RESEARCH PROGRAM ON
Roots, Tubers and Bananas

CGIAR

RTB
Working Paper

ISSN 2309-6586
RTB Working Paper
2014-6

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

Bernardo Creamer, Joseph Rusike, Carlos Gonzalez, Jesús José Rodriguez, Tahirou Abdoulaye and Arega Alene

A broad alliance of research-for-development stakeholders & partners

CENTRO INTERNACIONAL DE LA PAPA · CIP · Bioversity International · CIAT Centro Internacional de Agricultura Tropical International Center for Tropical Agriculture · cirad AGRICULTURAL RESEARCH FOR DEVELOPMENT · IITA Research to Nourish Africa

RTB Working Paper

Published by the CGIAR Research Program on Roots, Tubers and Bananas (RTB)

RTB is a broad alliance of research-for-development stakeholders and partners. Our shared purpose is to exploit the potential of root, tuber, and banana crops for improving nutrition and food security, increasing income generation and fostering greater gender equity– especially amongst the world's poorest and most vulnerable populations.

The RTB Working Paper Series is intended to disseminate research and practices about production and utilization of roots, tubers and bananas and to encourage debate and exchange of ideas. The views expressed in the papers are those of the author(s) and do not necessarily reflect the official position of RTB.

Contact:

RTB Program Management Unit
International Potato Center (CIP)
Apartado 1558, Lima 12, Peru
rtb@cgiar.org • www.rtb.cgiar.org

ISSN 2309-6586

© International Potato Center on behalf of RTB

Creative Commons License

This publication is licensed under the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.

Correct citation:

Creamer, B; Rusike, J.; Gonzalez, C.; Rodriguez, J.J.; Abdoulaye, T.; Alene, A. 2014. Prioritization of options for Cassava research for development – Results from a global expert survey. Lima (Peru). CGIAR Research Program on Roots, Tubers and Bananas (RTB). RTB Working Paper 2014-6. Available online at: www.rtb.cgiar.org

Table of Contents

List of Tables

Acknowledgements

Abstract

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

This paper applies the scoring method for priority setting of agricultural research investments to data collected through a survey of cassava experts in sub-Saharan Africa, Latin America and the Caribbean and Asia from mid-2012 to mid-2013. The survey ascertained the perspectives of cassava scientists, researchers and development practitioners about the major constraints and trends in cassava today and the importance of alternative research options to resolve the constraints in order reduce poverty and improve food security. Results show that the priority research options to resolve the constraints on cassava today and help to reduce poverty and improve food security are markets and value chains, including supply and distribution of planting materials; disease management; breeding of high yielding varieties with resistance to CMD and CBSD; small scale processing and assessing the impact of cassava research and development. Although there are some differences in prioritization of these options among different geographical regions in Africa, Latin America and the Caribbean and Asia, the globally highest ranked research options are similar for all regions.

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

1. Introduction

Cassava (Manihot esculenta Crantz), is one of the most important sources of calorific energy in the diet in many countries in the tropics, at latitudes of less than 30 degrees, and from sea level to 1800 m above sea level. This crop is native to South America. Although, the principal commercial product are its roots, cassava leaves also have potential economic value, and as a matter of fact, are extensively used in Africa and Asia as either human food or animal feed (Ceballos, 2012). In terms of volume produced, Cassava is the world's fourth most important crop after rice, wheat and maize.

On top of being a small farmers' preferred crop in many regions in the world, diverse commodities such as ethanol and starch can be obtained from Cassava. In general cassava is produced and processed by small scale producers and businesses. As an example, farm sizes in Asia tend to be small: from 0.24-1.15 per family in Africa; 0.2-0.8 has. per family in China, Vietnam, parts of India[1] and Indonesia[2]; and 2-3 has. per family in Thailand (Nweke et. al, 2002; Howeler, 2012). Possibly due to the small farm size of cassava crops, Cassava has never attracted private companies research, that seem to prefer products that have a potential for large scale commercial production, distribution and marketing.

Some of the key characteristics of the crop are 1) its efficiency in producing carbohydrates, 2) its tolerance to drought and good performance in impoverished soils (even though it thrives on fertile, sandy-clay soils), 3) its high flexibility with respect to the timing of planting and harvesting, and 4) its wide adaptability for competitive break-even yield production in varying agro-ecological and market conditions. For these reasons, cassava has significant potential to contribute to food security, income generation and poverty reduction especially in both favorable and unfavorable regions that are prone to drought and with poor soils (FAO, 2000). According to (Jarvis, Ramirez-Villegas, Herrera Campo, & Navarro-Racines, 2012) cassava is potentially highly resilient to future climatic changes and could provide Africa with options for adaptation whilst other major food staples face challenges. Therefore, due to its popularity among small farmers, its high starch production potential, drought resistance and adaptability to different growing environments, cassava has been of particular interest to non profit organizations doing public research (FAO, 2000).

Despite the significant agricultural production potential of cassava combined with its recognized tolerance for biotic and abiotic stresses and the diversity of its possible uses, cassava has yet to fully develop its potential in tropical agriculture. According to Ceballos (2012), some of the reasons for this delay are: competition from other temperate and region specific technologies, insufficient cultivars specifically developed for industry use, lengthy selection cycles and low reproduction rate, governmental policies towards promoting grain production, root bulk and rapid perishability, and

[1] Kerala estate, India
[2] Java island

limited market development. Due to the higher potential comparative advantage of cassava over cereals and traditional cash crops, as mentioned above, cassava is considered as a very important crop to increase food security in the tropics, and therefore there is urgent need to determine research priorities to optimize the impact of the scarce resources available for research and development (R&D). The R&D sector agents, as producers and providers of new technologies and applied knowledge, stand on the supply side of knowledge value chain that is intended to interact with producers and processors.

As pointed out by some authors (Norton, Pardey, & Alston, 1992), a big hurdle to determine a research portfolio that maximizes the social returns to investment, is related to the measurement of costs and benefits. When two or more objectives are involved, the complexity increases and it becomes even more challenging to set priorities. Priority setting under multiple objectives involves not only identifying the specific objectives and measuring the contributions of alternative research programs to each of them, but also requires trading off or weighting the alternative objectives.

