Input Use on Major Cereals as Measured by the Enquête Permanente Agricole (EPA) of Burkina Faso, 2009/10-2011/12

Melinda Smale, Hamza Haider, and Veronique Theriault

Draft May 1, 2015

Data source

The Ministry of Agriculture and Food Security (Ministère de l'Agriculture et de la Sécurité Alimentaire (MASA) of Burkina Faso estimates crop areas and yields each year using a nationally representative sample of 4130 household farms in 826 villages across 45 provinces. The sampling frame for the *Enquête Permanente Agricole (EPA)* is based on the 2006 Population Census. The Direction Générale des Études et des Statistiques Sectorielles (DGESS) manages data collection. The EPA generates production, area and yield data for rainfed crops, serves as an early warning system for food insecurity, and also furnishes general information about livestock holdings, income and expenditures of rural households, and farm input use. The survey involves over 800 enumerators, 100 monitors, 13 regional supervisors, 45 provincial supervisors, 13 regional statisticians, and DGESS staff.

In this summary, we examine input use on sorghum, maize and millet crops during the three-year period from 2009/10 through 2011/12. These are the last years for which fully cleaned data are available.

Measuring input use (adoption)

Conceptualizing adoption

Farmers often decide to change their input combinations from one season to the next, for any one of a number of reasons. For example, they may change their input combinations as a consequence of input and output prices, labor constraints, and learning experiences. Markets may be unreliable for purchased inputs. Thus, in this summary, we often refer to seasonal input use rather than "adoption." Ideally, we would define and measure adoption as the achievement of a longer-term outcome that represents some sort of supply-demand equilibrium (check Griliches, Rogers). Nonetheless, when measured on a national scale as in the EPA and over a 3-year period as presented here, annual use provides a valuable indication of cumulative adoption over a large population of smallholder farmers.

Here, we measure several aspects of input use (short-term adoption). First, we explore use of the input in terms of binary variable (1=use; 0=nonuse) in the survey year. Summarized in the sample data, this provides us with the percent of households and using (adopting) the input in Burkina Faso. Here, we call this the *household diffusion rate*. Similarly, we calculate the percent of sorghum plots on which a technique or practice was used, calling it the *plot diffusion rate*. Second, we report the average area (ha) or "extent" to which the input was applied per household. We also document the "extent" in terms of crop area shares, reporting the mean proportion per household. Third, we consider the "intensity" of use of fertilizer (N nutrient kgs per ha). Finally, we consider the percent of total crop area across all growers or the crop, or the aggregated "extent" of use or adoption for the nation. For convenience, we refer to this fourth indicator as the *area diffusion rate*.

Observational unit of analysis

A unique aspect of the EPA data, exploited below, reflects the organization of crop production in Burkina Faso. Within farm households, individual members manage some plots. Other plots, on which all members are expected to contribute labor, are managed on behalf of the household by the head of household or work team leader. Below, we differentiate the diffusion rate for each input, according to whether the unit of analysis is the household, whether the plot is managed individually or collectively, and whether the individual plot manager is male or female.

Table 1 provides the summary count over different observational units of analysis in the dataset we analyze below. Considering all of the three seasons studied, over three-quarters of households surveyed grew millet, 87% grew maize, and 93% grew sorghum. There are a total of 2769 households in the entire sample from 2009-10 to 2011-12; 2162 of them grew some millet in at least one year. Similarly, 2402 households grew maize and 2574 grew sorghum. Out of 2682 households in 2009-10, 1835 grew millet, 2123 grew maize and 2574 grew sorghum. Out of the 2691 households in 2010-11, 1692 grew millet, 2024 grew maize and 2248 grew sorghum. In 2011-12, out of the 2504 households, 1470 grew millet, 1882 grew maize and 2089 grew sorghum.

As expected, the most common management type for major cereals is collective, or joint management for the household as a whole. Among individual plots, those managed by women are more common for sorghum and millet, while individual maize plots are more often managed by men.

Table 1: Number of plots by type of management and crop, and number of households, 2009/10-2011/12

	Millet	Corn	Sorghum
Total No of Plots	11318	10799	18701
Collectively (jointly) Managed	7707	9321	12805
Individually Managed	3608	1475	5893
Managed by Women	2577	533	3991
Managed by Men	1028	939	1901
Total No of Households	2769	2769	2769
No of households growing crop	2162	2402	2574

Source: EPA data, as prepared by authors.

