

Analysis of Pre-requisites and Framework for Introducing Potato Crop in Non-traditional Anantapuramu District of Andhra Pradesh

Rajesh K. Rana^{*1}, S. Arya^{**}, Sanjay Kumar^{*}, B. P. Singh^{*}, G. Adinarayana^{***}, Shalander Kumar^{****} and M. S. Kadian^{**}

ABSTRACT: As per FAOSTAT database, India is the second largest producer of potatoes (45.34 million tonne in 2013) after China (88.99 million tonne in 2013). However, Indian potato production has not been uniformly distributed over its regions and states. About 80% potatoes are produced in Indian Indo-Gangetic plains whereas southern states collectively produce very meagre quantities of potatoes. Karnataka, is an important producers of kharif potatoes which are sold at premium price due to their off season supply. A very large proportion of kharif potato production from the south India is diverted to processing industry and hence the fresh availability of potatoes in the region becomes inadequate to meet the local demand. Consequently, the potato prices in the region remain very high throughout the year in southern part of the country. In order to device a sustainable solution to the problem, CIP and CPRI carried out a joint study to assess feasibility of introducing potato crop in south-western Anantapuramu district of Andhra Pradesh. Notably Andhra Pradesh produces just 1.7 kg/capita potatoes against 9.1 and 34.2 kg/ha at Karnataka and All India level, respectively. Results of this study give very strong indication about successful potato cultivation in selected villages of Anantapuramu district along with a comprehensive action plan for introduction of potato crop in the non-traditional area.

Keywords: Analysis of pre-requisites, Anantapuramu, non-traditional areas, potato cultivation.

INTRODUCTION

It has been widely documented that India is the second largest potato producer (45.34 million tonne in 2013) after China (88.99 million tonne in 2013). Nearly 80% potatoes in India are produced in the Indo-Gangetic plains in winter under short day conditions. South India produces very meagre quantities of potatoes (1.95% of national production). Karnataka is a well known for supplying off-season and fresh potatoes from its *kharif* crop not only to the potato processing companies but to northern markets like Delhi too. The difference of potato prices between north and south Indian states is much prominent and wide due to meagre potato supply from southern states during *rabi* season. A significant quantity of *kharif* season potato from southern states is consumed by the processing industry due to high dry matter and low reducing sugars, the supply of fresh potatoes in the region becomes limited to meet local demand at affordable

prices. Consequently, the potato prices in the region remain abnormally high throughout the year in southern part of the country keeping consumers at huge disadvantage.

It is worth noting that during triennium ending 2013-14, Andhra Pradesh produces just 1.7 kg/capita/year potatoes compared to 9.1 and 34.2 kg/capita/year at Karnataka and national level, respectively. All India average per capita/year potato production excluding south Indian states is still better at 42.4kg against 2.2 kg/capita/year for south Indian states collectively (**Table 1**). It indicates the real shortage of potato production in south India. Due to long distances of these states from the main potato producing north India, it takes long time for transporting the produce to south and in between the quality is deteriorated due to non-availability of cold chain transportation system. The systematic and scientific identification of such areas has not been

* ICAR-Central Potato Research Institute, Shimla, 171 001, HP, India, ¹E-mail: rkrana2004@yahoo.com

** International Potato Centre, CWSA, DPS Marg, NASC Complex, New Delhi-100 012, India.

*** Agricultural Research Station, DCMS Building, Kamala Nagar, Anantapuramu-515 001, AP, India.

**** International Crop Research Institute for the Semi-Arid Tropics, Patancheru, 502 324, Telangana, India.

Table 1
State-wise potato production and per capita availability in South-Indian states vis-a-vis rest of India