The CGIAR Research Program on Roots, Tubers and Bananas (RTB) is a global research initiative that aims is to exploit the underutilized potential of roots , tubers and bananas to improve food security, nutrition and livelihoods . The RTB is a joint initiative of the International Potato Center (CIP), Bioversity International, the International Center for Tropical Agriculture (CIAT), and the International Institute of Tropical Agriculture (IITA).

In order to identify research options with the greatest potential impact on targeted populations and guide decision making about allocation of resources among alternative research options, the RTB started a project in 2013 in which, by means of an economic analysis, it intends to identify research priorities in cassava research. A central component in this exercise is the broad participation of the scientific community and extensionists in order to obtain results based on parameters as close as possible to the real conditions.

This study applies the scoring method of priority setting based on Alston et. al. (1998) to data collected through a survey of cassava experts from mid-2012 to mid-2013. The survey ascertained the perspectives of cassava scientists, policy makers and development practitioners about the major constraints and trends in cassava today and the importance of alternative research options to resolve the constraints in order reduce poverty and improve food security. In Section 2 we present the methodological approach taken for the survey and its analysis. Section 3 presents the results of the survey, focusing on research options prioritized by the experts. The final section discusses the results focusing on the globally highest ranked research options and draws implication for the priority assessment.

2. Materials and methods

The survey of cassava research priorities and needs was directed to scientists, researchers and suppliers of technology in general. In the preparation phase, an extensive list of alternative research options were compiled by the task force drawing from the research proposal of the CRP-RTB program and discussions with scientists from CIAT and IITA. This list included the universe of alternative research options with manageable interest and a high likelihood of impact to achieve the System-Level Outcomes (SLOs) of the CGIAR of reducing rural poverty, increasing food security, improving human nutrition and health and more sustainable management of natural resources.

Cassava experts were questions on the research options that were clustered into 4 typologies. These include (a) crop genetic improvement; (b) production technology, agronomy and crop management; (c) improvement of seeds or planting materials; and (d) other options for cassava research, including genetic resource management, value chains, post-harvest utilization and marketing, socio-economic, policy and impact studies.

These typologies were used to develop specific questions on 89 research options that the experts were asked using a questionnaire interview survey. The questionnaire was organized into three main components. The first component elicited personal and contact information of the respondent, basic information about their professional background, agro-ecological zone or geographical region of work, and opinion about the current top constraints on the cassava sector and most important trends in the coming decade. The second component collected information about characterization of cassava research carried out by the respondents' organization and recent trends in the magnitude of these research investments. The final component asked respondents to assess the importance of alternative options for reducing poverty and improving food security through cassava research and capacity development.

Respondents were asked to rate, on a scale from 1 to 5, the importance of each of the research options, matching 1 in the scale to the "not important" category, passing by "low importance", "important", "very important", and "most important" equivalent to 5.

To make the survey accessible to as many people as possible, the questionnaires were translated and made available in English, French, Spanish and Portuguese.

The survey was implemented using a combination of three sampling methods. First, cassava experts who participated in international scientific meeting filled out the questionnaires during the Second Scientific Conference of the Global Cassava Partnership (GCP) for the 21st Century that was organized in Kampala, Uganda, from 18 to 22 June 2012 and the 16th Triennial Symposium of the International Society for Tropical Root Crops that was organized in Abeokuta, Nigeria, 23-28 September 2012. Second, respondents were interviewed through personal visits and interviews with extension staff and other NARS (from research institutes and universities) in Ghana, Togo and Benin from September to December 2012. The third method collected data from cassava experts through the online tool, Survey Monkey. A total of 378 questionnaires were completed, from which 343 had significant data. These consisted of 203 questionnaires that were completed during the Second Scientific Conference of the Global Cassava Partnership (GCP) for the 21st Century in Kampala; 29 questionnaires during the 16th Triennial Symposium of the International Society for Tropical Root Crops in Abeokuta; 25 questionnaires during the personal interviews; and 59 questionnaires through the online Money survey.

Respondents included in this survey characterized the geographical location and spread of their work on cassava, in decreasing order of importance, as Sub-Saharan Africa (Western and Central Africa, Eastern Africa, Southern Africa), global, Asia region (Southern Asia, Eastern Asia and Pacific, Southwest and Central Asia), Latin America and Caribbean , other and North America (Table 1).

TABLE 1: NUMBER OF RESPONDENTS BY REGION

	Total responses (N=343)	*Share in total*
Global	75	0.244
Sub-Saharan Africa (SSA)	173	0.562
Asia	31	0.101
Latin America and Caribbean (LAC)	26	0.084
North America	1	0.003
Other	2	0.006
Total	308	1
No information	35	
Total responses	***343***	

Source: Authors' calculations.

Sample experts reported that their cassava work was located in agro-ecological zones in tropical sub-humid environments (25%), tropical humid savannas environments (20%), tropical humid forest environments (16%), semi-arid environments (11%), sub-tropical sub-humid environments (8%), subtropical humid environments (8%), tropical or subtropical highlands (8%) and other (4%) (Table 2).

TABLE 2: NUMBER OF RESPONDENTS BY CROP AGRO-ECOLOGY

	Total responses (N=343)	*Share in total*
Tropical sub-humid environments	139	0,25
Tropical humid savannah environments (*Aw*)	109	0,20
Tropical humid forest environments (*Af*)	87	0,16
Semi-arid environments (*Bwh, Bsh)*	62	0,11
Subtropical sub-humid environments	44	0,08
Subtropical humid environments	47	0,08
Tropical or subtropical highlands (*Cwb)*	44	0,08
Other	23	0,04
Total	555	1

Source: Authors' calculations.

Most of the respondents were scientists from a national agricultural research institute (Table 3). These were followed by scientists at a university; research managers from a national agricultural research institute, CGIAR scientists, extension agents; representatives of a non-government; not-for-profit organization (NGO); employees of a private for-profit company; representatives of a donor to the CGIAR system; policy marker or civil servant, and a student conducting research at a university.