Variable definition

The definition of each input category is shown in Table 2. Improved seed includes use of any farmer-recognized variety of purchased for a given crop. Inorganic fertilizer use includes using NPK or urea. Organic manure includes application of manure, compost pit, household refuse, animal or other penning. Herbicides, fungicides and pesticides can be of solid or liquid form. Anti-erosion structures include stone contour bunds, planting pits (zai) or half-moons (demi-lunes), porous and nonporous dikes, living fences and grass bands (bandes enherbées).

Finally, to highlight certain combinations of practices, we have defined three input bundles according to the way that the input influences crop yields and its economic attributes (Table 3). Productivity-enhancing inputs (Bundle 1) include improved seed and inorganic fertilizer, which are often used together since improved seed is bred with the goal of attaining a higher response rate to fertilizer than local seed when planted with adequate moisture. Yield-protecting inputs (Bundle 2) are used with the aim of maintaining or saving yield when the crop is beset by plant pests or disease. These include pesticides, fungicides, and herbicides. Soil and water conservation (SWC) techniques (Bundle 3) are composed of soil amendments such as manure, as well as anti-erosion or water-harvesting structures. In terms of economic attributes, Bundle 1 inputs are often considered to be annual inputs that would be neutral to scale if not for the lumpiness of fertilizer (related to its weight and the costs of inland transport, in particular). Theory predicts that farmers consider input-out ratios, marginal rates of yield response to the inputs, and annual expenditure constraints when deciding whether to use them (see, for example, Feder and Slade; Heisey et al. 1998). Bundle 2 inputs are typically modeled with damage abatement frameworks rather than production functions (based on Lichtenberg and Zilberman 1987). Bundle 3 inputs are often thought to be labor-intensive and not to justify the costs of labor investment in a single year of production (e.g. Pender; Tripp; Lee).

Table 2: Definition of inputs

Variable	**Definition**
Improved seed	Improved variety of seed of the crop is used on the plot
Inorganic fertilizer	Urea or NPK is applied to the plot on which the crop is grown
Organic manure	Manure, compost pit, household refuse, animal or other penning is applied to the plot on which the crop is grown
Herbicide	Herbicide (solid or liquid) is applied to plot on which the crop is grown
Fungicide	Fungicide (solid or liquid) is applied to plot on which the crop is grown
Pesticide	Pesticide (solid or liquid) is applied to plot on which the crop is grown
Anti-erosion structures	Plot on which crop is grown contains stone contour bunds, porous and nonporous dikes, living fences and grass bands, planting pits (zai) or half-moons (demi-lunes)

Source: EPA data, as prepared by authors.

Table 3: Definition of bundles

Variable	**Definition**	**Inputs included in bundle**
Bundle 1	Yield-enhancement	Improved seed, inorganic fertilizer
Bundle 2	Yield-protection	Herbicide, fungicide, pesticide
Bundle 3	Soil & water conservation	Manure, anti-erosion structure

Source: EPA data, as prepared by authors.

Findings

Following the approach outlined above, this section presents summary statistics by observational unit of analysis, adoption indicator, and input category. Statistics are shown by cereal crop in each year (2009-10, 2010-11 and 2011-12), and then compared across crops for the entire three-year period.

Tables 4a-4c report summary statistics for sorghum by year. The first column (1) is the *household diffusion rate*, which is the percentage of households growing the given crop that use any quantity of the given input on at least one plot. Looking first at fertilizer use as an example, in 2009-10 inorganic fertilizer was applied by 16 percent of households that grew sorghum, rising to 17 and nearly 20 percent in subsequent years. The next columns (2-6) report the *plot diffusion rates* overall and differentiated by management type. In all years, the percentage of plots on which fertilizer was applied was little more than half the percentage of households, revealing that not all plots were treated with inorganic nutrients. In addition, the percent of collectively-managed plots on which some amount of fertilizer was applied was considerably higher than on individually-managed fields, which may express priorities placed on assuring food and cash needs of the household in general. Interestingly, estimates suggest that sorghum plots managed individually by men are not substantially more likely to receive fertilizer than those operated by women (e.g., 6 percent for both in 2009/10; 6 vs. 7 percent in 2010/11, and 7 vs. 9 percent in 2011/12). The average sorghum area fertilized per household was 0.18 ha in 2009/10, 0.16 ha in 2010/11, and 0.22 ha in 2011/12, but this represented only an average *extent* of 8, 11 and 13% of the crop's area per household.

Use of improved sorghum seed is very low. The household diffusion rate for first-generation improved seed remains under 2% in all years (Table 4, column 1). Again, most of this seed is allocated to collectively-managed plots in the 2009/10 and 2010/11, although the pattern changes toward individually-managed plots in 2011/12. Overall, the average extent of household area planted to improved sorghum is extremely limited, representing an average sorghum area share of under 1%.

