

## PERCEPTION OF GUJARAT FARMERS ON HEAT-TOLERANT POTATO VARIETIES

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**ABSTRACT:** Present study attempted to understand farmers' perception on attributes they want in future potato varieties in heat-prone areas. For better understanding, priority index (PI; range 0 to 100) and per cent relative importance (RI) of desirable attributes were calculated. Potato farmers' response on yield enhancing attributes, desirable/ undesirable varietal characters, abandonment of varieties, heat/ drought stress, and priorities on attributes in future potato varieties were collected and analysed. Heat tolerance (PI=92; RI=22.5%) followed by high yield (PI=72; RI=17.5%), late blight resistance (PI=48.5; RI=12%), potato-tuber-moth resistance (PI=39; RI=9.5%) and large sized uniform tubers (PI=36; RI=9%) were the top five desirable characteristics. The other attributes in this sequence were drought tolerance, processing quality, early maturity, shining skin and good storability. Heterogeneity of responses on various factors/ attributes related to potato within farm categories was studied using Chi-square statistics.

**KEYWORDS:** heat-tolerant potato varieties, varietal attributes, farmers' perception, abandonment of varieties

### INTRODUCTION

Gujarat has emerged as the fastest growing potato state in India during recent years. During the triennium ending 2000-01 and 2006-07, the area and production in Gujarat grew by 33 and 65.7% compared to all India growth of 8.5 and (-) 1.2%, respectively (Kesari and Rana, 2008). Over the same period the share of Gujarat in national potato production rose from 3.01 to 5.04%. The annual compound growth rates of area and production over a period of 1998-99 to 2006-07 were equal to 4.5 and 7.9% for Gujarat against 1.3 and -0.5 for all India. The latest official potato production data shows that Gujarat (1.21 million MT in 2006-07 and 1.80 million MT in 2007-08) has replaced Punjab (1.22 million MT in 2006-07 and 1.48 million MT in 2007-08) as the third largest potato producing state in India after Uttar Pradesh and West Bengal (GOI, 2009).

Gujarat also has the distinction of attaining the highest potato productivity among all Indian states during the period 2004-05 and 2007-08.

Global warming has been perceived as one of the biggest future threats to Indian agriculture in general and potato in particular. Temperature is estimated to rise approximately by 1, 3 and 5 °C during main Indian potato growing (winter) season by the year 2020, 2050 and 2080, respectively (Lal *et al.*, 2008). Potato production at national level was estimated to decline by 9.6 and 16.1% in year 2020 and 2050, respectively, *vis-à-vis* the current production (Singh *et al.*, 2008) if no adaptation strategy is followed. However, the estimated respective reduction in potato production over 2020 and 2050, would be much higher in states like Karnataka (19.7 and 44.9%) followed by Gujarat (18.2 and 31.8%); Maharashtra (13

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and 24.6%) and Madhya Pradesh (9.7 and 16.6%).

Almost all crops in tropics and sub-tropics have been adversely affected by the ill effects of rise in average temperature during current decade. So there is an urgent need to develop varieties which can cope up with this threat. Potato is badly affected by high temperature during tuber initiation (Basu and Minhas, 1991) and tuber bulking stages (Minhas and Kumar, 2005). Developing heat tolerant potato varieties will not only enhance production but may also extend its cultivation to non-traditional potato areas. Keeping these points into consideration a project funded by GTZ "Enhanced Food and Income Security in SWCA through Potato Varieties with Improved Tolerance to Abiotic Stress" was initiated.

### Survey objectives

Many agricultural technologies, including varieties, are not adopted by the farmers. Generally the reasons for non-adoption are explored once the failure has already occurred. Better understanding of farmers' preference to various attributes in new potato varieties in Gandhinagar district of Gujarat was an important component of this study. In this study effort was made to answer following questions.

1. What actions farmers think, can further increase potato yield and income on their

farms?

2. What is farmers' perception on desirable and undesirable characters of existing potato varieties grown by them?
3. Why farmers abandoned some potato varieties in the past?
4. To what extent potato growers consider abiotic stresses a limiting factor?
5. What priorities farmers elicit as desirable characters in the future potato varieties?

