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Does Organic Farming Provide a Viable Alternative for Smallholder Rice Farmers in India?

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Abstract: Smallholder rice farming is characterized by low returns and substantial environmental impact. Conversion to organic management and linking farmers to fair trade markets could offer an alternative. Engaging in certified cash-crop value chains could thereby provide an entry path to simultaneously reduce poverty and improve environmental sustainability. Based on comprehensive data from a representative sample of approximately 80 organic and 80 conventional farms in northern India, we compared yield and profitability of the main rotation crops over a period of five years. Contrary to the widespread belief that yields in organic farming are inevitably lower, our study shows that organic farmers achieved the same yields in cereals and pulses as conventional farmers, with considerably lower external inputs. Due to 45% lower production costs and higher sales prices, organic basmati cultivation was 105% more profitable than cultivating ordinary rice under conventional management. However, since holdings are small and the share of agricultural income of total household income is declining, conversion to organic basmati farming alone will not provide households a sufficiently attractive perspective into the future. We propose that future efforts to enhance the long-term viability of rice-based organic farming systems in this region focus on diversification involving higher value crops.

Keywords: farming systems; sustainable development; rural livelihoods; traditional varieties; system of rice intensification; contract farming

1. Introduction

Uptake of organic practices is growing worldwide, particularly among smallholders in low- and middle-income countries. India plays an important role in this development, hosting 835,000 of a global total of 2.7 million certified organic farms in 2016 [1]. The shift towards organic farming raises questions not only about sustainability but also about profitability and food security. A global meta-study found that organic farming systems produce lower yields, but they are more profitable and environmentally friendly in terms of soil quality, minimized energy use, biodiversity and minimized water pollution, compared with conventional agriculture [2]. An important mechanism to enhance profitability is farm–gate premium prices. Especially in combination with reduced production costs, an average yield drop of 10–18% can be more than compensated, resulting in a net profitability 22–35% higher than conventional agriculture [3]. Critics argue that due to lower productivity, a wider adoption of organic agriculture would exacerbate the challenge of providing sufficient food to feed the world [4–6]. However, transition processes are always long-term and gradual, requiring models that incorporate multiple factors and scenarios that include advances in technological options, for example in resource use efficiency, and other changes affecting food security, for example climate change resilience and reduction of food waste [7,8]. Moreover, ongoing changes in the agricultural sector need proper monitoring and assessment to better understand the dynamics of the transition process in particular places. Here, we present results of such an assessment, based on a study of rice farming in northern India.

Rice-based farming systems provide a suitable study field to investigate the question whether conversion to organic farming enables smallholders to earn a higher income and improve their livelihoods, without jeopardizing food security. Rice is the staple food for the largest number of people on Earth, and the inundated fields make paddy rice the largest single land-use food crop [9]. Paddy rice is grown by 150 million smallholders, mostly in Asia, who are increasingly vulnerable to the impacts of climate change [10]. Paddy rice cultivation is environmentally relevant: it consumes 34–43% of global irrigation water, is the cereal crop with the highest emission of greenhouse gases (particularly methane) and accounts for 13% of global nitrogen fertilizer use [9–11]. Less than 10% of the rice produced is placed on international markets, mostly high ('export')-quality rice, including aromatic varieties like basmati [9]. These aromatic varieties have yields that are typically lower than hybrid or open-pollinated local rice varieties (hereafter referred to as 'coarse paddy') but achieve substantially higher market prices. Market demand for organic and fair trade-certified basmati rice has been robust and growing over the past years [12].

Field experiments under optimized conditions have shown that after a conversion period in which soil fertility is built up organic cultivation methods can achieve approximately the same or even higher yields in basmati and rotation crops compared to the conventional system, provided that sufficient quantities of organic manures are applied [13,14]. Previous on-farm studies on conversion to organic rice farming systems in Asia indicated that organic farms achieve approximately the same yields but increased profitability due to lower input costs [15,16]. However, these studies were mainly based on interviews, and only covered farm data from one season. In this paper, we analyze how conversion to organic basmati cultivation and fair trade is a viable option for smallholder rice producers in northern India. We compare cropping patterns, yields and profitability of main crops in a representative sample of approximately 80 organic and 80 conventional farms over a period of five years.