There are several possible explanations for low use rates for improved sorghum seed. The survey form includes only a 0-1 variable for whether seed of a crop planted in a plot is "selected" or "local." The definition of "selected" refers to seed that is « imported or produced by specialized firms, certified seed producers, commercial enterprises, or supplied by extension services or non-governmental organizations. Imported seed without a label is considered as "local." Thus, one explanation for low use rates is that only first-generation, purchased seed fits the definition of "selected" seed. However, improved sorghum varieties do not need to be replaced each season to retain a yield advantage (compared to hybrids, for example). Recommended seed replacement rates for improved varieties are often every 3-4 seasons. Farmers often consider varieties whose seed they have saved and replanted to be their own, reporting these as local seed and often ascribing new names. Identifying varieties as local or improved is also difficult given that many of Burkina Faso's improved varieties are "purified" landraces. A prime example is Kapelga, which means "white" and is used to describe a prominent local variety of sorghum as well as an improved ("purified") variety (vom Brocke et al. 2011). Finally, it is worth nothing that in a recent comprehensive assessment of the adoption of improved varieties of crops across countries in Sub-Saharan Africa (DIIVA), no estimate was provided for sorghum in Burkina Faso (see http://www.asti.cgiar.org/DIIVA, accessed March 11, 2015).

Though diffusion rates for pesticides remain low across all three survey years on sorghum (5-8% of households and no more than about 5% of sorghum area per household), those reported for herbicides doubled in only three years (9% of households in 2009/10 and 18% in 2011/12; similarly for plots)). With respect to either of these inputs, plot diffusion rates are typically higher on collective than on individual sorghum plots, but differences between those managed by men and women switch in order and do not appear to be meaningful in magnitude. Fungicide usage appears more stable over time and less differentiated by management type, with household and plot diffusion rates of over 9-10% of sorghum plots in each year.

Manure is the most commonly used input across plots. Manure diffusion rates on sorghum rose to over 38% of households and 27% of sorghum plots in 2011/12. Manure is also much more frequently used on collectively managed plots. This may be because while manure is cheaper than other inputs, applying it is a labor- and capital- intensive process and of both are allocated to collectively managed plots in order to ensure household food security. Manure application is also slightly more frequent on male managed plots, but these differences are not particularly meaningful. In 2011/12, an average of 28% of all sorghum area per household was treated with manure.

Use of SWC structures/practices on sorghum plots is next in order of household diffusion rates after manure (28% in 2011/12), and much higher than use of purchased inputs, differentiated similarly to manure by plot management type. Between 2009-10 and 2011-12, the extent of area per household for SWC structures is fairly similar (18-19%).

Turning to input bundles, in sorghum production, the SWC bundle (constituting anti-erosion or water-harvesting structures and/or manure) is the most widely diffused according to any observational unit of analysis, reaching 50% of households and an average of 37% of sorghum area per household in 2011/12. By comparison, the average extent of sorghum area for the yield-protecting bundle attained 30% per household, while the yield-enhancing bundle represented only 14%. The use of the yield enhancing bundle, which includes use of improved seed varieties and inorganic fertilizer, rises over the three year period. Since improved seed use is very low for sorghum, the bundle largely consists of chemical fertilizer use.

Table 4a: Input use on sorghum, 2009-10

	Percent						Mean	
	Households	All plots	Collective plots	Individual Plots	Female-managed, individual	Male-managed, individual	Household crop area (ha)	% of household crop area
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Improved seeds	0.57	0.44	0.51	0.29	0.28	0.30	0.01	0.51
Fertilizer	15.5	8.12	8.94	6.26	6.38	6.01	0.18	9.43
Herbicide	8.65	5.23	5.90	3.73	3.09	5.11	0.17	7.81
Pesticide	4.17	3.50	3.95	2.48	2.73	1.95	0.09	4.41
Fungicide	15.2	9.67	9.53	9.99	10.1	9.76	0.20	10.5
Manure	37.3	23.6	27.8	14.0	13.7	14.4	0.42	24.6
SWC	29.5	18.1	20.3	13.2	12.8	14.1	0.36	18.1
Bundle 1	16.3	8.83	9.70	6.88	6.94	6.76	0.19	10.3
Bundle 2	25.9	17.3	18.0	15.7	15.6	15.9	0.42	21.2
Bundle 3	49.9	34.2	39.3	22.7	22.3	23.4	0.62	34.8

Source: EPA data, as prepared by authors.