| Region | Population (million) | | | Potato Production (million kg) | | | Per capita production (Kg/year) | | | |
|-------------------|----------------------|---------|-------|--------------------------------|----------|-----------|---------------------------------|----------|----------|-------|
| | 2001 | 2011 | ACGR# | 2013 | 2000-01@ | 2013-14 @ | ACGR# | 2000-01@ | 2013-14@ | ACGR# |
| Andhra Pradesh | 76.21 | 84.58 | 1.05 | 86.36 | 12.17 | 145.87 | 21.05 | 0.16 | 1.69 | 19.88 |
| Karnataka | 52.85 | 61.1 | 1.46 | 62.90 | 441.73 | 573.67 | 2.03 | 8.36 | 9.12 | 0.67 |
| Kerala | 31.84 | 33.41 | 0.48 | 33.73 | - | 6.33 | - | - | 0.19 | - |
| Tamil Nadu | 62.41 | 72.15 | 1.46 | 74.27 | 91.7 | 108.54 | 1.31 | 1.47 | 1.46 | -0.05 |
| Goa | 1.35 | 1.46 | 0.79 | 1.48 | Nil | Nil | - | Nil | Nil | - |
| Lakshadweep | 0.06 | 0.06 | 0.00 | 0.06 | Nil | Nil | - | Nil | Nil | - |
| Puducherry | 0.97 | 1.25 | 2.57 | 1.32 | Nil | Nil | - | Nil | Nil | - |
| Andaman & Nicobar | 0.36 | 0.38 | 0.54 | 0.38 | Nil | Nil | - | Nil | Nil | - |
| Total South India | 226.05 | 254.38 | 1.19 | 260.46 | 545.6 | 834.41 | 3.32 | 2.41 | 3.20 | 2.21 |
| Rest of India | 802.69 | 956.47 | 1.77 | 990.59 | 22943.27 | 41959.51 | 4.75 | 28.58 | 42.36 | 3.07 |
| Total India | 1028.74 | 1210.85 | 1.64 | 1250.97 | 23488.87 | 42793.92 | 4.72 | 22.83 | 34.21 | 3.16 |

#: ACGR values are in term of percentages; @: averages of triennium ending this year.

Source: National Horticulture Board (2014-15), and Census of India (2011), Government of India.

pursued to the desired extent. In order to devise a sustainable solution to the problem, CIP and CPRI carried out a joint study to assess feasibility of introducing potato crop in south-western Anantapuramu district of Andhra Pradesh.

METHODOLOGY

A diagnostic study on feasibility of potato cultivation in non-traditional potato growing areas of Anantapuramu district of Andhra Pradesh, was conducted with special emphasis on analysis of pre-requisites of potato cultivation in the area. Suitability of soil, availability of irrigation water during *rabi* (winter) season, favourable temperature conditions, availability of farm labour, extent of technical knowhow (both existing and potential) and efficient potato marketing system were some of the salient pre-requisites targeted in this study. Both primary and secondary information was used for this study. Secondary information on proportion of agriculture labourers in the total workforce, land use pattern, temperature data and information on soil types was considered. Detailed primary information on various aspects of feasibility of potato cultivation in the study area was carried in the form of a specially designed survey.

The survey was carried out during August 2014 in two districts of Andhra Pradesh *viz.* Anantapuramu and Kurnool. Forty farmer respondents from three villages (Kurlapalli, Mallapuram and Chintralapalli) of Anantapuramu and twenty seven farmer respondents from two villages (Bonthiralla and Yerragunthla) of Kurnool, making a total of sixty seven from both the districts, were interviewed in the survey. Villages were selected with the guidance of officers at Agricultural Research Station, Anantapuramu, Horticultural Research Station,

Anantapuramu, Directorate of Horticulture, Anantapuramu and ICRISAT. The respondents were selected with the help of simple random sampling and the interviews were conducted with the help of semi-structured questionnaires specifically designed for this diagnostic study. With this survey micro level investigations were made into deeper analysis of pre-requisites of potato cultivation in the study area. In order to assess profitability of potato cultivation in the area vis-a-vis other competing crops a comprehensive profitability analysis of such crops was also carried out. The estimated potato profitability in the sampled villages in Kurnool was less attractive in order to present a compelling situation for adoption of potato cultivation, hence, this district was not considered for the introduction of potato cultivation in the first phase. Rest of the paper discusses only the sampled villages in Anantapuramu district as the potential area for introduction of potato cultivation.

Annual compound growth rates (ACGRs) were calculated for population numbers, state/region wise potato production and per capita potato availability over two points in the period of time. The ACGRs were computed with the help of following expression:

$$r = \exp \left[\left(\ln \frac{Y_1}{Y_0} \right) / t \right] - 1$$

Where: r = Annual compound growth rate;
 \exp = Exponential value
 \ln = Natural log;
 Y_1 = Value at end of the interval for which ACGRs are calculated;
 Y_0 = Value at beginning of the interval for which ACGRs are calculated;
 and

t = Length of time interval in years for which ACGRs are calculated.

