The Changing Composition of the Global Diet: Implications for CGIAR Research

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Supplementary Information
To ***CIAT Policy Brief No. 18***

Methods

The Khoury et al. 2014 study utilized FAOSTAT food supply data from 1961–2009. Measurements of food supply included calories (kcal/capita/day), protein (g/capita/day), fat (g/capita/day), and food weight (g/capita/day). For this policy brief, our change in diets over time analysis covered the period 1969–2009, which is approximately the lifespan of CGIAR, and we focused on developing countries, including 112 nations in Africa, Asia and the Pacific, and Latin America and the Caribbean (Table S1). Note that for consistency across the time period, countries that experienced splitting into multiple countries during the past decades were re-aggregated. For full information on methods, see Khoury et al., 2014.

- Africa: all (48) countries with food supply data in FAOSTAT included
- Asia and the Pacific: 32 countries with food supply data in FAO included. Japan and South Korea not included
- Latin America and the Caribbean: all (33) countries included

Table S1. Countries included in the dietary change over time analyses

Africa	Asia and the Pacific	Latin America and the Caribbean
Algeria	Bangladesh	Antigua and Barbuda
Angola	Brunei Darussalam	Argentina
Benin	Cambodia	Bahamas
Botswana	China	Barbados
Burkina Faso	DPR Korea	Belize
Burundi	Fiji	Bolivia (Plurinational State of)
Cameroon	French Polynesia	Brazil
Cape Verde	India	Chile
Central African Republic	Indonesia	Colombia
Chad	Iran (Islamic Republic of)	Costa Rica
Comoros	Jordan	Cuba
Congo	Kiribati	Dominica
Côte d'Ivoire	Lao People's Democratic Republic	Dominican Republic
Djibouti	Lebanon	Ecuador
Egypt	Malaysia	El Salvador
Ethiopia PDR	Maldives	Grenada
Gabon	Mongolia	Guatemala
Gambia	Myanmar	Guyana
Ghana	Nepal	Haiti
Guinea	New Caledonia	Honduras
Guinea-Bissau	Pakistan	Jamaica
Kenya	Philippines	Mexico
Lesotho	Samoa	Nicaragua
Liberia	Solomon Islands	Panama
Libya	Sri Lanka	Paraguay
Madagascar	Syrian Arab Republic	Peru
Malawi	Thailand	Saint Kitts and Nevis
Mali	Timor-Leste	Saint Lucia

Mauritania	Vanuatu	Saint Vincent and the Grenadines
Mauritius	Vietnam	Suriname
Morocco	Yemen	Trinidad and Tobago
Mozambique		Uruguay
Niger		Venezuela
Nigeria		
Rwanda		
Sao Tome and Principe		
Senegal		
Seychelles		
Sierra Leone		
South Africa		
Sudan (former)		
Swaziland		
Togo		
Tunisia		
Uganda		
United Republic of Tanzania		
Zambia		
Zimbabwe		

Absolute importance and relative change in importance of crops in diets of developing countries

To determine the absolute importance of crops in food supplies, we individually listed the mean value across countries of those crops providing equal to or greater than 1.5% of the diet, with the remaining crops aggregated under "other crop commodities," for both 1969 and 2009 (Figure 1, Figures S1–4). We included the contribution from animal food sources for comparison and in order to provide a comprehensive picture of food supplies.

To determine the percent change in the relative importance of crops in food supplies, we calculated the difference between the relative importance of the particular crop in 1969 (within the total food supply, including both plant and animal food sources) and in 2009 for each country. We then calculated the mean and median as well as variance parameters across countries. The median was included as the data do not follow a normal distribution (Figure 2, Figures S5–8).

Crops included in the percent change analyses: We displayed changes in the relative importance of 15 FAOSTAT crop commodities covered by the CGIAR mandate (wheat, maize, rice, potato, sweet potato, beans, cassava, bananas & plantain, sorghum, millets, barley, pulses other [Old World Pulses, including cowpea, chickpea, lentil, and pigeonpea], yams, groundnut, and soybean) as well as a number of other crops that are important in food supplies or underwent substantial changes in their relative contribution over 1969–2009 for comparison (palm oil, sunflower, sugar, and coconuts). In the figures on percent change in relative importance, we displayed only those crops that contribute substantially (>1.5% of the diet) to the particular measurement. For calories and weight, these are typically all of the listed crops. For protein, we therefore excluded sugar, palm oil, and sunflower, while for fat, we excluded potatoes, sugar, beans, yams, bananas & plantains, cassava, barley, sweet potatoes, and pulses other. For a visualization of slopes of change in abundance per year as a global mean, see Khoury et al. 2014 Figure 1B and the Supporting Information.

Crop suitability in sub-Saharan Africa under climate change

Crop suitability maps for cassava, sorghum, and pearl millet (Figure 3) and boxplots for these plus five additional crops of importance in sub-Saharan Africa (Figure S9) were produced using EcoCrop (Hijmans et al. 2001, Ramírez-Villegas et al. 2013).

Climatic parameters were set for each crop based on the EcoCrop database (FAO 2014) and additional literature, and subsequently reviewed by crop experts. Climate input data (temperature and precipitation) for current and future conditions with a resolution of 10-arc minutes were obtained from WorldClim (www.worldclim.org/download) and from the fifth Coupled Model Intercomparison Project (CMIP5, http://cmip-pcmdi.llnl.gov/cmip5/data_portal.html). The maps display mean ensemble change in suitability, against current conditions (representative of 1950–2000), based on projected future crop suitability for the 2050s (2040–2069), for the RCP 6.0 climate forcing that is driven by 19 Global Climate Models (CMIP5) and for the RCP 8.5 climate forcing which uses 32 Global Climate Models (CMIP5).

For the boxplots, results were obtained by applying a suitability threshold, defining a minimum suitability value below which it is not viable to cultivate a crop because of very marginal prospects of success. The threshold was determined using a presence-absence analysis and applying a Receiver Operating Curve (ROC) (Fielding and Bell 1997; Hirzel et al. 2006). Spatial Production Allocation Model (SPAM) crop distribution data for rainfed agriculture conditions were utilized as a reference (You et al. 2009). The projected crop suitability distribution for the 2050s (2040–2069) was produced under RCP 8.5.

References

FAO (Food and Agriculture Organization of the United Nations). 2014. Land and Water Development Division. EcoCrop [online] Available at: http://ecocrop.fao.org/ecocrop/srv/en/about

Fielding A; Bell J. 1997. A review of methods for the assessment of prediction errors in conservation presence/absence models. Environmental Conservation 1:38–49.

Hijmans R; Guarino L; Cruz M; Rojas E. 2001. Computer tools for spatial analysis of plant genetic resources data: 1. DIVA-GIS. Plant Genetic Resources Newsletter 127:15–19.

Hirzel A; Le Lay G; Helfer V; Randin C; Guisan A. 2006. Evaluating the ability of habitat suitability models to predict species presences. Ecological Modelling 199(2):142–152.

Ramírez-Villegas J; Jarvis A; Läderach P. 2013. Empirical approaches for assessing impacts of climate change on agriculture: The EcoCrop model and a case study with grain sorghum. Agricultural and Forest Meteorology 170:67–78.

You L; Wood S; Wood-Sichra U. 2009. Generating plausible crop distribution maps for sub-Saharan Africa using a spatially disaggregated data fusion and optimization approach. Agricultural Systems 99(2–3):126–140.

Importance of crops in developing countries in comparison to CGIAR Research Program funding

For the comparison of crops in terms of their importance in developing-country food supplies versus CGIAR Research Program (CRP) funding (Figure 4, Figures S10–13), we compared the latest available year of food supply data (2011) with the nearest year for which CRP funding information was available (2012). We analyzed 124 total developing countries in Africa (47), Asia and the Pacific (43), and Latin America and the Caribbean (34) with the 2011 food supplies data (Table S2). Mean and median values across regions and developing countries as a whole were assessed; mean values are displayed in this brief.