Table 4b: Input use on sorghum, 2010-11

	Percent						Mean	
	Households	All plots	Collective plots	Individual Plots	Female-managed, individual	Male-managed, individual	Household crop area (ha)	% of household crop area
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Improved seeds	1.55	0.53	0.61	0.37	0.39	0.33	0.01	0.77
Fertilizer	17.2	9.63	11.3	5.97	5.64	6.67	0.16	10.8
Herbicide	14.5	9.03	10.3	6.29	5.01	9.00	0.23	13.0
Pesticide	4.22	4.27	4.42	3.94	4.31	3.17	0.09	4.78
Fungicide	13.0	9.83	10.0	9.43	8.61	11.2	0.16	10.4
Manure	37.0	24.7	29.1	15.1	15.0	15.3	0.36	25.1
SWC	26.3	18.7	21.4	12.6	11.4	15.2	0.30	18.8
Bundle 1	19.2	10.4	12.2	6.50	6.19	7.17	0.18	12.0
Bundle 2	28.4	21.8	23.0	19.0	17.3	22.5	0.45	26.1
Bundle 3	48.8	35.3	40.7	23.4	22.6	25.2	0.53	35.8

Source: EPA data, as prepared by authors.

Table 4c: Input use on sorghum, 2011-12

	Percent						Mean	
	Households	All plots	Collective plots	Individual Plots	Female-managed, individual	Male-managed, individual	Household crop area (ha)	% of household crop area
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Improved seeds	1.71	1.40	1.34	1.51	1.32	1.89	0.03	1.47
Fertilizer	19.6	11.7	13.6	7.80	7.14	9.13	0.22	13.2
Herbicide	17.5	13.0	14.3	10.0	10.1	9.92	0.36	17.4
Pesticide	7.54	4.47	4.47	4.47	4.89	3.62	0.10	5.10
Fungicide	11.3	9.14	9.37	8.68	8.77	8.50	0.18	10.6
Manure	38.2	27.4	32.2	17.6	16.8	19.2	0.45	27.5
SWC	28.0	17.3	19.3	13.0	12.3	14.5	0.28	17.5
Bundle 1	21.1	13.0	14.8	9.20	8.46	10.7	0.24	14.4
Bundle 2	32.4	24.1	25.6	21.1	21.7	19.8	0.57	30.1
Bundle 3	50.3	36.5	42.1	25.1	23.8	27.7	0.60	37.1

Source: EPA data, as prepared by authors.

Tables 5a-5c show comparable adoption indicators for maize. On maize, the differences between household and overall plot diffusion rates for improved seed and fertilizer are not pronounced. This implies that in households that use either input, most maize plots are planted in the same way. However, while household diffusion rates for improved seed rise from a mere 5 to 10% over the three years, fertilizer use is much more widespread—attaining 43% of households in 2011/12. Household average area shares are similar in magnitude (8% for seed in 2011/12; 43% for mineral fertilizer). Collectively managed plots appear to have a slightly higher likelihood of receiving these inputs; among individually-managed plots, those managed by men are nearly twice as likely to receive them.

Very little pesticide or fungicide appears to be used on maize (2-3% of households for pesticides and 4-5% of households for fungicides, with similar percentages of plots), but diffusion rates for herbicides rose over the three years to 25% of households and an average area share per household of 28%.

Over half of all households applied manure in all three survey years, on an average of nearly half their household maize area, but not to all plots—though differences between female- and male-managed individual plots only appear to be meaningful in 2011/12 for this category. Use of SWC practices in and of itself is not as prominent (about 18-21% over the three years), but when considered with manure, the SWC bundle is again the most widely diffused of the three (60-63% of households practicing at least one of the two on at least one of their maize plots). The yield-enhancing bundle is adopted by nearly half of households by 2011/12 (46%), while the yield-protecting bundle (represented primarily by herbicides) is used by nearly 30% of households.

Table 5a: Input use on maize, 2009-10

	Percent						Mean	
	Households	All plots	Collective plots	Individual Plots	Female-managed, individual	Male-managed, individual	Household crop area (ha)	% of household crop area
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Improved seeds	4.99	4.74	4.82	4.31	2.13	5.75	0.07	4.46
Fertilizer	33.5	34.6	35.6	29.4	24.3	32.9	0.53	34.0
Herbicide	16.9	18.0	19.1	11.4	8.09	13.7	0.41	17.3
Pesticide	2.87	3.71	3.84	2.99	1.70	3.84	0.05	3.47
Fungicide	6.21	4.66	4.63	4.81	2.98	6.03	0.06	4.67
Manure	58.6	41.5	43.7	28.5	27.7	29.0	0.25	47.1
SWC	21.7	12.8	13.0	11.3	13.6	9.86	0.07	14.8
Bundle 1	34.9	36.5	37.5	31.3	25.5	35.3	0.54	35.5
Bundle 2	22.7	22.7	23.9	16.4	11.9	19.5	0.44	22.3
Bundle 3	63.2	45.6	47.8	33.2	33.6	32.9	0.28	51.6

Source: EPA data, as prepared by authors.