2. Materials and Methods

The data analyzed in this paper originate from a project initiated by Coop, the second largest retailer in Switzerland. Since 2011, Coop has supported smallholder rice farmers in Uttarakhand State in northern India in converting to organic farming and selling their produce under fair-trade conditions [12]. The project is part of the company's strategy to convert its own rice brand to fair trade and organic. In recent years, Coop's rice processing and trading company Reismuehle Brunnen has continuously increased the share of sustainable rice, and today, it is the largest supplier of organic and fair trade specialty rice in the European market [12]. The Swiss development organization Helvetas was mandated to assist the establishment of an organic basmati rice value chain in collaboration with its sister organization Intercooperation Social Development India, local farmer organizations, processing companies and research institutes. The key partner in India is the company Nature Bio-Foods Ltd. (NBF) based in Sonepat, which buys the basmati paddy directly from the farmers, mills it in their own processing facilities, and exports it to Reismuehle Brunnen and other clients. It also sells some rice and rotation crops in the emerging domestic organic market under its "Ecolife" brand.

The project is located in Nainital District of Uttarakhand State in the foothills of the Indian Himalayan range. It spreads over approx. 140 villages and hamlets in three Blocks (Ramnagar, Kotabagh and Betalghat), located 300–800 m above sea level. The region receives, on average, 1650 mm rainfall, mainly during the monsoon season (June–September). Rainfall and irrigation from mainly seasonal water sources allow for two cropping cycles: Kharif (June–November) and Rabi (November–March). During the study period (2012–2016), rainfall in the Kharif season was 970 mm, on average [14].

In 2011, before the project started, trained surveyors collected agronomic and household baseline data in the project region. The number of farms participating in the project grew from 145 in 2011 to 2212 in 2016, and the total area under organic farming from 115 ha to 2730 ha over the same period. For the comparison of organic and conventional farming, field data were collected over five years (June 2012 to April 2017) from a representative sample of organic and conventional farms in the project area for main crops both in Kharif and Rabi seasons. To compare organic farming with the prevailing practice in the same region, we randomly selected 11 of the 81 village clusters where the organic basmati project was active. In the selected village clusters, we randomly selected a total of approximately 80 organic and 80 conventional farms that cultivated basmati and/or coarse paddy (clustered sample). Sample size varied slightly from year to year, due to changes in farmer availability and resulting from a rigorous quality check of survey data (Table 1). Farmers who, over the years, dropped out of the sample (conventional farmers who converted to organic farming, farmers who stopped basmati or paddy farming altogether) were replaced by randomly selected farmers in order to maintain the sample size. Due to delays in rains or provision of seeds, not all organic farmers were eventually able to grow basmati in every year. From 2013 onwards, following the example of organic farmers, some conventional farmers also grew basmati, for which they applied organic inputs only.

Table 1. Sample sizes of organic and conventional farms.

Sample Size	2012	2013	2014	2015	2016
Conventional	84	76	76	96	80
Organic	72	73	73	73	90
Conventional farms growing basmati	0	23	20	38	24
Organic farms growing basmati	56	54	49	49	61
Total conventional area in sample (ha)	47.8	36.8	39.9	53.7	45.0
Total organic area in sample (ha)	54.2	51.3	53.2	55.6	59.2

During each cropping cycle, trained surveyors visited the selected farms in regular intervals to monitor and verify land use, input and harvest data kept or recalled by the farmers. To get accurate per-hectare data, for all major crops, the area of one plot per farm was measured, and all inputs and harvests were recorded for that specific plot. Gross margins were calculated as yields into prices minus direct costs for inputs and hired labor. The cost of family own labor was not taken into consideration, since it would have been very difficult to get reliable data. Processed data were shared with the participating farmers both in individual and aggregated form at the end of the study period.

