RESEARCH PROGRAM ON
Roots, Tubers and Bananas

CGIAR

RTB
Working Paper

ISSN 2309-6586
RTB Working Paper
2014-7

Prioritization of options for potato research for development - Results from a global expert survey

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International Potato Center (CIP)

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ISSN 2309-6586

Correct citation:

Kleinwechter, U.; Hareau, G.; Suarez, V. 2014. Prioritization of options for potato research for development - Results from a global expert survey. Lima (Peru). CGIAR Research Program on Roots, Tubers and Bananas (RTB). RTB Working Paper 2014-7. Available online at: www.rtb.cgiar.org

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Acknowledgements

The authors are grateful for the support received by numerous individuals, including (but not limited to) Jorge Andrade, Merideth Bonierbale, Carlo Carli, André Devaux, Greg Forbes, Keith Fuglie, Mohinder Kadian, Awais Khan, Britta Kowalski, Jan Kreuze, Hannele Lindqvist-Kreuze, Thomas Miethbauer, Philippe Monneveux, Miguel Ordinola, Oscar Ortiz, Monica Parker, Gordon Prain, Claudio Proietti, Flor Rodriguez, Elmar Schulte-Geldermann, Reinhard Simon, Graham Thiele, Claudio Velasco, Kaiyun Xie, and Thomas zum Felde. All errors and omissions remain the authors' responsibility.

Prioritization of options for potato research for development – Results from a global expert survey

1. Introduction

In terms of both production and consumption, potato (Solanum tuberosum L.) is becoming increasingly important in the developing world. Over the past decades potato production in Asia, Africa, and Latin America has steadily increased, such that in 2006 production in developing countries equaled that of developed countries for the first time (Birch et al. 2012; Scott 2002; Walker et al. 2011). Mirroring these developments, the role of potato as a food and consumption commodity has strengthened and can be expected to continue to grow. At present, potato is the third most important food crop in the world, after rice and wheat (FAO 2013). It is also the one commodity in the developing world with consistent increases in quantities consumed per capita (Bruinsma 2003).

In Africa and Asia, potato is shifting from a largely subsistence crop to a food source for urban populations. In Africa especially, where population growth by 2050 is anticipated to outstrip all other regions, increased use of potato as a staple is highly important. In China, changes in consumption patterns are projected to be one of the factors driving growth in production between 1.75% and 2% in the coming years (Scott and Suarez 2012; Birch et al. 2012). Moreover, potatoes are grown in regions with high incidences of poverty, undernutrition, and food insecurity, such as the tropical highlands of Africa, the Andes of South America, or the Indo-Gangetic basin of southern Asia. Taken together, these trends underscore the particular importance of the crop (Bruinsma 2003; Thiele et al. 2010).

Potatoes stand out among the world's major food crops for other reasons as well. They play multiple and crucial roles in local food systems and for food security, and are well suited for cultivation in environmental conditions under which other crops may fail. They are highly versatile and adaptable, with short and flexible vegetative cycle that makes them ideal for rotation with other major crops, such as wheat, rice, maize, or soybeans (Birch et al. 2012; FAO 2008). This raises the aggregate efficiency of agricultural production systems and helps to increase the availability of food and improve land-use ratio. Potatoes are also important sources of energy, providing high dry matter, protein, and energy per unit of land, water, and time. Likewise, they serve as valuable sources of minerals and vitamins in the human diet (Burton 1989; Scott 2002; Walker, Schmiediche, and Hijmans 1999). This makes the crop attractive for areas with high population pressure and limited arable land (Scott 2002).

What is more, potato has the potential to contribute to poverty alleviation and food security. To that end, in the 1970s the International Potato Center (CIP), one of the international agricultural research centers of CGIAR, began investing in potato research and development (R&D) and improving the crop for target regions in developing countries. A number of national agricultural research services (NARS) also include potato research in their agenda. Despite these efforts, technological improvements in the crop so far have lagged behind the gains in potato R&D (Alexandratos 1997).

In this context—particularly with respect to international agricultural research oriented toward the provision of global public goods—it is important to identify relevant problem areas and priorities for

potato research. In the early 1990s, CIP asked the leaders and prominent scientists of national potato programs to identify the important constraints to potato production and utilization in Latin America (Herrera and Scott 1993) and Asia (Maldonado, Wright, and Scott 1998). And although these studies provide valuable information, they are limited to their two regions and are based on a small sample of experts. A 2005 study by Fuglie (2007a) greatly expanded the geographic coverage of the analysis by directing a survey to potato scientists in 46 countries across Asia, Africa, and Latin America. However, this study also still relies on a very small sample of only 55 responses globally. Single regions such as sub-Saharan Africa (SSA) and South, West, and Central Asia (SWCA) are poorly represented (eight and nine responses, respectively). In addition to these survey-based studies, several authors provide lists of priority areas for potato research (Birch et al. 2012; Bonnel 2008; Pandey 2008). But these recommendations appear to be based on the authors' understanding and assessment of the subject area rather than a broader empirical foundation.

In this paper, we present an analysis that not only draws upon the efforts outlined above, but also goes beyond and extends them. As part of a broader undertaking covering multiple crops that took place in the scope of the CGIAR Research Program on Roots, Tubers and Bananas (RTB), we follow an approach previously taken by Horton (1989) and Fuglie (2007a) and apply a scoring model for the assessment of priorities for potato research (Ruttan 1982). Potato experts in areas ranging from production to sector development across the developing world were asked in a survey to score a broad range of research options. They were asked to base their scores on the perceived importance for helping to reduce poverty and improve food security through potato research and capacity development, their perceptions of constraints to potato production and use, and their opinions about the relative importance of alternative research options.

The results give a broad overview of the perceptions of problems affecting the potato sector and potential solutions. The surveys lead to empirically founded and ranked lists of constraints and associated research options. In the first instance, the results provide a valuable resource for research and program planning in international agricultural research for development. Research centers of CGIAR and other national and international institutes dealing with the potato crop are the primary audiences here. Beyond that, the study offers a comprehensive insight into the perceptions of the global community of potato scientists and experts regarding different constraints. The unprecedented scope of the study in terms of geographic coverage and representation of the expert community makes the results a unique source of information.

Section 2 below sets out the methodological approach taken for the survey and its analysis, and describes the dataset obtained and used for the analysis. Section 3 presents the results from the survey, providing evidence of priorities for potato research in developing countries. Section 4 summarizes the paper and draws conclusions.

2. Materials and methods

For the expert survey, a structured questionnaire is applied (see Annex 4). The questionnaire is based on a format developed for an earlier priority assessment exercise carried out at CIP (Fuglie 2007a, 2007b) and consists of two sections. In a first section, the questionnaire asks for information about the respondents. This information encompasses personal information: gender and age, experience in work

on potato, type of organization a respondent works for, the country or region and the crop agro-ecology his/her work is focused on, and the respondent's professional and disciplinary background.

The main section of the questionnaire deals with the different constraints and research options. Respondents are provided with a list of 91 research options, organized around the areas of crop improvement, crop and resource management, seed management, genetic resources, value chains, postharvest utilization, and marketing, as well as socioeconomic research and extension. The list of research options draws on the questionnaire used by Fuglie (2007a), which has been revised to take into account the input by CIP potato experts and, where necessary, changed and amended. This approach ensures, on the one hand, a certain degree of comparability with the previous study, and on the other hand, the relevance of the list of research options and its endorsement by crop scientists.

For each of the research options, respondents are asked to assign a score from 1 (not important) to 5 (very important), according to their perception of the importance of that option for helping to reduce poverty and improve food security through crop research and capacity development. In addition, for each area, respondents can choose to specify and score other options that may not have been included in the initial list.

The selection of the group of participating experts was guided by several objectives. First, to obtain responses of sufficient high quality, the respondents would need a sound knowledge of the potato crop. They should be able to identify and assess problems and constraints associated with production and sector development. Further, the target group should be selected so as to consider the views of experts from a variety of backgrounds with a stake in potato research. Thus, the selection has to be wide enough to cover not only the science community, but also include representatives from the private sector and from the development community.

Accordingly, a combination of approaches has been taken to reach out to the expert community. First, questionnaires were distributed to participants of professional meetings with regional scope. These gatherings were (1) the XXV Congress of the Latin American Potato Association, held in Uberlandia, Brazil, 17–20 September 2012, and (2) the 16th International Symposium of the International Society for Tuber & Root Crops in Nigeria, 23–28 September 2012. Second, the survey has been rolled out online at a global scale. For the online survey, a list with experts and stakeholders has been compiled based on information requested from regional CIP researchers, crop experts in individual countries, professional networks (RED MIPapa, Papa Andina, Consorcio Papa Chile, or the Global Initiative on Late Blight) and the Inter-American Institute for Cooperation in Agriculture (IICA, for Latin America and the Caribbean). A review of scientific publications also was carried out to identify authors of relevant publications. A total of 1,249 individuals were invited via email to participate in the online survey and the contacted experts were asked to forward the invitation to interested colleagues. Invitations were sent in two waves, in December 2012 and in February 2013, with one reminder being sent two weeks after the initial invitation. The survey was also made available via the RTB website from September 2012 to June 2013.

To make the survey more accessible to a global audience, the questionnaire has been translated and made available in English, Spanish, French, Russian, and Chinese. A full timeline of the survey activities is available in Annex 1.