TABLE 3: NUMBER OF RESPONDENTS BY PROFESSION

	Total responses (N=343)	*Share in total*
Research scientist from a national agricultural research institute	99	0,29
Research scientist or lecturer at a university	67	0,20
Research manager from a national agricultural research institute	32	0,09
CGIAR center scientist	28	0,08
Extension agent	23	0,07
Representative of a non-government, not-for-profit organization (NGO)	16	0,05
Employee of a private, for-profit company	16	0,05
Representative of a donor to the CGIAR system	6	0,02
policy maker or civil servant	2	0,01
student conducting research at a university	1	0,00
no information	53	0,15
Total	**343**	**1**

Source: Authors' calculations.

Respondents sampled were drawn from a broad range of disciplines (Table 4). Nearly 50% included plant breeding and conventional genetics; genomics bioinformatics and molecular biology; crop management, agronomy, and physiology; tissue culture; crop diseases and their management; cropping/farming systems; post-harvest crop utilization/marketing; crop pests and their management; and crop genetic resources. The balance was in decreasing order of importance, drawn from research planning and administration; participatory plant breeding; transgenic research; training and knowledge management; soils/nutrient management; development planning and administration; economics or policy; water management in crop production; climate change specialist; cultural anthropology or rural sociology; Economics or public policy specialist and others.

TABLE 3: NUMBER OF RESPONDENTS BY DISCIPLINE

	Total responses (N=343)	*Share in total*
Plant breeding and conventional genetics	74	0,10
Genomics, bioinformatics, molecular biology	67	0,09
Crop management, agronomy, and physiology	65	0,09
Tissue culture	58	0,08
Crop diseases and their management	49	0,07
Cropping/farming systems	42	0,06
Post-harvest crop utilization/marketing	42	0,06
Crop pests and their management	39	0,05
Crop genetic resources	38	0,05
Research planning and administration	38	0,05
Participatory plant breeding	37	0,05
Transgenic research	37	0,05
Training and knowledge management	31	0,04
other	29	0,04
Soils/nutrient management	28	0,04
Development planning and administration	25	0,03
Economics or policy	17	0,02
Water management in crop production	12	0,02
Climate change specialist	6	0,01
Cultural anthropology or rural sociology	4	0,01
Economics or public policy specialist	2	0,00
Total	***740***	***1***

Source: Authors' calculations.

In the second module, respondents were asked to list and rank the three top constraints on the cassava sector and most important trends in cassava in the coming decade. Table 5 reports the constraints. The constraints include, in decreasing order of importance based on tallying the frequency of responses, (1) Pest, virus and Disseases; (2) Market problems; (3) Producers (lack of entrepreneurial mindset, inadequate technology, low productivity); (4) Policy and Governance; (5) Quality and Seed Multiplication; (6) Producction (loss of production, low productivity, low mechanization, transportation, etc.); (7) Breending and planting material; (8) problems Varieties; (9) Abiotic and biotic stresses; (10) Genetic and tecnhology; (11) Research; (12) Value addition; (13) Post Harvest; (14) Limitations of the work; (15) Soil (16) Others (17) Agronomy (18) Climate change (19) and (20) Gender.

TABLE 5: CURRENT CONSTRAINTS ON THE CASSAVA SECTOR

		freq	*Share in total*
1.	Pest, virus and Disseases	273	0,30
2.	Market problems (prices, competitiveness, distance markets, etc.)	93	0,10
3.	Producers (lack of entrepreneurial mindset, inadequate technology, low productivity)	57	0,06
4.	Policy and Governance (ack of order in the chain, poor organization, financing, subsidies, intervention in infrastructure)	54	0,06
5.	Quality and Seed Multiplication	48	0,05
6.	Producction (loss of production, low productivity, low mechanization, transportation, etc.)	48	0,05
7.	Breending and planting material (access to planting material, clean material quality, efficient distribution, etc.)	45	0,05
8.	problems Varieties (improvement, access, productivity, resistance, and development of varieties)	36	0,04
9.	Abiotic and biotic stresses (Biotic and abiotic stress tolerance to drought, climate change.)	33	0,04
10.	Genetic and tecnhology (enhance gene flow, genetic limitations, inefficient technologies, modified starch, increase nutrients, etc)	30	0,03
11.	Research (Agenda poor coordination, funding, researchers gap and growers)	30	0,03
12.	Value addition (trouble adding value uses of cassava, poor value chain)	27	0,03
13.	Post Harvest (difficulty in managing the harvest, storage problems, problems in plant and crop technology)	24	0,03
14.	Limitations of the work (high labor requirements, lack of investment in human capacity development, labor intensive.)	24	0,03
15.	Soil (exhausted soils, fertility problems, and nutrient use)	24	0,03
16.	Others	18	0,02
17.	Yield constraints (low yields)	15	0,02
18.	Agronomy (water management, lack of agricultural management, poor agronomic practices, poor crop managemen)	12	0,01
19.	Climate change	9	0,01
20.	Gender	3	0,00
	Total	903	1

Source: Authors' calculations.

Table 6 reports the most important trends experts perceive are underway in cassava in the coming ten years. The trends include, in decreasing order of frequency of responses, The trends, in decreasing order of importance, include (1) Increased industrialization; (2) Herbicide resistance, biotic and control diseases; (3) More production, more and more countries cultivated areas available to produce; (4) Development of efficient varieties / or tolerant resistors; (5) Higher marketing; (6) Fresh consumption and animal feed industry, energy; (7) Increased added value and chain; (8) Increase yield and consumption; (9 Starch-nutrientes-biofortificacion (Improvements of nutrients); (10) Food security to the whole world (key); (11) Production and yield low (decresed); (12) Greater adaptation to climate change (13) Research (Consolidated research team covering production and marketing); (14) Evolution of the sector in general (15) Farmer (16) Fuel use (use of cassava in Biofuels); (17) others (18) Technology adoption, infrastructure (19) government intervention (increased funding and support); (20) dynamic geographic (mobility of the population and demographic changes); (21) Foreign Trade (Export product transform and imports china) (22) seed and planting material and (23) Soil fertility improvement and soil erosion control.