In 2013 and 2014, data were also collected for additional Kharif crops in order to better understand the relative profitability of basmati cultivation. In 2014 and 2016, household income data were collected from the sample in order to get a better understanding on the relevance of crop revenues for overall household income. The information obtained from these data is used as reference in the discussion chapter. Additionally, two masters students at Wageningen University conducted semi-structured interviews in April and May 2017 with 51 organic farmers, 28 conventional farmers, representatives of the producer organization, local governments, traders, processors and facilitating NGOs. The interviews were based on questionnaires that included three different types of questions: Likert scale [17], open-end and closed-end questions [18]. Results from these interviews are used as background information in the discussion chapter.

We compared key indicators between production systems using analysis of variance (ANOVA) in STATA14. ANOVA uses ordinary least squares regression to assess whether means are statistically significant between groups. For pooled data we corrected for location effects (village clusters) and year effects. To compare monetary results over the years, prices, costs and returns were corrected by consumer price index (CPI of 31 December 2012 = 100, Government of India data).

3. Results

3.1. Characteristics of the Organic and Conventional Farming Systems

Smallholder farmers interested in converting to organic basmati farming joined the organic farmer organization Fair Farming Foundation – Ramnagar and signed a production contract with the processing company Nature Bio-Foods Ltd. in which they committed to adhere to organic standards (Indian National Program for Organic Production, EU Council Regulation (EC) No. 834/2007 and BIO SUISSE Standards) on their entire farm. The company provided them with organic seeds of traditional basmati (varieties Dehraduni Type 3 and Taraori HBC 19) and commercial bio-inputs (neem oil, pseudomonas, trichoderma, micro-nutrients) at cost-prices.

Nature Bio-Foods Ltd. managed an internal control system to ensure organic integrity and arranged and paid for third-party certification as per the specified organic standards and Fairtrade International standards. It purchased the certified basmati paddy, as well as some pulses directly from the farmers, following an agreed pricing mechanism (guaranteed fair-trade minimum price or market rates, whichever was higher, plus defined organic premiums of approx. 10–15%, and rebates for sub-standard quality).

Organic farmers participating in the project received initial training on organic farming practices and were assisted in testing different organic methods in their fields (participatory technology development). Farmers were also trained in improved paddy cultivation techniques based on the System of Rice Intensification (SRI), combining earlier and wider transplanting of seedlings, alternate wetting and drying, and mechanical weeding using hand-pushed "conoweeders" [19]. While a majority of farmers adopted the alternate wetting and drying regime in irrigation, the complete SRI system was only adopted by 19% of the farms in 2016. Farmers sold their organic basmati to Nature Bio-Foods Ltd., but sold most of their rotation crops on the general market, without getting a price premium for the organic quality. Conventional farmers in the region received some training and advice on best farming practices from the District's agricultural department. They sold their paddy and rotation crops to local traders or to local agricultural markets ('mandis').

Average holding of arable land was 33% higher in organic farms (0.72 ha) compared to conventional farms (0.54 ha). The number of cattle per farm and therefore the access to manure did not differ between the two groups. In both organic and conventional farms, the main crops grown in the Kharif season were paddy, soybean and amaranth, while in the Rabi season, wheat was the dominant crop, with some farmers also growing pulses, vegetables and spices (Figure 1). Organic farms had higher shares of arable land under basmati and pulses in Kharif season. In the first three years, the share of basmati in organic farms increased from 9% to 21%, but then declined to 14% and 13% in 2015 and 2016 due to unfavorable rain patterns. The reason that some of the conventional farms also grew basmati starting from 2013 onwards is that they wanted to try out the proposed innovation. Some of them converted to organic farming in subsequent years.