Results are analyzed by calculations of mean scores for each of the research options evaluated in the survey, where higher values indicate the perception of higher importance among the respondents.

To provide a rough indication of the significance of observed differences, the standard errors of the means are calculated. The results are presented at the global level (see Table 10 in Annex 2), using the entire sample, and breakdowns by regions as well as by gender are provided.

Overall, 411 questionnaires have been completed and returned to CIP. Of survey respondents 22% are female. Regarding the regional orientation, respondents have been asked to characterize their work as being global, regional (belonging to one out of nine regions), or national. For the purpose of this report, respondents who indicated a national focus were assigned to the respective region based on the provided country information. It was possible to give multiple responses. In the analyses, these cases are included in the sub-sample for each of the region indicated, which leads to some double counting. A total of 17% of respondents characterized their work as taking place in SSA, with Western and Central Africa accounting for 4%, Eastern Africa for 10%, and Southern Africa for 3% (Table 1). Latin America was stated by 30% of the responses; 39% of the responses referred to Asia, with Eastern Asia and the Pacific (mainly China) having the strongest representation (26%), followed by Southern Asia (9%) and SWCA (4%). A global scope of work was indicated by 10% and single cases mentioned the remaining regions. Sixty-one individuals reported more than one region.

TABLE 1: NUMBER OF RESPONDENTS BY REGION.

		Total responses (N=411)	***Share in total***
Global		47	0.10
Latin America		140	0.30
SSA			
	Western and Central Africa	18	0.04
	Eastern Africa	45	0.10
	Southern Africa	16	0.03
Asia			
	SWCA	20	0.04
	Southern Asia	41	0.09
	Eastern Asia and Pacific	121	0.26
Europe		4	0.01
North America		13	0.03
Other		7	0.02
Total		472	1

To assign the answers received to specific crop agro-ecologies, respondents were provided a list of potato crop agro-ecologies that represents a classification based on concepts of altitude and latitude. The survey covers all agro-ecologies considered relevant for potato (Table 2). The largest share of respondents indicated temperate highland environments (25%), followed by subtropical highlands (17%). Tropical highland and subtropical lowland environments were stated by 15% each, temperate lowland environments by 11%, another 6% indicated mid-elevation tropics, and 10% assigned themselves to others. It is worth highlighting that 253 respondents mentioned more than one agro-ecological zone (around 1.6 zones per respondent on average).

TABLE 2: NUMBER OF RESPONDENTS BY CROP AGRO-ECOLOGY

	Total responses (N=411)	***Share in total***
Tropical highlands	102	0.15
Subtropical highlands	115	0.17
Temperate highlands	166	0.25
Mid-elevation tropics	42	0.06
Subtropical lowlands	97	0.15
Temperate lowlands	76	0.11
Other	66	0.10
Total	664	1

As shown in Table 3, a large share of the sample is made up of scientists, from NARS (34%), universities (18%), or CGIAR (mostly CIP, 8%). Research managers from NARS and university students account for another 10% and 2%, respectively. Persons from outside the field of research (extensionists, nongovernmental organizations, donors, policy makers, others) make up the rest of the sample, accounting together for 27%.

The survey covered respondents from a broad range of disciplines (Table 4). On average, respondents indicated expertise in 3.3 different disciplines. The highest coverage has the wider field of natural sciences, including plant breeding, genetics, crop and resource management, climate change, and nutrition. Around three quarters of the responses can be attributed to one of the disciplines in that area. Disciplines that are related to social sciences in the broadest sense and management/administration are also well represented but make up a smaller share of the sample.

Respondents had a mean age of 46 years at the time of the survey: the youngest respondent was 22 years old and the oldest 79 years. On average, the survey respondents reported 14 years of experience in potato research, ranging 0–45 years.

TABLE 3: NUMBER OF RESPONDENTS BY PROFESSION

	Total responses (N=411)	*Share in total*
Research manager from a national agricultural research institute	41	0.10
Research scientist from a national agricultural research institute	138	0.34
Research scientist or lecturer at a university	74	0.18
Student conducting research at a university	10	0.02
Extension agent	22	0.05
Representative of a non-government, not-for-profit organization (NGO)	36	0.09
Representative of a donor to the CGIAR system	9	0.02
CGIAR center scientist	31	0.08
Employee of a private, for-profit company	33	0.08
Other	14	0.03
Total	411	1

TABLE 4: NUMBER OF RESPONDENTS BY DISCIPLINE

	Total responses (N=411)	*Share in total*
Crop genetic resources	64	0.05
Participatory plant breeding	108	0.08
Transgenic research	40	0.03
Tissue culture	86	0.06
Soils/nutrient management	55	0.04
Cropping/farming systems	128	0.10
Economics or policy	35	0.03
Climate change	15	0.01
Cultural anthropology or rural sociology	8	0.01
Training and knowledge management	55	0.04
Research planning and administration	64	0.05
Development planning and administration	49	0.04
Genomics, bioinformatics, and molecular biology	34	0.03
Plant breeding and genetics or molecular breeding	99	0.07
Crop management, agronomy, and physiology	157	0.12
Water management in crop production	34	0.03
Crop diseases and their management	118	0.09

	Total responses (N=411)	Share in total
Crop pests and their management	75	0.06
Postharvest utilization and management	75	0.06
Other	41	0.03
Total	1340	1

3. Results

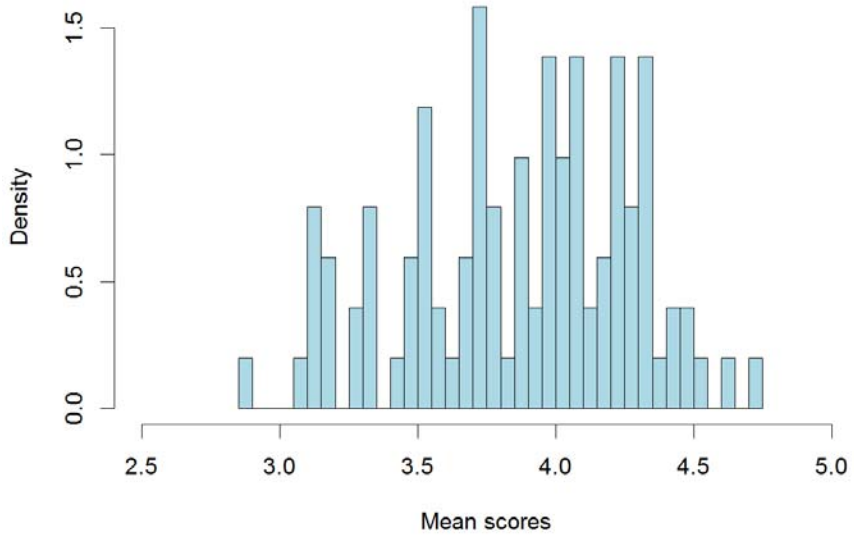
In this section we present the survey results, which provide interesting insights into the perceptions of the potato community about the relative importance of constraints and research options. The results are presented according to the way information was gathered in the questionnaire. Results are grouped into four broad categories of research options: crop genetic improvement; production technology, agronomy, and crop management; improvement of seed and planting materials; and other options for potato research. These are shown in Tables 5–8. For each category, the number of responses for each score over all responses (all regions) and the total number of responses are given. Further, for all options the mean score and the standard error of the mean are provided. Since those standard errors are around 0.07 on average, a 95% confidence interval lies roughly about 0.14 score points around the mean.[1] To offer a breakdown by regions, the mean scores for responses from Latin America, SSA, East and South East Asia (ESEA), and SWCA are reported. Finally, to distinguish between male and female respondents explicitly, the mean scores for both sexes are included in the tables.

To facilitate the interpretation of the results, Figure 1 displays the distribution of the mean scores in the sample. The mean of the global mean score across all research options is 3.87; the median is at 3.94. The highest mean score given to any of the research options is 4.71, the minimum is 2.89, and the first and third quartiles are marked by 3.55 and 4.19, respectively. Thus, most research options have received a score of 3.00 or higher and are therefore considered to be “important” to “very important.” For a verbal classification of the relative ranking of the research options, in the following discussions mean scores in the fourth quartile (>4.19) will be described as “high” and scores below the median (3.94) as “low.”

The prioritization of research options for crop genetic improvement made by the respondents is presented in Table 5. The first section of the table deals with options related to crop yield and quality. Respondents consider high yields to be of utmost importance for potato breeding in this section. With a global mean score of 4.38, this breeding goal scores significantly higher than any of the other options related to yield and quality. Breeding for processing quality and other consumer-preferred traits are ranked second (both 4.02), followed closely by quality traits preferred by producers (3.98). Other options related to yield and quality, such as dry matter and starch content (3.71) and starch quality (3.16), rank significantly lower.

[1] This calculation includes the questions on “others” at the end of each section of the questionnaires. These questions typically have higher standard errors. Thus, the confidence intervals will actually be smaller for most of the questions, in particular where specific research options were given.

FIGURE 1: HISTOGRAM OF MEAN SCORES, GLOBAL SAMPLE.



In the section on breeding for nutritional quality, tolerance to storage diseases receives a high score (4.29). The mean score of breeding for higher contents of iron and zinc is already significantly lower at 3.78. Protein and vitamin A content have a score of 3.70 and 3.60, respectively, and other nutritional quality traits have a score of 3.98 on average. In this section, it is noteworthy that the low-ranking options of vitamin A content, protein and other quality traits also received only a small number of responses, consistent with their relatively low importance by the expert community.