TABLE 6: MOST IMPORTANT TRENDS IN CASSAVA IN THE NEXT TEN YEARS

	Trend	Freq	Share in Total
1.	Increased industrialization (product diversification), processing and machining	29	0.12
2.	Herbicide resistance, biotic and control diseases	26	0.10
3.	More production, more and more countries cultivated areas available to produce	23	0.09
4.	Development of efficient varieties / or tolerant resistors	23	0.09
5.	Higher marketing	21	0.08
6.	Fresh consumption and animal feed industry, energy	19	0.08
7.	Increased added value and chain	17	0.07
8.	Increase yield and consumption	15	0.06
9.	Starch-nutrientes-biofortificacion (Improvements of nutrients)	10	0.04
10.	Food security to the whole world (key)	9	0.04
11.	Production and yield low (decresed)	8	0.03
12.	Greater adaptation to climate change (rainfall-tropic) and effect on production	8	0.03
13.	Research (Consolidated research team covering production and marketing)	6	0.02
14.	Evolution of the sector in general	6	0.02
15.	Farmer (increased income and transition to industrialization)	6	0.02
16.	Fuel use (use of cassava in Biofuels)	5	0.02
17.	others	5	0.02
18.	Technology adoption, infrastructure	4	0.02
19.	government intervention (increased funding and support)	3	0.01
20.	dynamic geographic (mobility of the population and demographic changes.)	3	0.01
21.	Foreign Trade (Export product transform and imports china)	2	0.01
22.	seed and planting material	2	0.01
23.	Soil fertility improvement and soil erosion control	1	0.00
	Total	251	1

Source: Authors' calculations.

3. Results

This section presents and discusses the results of the expert assessment of the importance of alternative research options to reduce food security through cassava research and capacity development. The discussion is organized by the typology of research options that was used to guide eliciting responses from experts during the interviews.

Focusing on crop genetic improvement 41 alternative research options were presented to respondents for rating. The top-ranked 25 options with a global mean score exceeding a cutoff point of 3.5 are, decreasing order of importance, High yield; Early harvest (6-8 months after planting); Drought tolerance / water use efficiency; Germplasm enhancement and pre-breeding; Cassava mosaic disease(Breeding for biotic stress resistance); Tolerance to post-harvest physiological deterioration; Bacterial blight (Xanthomonas spp); High dry matter; Processing quality; Whiteflies; Cassava brown streak disease(Breeding for biotic stress resistance); Nutrient use efficiency; Starch quality traits; Other specific producer preferred traits; Mechanization; Pro-Vitamin A (beta-carotene); Exploitation of heterosis; Other consumer preferred traits; Others (Long underground storage, Vitamin E; Starch modification, Early bulking, Leaves quality; Early bulking and maturing); Low cyanogenic potential, Root rots; Mites Protein; Mealybu and Others(Stability in starch once different harvest regime, Propagation success).

TABLE 7: PRIORITIZATION OF OPTIONS FOR CROP GENETIC IMPROVEMENT

	All responses														
	Number of responses ranking importance (1 to 5)[a]								AFRICA						
	1	2	3	4	5	Total responses	LAC	ASIA	WCA	EA	SA	Regional average AFRICA	REGIONAL average	GLOBAL	TOTAL average
							Mean score	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score
Yield and quality								**Yield and quality**							
High yield	10	13	34	127	123	307	4.18	4.28	3.99	4.07	4.00	4.02	4.16	4.17	4.16
High dry matter	15	17	56	109	102	299	4.05	4.07	3.74	3.97	3.94	3.89	3.98	3.81	3.94
Processing quality	6	22	71	124	65	288	4.05	3.76	3.71	3.76	3.81	3.76	3.86	3.71	3.82
Starch quality traits	5	23	76	106	56	266	3.82	3.50	3.68	3.64	3.58	3.63	3.67	3.84	3.71
Other consumer preferred traits	9	23	80	77	54	243	3.76	3.55	3.59	3.59	3.67	3.62	3.63	3.55	3.61
Low cyanogenic potential	11	44	77	73	65	270	3.89	3.62	3.39	3.57	3.63	3.53	3.67	3.38	3.60
Root mealiness	8	38	89	81	41	257	3.30	3.26	3.43	3.36	3.75	3.51	3.33	3.47	3.36
Other specific producer preferred traits	13	24	64	96	67	264	3.79	3.71	3.66	3.70	3.67	3.68	3.71	3.72	3.71
Nutritional quality								**Nutritional quality**							
Tolerance to post-harvest physiological deterioration	14	9	43	116	108	290	4.05	3.88	3.93	3.97	3.71	3.87	3.98	4.14	4.02
Pro-Vitamin A (beta-carotene)	10	29	68	99	79	285	4.00	3.22	3.77	3.88	3.69	3.78	3.68	3.68	3.68
Protein	13	45	76	87	69	290	3.78	3.32	3.49	3.52	3.50	3.50	3.54	3.61	3.56
Iron and zinc	10	64	81	79	47	281	3.56	3.14	3.44	3.29	3.33	3.35	3.36	3.30	3.34
Others(Long underground storage, Vitamin E, Starch modification, Early bulking, Leaves quality, Early bulking and maturing)	8	7	8	21	22	66	4.00	3.00	3.45	4.10	4.50	4.02	3.57	3.71	3.60
Biotic stress resistance								**Biotic stress resistance**							
Cassava mosaic disease(Breeding for biotic stress resistance)	10	14	32	107	131	294	3.58	4.22	4.18	4.21	4.06	4.15	4.00	4.11	4.03
Cassava brown streak disease(Breeding for biotic stress resistance)	15	19	29	83	135	281	2.93	3.67	4.13	4.46	4.07	4.22	3.62	4.12	3.75