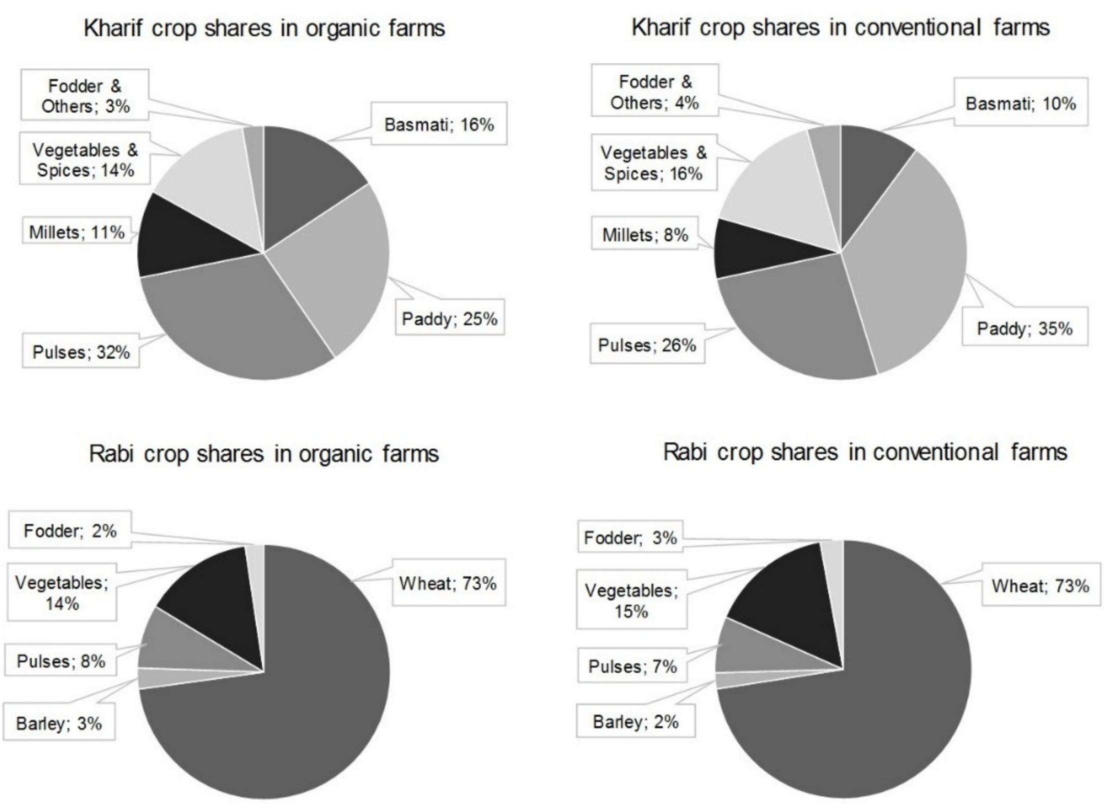

Figure 1. Crop shares in Kharif and Rabi season in organic and conventional farms, average of 2012–2016.

In Rabi season, cropping patterns did not significantly differ between organic and conventional farms, with wheat being the predominant crop. Only in the last year (Rabi 2016–2017), when the buyer started promoting organic lentil and chick pea production, organic farms had a higher share of pulses (13%) compared to conventional farms (10%). The recommendation to increase the share of nitrogen fixing leguminous crops in organic rotations [20] has so far only been implemented to a limited extent.

Crop management practices differed considerably: Conventional farmers used urea, di-ammonium phosphate (DAP) and compound NPK-fertilizers (on an average 98 kg N ha^{-1} in coarse paddy and 107 kg N ha^{-1} in wheat, ranging from 25–350 kg N ha^{-1}), along with farmyard manure, as nutrient sources. Synthetic fertilizer input in conventional paddy substantially decreased over time, from 179 kg N ha^{-1} in 2012 to 62 kg N ha^{-1} in 2016. Conventional farmers also applied various types of commercial insecticides, fungicides and herbicides (on an average 5.6 L ha^{-1} in coarse paddy and 1.0 L ha^{-1} in wheat). Organic farmers used farmyard manure, compost and green manure (mostly *Sesbania aculeate*) grown in situ. They applied bio-inputs provided by the buyer (Pseudomonas, Trichoderma, Neem oil, micro-nutrients derived from biomass) and home-made preparations based on cow urine and other natural ingredients for pest and disease control. Average cattle holding was the same in organic and conventional farms: 3.6 adult animals and 1.4 calves.

3.2. Yields

There was no significant difference in five-year average yields of main rotation crops in Kharif (basmati, coarse paddy and soy bean) and Rabi season (wheat, lentils and chick peas) between organic and conventional farms (Table 2). In single years, the only differences were in lentils in 2012 (organic yields were 14% lower than conventional yields) and in 2016 (organic yields were 2% higher). However, sample size was relatively small for lentils. Yield effects of the cropping system were also not significant when controlling for location (village).