Table 5b: Input use on maize, 2010-11

	Percent						Mean	
	Households	All plots	Collective plots	Individual Plots	Female-managed, individual	Male-managed, individual	Household crop area (ha)	% of household crop area
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Improved seeds	9.76	7.00	7.03	6.81	5.37	7.58	0.10	7.62
Fertilizer	41.5	38.6	40.2	27.7	26.0	28.7	0.56	38.7
Herbicide	22.3	23.6	24.3	18.9	16.7	20.1	0.46	23.6
Pesticide	3.20	2.75	2.88	1.86	2.00	1.79	0.04	2.92
Fungicide	4.89	4.33	4.72	1.63	0.67	2.15	0.05	4.70
Manure	55.9	40.4	41.1	35.4	28.7	39.1	0.22	46.8
SWC	19.8	13.7	13.8	12.8	17.3	10.4	0.07	15.5
Bundle 1	45.4	40.7	42.2	30.5	29.3	31.2	0.57	41.2
Bundle 2	26.1	27.2	28.2	20.3	17.3	21.9	0.48	27.4
Bundle 3	59.6	44.9	45.6	39.9	35.3	42.3	0.26	51.0

Source: EPA data, as prepared by authors.

Table 5c: Inputs use on maize, 2011-12

	Percent						Mean	
	Households	All plots	Collective plots	Individual Plots	Female-managed, individual	Male-managed, individual	Household crop area (ha)	% of household crop area
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Improved seeds	9.54	8.01	7.85	9.03	4.05	11.5	0.12	8.21
Fertilizer	43.2	43.9	45.1	35.9	31.1	38.3	0.64	43.2
Herbicide	25.1	28.9	30.5	18.7	16.9	19.7	0.55	28.0
Pesticide	3.39	2.38	2.50	1.58	1.35	1.69	0.04	2.80
Fungicide	4.96	4.49	4.69	3.16	0.68	4.41	0.07	4.86
Manure	56.6	44.0	45.0	37.3	28.4	41.7	0.31	50.0
SWC	18.2	12.1	12.7	8.13	7.43	8.47	0.06	14.0
Bundle 1	46.3	46.1	46.9	40.4	33.8	43.7	0.65	45.6
Bundle 2	29.9	31.9	33.4	22.1	18.9	23.7	0.57	31.8
Bundle 3	60.8	47.7	49.0	39.5	31.1	43.7	0.34	53.8

Source: EPA data, as prepared by authors.

Tables 6a-c report parallel statistics for millet. In millet production, use of first-generation improved seed does not surpass 1% of households over the three-year period, and an even lower percentage of plots, although higher percentages are reported in later seasons for individually managed than for collective plots in the case of millet. Still, the numbers are so small that this result is not likely to be meaningful. On millet, household and plot diffusion rates are higher for fungicides than for either herbicides or pesticides, though none are higher than 10% in any of the survey years. Household diffusion rates for fertilizer use on millet are 14-15%, with an average area share per household of under 10%. By contrast, manure and SWC practices are again adopted by at least one in four and one in five millet-growing households, respectively. In 2011/12, the SWC bundle was used by 42% if households on 33% of plots, including 37% of collective plots and 25% of individually-managed plots (23% of female-managed and 29% of male-managed).

Table 6a: Input use on millet, 2009-10

	Percent						Mean	
	Households	All plots	Collective plots	Individual Plots	Female-managed, individual	Male-managed, individual	Household crop area (ha)	% of household crop area
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Improved seeds	0.58	0.22	0.23	0.20	0.19	0.24	0.00	0.18
Fertilizer	13.4	7.22	8.26	5.11	4.71	6.16	0.16	8.68
Herbicide	3.54	2.30	2.97	0.94	0.75	1.42	0.06	3.89
Pesticide	4.07	3.26	3.77	2.22	2.45	1.66	0.07	4.12
Fungicide	13.7	7.95	8.59	6.66	6.60	6.87	0.17	10.1
Manure	27.8	19.0	22.9	11.0	10.8	11.4	0.42	20.7
SWC	21.8	15.0	17.0	10.8	10.8	10.9	0.28	16.5
Bundle 1	14.4	7.91	9.08	5.52	5.18	6.40	0.18	9.43
Bundle 2	20.4	12.9	14.5	9.56	9.52	9.72	0.28	17.2
Bundle 3	40.3	39.0	34.1	19.0	18.9	19.2	0.58	31.5

Source: EPA data, as prepared by authors.