Among the options for breeding for biotic stress resistance, resistance against late blight (LB) is ranked highly. In fact, with a mean score of 4.60, breeding for LB resistance is the second most important of all research options globally, after LB management (score of 4.71, see Table 9). The next highest ranked biotic resistance traits are BW (4.09) and the potato virus diseases potato virus Y (PVY) (4.08) and potato leafroll virus (PLRV) (3.99), whose scores are not significantly different from each other. Breeding for other bacterial and fungal diseases like Erwinia, common scab, Rhizoctonia, and fusarium wilt as well as other viral diseases get mean scores in the middle range, between 3.55 and 3.76. Potato pests like tuber moths (P. operculella, S. tangolias, T. solanivora), nematodes, aphids (Aphidoidae spp.), cutworms, leafminer fly, white fly, or mites received low scores.

TABLE 5: PRIORITIZATION OF OPTIONS FOR CROP GENETIC IMPROVEMENT

	All responses: Number of responses ranking importance (1 to 5)[a]						All regions		Latin America	SSA	ESEA	SWCA	CGIAR	Male	Female
	1	2	3	4	5	Total responses	Mean score	s.e. (mean)	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score
Yield and quality															
High yield	12	11	37	85	239	388	4.38	0.05	4.13	4.59	4.54	4.83	4.03	4.36	4.44
Processing quality	11	26	58	117	151	377	4.02	0.06	3.96	3.92	4.18	3.94	3.76	4.05	3.95
High dry matter/ starch/flour	17	35	79	122	99	369	3.71	0.06	3.43	3.62	3.99	4.28	3.72	3.74	3.63
Starch quality traits	34	44	62	66	43	334	3.16	0.08	3.06	2.72	3.58	3.27	2.85	3.09	3.43
Other consumer-preferred traits	5	15	56	118	107	345	4.02	0.05	4.12	3.85	4.08	3.85	4.05	4.01	4.05
Other producer-preferred traits	9	21	64	103	128	355	3.98	0.06	4.07	3.90	3.93	4.13	4.28	3.95	4.11
Nutritional quality															
Tolerance to storage diseases	10	17	41	83	208	370	4.29	0.05	4.21	4.23	4.37	4.65	3.85	4.23	4.53
Iron and zinc	19	32	68	91	116	366	3.78	0.07	4.02	3.73	3.63	4.00	4.04	3.74	3.95
Protein content	6	12	27	35	35	123	3.70	0.11	3.72	-	3.67	-	3.75	3.64	3.89
Vitamin A content	10	10	30	32	34	125	3.60	0.11	4.00	-	3.50	-	3.75	3.49	3.96
Other quality traits	6	2	12	28	32	134	3.98	0.13	4.46	3.44	4.28	3.60	4.00	3.94	4.44
Biotic stress resistance															
Late blight	11	7	12	60	284	384	4.60	0.05	4.56	4.52	4.76	3.82	4.36	4.57	4.78
Bacterial wilt	13	23	48	86	163	358	4.09	0.06	4.01	4.57	4.11	3.50	4.29	4.01	4.39
Virus PVY	11	18	54	100	150	356	4.08	0.06	3.76	4.24	4.21	4.47	4.31	3.98	4.46
Virus PLRV	9	29	55	100	137	354	3.99	0.06	3.67	4.29	4.16	4.12	3.88	3.90	4.32
Erwinia	10	26	91	89	98	346	3.76	0.06	3.74	3.53	4.00	3.13	3.50	3.69	4.05
Common scab	14	32	86	88	103	353	3.72	0.06	3.51	3.30	4.15	3.00	3.33	3.69	3.90
Other viral diseases	18	27	67	95	90	334	3.71	0.07	3.63	3.35	3.93	3.93	3.82	3.64	4.02
Rhizoctonia	12	37	84	97	89	352	3.67	0.06	3.80	3.48	3.76	3.50	3.50	3.62	3.86
Tuber moth	27	35	68	86	107	353	3.65	0.07	3.97	3.88	3.47	2.60	3.42	3.58	3.91
Fusarium wilt	13	46	96	81	83	350	3.55	0.06	3.45	3.51	3.75	3.25	3.17	3.46	3.90
Nematodes	27	31	48	77	73	327	3.54	0.08	3.87	3.47	3.26	3.50	3.33	3.41	3.96
Aphids	25	39	87	87	88	351	3.53	0.07	3.28	3.64	3.80	3.50	3.26	3.46	3.80
Cutworms	35	56	93	72	51	343	3.16	0.07	3.24	2.94	3.23	3.36	2.86	3.08	3.46
Leaf miner fly	35	54	86	77	42	343	3.13	0.07	3.50	2.89	3.02	2.57	3.10	3.03	3.50
White fly	35	56	86	69	44	334	3.11	0.07	3.30	3.05	3.06	2.73	3.19	3.02	3.42
Mites	43	65	96	58	30	337	2.89	0.07	2.93	2.90	2.91	2.67	2.85	2.80	3.23
Other biotic stresses	11	12	20	40	53	231	3.82	0.11	4.10	3.75	3.83	3.17	4.18	3.85	3.77

	All responses: Number of responses ranking importance (1 to 5)[a]						All regions		Latin America	SSA	ESEA	SWCA	CGIAR	Male	Female
	1	2	3	4	5	Total responses	Mean score	s.e. (mean)	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score
Abiotic stress resistance/tolerance															
Drought tolerance/ water-use efficiency	5	13	22	73	244	366	4.51	0.05	4.56	4.34	4.59	4.88	4.70	4.47	4.67
Heat tolerance	17	32	67	91	132	361	3.85	0.06	3.72	4.00	3.78	4.59	4.41	3.78	4.11
Cold or frost tolerance	25	34	50	83	143	351	3.85	0.07	4.27	3.12	3.95	3.14	3.52	3.79	4.07
Tolerance to marginal/toxic soils	31	37	65	60	56	334	3.29	0.08	3.24	3.25	3.51	2.85	2.90	3.22	3.50
Water logging	34	65	90	71	52	341	3.13	0.07	3.10	2.78	3.34	2.71	3.22	3.07	3.38
Other abiotic stresses of potato	23	17	28	44	32	273	3.31	0.11	3.29	3.59	3.12	4.13	3.79	3.27	3.41
Environmental adaptation															
Earliness	3	10	25	82	221	359	4.49	0.04	4.48	4.66	4.48	4.88	4.78	4.49	4.49
Seed dormancy	9	15	68	113	113	343	3.96	0.06	3.93	4.35	3.94	4.08	4.10	3.94	4.05
Long days	47	44	83	58	52	329	3.08	0.08	2.92	2.68	3.26	3.69	3.60	3.06	3.20
Other traits of environmental adaptation	14	8	24	23	30	231	3.47	0.14	3.85	3.38	3.30	4.00	3.50	3.54	3.19
Other opportunities for crop improvement															
Germplasm enhancement and pre-breeding	5	11	28	83	198	353	4.41	0.05	4.42	4.43	4.39	4.69	4.38	4.35	4.64
Exploitation of heterosis	11	24	42	106	105	344	3.94	0.06	3.88	3.98	4.02	3.75	3.82	3.91	4.07
TPS as alternative to clonal seed	40	42	71	84	85	350	3.41	0.07	3.47	3.78	3.25	3.67	3.38	3.34	3.71
Other opportunities for crop improvement	15	6	17	27	31	213	3.55	0.14	4.42	4.00	3.12	2.50	3.75	3.53	3.56

[a] 1 = not important, 2 = low importance, 3 = important, 4 = very important, 5 = most important.

Source: authors' survey.

With respect to abiotic stresses, breeding for drought tolerance and improved water-use efficiency is of high importance according to the experts (mean score of 4.51). It also is the third highest ranked of all research options, following only control and management of and breeding for LB (Table 9). Other abiotic constraints, in contrast, are given lower importance. The mean scores of heat tolerance, cold or frost tolerance, tolerance to marginal or toxic soils, as well as water logging are of low to medium levels, ranging 3.13–3.85.

In the field of breeding for environmental adaptation, breeding for earliness is ranked high (mean score of 4.49), ranking fourth of all research options that have been assessed (Table 9). Breeding for adaptation of seed dormancy to the requirements of local cropping calendars (3.96) and adaptation to long-day environments (3.08) received significantly lower scores.

Among other opportunities for crop improvement, germplasm enhancement and pre-breeding are ranked highly with a mean score of 4.41. It is followed by the exploitation of heterosis (3.94). True

potato seed (TPS) as an alternative to clonal seed has a low average score of 3.41. This result is in accord with findings from earlier priority assessments that see only a small niche with a correspondingly low adoption potential for this technology (Fuglie 2007a, 2007b).

Options for production technology, agronomy, and crop management comprise constraints and technologies related to the management of soils, water, weeds and harvest, and the control and management of diseases and pests (Table 6). Three options from the field of management of soils, water, weeds, and harvest received high scores. The improvement of soil fertility is the highest ranked research option in this section (mean score of 4.44), followed by the improvement of potato cropping systems (4.32) and water management in potato production (4.31). The mean score given to the management of soils and erosion control is significantly lower (4.06). The remaining options of improvement of harvesting methods or machinery (3.89), gender-friendly labor-saving tools (3.73), weed management and control (3.73), and the management of soil acidity (3.56) and salinity (3.46) get only low scores.