Values were forecasted using the following expression:

$$Z_1 = Z_0(1 + r)^t$$

Where: Z_1 = Value at end of the interval for which figures are forecasted;

Z_0 = Value at beginning of the interval for which figures are forecasted: and

t = Length of time interval in years for which figures are forecasted.

to cover each and every farmer in the study area. This analysis further supported the idea of introducing a new profitable crop in the study area.

Credit availability

The existing crops grown in the study area being less intensive in capital needs, the credit limits on Kisan Credit Cards or other credit instruments were found to be less than adequate. Potato cultivation being more intensive in capital needs, the credit limits of potential potato growers should be revised upwards if this crop is introduced in the study area.

Soil type

The soils in Anantapuramu district are 76% red and 24% black (GOAP, 2015). Gravel free red soils with needed fertility are suitable for potato cultivation and the villages were selected keeping this in into consideration. The surveyed villages possessed sandy loam soils which are suitable for successful cultivation of potatoes.

Profitability of competing crops

Musk melon/ cantaloupes, pomegranate, papaya, chillies, tomatoes, water melons, mangos, pigeon pea, small millets, groundnut, castor, onion, brinjal and cotton are the potato's competing crops, but potato was found to be one of the most profitable crops on per unit time basis (Rana *et al.*, 2015). Hence, profitability of competing crops will not be a limiting factor for introduction of potato cultivation in the study area.

Availability of land

The district of Anantapuramu has 1.91 million ha of geographical land out of which 58.23% (1.11 million ha) is under agriculture (GOAP, 2015) with an average cropping intensity of 106.63% (Table 3), indicating that availability of land is not a limiting factor for introduction of a new crop in the existing farming

RESULTS AND DISCUSSIONS

Analysis of pre-requisites

Availability of farm labour

Potato cultivation being a labour intensive enterprise, the analysis of availability of farm labour is one of the very important pre-requisites for its introduction. The proportion of total population working as agricultural labourers has increased in the census data of 2011 vis-a-vis 2001 both in Andhra Pradesh as well as in Anantapuramu district (Table 2). Interestingly, as per 2011 census data 21.55% population in Anantapuramu district resorted to seeking employment as farm labour compared to 18.43% during 2001 census data presenting a poor overall rural development indicator. However, this adversity creates an opportunity for introduction of a labour intensive crop like potato in the area.

Irrigation status in rabi season

In the selected villages 60% (on an average 2.36 ha out of which 0.51 ha was irrigated rented in land) of the cultivated land was found to be irrigated in rabi season when potato cultivation can be successfully carried out in the study area. Local government has been very liberal in providing ample subsidy (up to 90%) on micro-irrigation equipments with the intent

Table 2
Proportional distributional of work force in Andhra Pradesh and Anantapuramu

| | Andhra Pradesh | | | | Anantapuramu | | | |
|--------------------|----------------------|-------|--------|--------|----------------------|------|--------|--------|
| | Actual No. (million) | | % age | | Actual No. (million) | | % age | |
| | 2001 | 2011 | 2001 | 2011 | 2001 | 2011 | 2001 | 2011 |
| Workers | | | | | | | | |
| Agriculture labour | 13.83 | 16.97 | 18.15 | 20.06 | 0.67 | 0.88 | 18.43 | 21.55 |
| Cultivators | 7.86 | 6.49 | 10.31 | 7.67 | 0.53 | 0.41 | 14.54 | 10.13 |
| Other workers | 11.56 | 15.96 | 15.17 | 18.87 | 0.48 | 0.74 | 13.05 | 18.21 |
| Total worker | 34.89 | 39.42 | 45.79 | 46.61 | 1.78 | 2.04 | 48.83 | 49.89 |
| Total population | 76.21 | 84.58 | 100.00 | 100.00 | 3.64 | 4.08 | 100.00 | 100.00 |

Source: Census of India (2011), Government of India.

system. Further, analysis of selected villages with the help of survey study indicates that average land holding of the respondent farmers was 3.95 ha which is not very large but yet sufficient for considering another crop by the farmers if that crop provides better economic returns.