Table 6b: Input used on millet, 2010-11

	Percent						Mean	
	Households	All plots	Collective plots	Individual Plots	Female-managed, individual	Male-managed, individual	Household crop area (ha)	% of household crop area
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Improved seeds	1.06	0.51	0.59	0.35	0.12	0.96	0.02	0.72
Fertilizer	15.1	9.01	10.7	5.13	4.65	6.39	0.18	10.3
Herbicide	6.77	4.46	5.77	1.50	0.86	3.19	0.11	6.75
Pesticide	3.10	3.06	3.43	2.21	2.08	2.56	0.06	3.61
Fungicide	10.9	9.06	8.92	9.38	8.20	12.5	0.18	10.0
Manure	27.4	23.0	25.7	16.8	14.4	23.0	0.39	23.2
SWC	21.7	15.5	17.3	11.6	11.9	10.9	0.23	16.9
Bundle 1	16.2	9.90	11.6	6.11	5.26	8.31	0.21	11.3
Bundle 2	19.8	15.8	17.2	12.7	11.1	16.6	0.33	19.5
Bundle 3	39.5	32.4	36.0	24.1	22.2	29.1	0.52	33.4

Source: EPA data, as prepared by authors.

Table 6c: Input use on millet, 2011-12

	Percent						Mean	
	Households	All plots	Collective plots	Individual Plots	Female-managed, individual	Male-managed, individual	Household crop area (ha)	% of household crop area
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Improved seeds	1.41	1.55	1.19	2.32	2.15	2.73	0.01	1.57
Fertilizer	14.6	9.73	11.4	6.15	4.86	9.22	0.22	11.1
Herbicide	7.66	6.51	8.14	3.02	3.43	2.05	0.14	8.93
Pesticide	5.36	3.35	3.79	2.42	2.86	1.37	0.08	4.14
Fungicide	9.84	9.05	9.56	7.96	8.73	6.14	0.17	10.3
Manure	28.4	23.5	26.9	16.1	13.7	21.8	0.43	24.6
SWC	21.8	15.6	17.0	12.5	12.3	13.0	0.26	17.0
Bundle 1	16.7	11.7	13.1	8.57	7.15	12.0	0.27	13.0
Bundle 2	21.3	17.8	19.9	13.2	14.7	9.56	0.36	21.7
Bundle 3	42.3	33.0	36.7	24.9	23.2	29.0	0.58	35.0

Source: EPA data, as prepared by authors.

To test differences in *plot diffusion* rates between collectively- and individually-managed plots, and between those managed individually by men and women, we pooled the three years and conducted Pearson-chi squared tests. These are presented in Table 7-9, by crop.

Aside from fungicide use and use of improved seed, all inputs and input bundles are more likely to be used on collectively-managed sorghum plots (Table 7), and this advantage is statistically strong (p-value generally < 0.01) for all inputs except pesticides (p<0.05). Between plots managed by men and women, however, only the likelihood of herbicide use and anti-erosion practices (and the SWC bundle) is significantly different at less than 5% . This confirms the hypothesis that at least in terms of use (but not necessarily scale of use, or intensity of use), the importance of sorghum in food security means that both women and men have access to inputs within the household. Anti-erosion practices require often require more input of labor and other capital, and thus women are less favored for these, with a lower frequency of use.

Table 7. Tests of differences in *plot diffusion* rates, sorghum, by input and plot management, 2009/10-2011/12

	Collectively v. individually-managed		Individually- managed by men v. women	
	Pearson Chi Sq(1)	p-value	Pearson Chi Sq(1)	p-value
Improved seeds	0.37	0.54	0.66	0.42
Fertilizer	91.99	0.00	1.57	0.21
Herbicide	54.69	0.00	8.18	0.00
Pesticide	4.61	0.03	4.02	0.05
Fungicide	0.30	0.59	0.52	0.47
Manure	424.83	0.00	1.41	0.24
SWC	148.77	0.00	6.40	0.01
Bundle 1	88.39	0.00	1.91	0.17
Bundle 2	29.87	0.00	1.26	0.26
Bundle 3	503.68	0.00	4.47	0.03

Source: EPA data, as prepared by authors.

As in the case of sorghum, collectively-managed maize plots are significantly more likely to receive any input other than improved seed (Table 8). But in stark contrast to sorghum, plots that are individually-managed by men are also significantly more likely to receive any input other than pesticides. Maize production is more commercially-oriented in most settings that is sorghum.

