 years. Two-third of non-potato respondents elicited betterment in soil structure/ texture. About 40% potato respondents believed that their soil water holding capacity has decreased over the last ten years. The proportion of such respondents was much lower in case of non-potato growers. Category wise average responses were statistically significant for four out of five studied attributes under this head.

***Irrigation status*:** Furrow irrigation was the predominant method of irrigation followed by sprinkler and drip irrigation in the study area (Table 9). Selling and purchasing of irrigation water was a common practice in Hassan district and the average price for one hour irrigation was just Indian National Rupees (INR) 41. Time taken to irrigate one hectare of land varied from 7.5 to 12.5 hours as the flow of water (underground extraction) was very less. Since water availability situation in the study area was quite irregular and abrupt, very high proportion of potato and non-potato growing respondents elicited less or scarce availability of irrigation water. Scarcity of irrigation water forced farmers not to grow potatoes in *rabi* season (winter season from November to February). All respondents elicited irrigation water quality in the study area as good. Method of irrigation and status of availability of irrigation water statistically differed among farm size categories and between contact farming categories in the study area.

***Level of mechanisation*:** Mechanisation is a strong indicator of importance of agriculture in the household and local socio-economics. However, mechanization level in the study area was very low due to poverty and small and fragmented land holdings. Tractors (accounting for full mechanization) were used only for field preparation. Only the medium farmers used tractors for 100% field preparation while 76% of all potato growers used tractor for this operation (Table 10). Overall about 24% potato growers used bullocks (considered partial mechanization) for field preparation. Potato planting was primarily carried out with the help of bullocks but about 6% (mainly marginal and non-contract farmers) did planting manually (considered no

Table 9. Irrigation status and quality of irrigation water

Particulars	Potato growers						Non-potato growers	All growers
	Farm size			Contract farming		All potato growers		
	Marginal	Small	Medium	Adopter	Non-adopter			
Type of irrigation (%)								
Furrow**	62.92	60.37	40.00	58.88	56.86	57.74	75.00	71.40
Sprinkler**	32.92	32.22	60.00	33.70	40.29	37.42	25.00	27.59
Drip	4.17	7.41	--	7.41	2.86	4.84	--	1.01
Water availability (%)								
Adequate**	36.11	15.63	8.33	--	36.54	23.75	31.58	29.95
Less*@@	63.89	75.00	83.33	96.43	57.69	71.25	26.32	35.70
Scarce	-	9.37	8.33	3.57	5.77	5.00	42.10	34.35
Sale/Purchase of water (%)	32.26	25.81	18.18	34.62	23.40	27.40	50.00	45.28
Price of water (INR/hr)	38.00	35.00	37.50	35.60	37.70	36.80	42.50	41.31

Note: All respondents reported quality of irrigation water as good; INR=Indian National Rupee1

Table 10. Level of mechanisation (% responses)

Responses	Potato growers					
	Farm size			Contract farming		All potato growers
	Marginal	Small	Medium	Adopter	Non-adopter	
Field preparation (mechanization index; 0-1)	0.83	0.89	1.00	0.86	0.89	0.88
Partial	33.33	28.88	-	28.57	21.15	23.75
Total mechanization	66.67	78.13	100.00	71.43	78.85	76.25
Planting (mechanization index; 0-1)	0.43	0.50	0.50	0.50	0.45	0.47
No mechanization	13.89	-	-	-	9.62	6.25
Partial	86.11	100.00	100.00	100.00	90.38	93.75
Spraying (mechanization index; 0-1)	0.00	0.03	0.17	0.11	0.00	0.04
No mechanization	100.00	93.75	66.67	78.57	100.00	92.50
Partial	-	6.25	33.33	21.43	-	7.50
Earthing up (mechanization index, 0-1)	0.30	0.30	0.40	0.30	0.30	0.30
No mechanization	30.56	40.63	16.67	32.14	32.69	32.50
Partial	69.45	59.37	83.33	67.86	67.31	67.50
Digging (mechanization index, 0-1)	0.50	0.50	0.50	0.50	0.50	0.50
No mechanization	-	-	8.33	-	1.92	1.25
Partial	100.00	100.00	91.67	100.00	98.08	98.75

Note: Mechanization index was calculated assigning equal weight to full; half weight to partial; and zero weight to no mechanization.

mechanization). Use of power sprayers was considered partial mechanization and only 7.5% potato growers (no non-contract farmer) used such mechanization. Earthing up operation was carried out by two third potato growing respondents with the help of bullocks while rest of them did it manually. Except very few, the potato growers in the study area used bullocks for digging potatoes from the soil. The mechanization index ranged between the highest of 0.88 for field preparation to the lowest of 0.04 for spraying.

***Conclusions*:** Karnataka state in general and Hassan district in particular is strategically very important destination for Indian potato processors. This region bridges the gap in demand and supply of processing grade potato tubers during September and December. However, shallow soils, low soil carbon, heat stress, inadequate irrigation water, intermittent failure of rains and enhanced late blight infestation during recent years have drastically deteriorated profitability of sampled farmers. All these factors make this district an inhabitation of poor people where 33% of the households didn't have food security and 68% households were using open fields/ places as toilets. The sub 7 tonne/ hectare potato productivity as a dismal indicator of economic well being of growers in Hassan district is the real cause of concern for the development agencies as well as potato processing industry. In order to help potato farmers tackle the heat and drought stresses much more efficiently, International Potato Centre (CIP), New Delhi Centre and Central Potato Research

Institute (CPRI), Shimla are jointly developing heat and drought tolerant potato varieties for the farmers of such areas (Sharma *et al.*, 2011).

Some of the contractor companies have put sincere efforts in this direction and prepared a package of technologies for their adopted farmers which resulted in marked difference in yield levels of contract versus non-contract farmers. However, much is still left to be done by the state development agencies in the form of providing/ ensuring quality inputs at affordable prices to the farmers of this region. Overall the contract farming experience of this area was evaluated as a positive development in the interest of local potato farmers.

Inadequate availability of irrigation water and intermittent failure of rains are the prime reasons for low agricultural yields including potato in this area. Although, the state government is providing attractive subsidy on the use of micro-irrigation apparatuses, yet the resource-poor farmers with small and fragmented holdings are unable to get benefitted out of the scheme to the fullest extent. State government needs to act seriously in this direction where other rural development schemes such as Mahatama Gandhi National Rural Employment Guarantee Scheme (MNREGS) need to be linked with irrigation development. Similarly consolidation of farm holdings needs to be practiced to give impetus to the farm mechanization as potato crop responds to farm mechanization in a positive way.

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