Table 3
Land use pattern in Anantapuramu district

| Sr. | Category | Area (ha) |
|-----|---|-----------|
| 1. | Forests | 196978 |
| 2. | Barren land | 183451 |
| 3. | Land put to non-agricultural uses | 119810 |
| 4. | Cultivable waste | 52819 |
| 5. | Permanent pasture and other grazing land | 8951 |
| 6. | Land under miscellaneous tree crops not included in net area sown | 9652 |
| 7. | Current fallow | 143126 |
| 8. | Other fallow land | 84254 |
| 9. | Net area sown | 1113965 |
| 10. | Total geographical area | 1913000 |
| 11. | Total cropped area | 1187766 |

Source: [GOAP (2015); www.anantapur.gov.in, Government of Andhra Pradesh].

Mechanization level

Only 10% of the sampled households possessed tractors, but in the study area tractors were easily available on hiring bases as this service was largely provided by the non-farmers. About 15% of the respondents were preparing fields for sowing of seeds of different crops using bullocks. Similarly 44% of respondents did sowing operation manually while rest of respondents used bullocks for this operation. About 59.5% respondents carried out inter-cultural operations manually while this proportion was 58% for harvesting operation. Despite easy availability of tractors, several operations were carried out manually, which indicates that farm labour was easily available and economical. Potato machines especially planter and digger need to be ensured by the agricultural development agencies/personnel if potato cultivation has to be successfully introduced in the area.

Marketing infrastructure

Anantapuramu district has sufficient demand for its home grown fresh potatoes. However, 51% or estimated cost of potato cultivation in the study area is due to seed potatoes supplied by distant north-western Indian states. The local cold storage facility is crucial if home grown seed potato has to be partially used. Such development is likely to considerably reduce estimated cost for potato cultivation in this area, hence, local government need to support

potential potato growers with the facility of local cold storage.

Framework for potato crop introduction

Basic assumptions

The suggested plan is proposed with the assumption that farmers will be prepared/ trained/ supported to harvest a potato yield of ≥ 20 t/ha and they will get the opportunity to get an average per hectare targeted profitability from potato cultivation at \geq Rs. 75000/ha.

Challenges

The proposed action plan of introducing potato in this non-traditional area is subject to following challenges.

- Very deep ground water table results in very high cost of water extraction. Ground water availability is not uniform and there are only few locations in different villages where water is available.
- Higher minimum (average $>18^{\circ}$ C) and maximum temperature (average $>30^{\circ}$ C) range before mid December and after mid February at Anantapuramu town, leaves very short window for potato cultivation as potato is quite susceptible to the high temperature stress (Nagarajan and Bansal, 1990; van Dam *et al.*, 1996; Levy and Veilleux, 2007).
- Long distance of seed potato producing states of north-western Indian, lack of affordability of farmers to purchase expensive seed and poor quality of seed potato in this region has been a serious concern affecting potato yields adversely (Rana *et al.*, 2013b; Rana *et al.*, 2014). Supply of seed potato from Chikballapur area was very poor in the past which resulted in poor potato yield. Planting time in many areas was not appropriate which further deteriorated potato profitability.
- Large segment of consumers get poor quality potatoes as the traders of Chikballapur area supply left out potatoes to this region. How consumers will favourably respond to the fresh and good quality locally produced potatoes as an adequate section of the consumers has capability and willingness to pay higher for quality products.

Opportunities

- The Anantapuramu market on an average trades 10 tonne potatoes every day. For this supply the traders depend mainly on

Chikballapur. Local farmers, based on their past potato growing experience and analysis, are readily prepared to cultivate potatoes. However, spurious seed potato at higher prices is their biggest bottleneck.

- Based on the opinion of experts, average minimum and maximum temperature in villages, Kurlapalli and Mallapuram is 1-2^o C lower than Anantapuramu town. Weather stations were recently installed in these villages and the village wise data were not available at the time of survey.
- State government is providing very high 90% subsidy on drip irrigation equipments which provides favorable conditions for potato cultivation in the area.
- Heat and drought tolerant potato varieties have been found on top of farmers' preference among new varieties in potato growing areas having higher temperature and moisture stresses (Rana *et al.*, 2011; 2013a). Tremendous research efforts have been put in this direction at Indian and global level (Minhas and Kumar, 2005; Schafleitner *et al.*, 2007; Hassanpanah, 2010; Monneveux *et al.*, 2013; 2014). Heat and moisture stress tolerant CIP clones are at advanced stage of releasing as potato varieties under Indian conditions (Sharma *et al.*, 2011; Kadian *et al.*, 2012; Sharma *et al.*, 2014).
- Initial supply of local produce will be meager and will be easily sold locally at premium price.
- Contract farming has been very important and fruitful concept in potato cultivation both for farmers as well as for the industry partners (Chaturvedi, 2007; Singh *et al.*, 2011; Pandit *et al.*, 2015; Rais *et al.*, 2013). There are ample opportunities for contract farming in potato where the output is well accepted in the market and is in short supply.