TABLE 6: PRIORITIZATION OF OPTIONS FOR CROP GENETIC IMPROVEMENT

	All responses														
	Number of responses ranking importance (1 to 5)[a]						*All regions*		*Latin America*	*SSA*	*ESEA*	*SWCA*	*CGIAR*	*Male*	*Female*
	1	*2*	*3*	*4*	*5*	*Total responses*	*Mean score*	*s.e. (mean)*	*Mean score*	*Mean score*	*Mean score*	*Mean score*	*Mean score*	*Mean score*	*Mean score*
Soils, water, weeds, and harvest															
Improving soil fertility (micro-nutrients and fertilizer)	1	10	32	99	210	364	4.44	0.04	4.33	4.68	4.53	4.53	4.25	4.42	4.55
Improving potato cropping systems	1	12	37	124	174	360	4.32	0.04	4.28	4.46	4.33	4.29	4.41	4.27	4.51
Water management in crop production	3	18	37	98	189	361	4.31	0.05	4.40	4.16	4.35	4.41	4.30	4.31	4.32
Soil management and erosion control	8	25	53	99	146	352	4.06	0.06	4.20	4.09	4.02	4.00	3.95	4.02	4.22
Improving harvesting methods or machinery	12	35	63	93	132	349	3.89	0.06	3.74	3.73	4.15	4.00	3.73	3.85	4.07
Gender-friendly labor-saving tools	21	36	61	97	109	351	3.73	0.07	3.85	3.87	3.72	3.43	3.41	3.68	3.93
Weed management and control	11	39	71	124	91	354	3.73	0.06	3.54	3.70	3.89	4.06	3.52	3.68	3.94
Managing soil acidity	19	33	102	88	82	353	3.56	0.06	3.64	3.74	3.50	3.19	3.36	3.50	3.80
Managing soil salinity	26	43	83	90	76	345	3.46	0.07	3.47	3.28	3.48	3.88	3.48	3.37	3.80
Others	13	6	16	16	28	200	3.51	0.16	4.44	3.80	3.08	5.00	4.43	3.52	3.46
Disease control and management															
Late blight	5	3	8	55	271	352	4.71	0.04	4.63	4.77	4.85	4.06	4.52	4.68	4.80
Viruses	5	15	42	87	179	344	4.28	0.05	3.98	4.36	4.43	4.88	4.15	4.21	4.54
Bacterial wilt	5	25	49	92	137	332	4.07	0.06	4.02	4.65	4.03	3.53	4.00	4.00	4.32
Other fungal diseases	5	15	53	82	89	307	3.96	0.06	4.12	3.83	3.99	3.64	3.75	3.90	4.16

	All responses						All regions		Latin America	SSA	ESEA	SWCA	CGIAR	Male	Female
	Number of responses ranking importance (1 to 5)[a]														
	1	2	3	4	5	Total responses	Mean score	s.e. (mean)	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score
Other bacterial diseases	1	18	39	46	55	251	3.86	0.08	3.98	3.74	3.93	3.45	3.55	3.83	3.94
Pest control and management															
Potato tuber moths	16	26	56	96	117	343	3.87	0.07	4.05	4.23	3.72	3.00	3.78	3.83	4.05
Aphids	15	30	69	82	109	330	3.79	0.07	3.38	3.76	4.20	3.75	3.48	3.72	4.07
Nematodes	22	23	48	61	89	327	3.71	0.08	3.97	3.50	3.56	3.45	3.22	3.60	4.07
Andean potato weevil (*Premnotrypes* spp. Andean)	51	29	33	54	79	327	3.33	0.10	3.88	2.71	3.20	1.29	3.48	3.23	3.69
Leafminer fly (*Liriomyza huidobrensis*)	24	42	98	75	48	330	3.28	0.07	3.44	3.30	3.28	2.82	3.05	3.19	3.64
Colorado potato beetle (*Leptinotarsa decemlineata*)	48	35	51	59	51	316	3.12	0.09	2.71	2.97	3.35	3.93	3.32	3.05	3.44
Others	11	10	14	31	33	214	3.66	0.13	4.25	3.33	3.51	3.80	3.63	3.61	3.93

[a] 1 = not important, 2 = low importance, 3 = important, 4 = very important, 5 = most important.

Source: authors' survey.

The mean scores of options related to the control and management of diseases and pests are consistent with the results from the area of breeding: LB and virus diseases have high scores of 4.71 and 4.28, respectively. The management of LB is the single most important research option according to this survey (Table 9). The mean scores for the other alternatives in both fields are significantly lower and do not reach the high range. Control and management of BW gets a mean score of 4.07, although it is assessed to be of higher importance in SSA (4.65). Also, options for pest control and management get consistently lower scores than disease control options. In this section, control of tuber moths ranks highest (3.87), followed by aphids (3.79) and nematodes (3.71). Control and management of the Andean potato weevil (3.33), the leafminer fly (3.28), and the Colorado potato beetle (3.12) get only low scores.

Overall, the area of seeds and planting materials appears to be of high importance for potato research (Table 7). Both the improvement of the production and distribution of elite planting materials in formal contexts and the improvement of technologies for farmer-based production and distribution of quality planting material received high scores of 4.45 and 4.23, respectively. Similarly, the improvement of technologies for seed storage has a high average score (4.34). The development and improvement of mass propagation methods score in the middle range (4.15); only TPS scores lower (3.32).

TABLE 7: PRIORITIZATION OF OPTIONS FOR IMPROVEMENT OF SEEDS OR PLANTING MATERIALS

	All responses														
	Number of responses ranking importance (1 to 5)[a]						All regions		Latin America	SSA	ESEA	SWCA	CGIAR	Male	Female
	1	2	3	4	5	Total responses	Mean score	s.e. (mean)	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score
Improving production and distribution of elite planting materials (formal)	3	13	32	75	223	353	4.45	0.05	4.31	4.42	4.67	4.76	3.92	4.42	4.60
Improving seed storage	2	13	41	96	190	350	4.34	0.05	4.23	4.56	4.41	4.65	3.88	4.30	4.51
Improving technologies for farmer-based production and distribution of planting materials (informal)	8	17	47	86	183	355	4.23	0.06	4.39	4.59	4.00	4.29	4.35	4.19	4.36
Mass propagation methods	6	14	49	115	145	345	4.15	0.05	4.18	4.33	4.15	4.19	3.76	4.15	4.17
Developing TPS as alternative to clonal seed	46	41	75	79	78	342	3.32	0.08	3.45	3.70	3.09	3.56	3.17	3.24	3.58
Others	7	10	8	22	28	188	3.72	0.15	4.62	4.08	3.33	4.50	4.20	3.64	4.08

[a] 1 = not important, 2 = low importance, 3 = important, 4 = very important, 5 = most important.

Source: authors' survey.

Other options for potato research considered in the survey concern various other fields, including genetic resource management, value chains, postharvest utilization and marketing, socioeconomic, policy and impact studies, as well as extension (Table 8). In the area of genetic resource management, high average scores are given to the phenotypic or molecular screening of landraces (4.30); the conservation, health testing, and distribution of genetic resources (4.26); the evaluation of phytosanitary conditions before the distribution of plant genetic material (4.25); as well as the distribution itself (4.23). The scores given to ex-situ conservation (4.17), in-situ genetic resource management (4.10), and the management of intellectual property rights and material transfer agreements (4.04) lie in the middle range.

In the area of value chains, postharvest utilization, and marketing, four out of the seven research options presented are considered to be very important and received high mean scores. The highest ranked alternatives in that area are the development of farmer organizations and farmer clusters linked to markets (4.33) and, closely related, the development of competitive potato value chains (4.32). The next highest ranking research options are the improvement of ware storage of table and processing potatoes (4.31) and the development of new potato products for human consumption (4.29). The development of potato products for industrial applications like flour and starch has a significantly lower mean score (3.97), and the score given to research on gender-equitable value chains is only in the low range (3.54). Similarly, comparatively low importance is given to the development of potato products for animal feed (mean score of 3.18), reflecting the crop's marginal role as a feedstuff in most of the developing world (Scott 2002).