### METHODOLOGY

Gandhinagar being one of the hottest potato growing districts of Gujarat was purposively selected for this study. Hence, the interventions suggested for this area were assumed to be applicable in all heat prone potato growing areas of the state. Three villages of Gandhinagar, *viz.*, Premnagar, Indirapura and Nandol were randomly selected for this study. The survey was conducted during February 2009.

Depending upon the broader project objectives, sample was selected from all economic backgrounds, *viz.*, non cultivators (non farmers), non potato growers (farmers who have not grown potato continuously for last two years *i.e.* 2007-08 and 2008-09) and various categories of potato growers (marginal, small, medium and large). Category wise details of sample households are given in **table 1**. The respondents were selected in such

**Table 1. Sampling details of the study**

| Villages       | Category of potato growers |       |        |       |       | Non potato farmers | Land less | All   |
|----------------|----------------------------|-------|--------|-------|-------|--------------------|-----------|-------|
|                | Marginal                   | Small | Medium | Large | All   |                    |           |       |
| Indirapuram    | 13                         | 10    | 2      | 1     | 26    | 5                  | 11        | 42    |
| Nandol         | 2                          | 2     | 9      | 14    | 27    | 1                  | 5         | 33    |
| Premnagar      | 3                          | 5     | 5      | 1     | 14    | 0                  | 4         | 18    |
| All            | 18                         | 17    | 16     | 16    | 67    | 6                  | 20        | 93    |
| Population (%) | 11.47                      | 16.22 | 7.99   | 3.47  | 39.15 | 6.15               | 54.70     | 100.0 |

Marginal = having potato area up to 2.5 acres; small = having potato area more than 2.5 acres and up to 5 acres; medium = having potato area more than 5 acres and up to 10 acres; and large = having potato area more than 10 acres.

a way that all categories were represented. The responses of non farmers and non potato growers were not considered for the current research paper. Detailed information about the sampled villages was obtained from *Panchayat* office (Village council). Out of this information, the proportion of actual population across the categories was calculated. Overall weighted averages were calculated using population proportion within categories as weights.

Interview schedule was specially designed to meet the requirements of survey. Before finalizing, the schedule was circulated among multidisciplinary team of scientists involved in the project. Data were collected using personal interview method. Potato farmers' perception on yield enhancing attributes, desirable and

undesirable characters of existing varieties, reasons for abandonment of varieties in the past and abiotic stresses on potato were recorded. In addition to personal interviews, group discussions were also carried out in order to collect information related to village profile.

Data were tabulated and analysed using simple mathematical and statistical techniques. For better and easy understanding priority index and relative importance of desirable attributes were calculated. Priority index ranged from 0 to 100 where per cent multiple responses were assigned weights (1<sup>st</sup> response = double weight; 2<sup>nd</sup> and 3<sup>rd</sup> responses = equal weight; subsequent responses = half weight) on open ended questions. Relative importance