Table 2. Average yields of main rotation crops in organic and conventional farms.

Yield (kg ha^{-1})	System	2012	(n) [1]	2013	(n)	2014	(n)	2015	(n)	2016	(n)	Average of Five Years
Basmati	org. [2]	2137	(56)	2074	(51)	2129	(49)	2035	(49)	1734	(61)	2022
	conv. [3]	n.a.	(0)	2431	(23)	1927	(20)	1979	(38)	2035	(24)	2093
	F [4]	-		0.63		2.49		0.00		0.41		0.02
Coarse paddy	org.	4299	(50)	4821	(42)	3080	(41)	4235	(55)	2779	(63)	3843
	conv.	4363	(78)	4324	(52)	2999	(51)	4249	(81)	2861	(57)	3759
	F	0.08		0.65		0.40		0.51		0.04		0.03
Soybean	org.	1684	(16)	999	(34)	891	(33)	744	(58)	696	(34)	1003
	conv.	1708	(6)	1167	(33)	873	(41)	825	(69)	821	(31)	1079
	F	0.46		0.17		2.68		0.66		0.61		0.05
Wheat	org.	2742	(60)	2455	(72)	2383	(73)	2172	(71)	2309	(89)	2412
	conv.	2827	(70)	2659	(78)	2507	(73)	2234	(93)	2842	(79)	2614
	F	0.55		0.02		0.61		0.30		0.85		1.16
Lentil	org.	1088	(15)	744	(13)	313	(31)	614	(28)	1144	(32)	781
	conv.	1272	(8)	571	(8)	295	(24)	647	(35)	1124	(30)	782
	F	4.41	*	0.35		0.01		0.03		4.59	**	0.40
Chickpea	org.	1243	(10)	n.a.	(0)	726	(23)	691	(21)	902	(32)	891
	conv.	1381	(11)	n.a.	(0)	740	(26)	671	(23)	1094	(29)	972
	F	0.52				0.76		2.19		0.80		0.05

[1] sample size; [2] organic farms; [3] conventional farms; [4] analysis of variance including the effects of years (five year averages only) and location (village cluster). ** and * denote significance at 5% and 10%, respectively.

3.3. Profitability

Organic farms achieved the same or higher gross margins compared to conventional farms (Table 3). Five-year averages of gross margins were not only higher in organic basmati, for which farmers received a premium price, but also in coarse paddy, wheat and lentil. Effects of the cropping system were also significant when controlling for location (villages). Rotation crops were sold in local markets without premium price, except for Rabi 2016, when the buyer purchased lentils and chickpeas with a 7–13% organic premium. Production costs (for seeds, external inputs and hired labor) in organic farms were lower than in conventional farms only in some crops: −23% for coarse paddy (9434 INR ha^{-1} vs. 12,230 INR ha^{-1}, F = 15.9), and −25% for wheat (7748 INR ha^{-1} vs. 10,361 INR ha^{-1}, F = 37.0; 1 EUR = 71.48 EUR in 2016).

3.4. Agronomic Performance of Basmati versus Coarse Paddy

Farmers who joined the project and shifted to organic production switched part of their paddy cultivation to traditional basmati. Therefore, we are comparing the agronomic and economic performance of organic basmati with conventional coarse paddy. Organic basmati production achieved on average 46% lower yields, but 182% higher sales prices (Table 4). These differences are not surprising, since traditional basmati generally has lower yields but higher market prices than coarse paddy, irrespective of the production system [21]. Input costs (for external fertilizer and pest management means) and overall production costs (including costs for seed and hired labor) were 50% and 45% lower in organic basmati, respectively, resulting in 105% higher gross margins than in conventional coarse paddy cultivation.

Gross margins in organic basmati were consistently higher (by 63% to 221%) than conventional paddy in all five years (Figure 2). The particularly strong performance in 2013 was due to a temporary price spike in the overall basmati market (organic farmers received 46.4 INR kg^{-1} on average, compared to 29.9 INR kg^{-1} in the other years), while in 2016, unfavorable rainfalls affected coarse paddy yields and profitability.