To approximate the current and projected strategic funding priorities of CGIAR, we based our analysis on CRP funding, which in 2012 amounted to 80% of total CGIAR funding. Total funding per CRP data was sourced from CRP summary statistics (www.cgiar.org/ar2012/investment-in-cgiar-financial-summary/cgiar-research-program-financial-summary/). The data presented cover direct funding for crop research within CRPs directly related to crops: Dryland Cereals; Roots, Tubers and Bananas (RTB); Grain Legumes; Maize; Rice; and Wheat. The Livestock and Fish CRP was included as the Animal products equivalent. Dryland Systems; Humid Tropics; Aquatic Agricultural Systems (AAS); Policies, Institutions and Markets (PIM); Agriculture for Nutrition and Health (A4NH); Water, Land and Ecosystems (WLE); Forests, Trees and Agroforestry (FTA); Climate Change, Agriculture and Food Security (CCAFS); and Genebanks (with a total of US$389 million or 55.6% of CRP funding in 2012) were not included in the comparative analysis, as it was not possible to assign these to specific crops, although we acknowledge that some of these programs do encompass research on specific crops. For CRPs dealing with multiple crops (Dryland Cereals, RTB, and Grain Legumes), funding estimates were allocated to specific crops as designated in the CRP reports (2012), or where crop-specific data were not available in reports (i.e., for RTB), as indicated in CRP funding proposals. In both these sources, total budgets were not equivalent to summary CRP funding statistics. To align funding information sources, we therefore derived the percent funding per crop within such CRPs from the reports and applied these percentages to the total summary funding for those CRPs to estimate CRP funding per crop in 2012 (Table S3). When multiple crops were included within single budget lines in the reports (as in Grain Legumes), funding for those budget lines was divided evenly between crops. Budgets within the Dryland Cereals CRP for Gender and for Management (totaling 7.6% of funding within that CRP) were not included in the analysis. Figures S14–15 display CRP funding per crop in 2012 as stacked bar charts.
Data on CGIAR funding in regard to total global public and private R&D investment was sourced from ASTI (www.asti.cgiar.org).

Table S2. Countries included in the current importance in diets vs. CGIAR funding analysis.

Africa	Asia and the Pacific	Latin America and the Caribbean
Algeria	Afghanistan	Antigua and Barbuda
Angola	Armenia	Argentina
Benin	Azerbaijan	Bahamas
Botswana	Bangladesh	Barbados
Burkina Faso	Brunei Darussalam	Belize
Cabo Verde	Cambodia	Bermuda
Cameroon	China, mainland	Bolivia (Plurinational State of)
Central African Republic	DPR Korea	Brazil
Chad	Fiji	Chile
Congo	French Polynesia	Colombia
Côte d'Ivoire	Georgia	Costa Rica
Djibouti	India	Cuba
Egypt	Indonesia	Dominica
Ethiopia	Iran (Islamic Republic of)	Dominican Republic
Gabon	Iraq	Ecuador

Gambia	Jordan	El Salvador
Ghana	Kazakhstan	Grenada
Guinea	Kiribati	Guatemala
Guinea-Bissau	Kyrgyzstan	Guyana
Kenya	Lao People's Democratic Republic	Haiti
Lesotho	Lebanon	Honduras
Liberia	Malaysia	Jamaica
Libya	Maldives	Mexico
Madagascar	Mongolia	Nicaragua
Malawi	Myanmar	Panama
Mali	Nepal	Paraguay
Mauritania	New Caledonia	Peru
Mauritius	Occupied Palestinian Territory	Saint Kitts and Nevis
Morocco	Pakistan	Saint Lucia
Mozambique	Philippines	Saint Vincent and the Grenadines
Namibia	Samoa	Suriname
Niger	Solomon Islands	Trinidad and Tobago
Nigeria	Sri Lanka	Uruguay
Rwanda	Syrian Arab Republic	Venezuela (Bolivarian Republic of)
Sao Tome and Principe	Tajikistan	
Senegal	Thailand	
Sierra Leone	Timor-Leste	
Somalia	Turkey	
South Africa	Turkmenistan	
Sudan (former)	Uzbekistan	
Swaziland	Vanuatu	
Togo	Viet Nam	
Tunisia	Yemen	
Uganda		
United Republic of Tanzania		
Zambia		
Zimbabwe		

Table S3. 2012 CGIAR Research Program funding allocated to specific crops

CGIAR Research Program	Specific crop	FAO food supplies commodity equivalent	Funding per crop in US$ (2012)
Dryland Cereals	Sorghum	Sorghum	$3,025,139
Dryland Cereals	Pearl millet	Millets	$2,407,036
Dryland Cereals	Finger millet	Millets	$1,041,266
Dryland Cereals	Barley	Barley	$364,324
RTB	Potatoes	Potatoes	$8,169,617
RTB	Sweet potatoes	Sweet potatoes	$8,505,355
RTB	Bananas & plantains	Bananas & plantains	$13,065,792
RTB	Cassava	Cassava	$14,996,284
RTB	Yams	Yams	$4,840,219
RTB	Other RTB	Roots, other	$1,594,754
Grain Legumes	Beans	Beans	$2,990,164
Grain Legumes	Cowpea	Pulses, other	$2,411,892
Grain Legumes	Soybean	Soybean	$2,477,248
Grain Legumes	Groundnut	Groundnut	$3,945,927
Grain Legumes	Chickpea	Pulses, other	$3,764,109
Grain Legumes	Faba bean	Pulses, other	$1,986,478
Grain Legumes	Pigeonpea	Pulses, other	$2,705,344
Grain Legumes	Lentil	Pulses, other	$2,118,838
Maize	Maize	Maize	$74,200,000
Rice	Rice	Rice	$99,000,000
Wheat	Wheat	Wheat	$40,700,000
Livestock and Fish	Livestock and Fish	Animal Products (Total)	$15,900,000
Dryland Systems, Humid Tropics, AAS, PIM, A4NH, WLE, FTA, CCAFS, Genebanks			$389,000,000
Total			**$699,209,786**

Supplementary Figures

Figure S1. Contribution of crops to mean food supplies in developing countries in terms of calories (kcal/capita/day), protein (g/capita/day), fat (g/capita/day), and food weight (g/capita/day), 1969 and 2009.

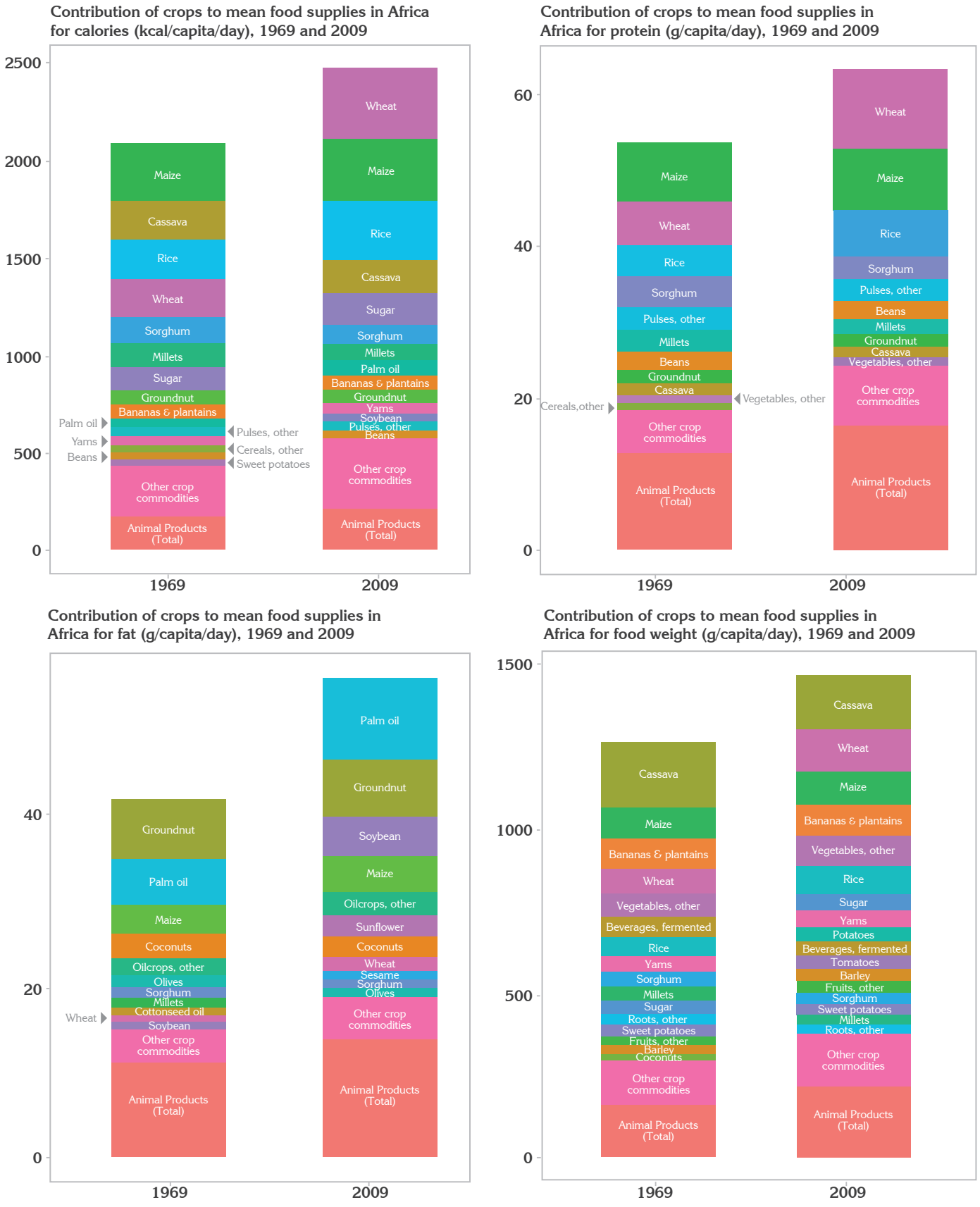


Figure S2. Contribution of crops to mean food supplies in Africa in terms of calories (kcal/capita/day), protein (g/capita/day), fat (g/capita/day), and food weight (g/capita/day), 1969 and 2009.