TABLE 8: PRIORITIZATION OF OPTIONS FOR IMPROVEMENT OF SEEDS OR PLANTING MATERIALS

	All responses														
	Number of responses ranking importance (1 to 5)[a]						All regions		Latin America	SSA	ESEA	SWCA	CGIAR	Male	Female
	1	2	3	4	5	Total responses	Mean score	s.e. (mean)	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score
Genetic resource management															
Phenotypic/molecular screening of landraces in search of high-value traits/ new sources/tolerance/ resistance to stress	7	5	45	89	172	340	4.30	0.05	4.46	4.11	4.28	4.21	4.36	4.21	4.63
Conservation, health testing, and distribution	4	9	42	106	153	334	4.26	0.05	4.33	4.42	4.15	4.31	4.29	4.20	4.48
Evaluation of phytosanitary conditions before the distribution of plant genetic material	4	12	50	87	165	336	4.25	0.05	4.26	4.53	4.13	4.53	4.12	4.19	4.49
Distribution of plant genetic material of potatoes	5	10	43	112	150	341	4.23	0.05	4.19	4.53	4.08	4.50	4.65	4.18	4.39
Collection, characterization, evaluation, and documentation (ex situ)	7	12	47	110	145	338	4.17	0.05	4.09	4.26	4.27	4.00	3.84	4.14	4.24
In-situ genetic resource management	10	19	49	89	149	341	4.10	0.06	4.22	4.26	4.09	4.08	3.80	4.01	4.43
Management of intellectual property rights and material transfer agreements	13	14	46	115	126	335	4.04	0.06	4.15	3.98	4.03	4.20	3.76	3.98	4.24
Other (specify below)	9	6	5	10	20	180	3.52	0.22	4.33	3.29	3.20	NA	4.75	3.26	4.33
Value chains, postharvest utilization, and marketing															
Development of farmer organizations and farmer clusters linked to markets	8	11	30	103	186	344	4.33	0.05	4.46	4.60	4.26	4.06	4.15	4.27	4.51
Development of competitive potato value chains	10	9	33	93	185	341	4.32	0.05	4.38	4.50	4.32	3.93	4.04	4.28	4.42
Improving ware storage of table and processing potatoes	6	15	42	82	194	344	4.31	0.05	4.09	4.57	4.51	4.38	3.43	4.25	4.49
Developing potato products for human consumption	10	8	39	102	184	346	4.29	0.05	4.35	4.38	4.35	4.20	3.68	4.27	4.36
Developing potato products for industrial applications (flour and starch)	15	24	61	90	144	341	3.97	0.06	3.98	3.73	4.20	3.67	3.00	3.93	4.11
Research on more gender-equitable value chains	21	44	76	92	83	340	3.54	0.07	3.93	3.55	3.29	3.21	3.75	3.50	3.67
Developing potato products for animal feed	51	46	84	78	64	334	3.18	0.07	3.11	3.20	3.40	2.60	2.38	3.07	3.54
Others	5	8	4	16	23	163	3.79	0.18	4.54	4.20	3.25	4.50	5.00	3.63	4.31

	All responses: Number of responses ranking importance (1 to 5)[a]						All regions		Latin America	SSA	ESEA	SWCA	CGIAR	Male	Female
	1	2	3	4	5	Total responses	Mean score	s.e. (mean)	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score
Socioeconomic, policy, and impact studies															
Assessment of impact of potato R&D	6	6	48	124	156	346	4.23	0.05	4.19	4.35	4.28	4.44	4.36	4.15	4.47
Assessment of small farmer access to new technologies	6	14	48	111	166	349	4.21	0.05	4.33	4.47	4.06	4.35	4.28	4.13	4.48
Assessment of potato technology adoption	4	15	49	112	160	345	4.20	0.05	4.25	4.40	4.18	4.18	4.20	4.15	4.40
Assessment of health and environmental risks of pesticide use in potato systems	8	17	59	79	170	339	4.16	0.06	4.44	3.87	4.14	4.19	4.08	4.05	4.53
Improving policy framework for potato planting materials (distribution, regulations, IPRs, etc.)	6	12	55	111	146	345	4.15	0.05	4.21	4.36	4.14	4.13	4.24	4.11	4.25
Assessment of potato-based innovation systems	6	19	53	114	137	341	4.09	0.05	4.18	4.24	4.01	4.20	3.92	4.05	4.20
Research on food and agricultural policies affecting potatoes	8	12	58	115	134	340	4.09	0.05	4.12	3.94	4.25	4.00	4.09	4.06	4.20
Assessment of health effects of bio-fortified potato varieties	9	24	53	98	138	339	4.03	0.06	4.27	3.85	4.01	3.69	3.88	3.94	4.32
Study gender inequality in potato production systems	26	54	87	86	61	340	3.32	0.07	3.58	3.56	3.06	3.13	3.54	3.26	3.53
Others	7	8	3	12	16	165	3.48	0.22	3.71	3.78	3.19	4.50	4.67	3.33	3.89
Extension															
Development of new extension strategies	8	11	53	99	168	345	4.20	0.05	4.25	4.47	4.21	4.13	4.16	4.15	4.40
Use of information and mobile telephony technologies	9	13	56	113	133	336	4.07	0.06	4.07	4.16	4.03	4.27	4.13	4.06	4.14
Development of new didactic materials for extension	9	12	60	128	113	340	4.01	0.05	4.09	4.16	3.96	3.80	4.04	3.96	4.14
Others	7	6	6	26	39	187	4.00	0.14	4.61	4.17	3.57	4.50	4.33	3.92	4.25

[a] 1 = not important, 2 = low importance, 3 = important, 4 = very important, 5 = most important.

Source: authors' survey.

Most of the options for socioeconomic, policy, and impact studies received are ranked above the average of all research options, but the scores reached are not among the highest (compare Table 9). However, the assessment of the impact of potato R&D (4.23), the assessment of the access of small farmers to new technologies (4.21), and the assessment of potato technology adoption (4.20) all received high mean scores. This shows that the respondents recognize the need for providing evidence about the impacts of their work and are interested in the topic. While possibly a consequence of the mainly natural sciences background of the survey respondents, another result worth mentioning is the low score given to the study of gender inequality in potato production systems (3.32). Such a score points to a low perceived relevance of gender-related issues within the community of experts.

The final area of other options for potato research is extension. In this area, the development of new extension strategies, the use of information technology and mobile telephony technologies for extension, and the development of new training materials have been provided as alternatives to be evaluated in the survey. The former two received mean scores of 4.20 and 4.07, respectively. The development of new training materials for extension scores at 4.01.

4. Discussion and Conclusions

The results from the expert survey presented in this report provide an insight into the perceptions of the potato community of practice about the priorities and needs for potato research and offer evidence about the relative importance of individual research options and constraints.

The first important observation is that the largest part of the research options is seen as important or very important. In fact, only one of the research options received a mean score below 3.0: breeding for resistance to mites (2.89). Such a score pushes the option into the area of low importance when following the nomenclature used in the survey.

At the other end of the spectrum, a number of front-runners can be identified (Table 9). It is noteworthy that the highest ranked research options cover diverse fields of concern for potato production, commercialization, and use.

TABLE 9: HIGHEST RANKED OPTIONS FOR POTATO RESEARCH ACCORDING TO GLOBAL MEAN SCORE

	All regions		*Latin America*	*SSA*	*ESEA*	*SWCA*	*CGIAR*	*Male*	*Female*
	Mean score	*s.e. (mean)*	*Mean score*	*Mean score*	*Mean score*	*Mean score*	*Mean score*	*Mean score*	*Mean score*
Late blight control and management	4.71	0.04	4.63	4.77	4.85	4.06	4.52	4.68	4.80
Breeding for late blight resistance	4.60	0.05	4.56	4.52	4.76	3.82	4.36	4.57	4.78
Breeding for drought tolerance/water use efficiency	4.51	0.05	4.56	4.34	4.59	4.88	4.70	4.47	4.67
Breeding for earliness	4.49	0.04	4.48	4.66	4.48	4.88	4.78	4.49	4.49
Improving production and distribution of elite planting materials (formal)	4.45	0.05	4.31	4.42	4.67	4.76	3.92	4.42	4.60
Improving soil fertility (micro-nutrients and fertilizer)	4.44	0.04	4.33	4.68	4.53	4.53	4.25	4.42	4.55
Germplasm enhancement and pre-breeding	4.41	0.05	4.42	4.43	4.39	4.69	4.38	4.35	4.64
Breeding for high yield	4.38	0.05	4.13	4.59	4.54	4.83	4.03	4.36	4.44
Improving seed storage	4.34	0.05	4.23	4.56	4.41	4.65	3.88	4.30	4.51
Development of farmer organizations and farmer clusters linked to markets	4.33	0.05	4.46	4.60	4.26	4.06	4.15	4.27	4.51
Improving potato cropping systems	4.32	0.04	4.28	4.46	4.33	4.29	4.41	4.27	4.51
…	…	…	…	…	…	…	…	…	…
Breeding for resistance to mites (LOWEST RANKED)	2.89	0.07	2.93	2.90	2.91	2.67	2.85	2.80	3.23

[a] 1 = not important, 2 = low importance, 3 = important, 4 = very important, 5 = most important.

Source: authors' survey.

Four of the highest ranked options concern biotic and abiotic constraints to potato production. The control and management of LB and, closely related, breeding for LB resistance, received the highest mean scores of all research options (4.71 and 4.60, respectively). This is consistent with the most recent global analysis of potato production constraints, which also gives salient importance to LB (Fuglie 2007a). It also confirms statements from the literature where LB is considered the principal abiotic constraint affecting potato production worldwide (Birch et al. 2012; Forbes 2008; Hardy, Trognitz, and Forbes 1995; Haverkort 1990; Haverkort et al. 2009). Breeding for drought tolerance and/or improved water-use efficiency is the next highest ranked option globally (4.51). This result agrees with the perceived significance of traits related to water use due to an anticipated shortage and heterogeneity of water resources worldwide and the sensitivity of potato to drought stress (Birch et al. 2012). Once more, it confirms the results obtained by Fuglie (2007a), which place drought as the most important biotic constraint to potato production. Breeding for high yields (4.38), finally, is sought to improve the biological yield potential of the crop. In this context, the ranking of germplasm enhancement and pre-breeding (4.41) also reflects the need for more up-stream work to provide and improve the conditions for successful breeding efforts.