Whiteflies	12	17	51	97	79	256	3.53	3.84	3.85	3.91	3.69	3.82	3.75	3.92	3.79
Bacterial blight (Xanthomonas spp)	9	21	67	98	78	273	4.35	3.96	3.84	3.65	3.14	3.54	4.01	3.82	3.96
Mites	7	30	70	103	48	258	3.40	3.76	3.69	3.48	3.58	3.59	3.60	3.50	3.58
Root rots	12	24	75	82	52	245	3.86	3.56	3.82	3.21	3.33	3.46	3.68	3.35	3.60
Mealybug	6	27	84	78	47	242	3.13	3.96	3.63	3.34	3.09	3.35	3.55	3.42	3.52
Cassava anthracnose disease	11	42	85	80	46	264	3.06	3.48	3.58	3.32	3.38	3.43	3.34	3.28	3.32
Other diseases of cassava	17	20	35	33	21	126	2.67	3.24	3.40	2.91	3.00	3.10	3.04	3.10	3.05
Other insect pest of cassava	18	21	42	44	22	147	3.89	3.05	3.49	3.00	3.75	3.41	3.39	3.00	3.29
Herbicide resistance	30	35	44	53	34	196	3.45	3.32	3.49	2.55	2.73	2.92	3.29	3.11	3.25
Cassava frogskin	32	40	83	45	41	241	3.72	2.91	3.21	2.67	2.50	2.79	3.22	3.11	3.19
Abiotic stress resistance / tolerance								**Abiotic stress resistance / tolerance**							
Drought tolerance / water use efficiency	16	20	53	107	103	299	4.14	4.28	3.81	4.01	4.13	3.98	4.11	3.97	4.07
Nutrient use efficiency	12	33	59	88	56	248	3.94	3.70	3.60	3.79	3.79	3.72	3.76	3.65	3.73
Other abiotic stresses of cassava	14	19	39	28	20	120	3.63	3.12	3.33	3.19	3.50	3.34	3.33	3.21	3.30
Tolerance of marginal/toxic soils	18	50	96	65	25	254	3.40	3.32	3.12	3.13	3.25	3.17	3.29	3.18	3.26
Water logging	30	76	79	51	30	266	3.50	3.69	3.05	2.63	3.00	2.89	3.35	3.00	3.26
Low temperature/winter hardiness	69	59	74	37	25	264	2.47	3.08	2.45	2.49	3.20	2.71	2.67	2.57	2.65
Environmental adaptation								**Environmental adaptation**							
Early harvest (6-8 months after planting)	9	10	51	104	114	288	4.10	4.14	4.01	4.05	4.00	4.02	4.10	4.00	4.07
Mechanization	20	26	56	78	63	243	4.05	3.57	3.62	3.43	3.83	3.63	3.73	3.52	3.68
For use as a forage or dual-purpose roots + forage	26	38	98	73	39	274	3.90	3.30	3.23	3.28	2.92	3.14	3.48	3.03	3.37
Delayed harvest (16-18 months after planting)	51	59	74	53	30	267	2.76	2.96	2.67	3.03	3.25	2.98	2.84	2.81	2.83
Others(Stability in starch once different harvest regime, Propagation success)	7	7	9	15	18	56	3.86	3.10	3.57	3.33		3.45	3.49	3.57	3.51
Other opportunities for crop improvement								**Other opportunities for crop improvement**							

Germplasm enhancement and pre-breeding	7	17	54	107	89	274	4.20	4.25	3.77	3.97	3.80	3.84	4.11	3.82	4.04
Exploitation of heterosis	9	30	74	84	41	238	3.88	3.58	3.41	3.65	3.42	3.49	3.64	3.52	3.61
Others(Marker assisted breeding, Nutrition breeding, Response to prevailing climate change)	9	7	15	8	17	56	3.00	2.90	3.50	3.75	3.00	3.42	3.13	3.00	3.10
Flowering ability/botanic seed production	17	38	64	78	46	243	3.67	3.35	3.41	3.64	3.09	3.38	3.48	3.36	3.45
Polyploidy	14	38	85	55	33	225	3.60	3.36	3.21	3.45	3.10	3.25	3.40	3.19	3.35

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

Source: Authors' survey.

Turning to production technology, agronomy and crop management, experts rated 26 alternative research options (Table 8). Respondents top-ranked 16 options with a global mean score exceeding a cutoff point of 3.5. These include, in decreasing order of importance, as Cassava Mosaic disease(Disease management); Improving soil fertility (micro-nutrients and fertilizer); White flies; Improving cassava cropping systems; Harvesting methods or machinery for planting / harvesting; Bacterial blight; Weed management and control; Weed; Cassava brown streak disease(Disease management); Mites; Gender friendly labor saving too; Soil management and erosion control; Root rots; Others(Inter cropping, site specific nutrients management using models, seeded cropping system, Irrigation-potential); Water management in crop production and Mealybugs.

TABLE 8: PRIORITIZATION OF OPTIONS FOR PRODUCTION TECHNOLOGY, AGRONOMY AND CROP MANAGEMENT.

	All responses														
	Number of responses ranking importance (1 to 5)[a]								AFRICA						
	1	2	3	4	5	Total responses	LAC	ASIA	WCA	EA	SA	average regional AFRICA	average REGIONAL	GLOBAL	average TOTAL
							Mean score	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score
Soils, water, weeds and harvest.							**Soils, water, weeds and harvest.**								
Improving soil fertility (micro-nutrients and fertilizer)	10	14	53	116	94	287	4.23	4.17	4.00	3.88	4.00	3.96	4.12	3.74	4.02
Improving cassava cropping systems	8	13	62	131	76	290	4.14	4.03	3.80	3.74	4.33	3.96	3.99	3.87	3.96
Weed management and control	8	17	68	107	79	279	4.20	3.93	3.96	3.81	3.71	3.83	4.01	3.59	3.90
Harvesting methods or machinery for planting / harvesting	13	30	62	92	89	286	4.35	4.07	3.75	3.59	3.69	3.68	4.03	3.68	3.95
Gender friendly labor saving tools	8	27	77	105	57	274	4.11	3.77	3.56	3.65	3.46	3.56	3.83	3.55	3.76
Others(Inter cropping, site specific nutrients management using models, seeded cropping system, Irrigation-potential)	6	6	7	20	21	60	3.80	3.64	3.95	4.00	2.00	3.32	3.77	3.50	3.70
Soil management and erosion control	13	20	84	100	54	271	3.95	4.07	3.53	3.59	3.80	3.64	3.86	3.43	3.75
Managing soil acidity	16	29	95	88	36	264	3.58	3.73	3.42	3.21	3.23	3.29	3.56	3.17	3.46
Managing soil salinity	22	40	101	62	28	253	3.19	3.58	3.19	3.16	3.15	3.17	3.30	2.97	3.21
Water management in crop production	14	31	67	87	71	270	3.62	4.00	3.57	3.69	4.00	3.75	3.75	3.53	3.70
Disease control and management							**Disease control and management**								
Cassava Mosaic disease(Disease management)	9	7	30	105	133	284	3.84	3.89	4.38	4.28	4.36	4.34	4.03	4.08	4.04
Cassava brown streak disease(Disease management)	14	16	37	68	141	276	3.39	3.42	4.20	4.42	4.29	4.30	3.71	4.11	3.81