Figure S3. Contribution of crops to mean food supplies in Asia in terms of calories (kcal/capita/day), protein (g/capita/day), fat (g/capita/day), and food weight (g/capita/day), 1969 and 2009.

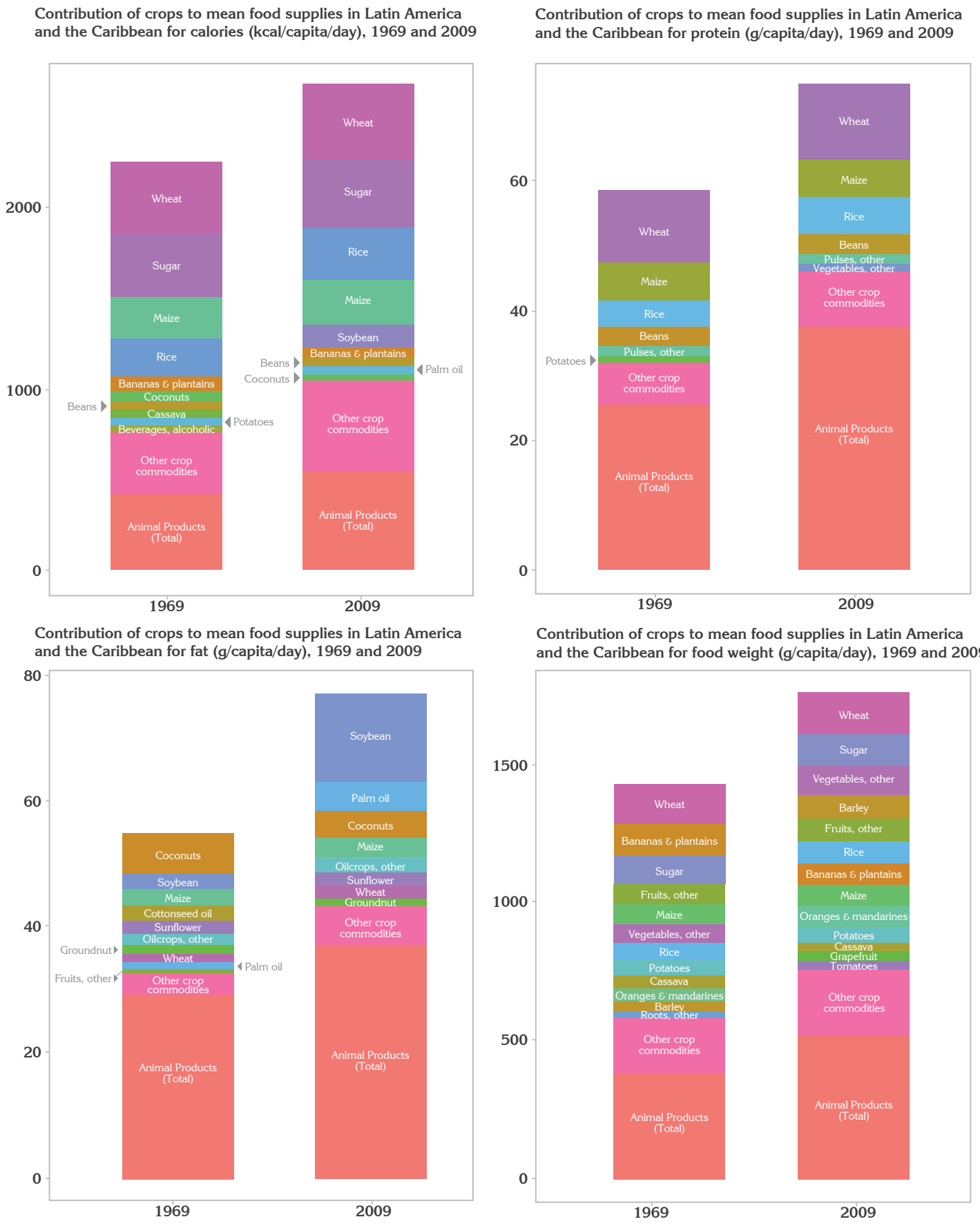


Figure S4. Contribution of crops to mean food supplies in Latin America and the Caribbean in terms of calories (kcal/capita/day), protein (g/capita/day), fat (g/capita/day), and food weight (g/capita/day), 1969 and 2009.

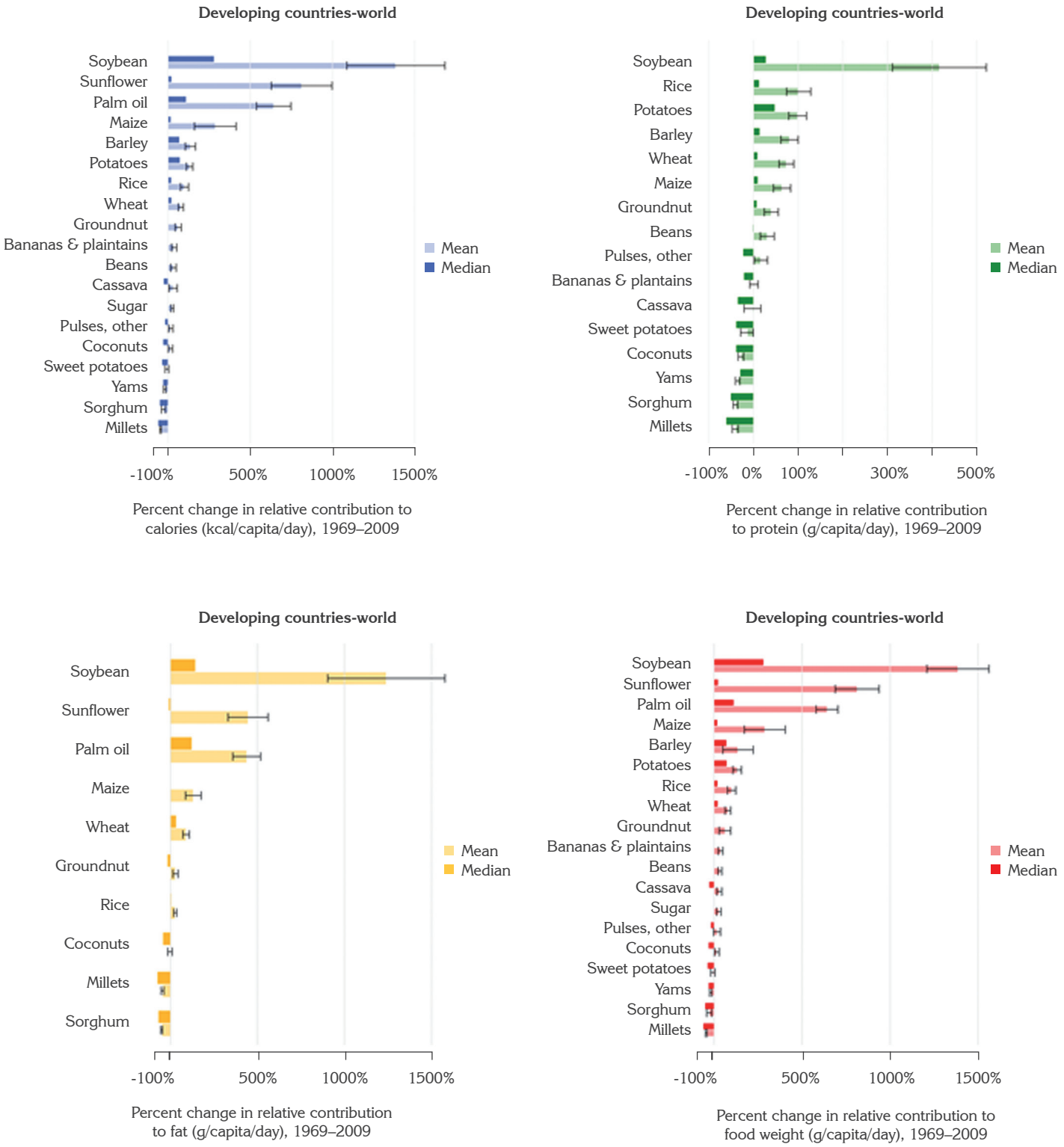


Figure S5. Change in the relative contribution of crops of interest for CGIAR to calories, protein, fat, and food weight in national diets in developing countries, 1969–2009.