Next, a number of the highest ranked research options are related to agronomic aspects of the crop. Breeding for earliness is given a high average score (4.49), pointing on the one hand again to the need to deal with biotic and abiotic constraints to potato production (in this case, through escape), but also to a desire to make the potato a more flexible crop and improve its ability to fit into cereal-based cropping systems like, for example, those in Asia. The result also is in accordance with earlier findings by Fuglie (2007a), which already attach a high importance to earliness. The improvement of soil fertility (4.44) as well as the improvement of potato cropping systems (4.32) are further research options related to the agronomy of the potato crop that are given very high importance by the expert community.

The positioning of the improvement of production and distribution of elite planting material in formal settings (4.45, rank 5), as well as the improvement of seed storage (4.34, rank 9), highlights the role of seed systems to tackle seed-borne diseases and thereby improve crop productivity. It also emphasizes the need to make high-quality planting material and improved varieties available to farmers. Once more, this result corresponds to the (on average) high scores given to issues related to potato seed improvement in the earlier survey by Fuglie (2007a).

One of the most highly ranked research options, finally, relates to the problem area of potato value chains. The development of farmer organizations and farmer clusters linked to markets (4.33) indicates a perceived need to improve potato farmers' access to higher value markets for their products, thus helping them to add value to their product and increase farm incomes.

Attention should also be paid to the regional differences in the results. In SWCA, for example, research on LB is ranked behind virtually all other research options listed in Table 9. At the same time, breeding for drought tolerance and earliness come out with exceptionally high average scores in that region. As can be seen from Tables 11–14 in Annex 3, in the two Asian regions (SWCA and ESEA) the management and control of virus diseases are among the highest ranked options. But these same options are not given the same importance in Latin America or SSA. Likewise, SWCA is the only region in which breeding for heat tolerance is given priority. In SSA, in turn, drought tolerance does not play a major role (Table 12 of Annex 3): Highest ranked options for potato research according to regional mean score). And though management and control of BW and breeding for BW resistance figure prominently, they do not appear on the lists of the other regions. In SSA as well, high importance is given to the

improvement of soil fertility, which is ranked second only after LB management. Another example of regional differences in research priorities is a high importance given to the phenotypic and/or molecular screening of landraces in search of high-value traits and new sources to stress tolerance or resistance in Latin America (Table 11 of Annex 3)—a result that can be interpreted as a logical consequence of the potato's high biodiversity in that region.

These observations give only a glimpse of regional differences in the results and underline the need to go beyond the scope of this report. Clearly, a more thorough analysis is needed of regional priorities for potato research by using the data from the survey.

In a similar manner, female and male experts have different perspectives on priorities for potato research. As an example, only men consider breeding for earliness as outstanding importance, whereas the research option does not show up among the front-runners of women experts. Similarly, women appear to put a high emphasis on the control and management of viruses (Table 6) and on the assessment of health and environmental risks of pesticide use in potato production systems (Table 8). Both research options are ranked lower when only the views of male experts are taken into account. As there is a demand to make priority assessment processes for agricultural R&D gender responsive (Meinzen-Dick et al. 2010), a more thorough analysis on gender differences in the prioritization of research options is indicated. Such analysis could, for example, search for systematic differences between male and female experts, looking both at individual research options and only at categories of research options, or controlling for other characteristics of the respondents, such as profession or discipline.

In the context of gender, it is worth mentioning that the three research options that explicitly incorporate gender aspects—namely gender-friendly labor-saving tools (mean score: 3.73; Table 6), research on more gender-equitable value chains (3.54; Table 8), and the study of gender inequality in potato production systems (3.32; Table 8)—are only given relatively low mean scores by the experts. This result is possibly a consequence of the mainly natural sciences background of the survey respondents. However, it is also in contrast to the currently prominent position of gender issues in (parts of) the international agricultural research for development community (CGIAR Consortium 2011; RTB 2013). It raises the general question of how to assess options for research that rank low in the perception of the broader expert community but have a high and recognized importance within particular expert groups.

Finally, some qualification of these results is in order. First, the results convey a rather aggregate picture of the importance of the different constraints and research options. This implies that options that appear to rank low in this report may well have high importance in a particular locality or region or for particular target groups. Similarly, not everything given high importance by the respondents will provide a universal solution to be applied anywhere. The analysis takes a mainly global perspective, with some disaggregation along the lines of regions and gender, but a closer look may be warranted. It has already been suggested that a more detailed and profound analysis be carried out with respect to regions and gender. But further analyses of differences in priorities by crop agro-ecologies, professions, disciplines, and other control variables recorded in the survey also promise to yield additional highly useful insights. The open-ended questions on the top constraints to sweetpotato production and sector development included in the survey, as well as the responses to the questions on other research options in each technology section, have not been analyzed so far. In the event, the dataset generated through

the survey and presented in this report constitutes an invaluable resource whose wealth of information can be exploited with further and more in-depth and disaggregated analysis.

However, even at the current level of analysis, the global survey of options for potato research for development presented in this report provides important information and guidelines for the strategic planning of research endeavors that aim to provide global public goods and create large impacts through broad technology spill-overs.

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ANNEXES

6. Annex 1. Timeline of expert survey

2012	
March	First meeting of RTB priority assessment taskforce and plan to conduct expert surveys
June	Questionnaire developed by priority assessment taskforce and draft cassava questionnaire pre-tested during international cassava conference in Kampala
July – Aug	Questionnaire adapted for potato survey and reviewed by team of potato experts
Sep-Dec	Questionnaire translated into Chinese, French, Russian, and Spanish and global potato expert survey set up as online tool
September	Survey carried out at the XXV Congress of the Latin American Potato Association, Uberlandia, Brazil, 17–20 September 2012, and the 16th International Symposium of the International Society for Tuber & Root Crops, Ibadan, Nigeria, 23–28 September 2012
Oct – Dec	Preparation of lists of potato experts for online surveys
December	First wave of invitations for participation in online survey sent to potato experts in Latin America and Africa

2013	
February	Second wave of invitations sent to potato experts in Latin America, Asia (incl. China), and Africa
June	Survey closes officially
August	Analysis of survey data and writing of draft report
December	Final report of global potato expert survey submitted to RTB

7. Annex 2. Highest ranked options for potato research according to global mean score with Asia/Pacific as a single region

To ensure comparability with similar surveys on other crops carried out by RTB, Table 10 presents the highest ranked options for potato research within a single region, Asia/Pacific, instead of the disaggregation of ESAE and SWCA (Tables 13 and 14).

TABLE 10: HIGHEST RANKED OPTIONS FOR POTATO RESEARCH ACCORDING TO GLOBAL MEAN SCORE WITH ASIA/PACIFIC AS A SINGLE REGION

	All regions		*Latin America*	*SSA*	*APA*	*CGIAR*	*Male*	*Female*
	Mean score	*s.e. (mean)*	*Mean score*	*Mean score*	*Mean score*	*Mean score*	*Mean score*	*Mean score*
Late blight control and management	4.71	0.04	4.63	4.77	4.77	4.52	4.68	4.80
Breeding for late blight resistance	4.60	0.05	4.56	4.52	4.66	4.36	4.57	4.78
Breeding for drought tolerance/water-use efficiency	4.51	0.05	4.56	4.34	4.62	4.70	4.47	4.67
Breeding for earliness	4.49	0.04	4.48	4.66	4.52	4.78	4.49	4.49
Improving production and distribution of elite planting materials (formal)	4.45	0.05	4.31	4.42	4.68	3.92	4.42	4.60
Improving soil fertility (micro-nutrients and fertilizer)	4.44	0.04	4.33	4.68	4.53	4.25	4.42	4.55
Germplasm enhancement and pre-breeding	4.41	0.05	4.42	4.43	4.42	4.38	4.35	4.64
Breeding for high yield	4.38	0.05	4.13	4.59	4.57	4.03	4.36	4.44
Improving seed storage	4.34	0.05	4.23	4.56	4.44	3.88	4.30	4.51
Development of farmer organizations and farmer clusters linked to markets	4.33	0.05	4.46	4.60	4.24	4.15	4.27	4.51
Improving potato cropping systems	4.32	0.04	4.28	4.46	4.33	4.41	4.27	4.51
…	…	…	…	…	…	…	…	…
Breeding for resistance to Mites (LOWEST RANKED)	2.89	0.07	2.93	2.90	2.88	2.85	2.80	3.23

[a] 1 = not important, 2 = low importance, 3 = important, 4 = very important, 5 = most important.

Source: authors' survey.

8. Annex 3. Highest ranked options for potato research according to regional mean score

TABLE 11: HIGHEST RANKED OPTIONS FOR POTATO RESEARCH ACCORDING TO LATIN AMERICA REGIONAL MEAN SCORE

	All regions		*Latin America*	*SSA*	*ESEA*	*SWCA*	*CGIAR*	*Male*	*Female*
	Mean score	*s.e. (mean)*	*Mean score*	*Mean score*	*Mean score*	*Mean score*	*Mean score*	*Mean score*	*Mean score*
Late blight control and management	4.71	0.04	4.63	4.77	4.85	4.06	4.52	4.68	4.80
Breeding for drought tolerance/water-use efficiency	4.51	0.05	4.56	4.34	4.59	4.88	4.70	4.47	4.67
Breeding for late blight resistance	4.60	0.05	4.56	4.52	4.76	3.82	4.36	4.57	4.78
Breeding for earliness	4.49	0.04	4.48	4.66	4.48	4.88	4.78	4.49	4.49
Phenotypic/molecular screening of landraces in search of high-value traits/new sources/tolerance/resistance to stress	4.30	0.05	4.46	4.11	4.28	4.21	4.36	4.21	4.63
Development of farmer organizations and farmer clusters linked to markets	4.33	0.05	4.46	4.60	4.26	4.06	4.15	4.27	4.51
Assessment of health and environmental risks of pesticide use in potato systems	4.16	0.06	4.44	3.87	4.14	4.19	4.08	4.05	4.53
Germplasm enhancement and pre-breeding	4.41	0.05	4.42	4.43	4.39	4.69	4.38	4.35	4.64
Water management in crop production	4.31	0.05	4.40	4.16	4.35	4.41	4.30	4.31	4.32
Improving technologies for farmer-based production and distribution of planting materials (informal)	4.23	0.06	4.39	4.59	4.00	4.29	4.35	4.19	4.36
Development of competitive potato value chains	4.32	0.05	4.38	4.50	4.32	3.93	4.04	4.28	4.42
…	…	…	…	…	…	…	…	…	…
Colorado potato beetle (LOWEST RANKED)	3.12	0.09	2.71	2.97	3.35	3.93	3.32	3.05	3.44

[a] 1 = not important, 2 = low importance, 3 = important, 4 = very important, 5 = most important.