Needed initiatives

In order to make this endeavour successful, some initiatives needs to be taken by the agricultural/potato development agencies.

- Establishment of a robust seed potato supply chain with the active participation of potato growers under co-operative mode.
- Trainings of farmers to adopt latest scientific package of practices for potato cultivation should be part of core strategy.

Recommendation

Authors of this research article recommend following action plan for successful implementation of the proposed activity in the study area.

- On station (government research farm) potato cultivation trial may be conducted at Horticultural Research Station, Dr YSR Horticultural University, Anantapuramu-515 001, AP.
- Kurlapalli and Mallapuram in Anantapuramu district were found to possess advantage over the Anantapuramu town due to lower average reported temperature. On-farm trials and demonstrations may also be conducted in these villages for more precise information on feasibility of potato cultivation in the study area.

CONCLUSION

Potato has been widely described as global food and nutritional security option particularly for the poor people (Thiele *et al.*, 2010; Singh and Rana, 2013). Overall economic development and rapidly growing potato processing industry in India have changed the dynamics of potato demand in India (Singh *et al.*, 2014; Keijbets, 2008; Rana *et al.* 2010). During last few years the gap of potato prices in the northern and southern states has further widened due to such developments (Rana *et al.*, 2015). This study was an effort to identify potential new areas in southern India where potato can be successfully and profitably grown by the farmers. Results of detailed analysis of the pre-requisites of introducing potato in the study area give very strong indication about successful potato cultivation in selected villages of Anantapuramu district. A comprehensive action plan has been suggested for successful introduction of potato crop in this non-traditional area with an assumption of harvesting a potato yield of ≥ 20 tonne/ha. The action plan needs to be rigorously followed in order to tackle the listed challenges.

ACKNOWLEDGMENTS

Authors are thankful to the Indian Council of Agricultural Research, New Delhi, for financially supporting this study. Active support of Dr. B. Sahadev Reddy, Agricultural Research Station, Anantapuramu, Dr. K. Subramaniam, Horticultural Research Station, Anantapuramu, Mr. C.H.S. Satyanarayana and Mr. K. Chandershekhar, Directorate of Horticulture, Anantapuramu and ICRISAT in the form of local support and field guidance was very important for successful completion of this study.