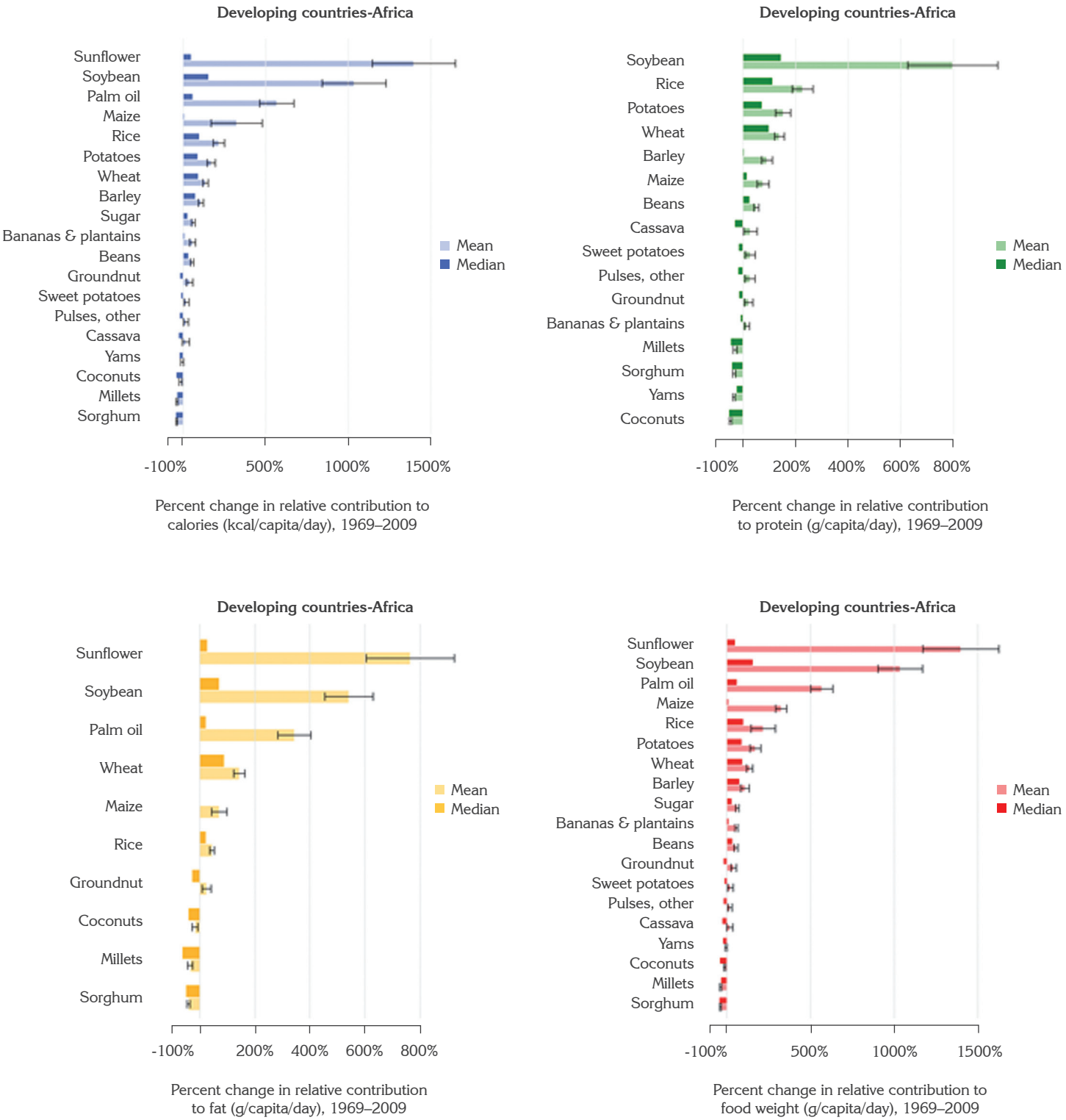


Figure S6. Change in the relative contribution of crops of interest for CGIAR to calories, protein, fat, and food weight in national diets of Africa, 1969–2009.