**Table 2. Farmers' perception on potato yield enhancing attributes**

| Responses                            | Potato growers |       |        |       |        |       |        |       |        |       |
|--------------------------------------|----------------|-------|--------|-------|--------|-------|--------|-------|--------|-------|
|                                      | Marginal       |       | Small  |       | Medium |       | Large  |       | All    |       |
|                                      | % MR           | Im In | % MR   | Im In | % MR   | Im In | % MR   | Im In | % MR   | Im In |
| Can yield be increased? (%)          | 100.00         | n/a   | 100.00 | n/a   | 100.00 | n/a   | 100.00 | n/a   | 100.00 | n/a   |
| Sufficient irrigation water          | 50.00          | 2.31  | 62.50  | 2.92  | 68.75  | 2.92  | 62.50  | 2.33  | 60.61  | 2.62  |
| Soil reclamation***                  | 27.78          | 1.75  | 6.67   | 1.00  | 40.00  | 1.67  | 21.43  | 1.83  | 24.19  | 1.65  |
| High Yielding Potato varieties       | 100.00         | 3.12  | 100.00 | 3.75  | 93.75  | 3.56  | 100.00 | 3.38  | 98.51  | 3.45  |
| Water saving technology              | 83.33          | 2.67  | 76.47  | 2.92  | 62.50  | 2.79  | 75.00  | 3.00  | 74.63  | 2.84  |
| Drought resistant varieties**        | 81.25          | 2.69  | 58.82  | 2.69  | 56.25  | 2.69  | 81.25  | 3.13  | 69.23  | 2.81  |
| Heat tolerant varieties              | 94.44          | 3.53  | 100.00 | 3.81  | 93.75  | 4.00  | 93.33  | 4.13  | 95.45  | 3.87  |
| High dose of fertilizer***           | 44.44          | 2.42  | 40.00  | 2.67  | 66.67  | 3.09  | 26.67  | 1.67  | 44.44  | 2.55  |
| Proper weed control*                 | 29.41          | 1.78  | 53.33  | 2.60  | 46.67  | 2.56  | 40.00  | 1.56  | 49.53  | 2.14  |
| Insect pest control**                | 47.06          | 1.85  | 68.75  | 2.31  | 80.00  | 2.75  | 68.75  | 2.46  | 67.19  | 2.33  |
| Proper Late Blight management        | 88.89          | 2.94  | 75.00  | 3.33  | 68.75  | 2.79  | 93.33  | 3.54  | 81.54  | 3.13  |
| Management of other diseases*        | 43.75          | 1.75  | 53.33  | 2.00  | 43.67  | 1.50  | 66.67  | 2.00  | 52.46  | 1.83  |
| Adequate availability of pesticides  | 50.00          | 2.08  | 43.75  | 2.56  | 56.25  | 2.18  | 37.50  | 2.33  | 46.97  | 2.27  |
| Adequate availability of fertilizers | 50.00          | 2.45  | 53.33  | 2.11  | 53.33  | 2.00  | 43.75  | 2.36  | 50.00  | 2.25  |
| Adequate availability of funds       | 55.56          | 3.18  | 60.00  | 2.89  | 75.00  | 2.78  | 56.35  | 2.40  | 61.54  | 2.82  |
| Availability of cheaper machinery*   | 47.06          | 2.88  | 53.33  | 2.38  | 66.67  | 3.11  | 42.86  | 2.43  | 52.46  | 2.72  |
| Low input prices***                  | 72.22          | 2.92  | 66.67  | 2.70  | 80.00  | 2.90  | 40.00  | 2.22  | 65.08  | 2.71  |
| Better Agril Extension Services***   | 94.12          | 3.31  | 23.53  | 2.91  | 31.25  | 3.45  | 85.71  | 3.25  | 57.81  | 3.24  |

% MR = Per cent multiple responses; Im In = Farmers' perceived Importance index (range 1 to 5); Chi-square test indicated statistically different response levels among farm categories at \* = 10%; \*\* = 5%; and \*\*\* = 1% level of significance.

of top ten desirable varietal attributes was simple percentage of their priority indices. In order to test the independence among potato farmers' categories on various factors/ attributes, chi-square test (Gupta, 2009), was used where O and E represent observed and expected frequencies, respectively.

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

## RESULTS AND DISCUSSION

### Yield enhancing attributes

All the respondents across all farmers' categories had a belief that yields of potato crop on their farms can increase further. Very high proportion of farmers (98.5%) believed that high yielding new potato varieties can further increase their potato yield (Table 2). Other closely perceived factor by the farmers was heat tolerant potato varieties (95.5%) followed by proper late blight control (81.5%), water saving technologies<sup>1</sup> (74.5%) and drought tolerant varieties (69%). Overall importance index of these factors, ranging from 1 (low) to 5 (high) was the highest for heat tolerant varieties (3.9) followed by high yielding new potato varieties (3.5), better agricultural extension services (3.2), proper late blight control (3.1) and water saving technologies (2.8).

Chi-square test indicated that farmers of different categories provided statistically different weights for role of soil reclamation, fertilizer doses, low prices of inputs and better

agricultural extension services in increasing their potato yield at 1% level of significance. Marginal farmers put higher stress on having drought tolerant potato varieties and need for better agricultural extension services. It was observed that marginal farmers didn't have assured source of irrigation and progressive farmers, who are generally targeted by extension agencies, were not extending information to the farmers.

### Desirable and undesirable characters

Higher yield, early maturity, desirable (large and uniform) tuber size, good storability, higher price of the output and suitability for processing were important desirable characters the farmers were looking for (Table 3). Low yield, susceptibility to heat and late blight, late maturity, bad storability and low price of the output were important undesirable characters in farmers' mind. Bad storability in the preceding sentence refers to higher storage losses at ambient temperature as well as during cold storage.