Differences in diffusion rates by plot management are similar in statistical significance for millet and sorghum, since millet is also a food staple in the regions where it is grown (Table 9). However, unlike in the sorghum diffusion rates, significant differences appear by plot management in the likelihood of use of either fertilizer or manure, and also in terms of the productivity-enhancing bundle, which is largely explained by fertilizer. These inputs are not nearly as widely used, in general, on millet as on sorghum, given where the millet-growing regions are found.

Table 8. Tests of differences in *plot diffusion* rates, maize, by input and plot management, 2009/10-2011/12

	Collectively v. individually-managed		Individually- managed by men v. women	
	Pearson Chi Sq(1)	p-value	Pearson Chi Sq(1)	p-value

Improved seeds	0.00	0.98	11.56	0.00
Fertilizer	45.21	0.00	7.13	0.01
Herbicide	52.36	0.00	5.21	0.02
Pesticide	3.35	0.07	1.17	0.28
Fungicide	4.91	0.03	7.43	0.01
Manure	53.75	0.00	9.46	0.00
SWC	6.36	0.01	3.99	0.05
Bundle 1	34.82	0.00	9.35	0.00
Bundle 2	52.13	0.00	8.20	0.00
Bundle 3	55.82	0.00	4.72	0.03

Source: EPA data, as prepared by authors.

Table 9. Tests of differences in *plot diffusion* rates, maize, by input and plot management, 2009/10-2011/12

	Collectively v. individually-managed		Individually- managed by men v. women	
	Pearson Chi Sq(1)	p-value	Pearson Chi Sq(1)	p-value
Improved seeds	1.77	0.18	1.95	0.16
Fertilizer	65.01	0.00	8.05	0.01
Herbicide	81.13	0.00	1.74	0.19
Pesticide	15.17	0.00	1.18	0.28
Fungicide	3.74	0.05	0.47	0.49
Manure	166.15	0.00	15.86	0.00
SWC	58.54	0.00	0.01	0.94
Bundle 1	56.76	0.00	9.53	0.00
Bundle 2	54.66	0.00	0.08	0.78
Bundle 3	200.84	0.00	6.43	0.01

Table 9. Tests of differences in *plot diffusion* rates, millet, by input and plot management, 2009/10-2011/12

	Collectively v. individually-managed		Individually- managed by men v. women	
	Pearson Chi Sq(1)	p-value	Pearson Chi Sq(1)	p-value
Improved seeds	0.37	0.54	0.66	0.42
Fertilizer	91.99	0.00	1.57	0.21
Herbicide	54.69	0.00	8.18	0.00
Pesticide	4.61	0.03	4.02	0.05

Fungicide	0.30	0.59	0.52	0.47
Manure	424.83	0.00	1.41	0.24
SWC	148.77	0.00	6.40	0.01
Bundle 1	88.39	0.00	1.91	0.17
Bundle 2	29.87	0.00	1.26	0.26
Bundle 3	503.68	0.00	4.47	0.03

Source: EPA data, as prepared by authors.

With respect to improved seed, it is worth noting that the extremely small sample sizes and variation could explain lack of statistical significance, but so could the explanation that seed travels within a household decision-making unit easily given its low weight and potentially small volume.

Intensity rates were calculated only for fertilizer, in terms of nitrogen nutrient kgs/ha (Table 10). Rates are extremely low on average for millet and sorghum, and many times higher on maize in each of the three years of the survey. Although rates do appear to rise in general across the three years, the average nitrogen nutrient kgs/ha were only 1.7 on millet and 2.6 in sorghum, compared to 20.3 in maize.

Table 10. Average *intensity* of fertilizer applied per household (N nutrient kgs/ha) to major cereals, 2009/10-2011/12

	Nitrogen nutrient kgs/ha			
Crop	2009-12	2009-10	2010-11	2011-12
Millet	1.70	1.11	2.26	1.80
Maize	20.3	16.3	19.0	26.2
Sorghum	2.63	1.25	2.52	4.26

Source: EPA data, as prepared by authors.

For each input category, Table 11 presents *area diffusion* rates over the three survey years, facilitating a cross-crop comparison at a national scale. In any of the three crops, input use rose in nearly all input use categories over this time period. Where this may not be the case, as in pesticide use on maize and SWC use in maize and sorghum production, rates are only a percentage point or two lower in the third year, and probably are not meaningful.