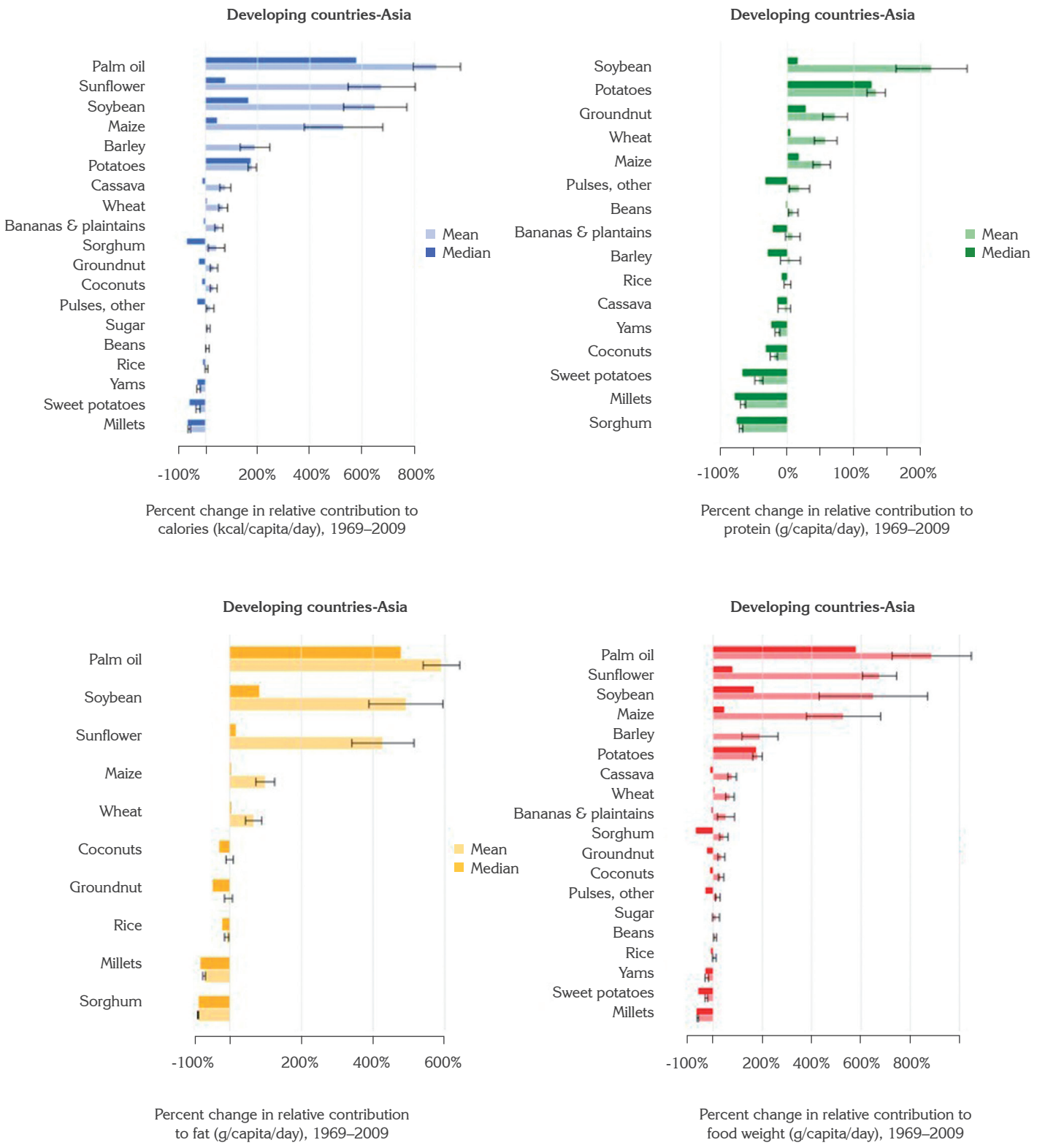
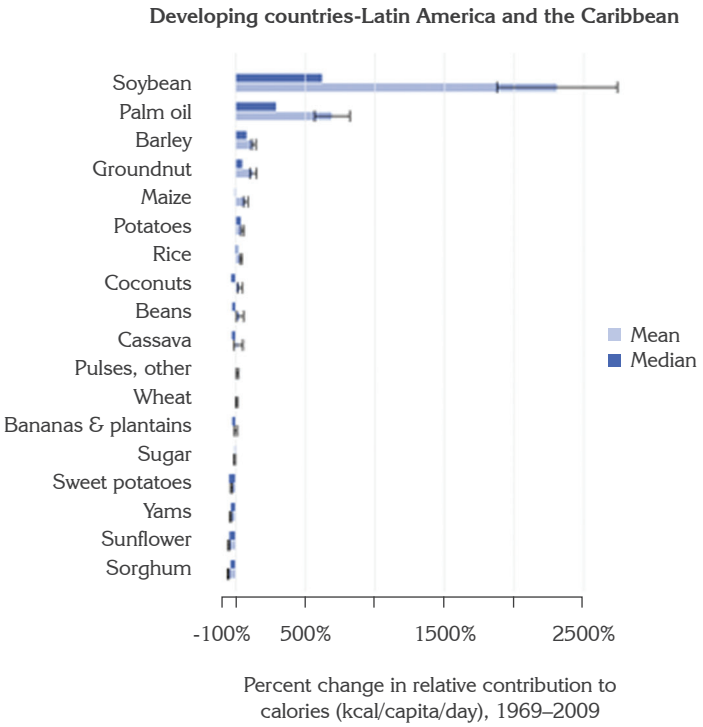
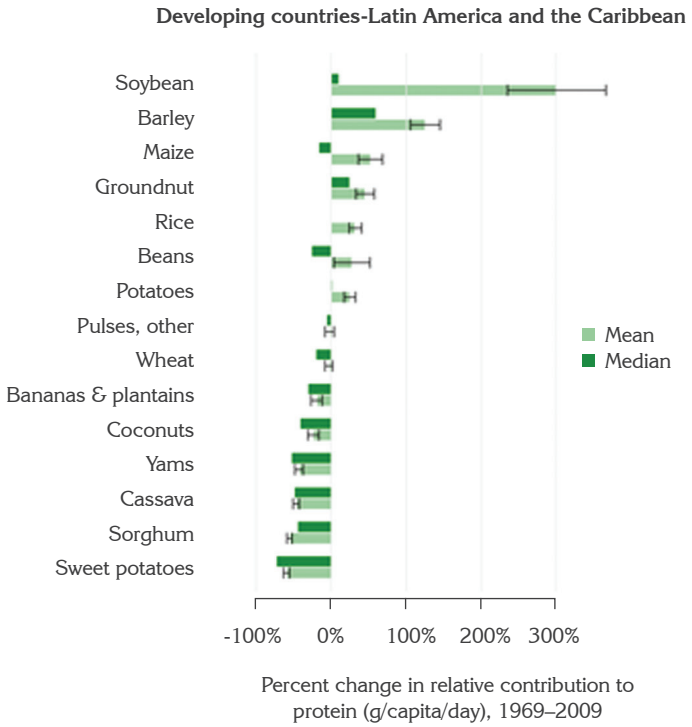
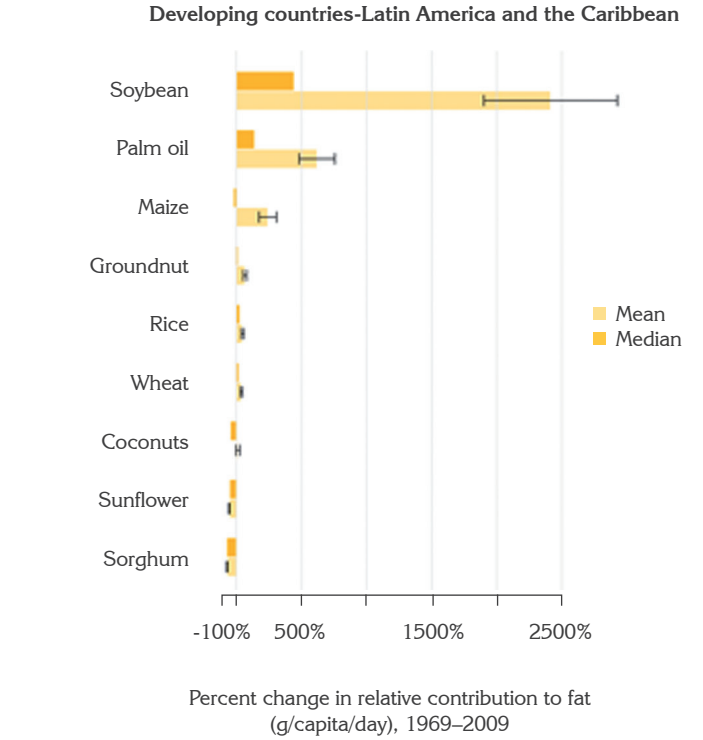


Figure S7. Change in the relative contribution of crops of interest for CGIAR to calories, protein, fat, and food weight in national diets of Asia, 1969–2009.







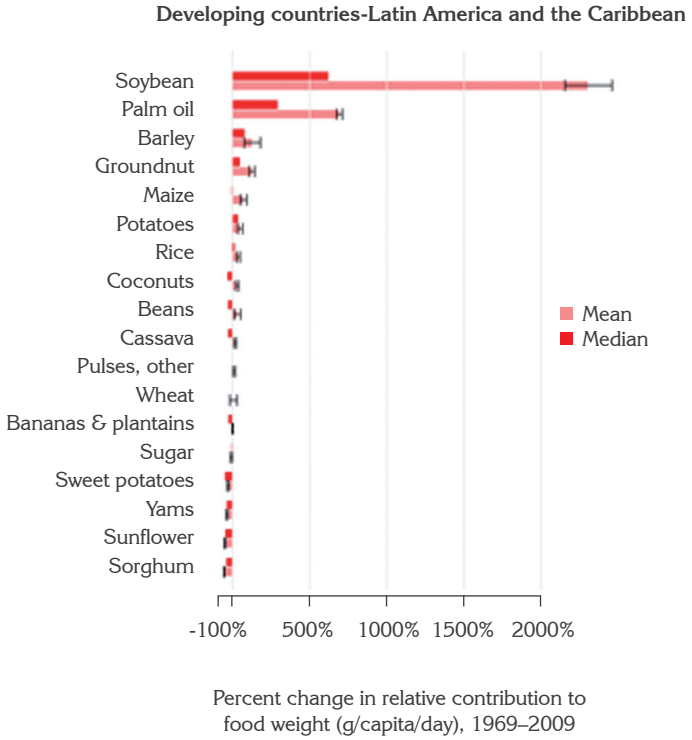


Figure S8. Change in the relative contribution of crops of interest for CGIAR to calories, protein, fat, and food weight in national diets of Latin America and the Caribbean, 1969–2009.