Source: authors' survey.

TABLE 12: HIGHEST RANKED OPTIONS FOR POTATO RESEARCH ACCORDING TO SSA REGIONAL MEAN SCORE

	All regions		Latin America	SSA	ESEA	SWCA	CGIAR	Male	Female
	Mean score	s.e. (mean)	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score
Late blight control and management	4.71	0.04	4.63	4.77	4.85	4.06	4.52	4.68	4.80
Improving soil fertility (micro-nutrients and fertilizer)	4.44	0.04	4.33	4.68	4.53	4.53	4.25	4.42	4.55
Breeding for earliness	4.49	0.04	4.48	4.66	4.48	4.88	4.78	4.49	4.49
Bacterial wilt control and management	4.07	0.06	4.02	4.65	4.03	3.53	4.00	4.00	4.32
Development of farmer organizations and farmer clusters linked to markets	4.33	0.05	4.46	4.60	4.26	4.06	4.15	4.27	4.51
Breeding for high yield	4.38	0.05	4.13	4.59	4.54	4.83	4.03	4.36	4.44
Improving technologies for farmer-based production and distribution of planting materials (informal)	4.23	0.06	4.39	4.59	4.00	4.29	4.35	4.19	4.36
Breeding for resistance to bacterial wilt	4.09	0.06	4.01	4.57	4.11	3.50	4.29	4.01	4.39
Improving ware storage of table and processing potatoes	4.31	0.05	4.09	4.57	4.51	4.38	3.43	4.25	4.49
Improving seed storage	4.34	0.05	4.23	4.56	4.41	4.65	3.88	4.30	4.51
Evaluation of phytosanitary conditions before the distribution of plant genetic material	4.25	0.05	4.26	4.53	4.13	4.53	4.12	4.19	4.49
…	…	…	…	…	…	…	…	…	…
Breeding for long days (LOWEST RANKED)	3.08	0.08	2.92	2.68	3.26	3.69	3.60	3.06	3.20

[a] 1 = not important, 2 = low importance, 3 = important, 4 = very important, 5 = most important.

Source: authors' survey.

TABLE 13: HIGHEST RANKED OPTIONS FOR POTATO RESEARCH ACCORDING TO ESEA REGIONAL MEAN SCORE

	All regions		Latin America	SSA	ESEA	SWCA	CGIAR	Male	Female
	Mean score	s.e. (mean)	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score
Late blight disease (*Phytophtora infestans*)	4.71	0.04	4.63	4.77	4.85	4.06	4.52	4.68	4.80
Breeding for Late blight (*Phytophtora infestans*)	4.60	0.05	4.56	4.52	4.76	3.82	4.36	4.57	4.78
Improving production and distribution of elite planting materials (formal)	4.45	0.05	4.31	4.42	4.67	4.76	3.92	4.42	4.60
Breeding for drought tolerance/water-use efficiency	4.51	0.05	4.56	4.34	4.59	4.88	4.70	4.47	4.67
Breeding for high yield	4.38	0.05	4.13	4.59	4.54	4.83	4.03	4.36	4.44
Improving soil fertility (micro-nutrients and fertilizer)	4.44	0.04	4.33	4.68	4.53	4.53	4.25	4.42	4.55
Improving ware storage of table and processing potatoes	4.31	0.05	4.09	4.57	4.51	4.38	3.43	4.25	4.49
Breeding for earliness	4.49	0.04	4.48	4.66	4.48	4.88	4.78	4.49	4.49
Virus control and management	4.28	0.05	3.98	4.36	4.43	4.88	4.15	4.21	4.54
Improving seed storage	4.34	0.05	4.23	4.56	4.41	4.65	3.88	4.30	4.51
Germplasm enhancement and pre-breeding	4.71	0.04	4.63	4.77	4.85	4.06	4.52	4.68	4.80
…	…	…	…	…	…	…	…	…	…
Breeding for resistance to mites (LOWEST RANKED)	2.89	0.07	2.93	2.90	2.91	2.67	2.85	2.80	3.23

[a] 1 = not important, 2 = low importance, 3 = important, 4 = very important, 5 = most important. Source: authors' survey.

TABLE 14: HIGHEST RANKED OPTIONS FOR POTATO RESEARCH ACCORDING TO SWCA REGIONAL MEAN SCORE

	All regions		Latin America	SSA	ESEA	SWCA	CGIAR	Male	Female
	Mean score	s.e. (mean)	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score
Breeding for drought tolerance/water-use efficiency	4.51	0.05	4.56	4.34	4.59	4.88	4.70	4.47	4.67
Virus control and management	4.28	0.05	3.98	4.36	4.43	4.88	4.15	4.21	4.54
Breeding for earliness	4.49	0.04	4.48	4.66	4.48	4.88	4.78	4.49	4.49
Breeding for high yield	4.38	0.05	4.13	4.59	4.54	4.83	4.03	4.36	4.44
Improving production and distribution of elite planting materials (formal)	4.45	0.05	4.31	4.42	4.67	4.76	3.92	4.42	4.60
Germplasm enhancement and pre-breeding	4.41	0.05	4.42	4.43	4.39	4.69	4.38	4.35	4.64
Improving seed storage	4.34	0.05	4.23	4.56	4.41	4.65	3.88	4.30	4.51
Breeding for tolerance to storage diseases	4.29	0.05	4.21	4.23	4.37	4.65	3.85	4.23	4.53
Breeding for heat tolerance	3.85	0.06	3.72	4.00	3.78	4.59	4.41	3.78	4.11
Evaluation of phytosanitary conditions before the distribution of plant genetic material	4.25	0.05	4.26	4.53	4.13	4.53	4.12	4.19	4.49
Improving soil fertility (micro-nutrients and fertilizer)	4.44	0.04	4.33	4.68	4.53	4.53	4.25	4.42	4.55
…	…	…	…	…	…	…	…	…	…
Andean potato weevil (LOWEST RANKED)	3.33	0.10	3.88	2.71	3.20	1.29	3.48	3.23	3.69

[a] 1 = not important, 2 = low importance, 3 = important, 4 = very important, 5 = most important.

Source: authors' survey.

9. Annex 4. Survey questionnaire

RESEARCH PROGRAM ON Roots, Tubers and Bananas
CGIAR

SURVEY OF PRIORITIES AND NEEDS FOR POTATO RESEARCH – 2013

Dear member of the potato community of practice, we appreciate you taking the time to complete the survey, even if you are not a researcher!

Section A. Please tell us a little about yourself

1. **Your name** (optional)**:** _____
2. **E-mail address** (optional)**:** _____
3. **Your gender** (please encircle)**:** **M** **F**
   •
4. **Your age:** _____ years
5. **Your Organization:** _____
   •
6. **How many years have you been involved, at least part-time, in potato research?** ____
   •
7. **Would you characterize your potato work as**

   ☐ Global

   ☐ Regional (tick boxes)

   ☐ Western and Central Africa ☐ Eastern Africa

   ☐ Southern Africa ☐ North America

   ☐ Central America and the Caribbean ☐ South America

   ☐ South-west and Central Asia ☐ Southern Asia

   ☐ Eastern Asia and Pacific ☐ Europe

   ☐ Other

☐ National (specify country) _____

8. On which agro-ecological zones is your potato work focused? (tick all that apply)

☐ Tropical highlands
☐ Mid-elevation tropics
☐ Subtropical highlands
☐ Subtropical lowlands
☐ Temperate highlands
☐ Temperate lowlands
☐ Others (specify) _____

9. In your opinion, what are the three top constraints to the potato sector in general, from production to consumption, today? (please rank and be specific; 1 is the highest possible rank)

1. _____
•
2. _____
•
3. _____
•

10. In your opinion, what will be the single one most important trend in potatoes seen from production to consumption in the next ten years?

_____

11. Are you (please mark the one most relevant answer)

☐ a research leader/manager from a national agricultural research institute?
☐ a research scientist from a national agricultural research institute?
☐ a research scientist or lecturer at a university?
☐ a student conducting research at a university?
☐ an extension agent?
☐ a representative of a non-government, not-for-profit organization (NGO)?
☐ a representative of a donor to the CGIAR system?

☐ a CGIAR center scientist?

☐ employed by a private, for-profit company?

☐ a policy maker or civil servant?