Bacterial blight	10	17	66	92	78	263	4.19	3.96	3.98	3.62	3.75	3.78	4.00	3.67	3.91
Root rots	15	30	62	94	50	251	3.94	3.92	3.68	3.24	3.50	3.47	3.79	3.44	3.70
Others(Cassava anthranocse disease, Nematodes)	10	19	16	18	18	81	3.33	3.29	3.32	3.00	3.00	3.11	3.26	3.06	3.21
Witches broom	33	51	55	41	35	215	2.50	3.58	3.13	2.69	2.70	2.84	3.01	2.98	3.00
Super elongation disease	37	37	67	46	28	215	3.40	3.04	3.24	2.69	2.70	2.87	3.14	2.78	3.05
Frogskin disease	40	42	69	33	32	216	3.56	2.86	3.06	2.58	2.40	2.68	3.07	2.91	3.03
Pest control and management							**Pest control and management**								
White flies	10	15	47	93	112	277	3.71	4.07	4.00	4.14	3.71	3.95	3.95	4.03	3.97
Mites	6	20	71	96	74	267	3.81	3.89	3.80	3.77	3.62	3.73	3.83	3.67	3.79
Weed	11	22	58	102	61	254	4.21	3.96	3.86	3.62	3.45	3.64	3.96	3.44	3.83
Mealybugs	8	23	74	93	61	259	3.24	3.89	3.76	3.54	3.64	3.65	3.62	3.53	3.59
Termites	19	38	77	63	41	238	2.73	3.08	3.43	3.41	3.63	3.49	3.09	3.04	3.08
Thrips	21	53	86	55	30	245	3.40	3.08	3.16	2.91	2.70	2.93	3.19	3.00	3.14
Stem bores	32	52	84	53	19	240	3.11	2.75	2.98	2.72	2.44	2.71	2.91	2.93	2.92
Grasshoppers	40	58	72	44	21	235	2.27	2.57	3.10	2.55	2.89	2.85	2.58	2.60	2.58
Others(Rodents, Root and tuber scale, Scale insects, Spiralling Whiteflies)	9	7	12	18	14	60	2.67	3.13	3.61	3.78	4.50	3.96	3.17	3.00	3.13

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

Source: Authors' survey.

With respect to improvement of seeds or planting materials, respondents were asked to rate 7 alternative research options (Table 9). Respondents top-ranked 4 options with a global mean score exceeding a cutoff point of 3.7. These include, in decreasing order of importance, improving production and distribution of elite planting materials; improving technologies for farmer based production and distribution of planting materials (informal); Mass propagation methods, including tissue culture & hydroponics and Alternatives for microstakes from disease free stocks.

TABLE 9: PRIORITIZATION OF OPTIONS FOR IMPROVEMENT OF SEEDS OR PLANTING MATERIALS.

	All responses														
	Number of responses ranking importance (1 to 5)[a]								AFRICA						
	1	*2*	*3*	*4*	*5*	*Total responses*	LAC Mean score	ASIA Mean score	**WCA** Mean score	**EA** Mean score	**SA** Mean score	**Regional average AFRICA** Mean score	**REGIONAL average** Mean score	GLOBAL Mean score	TOTAL average Mean score
n of elite planting	6	8	38	104	123	279	4.17	4.00	4.19	4.14	4.13	4.16	4.13	4.20	4.14
sed production and ormal)	9	15	42	103	112	281	4.29	4.15	3.97	3.98	3.93	3.96	4.14	4.05	4.12
g tissue culture &	7	15	49	108	88	267	4.22	3.89	3.87	4.06	4.08	4.01	4.03	3.84	3.99
ease free stocks	6	16	72	90	66	250	4.16	4.12	3.57	3.94	3.08	3.53	4.00	3.75	3.94
ogenitors	14	36	73	69	40	232	3.07	3.35	3.30	3.61	3.42	3.44	3.28	3.40	3.31
etative seed	17	40	79	61	24	221	2.92	3.35	3.16	3.47	3.10	3.24	3.19	2.93	3.12
roduction, Separate ocation, Quality of	5	6	8	10	16	45	3.67	3.56	3.82	4.00	4.00	3.94	3.70	2.71	3.45

, 3=important, 4=very important, 5=most important.

For other options for cassava research, experts rated 26 alternative research options (Table 10). Respondents top-ranked 16 options with a global mean score exceeding a cutoff point of 3.9. These include, in decreasing order of importance, Assessment of cassava based innovation systems Improving shelf life of cassava roots ; Developing cassava products for industrial applications (flour and starch); Improving small scale processing of cassava for human consumption (e.g. gari, fufu, farinha, sago, kokonte, casabe, gaplek, etc.) ; Phenotypic/molecular screening of landraces in search of high-value traits/new sources/tolerance/resistance to stress; Alternative on-farm utilization/processing for value addition, Collection, characterization, evaluation, documentation (ex situ); Assessment of small farmer access to new technologies; Development of farmer organizations and farmer clusters linked to markets; Developing cassava products for human consumption; Others(Transport, Agricultural insurance, Capacity building to farmers, Fabrication of cassava processing equipment, Developing cassava chips for export market); Assessment of cassava technology adoption; Assess impact of cassava research and development ; Development of competitive cassava value chains; Improving policy framework for cassava planting materials (distribution, regulations, IPRs, etc.) ; Others(Gender assessment, Certification standards, Support of policy and advocacy and Research of impact for addition edition)

TABLE 10: PRIORITIZATION OF OTHER OPTIONS FOR CASSAVA RESEARCH.