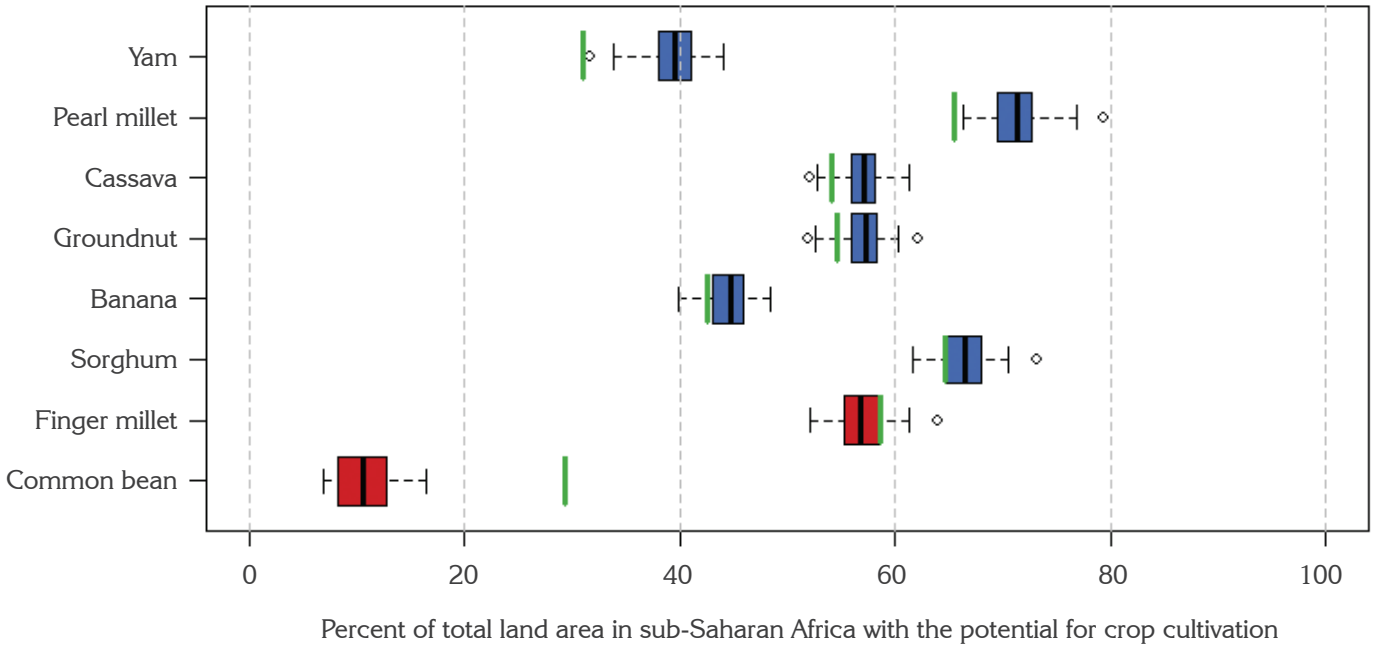


Figure S9 Projected change in the potential area of cultivation for selected crops in sub-Saharan Africa in the 2050s (2040–2069) under a high representative concentration pathway (RCP 8.5). Green lines represent current potential cultivation area (WorldClim baseline 1950–2000). Box plots represent projected potential cultivation area for the 2050s (using 32 CMIP5 models) as a percentage of the total area, with blue plots displaying positive change and red plots negative change in the suitable cultivation area. Box plots display model uncertainty, indicating the median (the thick black line) and 25–75% variation, with tails displaying 5–95% and open circles as outliers.

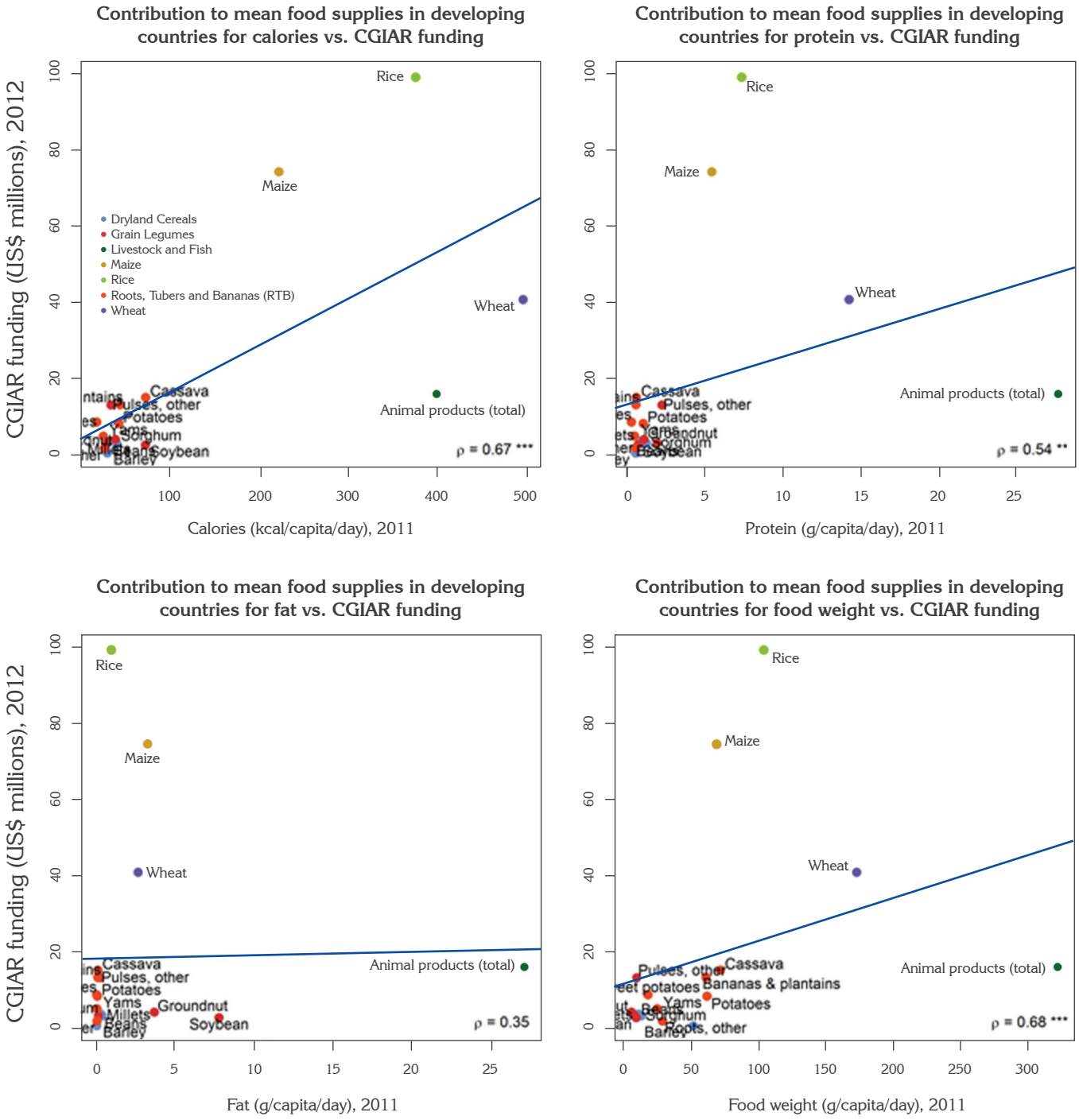


Figure S10. Contribution of crops to mean food supplies in developing countries in terms of calories (kcal/capita/day), protein (g/capita/day), fat (g/capita/day), and food weight (g/capita/day), 2011 vs. CGIAR crop research funding, 2012.

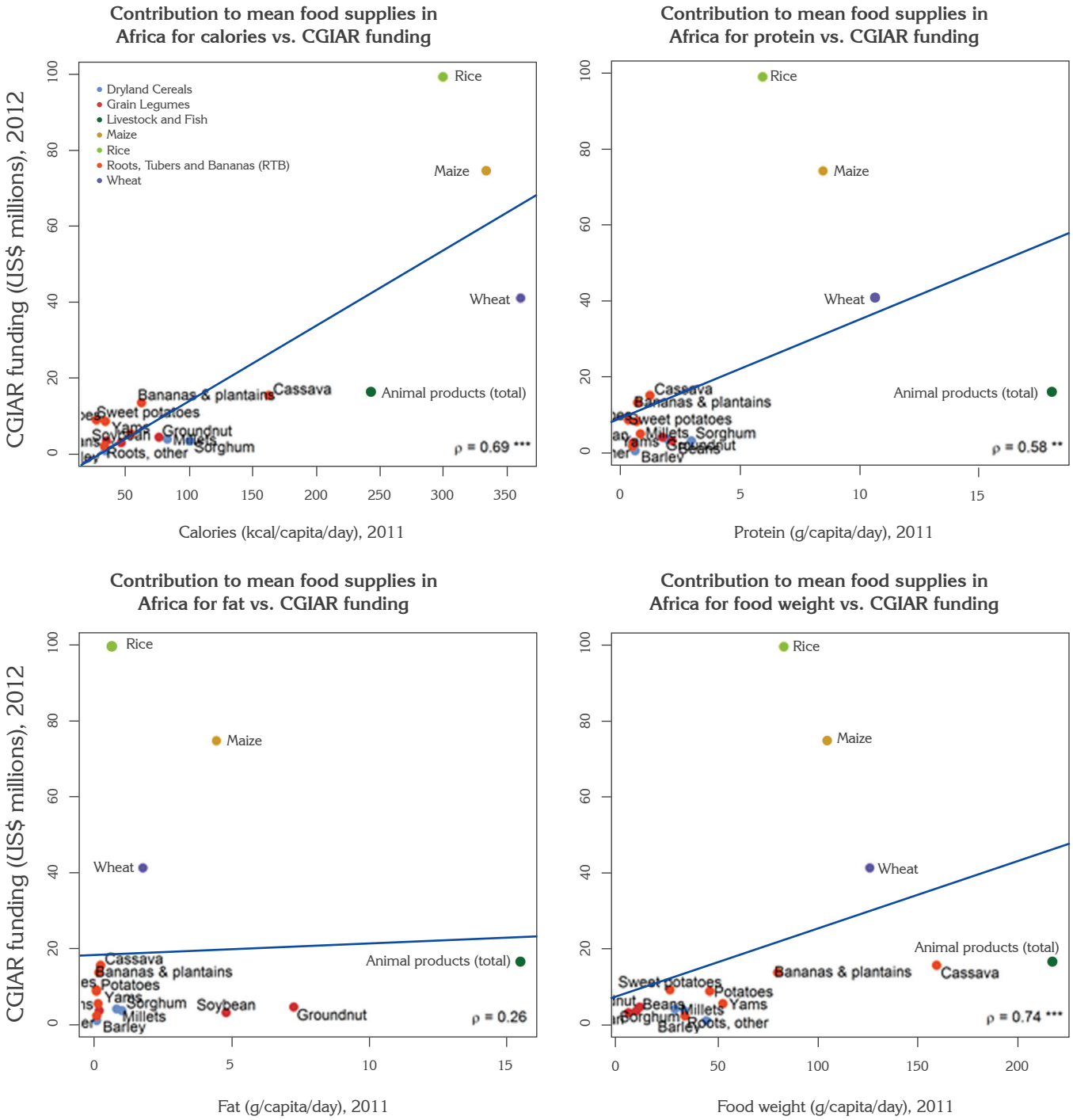


Figure S11. Contribution of crops to mean food supplies in Africa in terms of calories (kcal/capita/day), protein (g/capita/day), fat (g/capita/day), and food weight (g/capita/day), 2011 vs. CGIAR crop research funding, 2012.