### Reasons for abandoning varieties

Four potato varieties were reported abandoned<sup>2</sup> by respondents. While Kufri Chandramukhi was abandoned by all; the cultivation of Kufri Jyoti, Kufri Lauvkar and Kufri Pukhraj was discontinued by some of the respondents (Table 4). Low yield as a reason for abandoning Kufri Chandramukhi and Kufri Lauvkar was reported by all the concerned respondents. Late blight susceptibility was another reason for abandoning Kufri Chandramukhi by two third of the respondents. Low yield, problem of tuber cracking during bulking stage and longer duration of maturity were important reasons reported by responding farmers for

<sup>1</sup>Drip and sprinkler irrigation were the two important water saving technologies used in the study area. Reportedly drip and sprinkler irrigation save up to 70% and 50% water, respectively. Sprinkler irrigation was found to initiate and aggravate late-blight infection in potato crop. Drip-irrigation was the best available water saving technology as it was also responsible for checking late-blight infection (vis-à-vis furrow irrigation) and better efficiency of nutrients use through fertigation.

<sup>2</sup>Potato varieties which farmers stopped planting due to some negative perception at least five years ago were considered abandoned.

**Table 3. Desirable and undesirable qualities of different varieties (% multiple responses)**

| Particulars             | Variety       |               |               |
|-------------------------|---------------|---------------|---------------|
|                         | Kufri Badshah | Kufri Pukhraj | Kufri Lauvkar |
| Good qualities          |               |               |               |
| Yield                   | 47.5          | 72.7          | --            |
| Early maturing          | --            | 63.6          | 50.0          |
| Desirable tuber size    | 32.8          | --            | --            |
| Good storability        | 52.5          | --            | 75.0          |
| High price              | 47.5          | --            | 50.0          |
| Good for processing     | --            | --            | 50.0          |
| Bad qualities           |               |               |               |
| Low yield               | --            | --            | 50.0          |
| Susceptible to heat     | 43.2          | 23.1          | --            |
| Late blight susceptible | --            | 23.1          | 25.0          |
| Late maturing           | 24.3          | --            | --            |
| Bad storability         | --            | 46.2          | --            |
| Low price               | --            | 30.8          | --            |

abandoning Kufri Jyoti. Cultivation of Kufri Pukhraj, which is still an important potato variety in the study area, was stopped by some growers. The main reasons for abandoning this variety were low price of its output followed by its heat susceptibility and poor storability. Tubers of this variety fetch lower prices on account of early<sup>3</sup> (pre mature) harvesting, lower dry matter and poor storability.

### Heat and drought stress

Heat and drought are very important abiotic stress factors for potato crop in the study area. Night temperature should be less than 18 to 20°C for proper tuber initiation and bulking. With exposure to higher temperature, potato plants show increased vegetative growth without converting carbohydrates into tubers (Basu and Minhas, 1991). Plants become tall and lanky. Drought on the other hand is responsible for general deterioration

in plant health. Plant becomes weak and more susceptible to other biotic and abiotic stresses.

Ninety per cent respondents believed that heat was a limiting factor towards achieving higher yield levels (Table 5). A lower proportion (31.5%) of respondents revealed

**Table 4. Varieties abandoned and reasons (multiple responses)**

| Variety            | Reasons                 | % age of respondents |
|--------------------|-------------------------|----------------------|
| Kufri Chandramukhi | Low yield               | 100                  |
|                    | Late blight susceptible | 67                   |
| Kufri Jyoti        | Long duration           | 33                   |
|                    | Cracking                | 67                   |
| Kufri Lauvkar      | Low yield               | 67                   |
|                    | Expensive seed          | 100                  |
| Kufri Pukhraj      | Low prices              | 33                   |
|                    | Heat susceptible        | 67                   |
|                    | Poor storability        | 50                   |

Note: Due to less number of respondents, category wise analysis was not carried out

<sup>3</sup>Kufri Pukhraj is an excellent early bulking potato variety. Farmers plant it for early harvesting in order to fit an additional crop in the annual cropping cycle and exploit the lucrative early market.