In the latest year reported (2011/12), the area diffusion rate for improved seed was nearly 7 times as high in maize as it is in sorghum, and lowest in millet of the three main cereals. Maize is grown in the cotton-based farming system, benefiting from a stronger, vertically-integrated value chain. Similarly, over two-thirds of maize area during this time period benefited from at least some inorganic fertilizer. Use rates were only 16% of the national millet area. The area diffusion rate for fertilizer across all sorghum grown nationally reached only 13%. Herbicides were applied to 61% maize area, as compared to 21% of sorghum area and 10% percent of millet area. Pesticides were used on only about 5-6% of area in any of the three major cereal crops. Fungicides were extensively used on maize (7%), compared to sorghum (10%) and millet (12%). About one-third of maize area received manure (33%), compared to a little over one-quarter of sorghum area (27%) and 30% of millet area. Soil and water conservation structures were most extensively used in sorghum and millet (17-18% of area), compared to only 7% of national maize area.

Considering inputs grouped by their attributes, yield-enhancing and yield-protecting inputs strongly favored maize relative to either of the other main cereals, although not in the case of fungicides. The SWC bundle (including manure and/or SWC practices) clearly favored sorghum and millet, which are grown in the drier, riskier, and more eroded landscapes of Burkina Faso.

Table 11. *Area diffusion* rate on a national scale, major cereals, 2009/10-2011/2012

	Millet			Maize			Sorghum		
Input	2009-10	2010-11	2011-12	2009-10	2010-11	2011-12	2009-10	2010-11	2011-12
Improved seed	0.22	1.32	0.66	8.13	11.8	12.7	0.64	0.77	1.73
Fertilizer	9.70	12.6	15.5	62.5	67.5	69.9	10.0	10.3	13.3
Manure	25.4	26.7	29.7	28.9	27.0	33.9	23.9	23.6	27.0
Herbicide	3.44	7.85	9.81	47.6	55.0	60.9	9.49	15.2	21.9
Pesticide	3.97	4.03	5.32	6.28	4.93	4.81	5.10	5.71	5.9
Fungicide	10.5	12.5	11.5	6.49	6.48	7.28	11.5	10.3	10.6
SWC	17.2	15.6	17.7	7.81	8.76	6.85	20.4	19.3	17.1

Source: EPA data, as prepared by authors.

Concluding points

The EPA of Burkina Faso furnishes detailed multi-year data that facilitates the analysis of input use by crop at a national scale. In addition, the data enable us to differentiate input use by adoption concepts and by observational unit of analysis to reflect the complex socio-demographic structure of family farming in Burkina Faso. Based on the last three years for which data have been cleaned, we summarize short term adoption over a three-year period at the national scale, by crop, input type, adoption concept (household diffusion and extent of use; plot diffusion; aggregated area diffusion or extent of use; intensity of use) and observational unit (household; plot; plot management type (collective; individual); gender of plot manager (male, female).

Considering all of the three seasons studied, over three-quarters of households surveyed grew millet, 87% grew maize, and 93% grew sorghum. The most common management type for all three cereals is collective, or joint management with the aim of meeting the food and cash needs of the family as a whole. Among individual plots, those managed by women are more likely to be sorghum or millet, while individual maize plots are most often managed by men.

In terms of area diffusion on a national scale, improved seed of either sorghum or millet represents no more than 1-2% of cropped area, though explanations for this finding are in part definitional. By contrast, use of improved seed in maize is over 10% of cropped area. Referring also to other studies, we contend that a better understanding of adoption rates for improved seed is fundamental for policy design. ADD gender.

The extent of use of mineral fertilizer at the national scale is similar for millet and sorghum (10-15%), but greater than two-thirds of maize area. Intensity of fertilizer use (N nutrient kgs per ha) is several times higher on maize plots than on sorghum or millet plots.

Use of herbicides grows considerably by any indicator over the three years evaluated, attaining over 60% of maize area, compared to 10% of millet area and over 20% of sorghum area in the nation. Manure and SWC use is relatively high compared to other inputs on all three crops, though SWC is of less importance in maize than in the other two crops, given that they are grow in the drier areas with more degraded soils.

Collectively-managed plots appear to receive more inputs than individually-managed plots, but, but particularly inputs such as mineral fertilizer, manure, and SWC practices, which require considerable labor, cash or equipment outlay. This seems to be the case for all three major cereals studied.

Gender differences appear to be more pronounced among individual maize plots than individual sorghum or millet plots. For example, estimates suggest that sorghum plots managed individually by men are not substantially more likely to receive fertilizer than those operated by women. There are some differences for manure application, though they may not be meaningful or statistically significant (this should be checked). Use of SWC practices is higher by a few percentage points on individual plots managed by men. These and manure application require more labor and possibly, access to equipment. Further research should verify compare intensity of use and extent of plot use between these two groups.