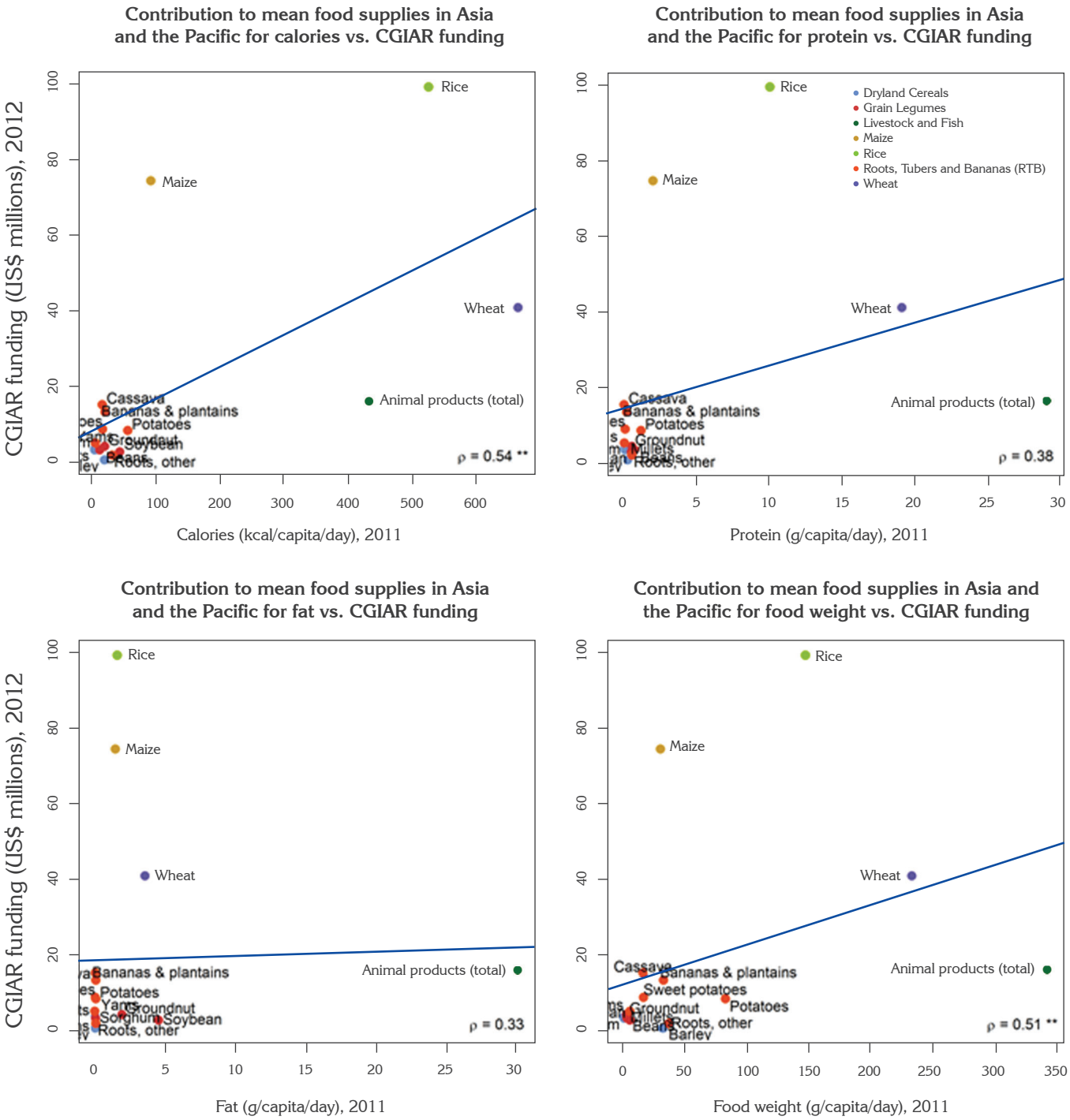


Figure S12. Contribution of crops to mean food supplies in Asia in terms of calories (kcal/capita/day), protein (g/capita/day), fat (g/capita/day), and food weight (g/capita/day), 2011 vs. CGIAR crop research funding, 2012

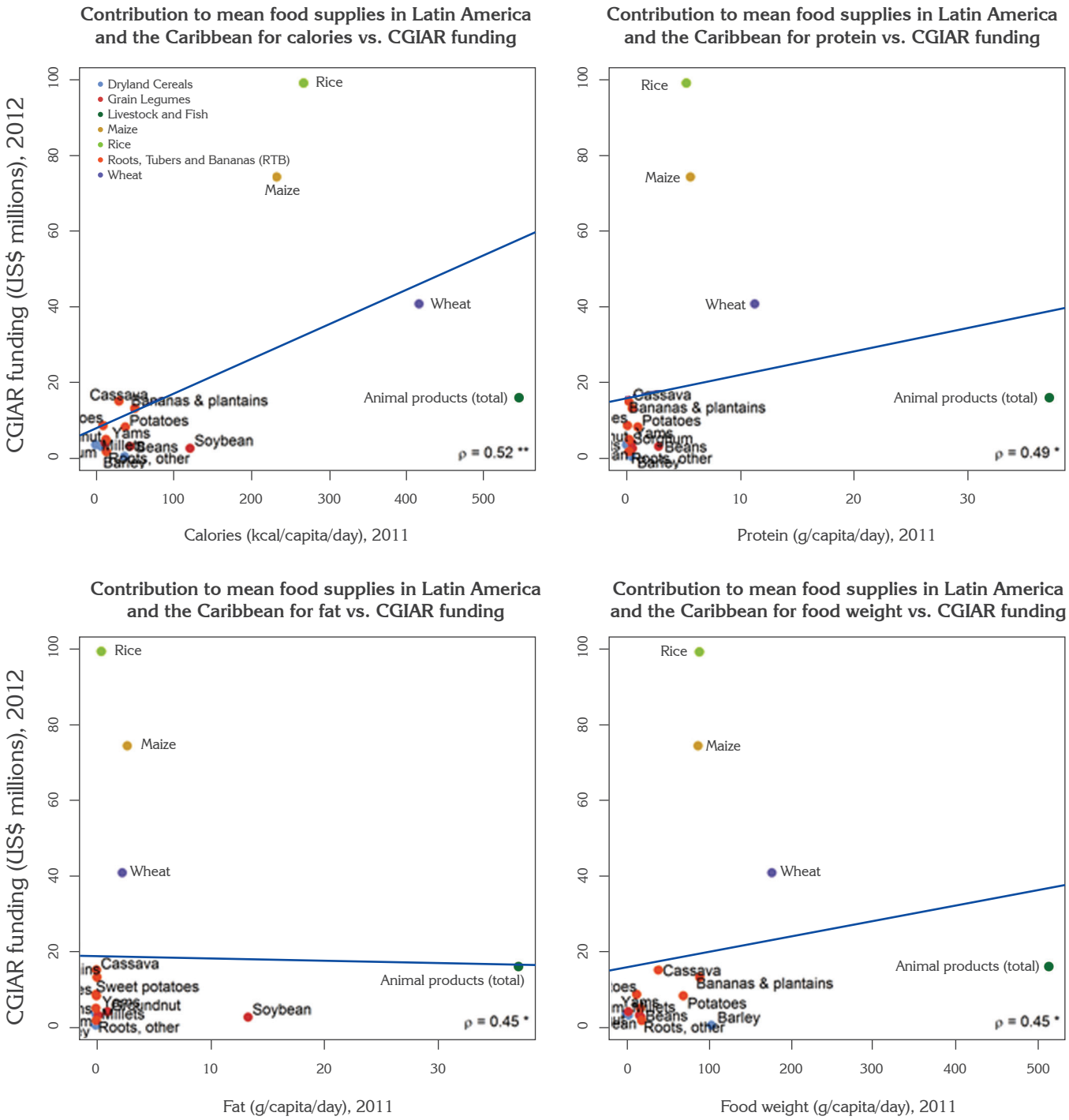


Figure S13. Contribution of crops to mean food supplies in Latin America and the Caribbean in terms of calories (kcal/capita/day), protein (g/capita/day), fat (g/capita/day), and food weight (g/capita/day), 2011 vs. CGIAR crop research funding, 2012.