**Table 5. Responses on abiotic stresses (%)**

| Particulars | Category of potato growers |       |        |       |      |
|-------------|----------------------------|-------|--------|-------|------|
|             | Marginal                   | Small | Medium | Large | All  |
| Drought     | 33.3                       | 47.1  | 18.8   | 25.0  | 31.5 |
| Heat        | 88.9                       | 82.2  | 100.0  | 100.0 | 94.0 |

drought as abiotic stress to the potato crop. However, higher proportion of small and marginal farmers expressed drought as a potential threat to their potato crop. Since ground water level in the study area was very deep, the cost of digging tube wells was very high. Small and medium farmers on account of paucity of funds along with small and fragmented landholdings were at disadvantage to have personal source of assured irrigation. They depend increasingly on larger farmers for irrigation water which they get at comparatively higher charges. Large farmers may or may not provide them irrigation water at the right time as per personal needs.

### Priorities of varietal attributes

Year 2008-09 being hot, farmers experienced significant losses on account of low potato yields. The phenomenon of high temperature

during current potato crop season was wide spread and lower potato yields were also reported from other parts of Gujarat (overall -35%), Madhya Pradesh (-30%) and Chattisgarh (-25%) (CPRI, 2009). The responding farmers showed heat tolerance in potato varieties as their first priority (index = 92 and relative importance = 22.4%) (Table 6).

High yield was the second most important attribute. High potato yield scored relatively low on the rating scale of large farmers as they were more concerned with quality attributes than just the higher yield. Large farmers, generally the trend setters, had less focus on higher yield *vis-a-vis* the other attributes such as resistance to late blight followed by processing grade varieties, resistance to potato-tuber-moth and early maturing potato varieties. Overall, resistance to late blight and potato-tuber-moth were the third and fourth most important attributes on farmers' preference list (Table 6). Chi-square statistics showed that respondents among farm categories had different levels of preferences for high yield, resistance to late blight and potato-tuber-moth, suitability for processing, early maturity and shining skin at 1% level of significance.

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

| Top 10 breeding priorities     | Category of potato growers |        |        |        |       | % importance |
|--------------------------------|----------------------------|--------|--------|--------|-------|--------------|
|                                | Marginal                   | Small  | Medium | Large  | All   |              |
| 1. Heat tolerant**             | 100.00                     | 68.75  | 100.00 | 100.00 | 92.19 | 22.43        |
| 2. High yield***               | 56.25                      | 100.00 | 93.75  | 37.50  | 71.88 | 17.49        |
| 3. Resistant to late blight*** | 31.25                      | 43.75  | 25.00  | 93.50  | 48.43 | 11.78        |
| 4. Resistance to PTM***        | 25.00                      | 31.25  | 43.75  | 56.25  | 39.06 | 9.50         |
| 5. Large and uniform tubers    | 31.25                      | 37.50  | 37.50  | 37.50  | 35.94 | 8.75         |
| 6. Drought tolerant**          | 18.75                      | 37.50  | 25.00  | 37.50  | 29.69 | 7.22         |
| 7. Fit for processing***       | 6.25                       | 6.25   | 37.50  | 68.75  | 29.69 | 7.22         |
| 8. Early maturing***           | 18.75                      | 12.50  | 31.25  | 50.00  | 28.13 | 6.84         |
| 9. Shining skin***             | 18.75                      | 18.75  | 37.50  | 12.50  | 21.88 | 5.32         |
| 10. Good storability           | 18.75                      | 12.50  | 12.50  | 12.50  | 14.06 | 3.42         |

Note: Chi-square test indicated statistically different response levels among farm categories at \*\* = 5%; and \*\*\* = 1% level of significance

**Heat tolerance:** Gujarat, in spite of being heat prone, is the third largest potato producing state and has the highest productivity among all Indian states. Potato varieties intended to be released under GTZ project (assuming release in 2012-13 and full adoption in 2016-17) are expected to remain under cultivation up to or beyond 2020. Taking into account the perceivable threat of climate change on Indian potato along with the fact that higher temperature is already affecting potato yield in the study area, crop improvement project should consider development of potato varieties that can give normal yield at least at 2°C higher minimum night temperature (*i.e.* 22°C) than the conventional potato varieties. Such varieties are expected to increase potato yield in states like Karnataka and Gujarat by at least 20%.