	All responses						AFRICA						
	Number of responses ranking importance (1 to 5)[a]						LAC	ASIA	**WCA**	**EA**	**SA**	**Regional average AFRICA**	**REGIONAL average**	GLOBAL	TOTAL average
	1	*2*	*3*	*4*	*5*	*Total responses*	Mean score	Mean score	Mean score	Mean score	Mean score			Mean score	Mean score
Genetic resource management							**Genetic resource management**								
f landraces in search of high-e/resistance to stress	8	16	36	84	113	257	4.63	4.04	3.74	4.17	4.00	3.97	4.21	4.20	4.21
ation, documentation (ex	6	13	53	90	108	270	4.43	4.12	3.83	4.10	3.64	3.86	4.17	4.06	4.14
ent	8	27	61	87	68	251	4.17	3.60	3.49	3.84	3.38	3.57	3.80	3.68	3.77
nd genomic resources,	7	6	10	11	14	48	3.00	2.89	3.87	4.50	2.00	3.46	3.28	2.44	3.07
e chains, post-harvest utilization and marketing							**Value chains, post-harvest utilization and marketing**								
ots	6	10	40	84	144	284	4.20	4.33	4.16	4.07	4.06	4.10	4.24	4.29	4.25
ndustrial applications (flour	4	10	39	114	119	286	4.39	4.10	4.11	4.12	3.92	4.05	4.22	4.13	4.20
of cassava for human na, sago, kokonte, casabe,	5	12	43	112	116	288	4.35	3.86	4.26	4.00	3.88	4.04	4.14	3.92	4.08
uman consumption	8	12	50	115	104	289	4.53	4.00	3.99	3.89	3.73	3.87	4.18	3.93	4.11
ocessing for value addition	5	10	55	109	102	281	4.47	4.07	4.07	3.88	3.62	3.85	4.20	3.84	4.11
ons and farmer clusters	5	14	47	109	97	272	4.42	3.90	4.04	3.92	3.64	3.87	4.11	3.88	4.05
ava value chains	2	17	60	115	84	278	4.37	3.81	3.93	3.95	3.56	3.82	4.03	3.89	4.00
nimal feed	8	25	86	95	75	289	4.33	4.04	3.63	3.51	3.33	3.49	4.00	3.63	3.90
le value chains	4	23	92	96	57	272	4.17	3.38	3.63	3.62	3.57	3.61	3.72	3.60	3.69

Ethanol production from cassava	22	42	88	65	64	281	3.50	3.93	3.41	3.21	2.93	3.18	3.58	3.45	3.55
Others(Transport, Agricultural insurance, Capacity building to farmers, Fabrication of cassava processing equipment, Developing cassava chips for export market)	3	2	7	16	21	49	3.67	3.44	4.18	4.67	5.00	4.61	3.83	3.71	3.80
Socio-economic, policy and impact studies							**Socio-economic, policy and impact studies**								
Assess impact of cassava research and development	4	14	55	120	85	278	4.32	4.18	3.95	3.71	3.92	3.86	4.13	3.98	4.09
Assessment of small farmer access to new technologies	6	9	53	121	98	287	4.25	4.07	4.05	3.89	3.86	3.93	4.11	4.04	4.09
Assessment of cassava technology adoption	4	11	51	130	86	282	4.26	4.14	4.01	3.76	3.64	3.80	4.12	4.01	4.09
Improving policy framework for cassava planting materials (distribution, regulations, IPRs, etc.)	5	18	62	97	92	274	4.26	3.96	3.86	3.84	3.75	3.82	4.04	3.93	4.01
Assessment of cassava based innovation systems			1	9	11	21	4.41						4.41	4.44	4.43
Research on food and agricultural policies affecting cassava	12	31	79	96	55	273	3.84	3.68	3.51	3.46	3.50	3.49	3.68	3.59	3.66
Assess health effects of bio-fortified cassava varieties	21	36	60	97	62	276	3.88	3.70	3.55	3.34	3.31	3.40	3.69	3.53	3.65
Assess health and environmental risks of herbicide and pesticide use in cassava systems	9	25	61	100	81	276	3.89	3.71	3.82	3.82	3.53	3.72	3.81	3.81	3.81
Study gender inequality in cassava production systems	15	27	100	71	52	265	3.54	3.62	3.45	3.42	3.85	3.57	3.52	3.44	3.50
Others(Gender assessment, Certification standards, Support of policy and advocacy, Research of impact for addition edition)	7	5	28	40	48	128	2.50	3.45	4.15	3.88	3.60	3.88	3.33	3.95	3.49

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

Source: Authors' survey.

4. Discussions and Conclusions

This section discusses the globally highest ranked research options. The section draws implications for the priority assessment of cassava research based on the scoring method of priority setting.

Table 11 reports the globally top-ranked research options. These include, in decreasing order of importance, Assessment of cassava based innovation systems; Improving shelf life of cassava roots; Phenotypic/molecular screening of landraces in search of high-value traits/new sources/tolerance/resistance to stress; Developing cassava products for industrial applications (flour and starch); High yield; Improving production and distribution of elite planting materials Collection, characterization, evaluation, documenta; tion (ex situ); Improving technologies for farmer based production and distribution of planting materials (informal); Developing cassava products for human consumption; Alternative on-farm utilization/processing for value addition ; Assessment of small farmer access to new technologies and Assess impact of cassava research and development