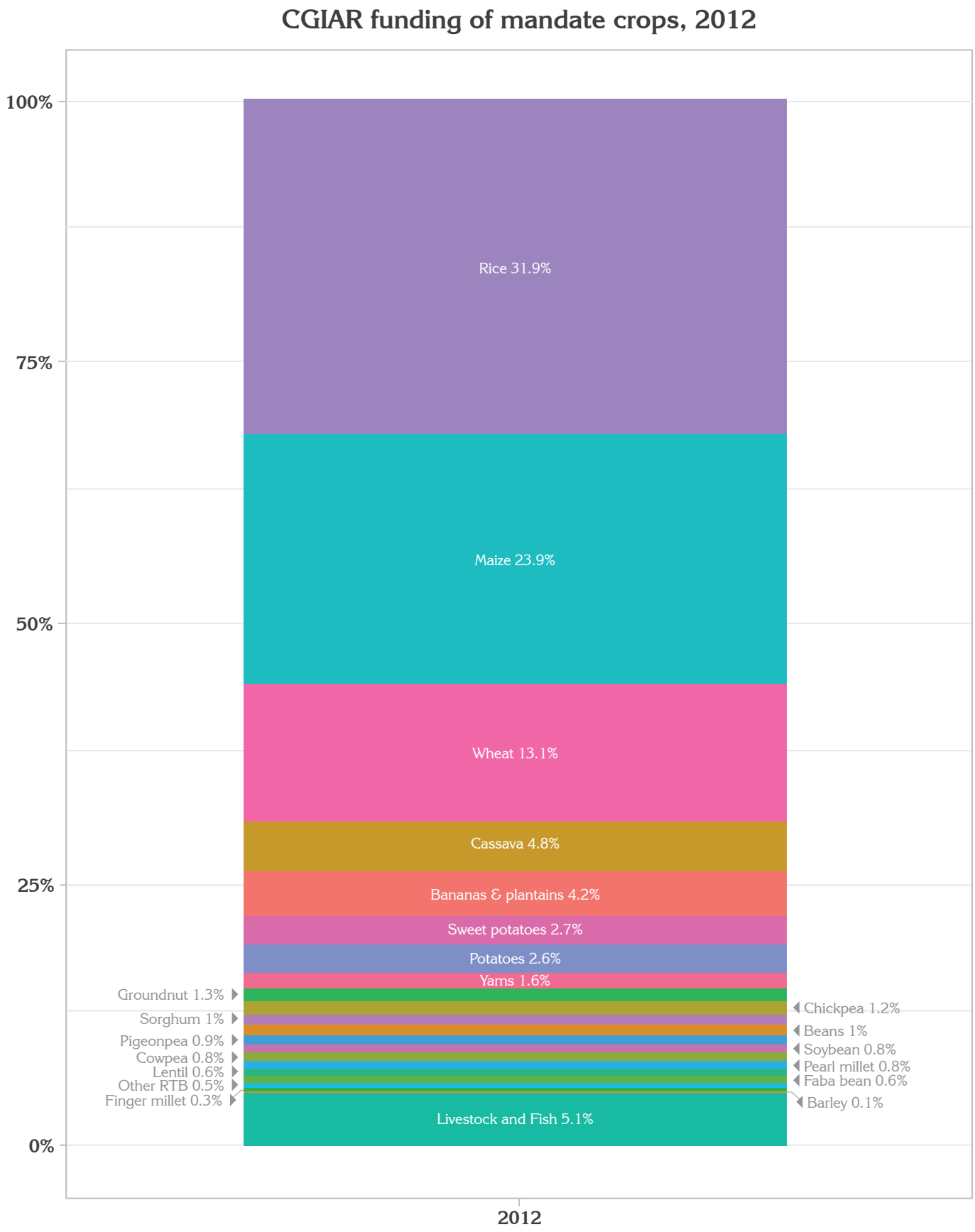


Figure S14. CGIAR crop research funding per mandate crop, expressed as the percentage of total crop research funding, 2012.

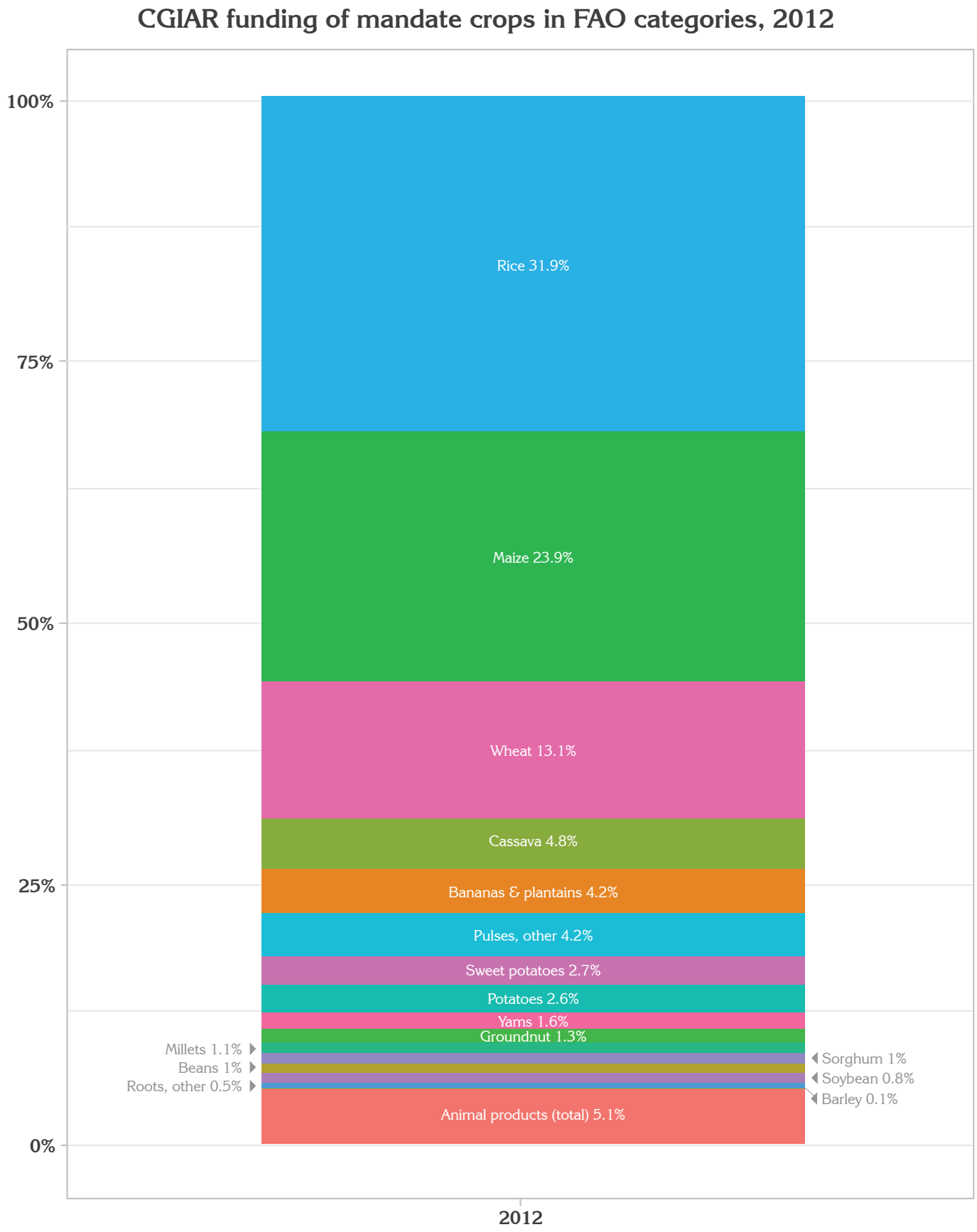


Figure S15. CGIAR crop research funding per mandate crop, organized according to FAOSTAT food supply crop commodities and expressed as the percentage of total crop research funding, 2012.