Other (please specify)?: _____

12. What is your background? (please mark all that apply)

☐ Crop genetic resources ☐ Genomics or molecular biology

☐ Participatory variety selection ☐ Plant breeding and genetics or molecular breeding

☐ Transgenic research ☐ Crop management, agronomy, and physiology

☐ Tissue culture ☐ Water management in crop production

☐ Soils/nutrient management ☐ Crop diseases and their management

☐ Cropping/farming systems ☐ Crop pests and their management

☐ Economics or policy ☐ Post-harvest crop utilization / marketing

☐ Climate change specialist

☐ Cultural anthropology or rural sociology

☐ Training and knowledge management

☐ Research planning and administration

☐ Development planning and administration

☐ Other (please specify): _____

Section B. Please assess the importance of the following options for helping to reduce poverty and improve food security through potato research and capacity development.

Research options to reduce poverty and improve food security	**Importance for research** please mark: ⟺ least important=1 most important=5
A Crop improvement	
1. Breeding for high yield	1 2 3 4 5 don't know
2. Breeding for other specific producer preferred traits (specify)	1 2 3 4 5 don't know
3. Breeding for dry matter, high starch and flour yield	1 2 3 4 5 don't know
4. Breeding for other consumer preferred traits (specify)	1 2 3 4 5 don't know
5. Breeding for processing quality	1 2 3 4 5 don't know
6. Breeding for starch quality traits (specify)	1 2 3 4 5 don't know
Breeding for improvements in nutritional quality	
7. Pro-vitamin A carotenoids	1 2 3 4 5 don't know
8. Protein	1 2 3 4 5 don't know
9. Iron and zinc	1 2 3 4 5 don't know
10. Tolerance to storage diseases	1 2 3 4 5 don't know
11. Other (specify)	1 2 3 4 5 don't know
Breeding for biotic stress resistance	
12. Late blight (*Phytophtora infestans*)	1 2 3 4 5 don't know
13. Fusarium wilt (*Fusarium oxysporum*)	1 2 3 4 5 don't know
14. Rhizoctonia	1 2 3 4 5 don't know
15. Bacterial wilt (*Raistonia Solanacerum*)	1 2 3 4 5 don't know
16. Erwinia – soft rot, black leg	1 2 3 4 5 don't know
17. Common scab (*Streptomyces spp.*)	1 2 3 4 5 don't know
18. Virus PVY	1 2 3 4 5 don't know
19. Virus PLRV	1 2 3 4 5 don't know
20. Other viral diseases of potato	1 2 3 4 5 don't know
21. Tuber moth	1 2 3 4 5 don't know

Research options to reduce poverty and improve food security	**Importance for research** please mark: ⟺ least important=1 most important=5
22. Aphids	1 2 3 4 5 don't know
23. White fly	1 2 3 4 5 don't know
24. Leafminer fly	1 2 3 4 5 don't know
25. Mites	1 2 3 4 5 don't know
26. Cutworms	1 2 3 4 5 don't know
27. Nematodes (specify)	1 2 3 4 5 don't know
28. Other biotic stresses of potato (specify)	1 2 3 4 5 don't know
Breeding for abiotic stress resistance	
29. Drought tolerance/water-use efficiency	1 2 3 4 5 don't know
30. Heat tolerance	1 2 3 4 5 don't know
31. Cold or frost tolerance	1 2 3 4 5 don't know
32. Water logging	1 2 3 4 5 don't know
33. Tolerance of marginal/toxic soils (specify)	1 2 3 4 5 don't know
34. Other abiotic stresses of potato (specify)	1 2 3 4 5 don't know
Breeding for environmental adaptation or new uses	
35. Long days	1 2 3 4 5 don't know
36. Earliness	1 2 3 4 5 don't know
37. Seed dormancy	1 2 3 4 5 don't know
38. Other (specify)	1 2 3 4 5 don't know
Other opportunities for crop improvement	
39. Germplasm enhancement and pre-breeding	1 2 3 4 5 don't know
40. Exploitation of heterosis	1 2 3 4 5 don't know
41. Breeding TPS (True Potato Seed) as alternative to clonal seed	1 2 3 4 5 don't know
42. Others (specify)	1 2 3 4 5 don't know

Research options to reduce poverty and improve food security	**Importance for research** please mark: ⟺ least important=1 most important=5
B. Management of soils, water, weeds, and harvest	
1. Improving soil fertility (micro-nutrients and fertilizer)	1 2 3 4 5 don't know
2. Managing soil acidity	1 2 3 4 5 don't know
3. Managing soil salinity	1 2 3 4 5 don't know
4. Soil management and erosion control	1 2 3 4 5 don't know
5. Water management in crop production	1 2 3 4 5 don't know
6. Improving potato cropping systems	1 2 3 4 5 don't know
7. Improving harvesting methods or machinery	1 2 3 4 5 don't know
8. Gender-friendly labor-saving tools	1 2 3 4 5 don't know
9. Weed management and control	1 2 3 4 5 don't know
10. Others (specify)	1 2 3 4 5 don't know
C Improvement of seeds or planting materials	
1. Improving technologies for farmer based production and distribution of planting materials (informal)	1 2 3 4 5 don't know
2. Improving production and distribution of elite planting materials (formal)	1 2 3 4 5 don't know
3. Improving seed storage	1 2 3 4 5 don't know
4. Mass propagation methods	1 2 3 4 5 don't know
5. Developing TPS (True Potato Seed) as alternative to clonal seed	1 2 3 4 5 don't know
6. Others (specify)	1 2 3 4 5 don't know
D Disease control/management, incl. use of resistant varieties	
1. Viruses	1 2 3 4 5 don't know
2. Late blight disease (*Phytophtora infestans*)	1 2 3 4 5 don't know
3. Other fungal diseases (specify)	1 2 3 4 5 don't know
4. Bacterial wilt (*Ralstonia solanacearum*)	1 2 3 4 5 don't know
5. Other bacterial diseases (specify)	1 2 3 4 5 don't know
E Pest control and management, incl. use of resistant varieties	
1. Nematodes (specify kind)	1 2 3 4 5 don't know

Research options to reduce poverty and improve food security	**Importance for research** please mark: ⟺ least important=1 most important=5
2. Potato tuber moths (*P. operculella, S. tangolias, T. solanivora*)	1 2 3 4 5 don't know
3. Leafminer fly (*Liriomyza huidobrensis*)	1 2 3 4 5 don't know
4. Colorado potato beetle (*Leptinotarsa decemlineata)*	1 2 3 4 5 don't know
5. Andean potato weevil (*Premnotrypes spp*. Andean)	1 2 3 4 5 don't know
6. Aphids (*Aphidoidae spp.)*	1 2 3 4 5 don't know
7. Others (specify)	1 2 3 4 5 don't know
G Genetic resource management	
1. In-situ genetic resource management	1 2 3 4 5 don't know
2. Collection, characterization, evaluation, documentation (ex situ*)*	1 2 3 4 5 don't know
3. Phenotypic/molecular screening of landraces in search of high-value traits/new sources/tolerance/resistance to stress	1 2 3 4 5 don't know
4. Conservation, health testing, and distribution	1 2 3 4 5 don't know
5. Evaluation of phytosanitary conditions before the distribution of plant genetic material	1 2 3 4 5 don't know
6. Distribution of plant genetic material of potatoes	1 2 3 4 5 don't know
7. Management of intellectual property rights and material transfer agreements	1 2 3 4 5 don't know
8. Others (specify)	1 2 3 4 5 don't know
H Value chains, postharvest utilization, and marketing	
1. Improving ware storage of table and processing potatoes	1 2 3 4 5 don't know
2. Developing potato products for human consumption	1 2 3 4 5 don't know
3. Developing potato products for industrial applications (flour and starch)	1 2 3 4 5 don't know
4. Developing potato products for animal feed	1 2 3 4 5 don't know
5. Development of competitive potato value chains	1 2 3 4 5 don't know
6. Research on more gender equitable value chains	1 2 3 4 5 don't know
7. Development of farmer organizations and farmer clusters linked to markets	1 2 3 4 5 don't know
8. Others (specify)	1 2 3 4 5 don't know

Research options to reduce poverty and improve food security	**Importance for research** please mark: ⟺ least important=1 most important=5
I Socioeconomic, policy, and impact studies on potatoes	
1. Assessment of small farmer access to new technologies	1 2 3 4 5 don't know
2. Assessment of potato technology adoption	1 2 3 4 5 don't know
3. Assessment of potato-based innovation systems	1 2 3 4 5 don't know
4. Assessment of impact of potato research and development	1 2 3 4 5 don't know
5. Assessment of health and environmental risks of pesticide use in potato systems	1 2 3 4 5 don't know
6. Assessment of health effects of bio-fortified potato varieties	1 2 3 4 5 don't know
7. Study gender inequality in potato production systems	1 2 3 4 5 don't know
8. Research on food and agricultural policies affecting potatoes	1 2 3 4 5 don't know
9. Improving policy framework for potato planting materials (distribution, regulations, IPRs, etc.)	1 2 3 4 5 don't know
10. Others (specify)	1 2 3 4 5 don't know
J Extension	
1. Development of new extension strategies	1 2 3 4 5 don't know
2. Development of new didactic materials for extension	1 2 3 4 5 don't know
3. Use of information and mobile telephony technologies	1 2 3 4 5 don't know
4. Others (specify)	1 2 3 4 5 don't know

Please add any comments here:

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