On the whole, the majority of the experts clearly rated Assessment of cassava based innovation systems; improving shelf life of cassava roots; Phenotypic/molecular screening of landraces in search of high-value traits/new sources/tolerance/resistance to stress; Developing cassava products for industrial applications (flour and starch), High yield and Improving production and distribution of elite planting materials, as the highest priority research options to reduce poverty and improve food security through cassava research and capacity development. Not surprisingly these options contribute most to resolving the factors of policy and impact studies; market and pest, virus and disseases and Quality and Seed Multiplication; that were perceived as the binding constraints on cassava today. In conclusion, the results of the expert survey clearly show that the priority research options to resolve the constraints on cassava today and help to reduce poverty and improve food security are:

- **Policys:** Assessment of cassava based innovation systems
- **Value chains, post-harvest utilization and marketing:** Improving shelf life of cassava roots, Developing cassava products for industrial applications (flour and starch)
- **Genetic resource management:** Phenotypic/molecular screening of landraces in search of high-value traits/new sources/tolerance/resistance to stress
- **Disease control and management:** Cassava Mosaic disease(Disease management)
- **improvement of seeds or planting materials**: Improving production and distribution of elite planting materials
- **Crop genetic improvement:** High yield

There are some differences in prioritization of these options among different geographical regions in Africa, Latin America and the Caribbean and Asia. These globally highest ranked research options are used for the economic surplus analysis.

TABLE 11: HIGHEST RANKED OPTIONS FOR CASSAVA RESEARCH ACCORDING TO GLOBAL MEAN SCORE.

			AFRICA						
	LAC	ASIA	WCA	EA	SA	Regional average AFRICA	REGIONAL average	GLOBAL	TOTAL average
	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score
Assessment of cassava based innovation systems	4.41						4.41	4.44	4.43
Improving shelf life of cassava roots	4.20	4.33	4.16	4.07	4.06	4.10	4.24	4.29	4.25
Phenotypic/molecular screening of landraces in search of high-value traits/new sources/tolerance/resistance to stress	4.63	4.04	3.74	4.17	4.00	3.97	4.21	4.20	4.21
Developing cassava products for industrial applications (flour and starch)	4.39	4.10	4.11	4.12	3.92	4.05	4.22	4.13	4.20
High yield	4.18	4.28	3.99	4.07	4.00	4.02	4.16	4.17	4.16
Improving production and distribution of elite planting materials	4.17	4.00	4.19	4.14	4.13	4.16	4.13	4.20	4.14
Collection, characterization, evaluation, documentation (ex situ)	4.43	4.12	3.83	4.10	3.64	3.86	4.17	4.06	4.14
Improving technologies for farmer based production and distribution of planting materials (informal)	4.29	4.15	3.97	3.98	3.93	3.96	4.14	4.05	4.12
Developing cassava products for human consumption	4.53	4.00	3.99	3.89	3.73	3.87	4.18	3.93	4.11
Alternative on-farm utilization/processing for value addition	4.47	4.07	4.07	3.88	3.62	3.85	4.20	3.84	4.11
Assessment of cassava technology adoption	4.26	4.14	4.01	3.76	3.64	3.80	4.12	4.01	4.09
Assessment of small farmer access to new technologies	4.25	4.07	4.05	3.89	3.86	3.93	4.11	4.04	4.09

Assess impact of cassava research and development	4.32	4.18	3.95	3.71	3.92	3.86	4.13	3.98	4.09
Improving small scale processing of cassava for human consumption (e.g. gari, fufu, farinha, sago, kokonte, casabe, gaplek, etc.)	4.35	3.86	4.26	4.00	3.88	4.04	4.14	3.92	4.08
Early harvest (6-8 months after planting)	4.10	4.14	4.01	4.05	4.00	4.03	4.10	4.00	4.07
Drought tolerance / water use efficiency	4.14	4.28	3.81	4.01	4.13	3.96	4.11	3.97	4.07

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

Source: Authors' survey.

5. References

Alston, J.M., Norton, G.W. and Pardey, P.G., 1998. Science under scarcity: Principle and practice for agricultural research evaluation and priority setting. CAB International in association with the International Service for National Agricultural Research.

Belloti, A., Arias, B., Vargas, O., Reyes, J., & Guerrero, J. M. (2012). Insects and Mites that Attack Cassava, and their Control. In B. Ospina & H. Ceballos (Eds.), *Cassava in the Third Millennium* (CIAT., pp. 213– 250). Cali.

Ceballos, H. (2012). Cassava in Colombia and the World: New Prospects for a Millennial Crop. In B. Ospina & H. Ceballos (Eds.), *Cassava in the Third Millennium* (CIAT., pp. 1 – 11). Cali.

FAO. (2000). The world cassava economy. Retrieved from ftp://ftp.fao.org/docrep/fao/009/x4007e/X4007E01.pdf

Howeler, R. H. (2012). *The Cassava Handbook: A reference Manual based on the Asian Regional Cassava Training Course Held in Thailand*.

Jarvis, A., Ramirez-Villegas, J., Herrera Campo, B. V., & Navarro-Racines, C. (2012). Is Cassava the Answer to African Climate Change Adaptation? *Tropical Plant Biology*, *5*(1), 9–29. doi:10.1007/s12042-012-9096-7

Legg, J. P., Jeremiah, S. C., Obiero, H. M., Maruthi, M. N., Ndyetabula, I., Okao-Okuja, G., … Kumar, P. L. (2011). Comparing the regional epidemiology of the cassava mosaic and cassava brown streak virus pandemics in Africa. *Virus Research*, *159*(2), 161–170. doi:http://dx.doi.org/10.1016/j.virusres.2011.04.018

Norton, G. W., Pardey, P. G., & Alston, J. M. (1992). Issues in Priority Agricultural Setting. *American Journal of Agricultural Economics*, *74*(5), 1089–1094.

Nweke, F.I., Spencer, D.S.C., Lynam, J.K., 2002. The cassava transformation: Africa's best-kept secret. Michigan State University Press, East Lansing.

Sánchez, T., Dufour, D., Moreno, J. L., Pizarro, M., Aragón, I. J., Domínguez, M., & Ceballos, H. (2013). Changes in extended shelf life of cassava roots during storage in ambient conditions. *Postharvest Biology and Technology*, *86*(0), 520–528. doi:http://dx.doi.org/10.1016/j.postharvbio.2013.07.014

www.rtb.cgiar.org