**Potato-tuber-moth resistance:** The second and third most important attributes in new potato varieties *i.e.* high yield and late blight resistance generally get adequate attention in potato breeding programmes. However, special attention needs to be given to breeding potato-tuber-moth (PTM) resistant varieties for the study area. PTM is a severe problem in the study area which is leading potato growers to adopt only early varieties for table purpose. Potato growers find themselves handicapped for traditionally storing produce in heap *etc.* even for short duration of one month. Agro-climatically the study area is highly suited for producing processing grade potatoes; however, the PTM menace restricts potato farmers from pursuing this lucrative option.

**Early maturing varieties:** Early maturity of potato varieties is very important criteria in Gujarat. Its importance stems from the fact that farmers in this state seriously try to take an additional crop after potato; and escape heat and potato-tuber-moth damage during February-March. However, the priority rank for early maturing attribute in potato varieties, due

to relatively lower priority index and relative importance, was lower than the expectation. It was due to the fact that studied farmers grow Kufri Pukhraj which is an excellent early maturing and high yielding potato variety. However, the shortcomings of this variety in the form of low dry matter, poor storability, yellow flesh<sup>4</sup> and susceptibility to late blight were reflected under respective attributes in addition to the early maturity. Hence, this attribute needs to be addressed along with better dry matter, storability and late blight resistance in the new potato varieties, at higher priority level than listed in the table.

**Processing varieties:** Responses of farmers might have been guided by their personal needs and experiences undermining attributes of wider interest. India in general and Gujarat in particular have shown tremendous growth in potato processing sector (Rana and Pandey, 2007; Rana, 2011). Gujarat state is still showing extra-ordinary growth in this field and most of the units in the state are now facing supply constraint of processing grade potatoes.

Raw material (processing grade tubers) demand of potato processing industry in India was estimated at 2.68 million MT during 2010-11 (Rana and Pandey, 2007). This demand constitutes 10.8% of Indian average potato production during TE 2007-08 (GOI, 2009). Although, specific estimates for Gujarat state are not available yet the literature (Rana and Pandey, 2007) clearly indicates that proportion of processing grade tubers' requirement (out of state's production) in this state is much higher than the national one. Although the varietal attribute suggesting suitability of potato variety for processing has got seventh highest ranking with a priority index of 29.7, yet, the breeders may assign a higher importance to this attribute too.

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<sup>4</sup>Yellow flesh of potato tubers, a desirable character in general, is not preferred particularly in Gujarat.

**Storability:** Marginal farmers usually have low volume of produce and are more likely to be exploited in the process of marketing. They have the tendency of avoiding marketing risk and try to sell at the farm itself. However, it is general experience that potato prices are low during harvesting season and prices rise after the produce is cold stored. Marginal farmers tend to avoid paying cold storage charges and mostly opt for storing their produce using conventional methods. Hence better storability as an attribute in new potato varieties is likely to be more beneficial to the poor potato farmers having small land holdings.

## CONCLUSIONS

Food security issues in Indian context have been aptly addressed (Acharya, 2009; Chand, 2007); and importance of potato in socio-economic life of people in the country was also adequately emphasized (Shekhawat and Naik, 1999). FAO has identified potato as an important food crop to fight hunger and poverty in many parts of the world (FAO, 2008). However, rising temperature is becoming a serious threat to potato cultivation in many sub-tropical regions of the world. In India important heat prone potato producing states, viz., Gujarat, Madhya Pradesh and Karnataka have already started experiencing ill effects of higher temperature. Development of heat tolerant potato varieties, under GTZ funded CIP-CPRI joint project, was considered an important tool to tackle global warming. Present study was undertaken in relatively hot Gandhinagar district of Gujarat to assess farmers' expectations from future potato varieties.

Higher yield, early maturity, desirable (large sized uniform) tubers, good storability, higher price of produce and suitability for processing were important desirable varietal characters of potato farmers. Low yield, late-blight susceptibility, tuber cracking, low

price of output (due to low dry matter), heat susceptibility and poor storability were important reasons for farmers to abandon potato varieties in the past. Priority index of varietal characters in future potato varieties indicated that heat-tolerance was the most important attribute followed by high yield, resistance to late-blight, resistance to potato-tuber-moth and large sized uniform tubers. However, taking various socio-economic factors into consideration survey team recommended that breeders should assign still higher priority for early maturity, processing quality and good storability characters.

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