REFERENCES

- Census of India, (2015), Census database for 2011, <http://censusindia.gov.in/>
- Chaturvedi R., (2007), Contract farming and Frito-Lay's model of contract farming for potato, *Potato Journal*, **34**(1-2): 147-150.
- FAOSTAT, (2015), FAO, statistical databases FAOSTAT, <http://faostat.fao.org/site/567/default>
- GOAP, (2015), Government of Andhra Pradesh, profit of district Anantapuramu, <http://anantapur.gov.in/home.html>
- Hassanpanah D., (2010), Evaluation of potato advanced cultivars against water deficit stress under *in vitro* and *in vivo* conditions, *Biotechnology*, **9**(2): 164-169.
- Kadian M. S., Luthra S. K., Patel N. H., Bonierbale M., Singh S. V. and Sharma N., 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*, **82**(9): 814-818.
- Keijbets M. J. H., (2008), Potato processing for the consumer: developments and future challenges, *Potato Research*, **51**(3): 271-281.
- Levy D., and Veilleux R. E., (2007), Adaptation of potato to high temperatures and salinity, A review, *American Journal of Potato Research*, **84**: 487-506.
- Minhas J. S., and Kumar D., (2005), Tuberization in heat tolerant hybrid HT/92-621 under controlled temperature conditions, *Potato Journal*, **32**: 195-196.
- Monneveux P., Ramírez D. A., Pino M-T., (2013), Drought tolerance in potato (*S. tuberosum* L.): can we learn from drought tolerance research in cereals? *Plant Science*, **205-206**: 76-86.
- Monneveux P., Ramírez D. A., Awais Khan M., Raymundo R. M., Loayza H., and Quiroz R., (2014), Drought and heat tolerance evaluation in potato (*Solanum tuberosum* L.) *Potato Research*, **57**: 225-247.
- Nagarajan S. and Bansal K. C., (1990), Growth and distribution of dry matter in a heat tolerant and a susceptible potato cultivar under normal and high temperature, *Journal of Agronomy and Crop Science*, **165**: 306-311.
- N. H. B., (2015), National Horticulture Database, <http://nhb.gov.in/>
- Pandit A., Lal B., and Rana Rajesh K., (2015), An assessment of potato contract farming in West Bengal state, India, *Potato Research*, **58**: 1-14.
- Rais M., Acharya S., and Sharma N., (2013), Food processing industry in India: S & T capability, skills and employment opportunities, *Journal of Food Processing Technology*, **4**(9): 1-13.
- Rana Rajesh K., Arya S., Kadian M. S., Singh B. P., Quiroz R. and Monneveux P., (2015), Socio-economic feasibility of potato cultivation in Andhra Pradesh, India, *Potato Research* (Communicated).
- Rana Rajesh K., Pandit A., and Pandey N. K., (2010), Demand for processed potato products and processing quality potato tubers in India, *Potato Research*, **53**: 181-197.
- Rana Rajesh K., Sharma N., Arya S., Kadian M. S., Singh B. P., (2013b), Seed potato utilization pattern and its impact on farmers' profitability in Karnataka, *Indian Journal of Agricultural Research*, **47**(6): 488-95.
- Rana Rajesh K., Sharma N., Arya S., Kadian M. S., Singh B. P., and Pandey S. K., (2014), Status of potato husbandry and farmers' socio-economic profile in moisture and heat prone Karnataka, India, *Pakistan Journal of Agricultural Sciences*, **51**(1): 7-16.
- Rana Rajesh K., Sharma N., Arya S., Singh B. P., Kadian M. S., Chaturvedi R., and Pandey S. K., (2013a), Tackling moisture stress with drought-tolerant potato (*Solanum tuberosum*) varieties: perception of Karnataka farmers, *Indian Journal of Agricultural Sciences*, **83**(2): 216-22.
- Rana Rajesh K., Sharma N., Kadian M. S., Girish B. H., Arya S., Campilan D., Pandey S. K., Carli C., Patel N. H. and Singh B. P., (2011), Perception of Gujarat farmers on heat tolerant potato varieties, *Potato Journal*, **38**(2): 121-29.
- Schafleitner R., Gutierrez R., Espino R., Gaudin A., Perez J., Martinez M., Dominguez A., Tincopa L., Alvarado C., Numberto G., Bonierbale M., (2007), Field screening for variation of drought tolerance in *Solanum tuberosum* L. by agronomical, physiological and genetic analysis, *Potato Research*, **50**(1): 71-85.
- Sharma N., 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 Agricultural Sciences*, **81**(9): 825-29.
- Sharma N., S. Rawal, M. S. Kadian, S. Arya, M. Bonierbale and Singh B. P., (2014), Evaluation of advanced potato clones for drought tolerance in arid zone in Rajasthan, India, *Potato Journal*, **41**(2): 189-193.
- Singh B. P. and Rana Rajesh K., (2013), Potato for food and nutritional security in India, *Indian Farming*, **63**(7): 37-43.
- Singh B. P., Rana Rajesh K. and Govindakrishnan P. M., (2014), Vision 2050, Central Potato Research Institute, Shimla, 26 p.
- Singh B. P., Rana Rajesh K. and Kumar M., (2011), Technology infusion through contact farming: success story of potato, *Indian Horticulture*, **56**: 49-51.
- Thiele G., Theisen K., Bonierbale M. and Walker T., (2010), Targeting the poor and hungry with potato science, *Potato Journal*, **37**(3-4): 75-86.
- van Dam J., Kooman P. L. and Struik P. C., (1996), Effects of temperature and photoperiod on early growth and final number of tubers in potato (*Solanum tuberosum* L.), *Potato Research*, **39**(1): 51-62.