Table 3. Gross margins of main rotation crops in organic and conventional farms.

Gross Margin (in 1000 INR ha^{-1}) [1]	System	2012	(n) [2]	2013	(n)	2014	(n)	2015	(n)	2016	(n)	Average of Five Years
Basmati	org. [3]	55.8	(56)	85.4	(51)	42.7	(49)	36.9	(49)	34.5	(61)	51.0
	conv. [4]	n.a.	(0)	90.9	(23)	27.7	(20)	24.9	(38)	38.3	(24)	45.5
	F [5]	-		0.03		29.3	***	43.0	***	0.60		13.0 ***
Paddy	org.	36.0	(50)	40.3	(42)	23.9	(41)	26.7	(55)	16.8	(63)	28.2
	conv.	34.3	(78)	35.8	(52)	22.1	(51)	22.3	(81)	10.7	(57)	24.4
	F	2.55		1.03		3.76	*	9.61	***	0.16		6.11 **
Soybean	org.	42.1	(16)	23.2	(34)	16.3	(33)	12.1	(58)	6.8	(34)	19.1
	conv.	36.1	(6)	27.4	(33)	14.2	(41)	10.1	(69)	7.1	(31)	18.1
	F	1.41		0.54		5.38	**	22.13	***	0.02		1.68
Wheat	org.	30.1	(60)	26.0	(72)	21.1	(73)	20.1	(71)	22.0	(89)	23.6
	conv.	30.6	(70)	26.2	(78)	19.4	(73)	17.7	(93)	24.9	(79)	23.5
	F	0.68		0.06		4.74	**	21.09	***	0.08		7.84 **
Lentil	org.	43.5	(15)	24.8	(13)	8.7	(31)	40.1	(28)	38.1	(32)	31.0
	conv.	40.3	(8)	19.1	(8)	8.1	(24)	40.1	(35)	33.1	(30)	28.2
	F	0.35		0.33		0.05		0.15		8.51	***	4.69 **
Chickpea	org.	49.7	(10)	n.a.	(0)	25.3	(23)	34.5	(21)	9.8	(32)	29.1
	conv.	46.9	(11)	n.a.	(0)	17.4	(26)	29.5	(23)	11.2	(29)	25.5
	F	0.01				0.92		2.13		0.50		2.44
	CPI	104.90		115.50		120.30		127.90		132.80		120.28

[1] Financial values adjusted by Consumer Price Index (2012 = 100); [2] sample size; [3] organic farms; [4] conventional farms; [5] analysis of variance including the effects of years (five year averages only) and location (village cluster); ***, ** and * denote significance at 1%, 5% and 10%, respectively. Please note that no premium was paid for organic rotation crops except for lentils and chick peas in Rabi 2016.

Table 4. Organic basmati compared with conventional and organic coarse paddy cultivation.

Basmati vs. Paddy Cultivation [1]	Basmati Organic	Paddy Conventional	Paddy Organic	Org. vs. Conv. Paddy (F) [2]	Org. Basmati vs. Conv. Paddy (F) [2]
Yield (kg ha^{-1})	2039	3759	3843	0.03	512.45 ***
Price (INR kg^{-1})	27.89	9.86	9.88	2.88	4895.87 ***
Revenue (INR ha^{-1})	56,858	37,152	37,879	0.01	215.02 ***
Production cost (INR ha^{-1})	6759	12,230	9434	20.11 ***	60.95 ***
Input cost (INR ha^{-1})	2628	5297	3918	42.81 ***	58.62 ***
Gross margin (INR ha^{-1})	51,047	25,063	28,713	6.10 *	16.60 ***
CV Gross margin [3]	0.50	0.40	0.38	0.04	2.28

[1] Average performance over 5 years; financial results in Indian Rupees adjusted by Consumer Price Index (2012 = 100, 1 EUR = 54.7 INR). [2] (F) refers to analysis of variance including the effects of years (five-year averages only) and location (village cluster). [3] CV refers to the coefficient of variation, calculated as mean/standard deviation at the farm level. *** and * denote significance at 1% and 10%, respectively.

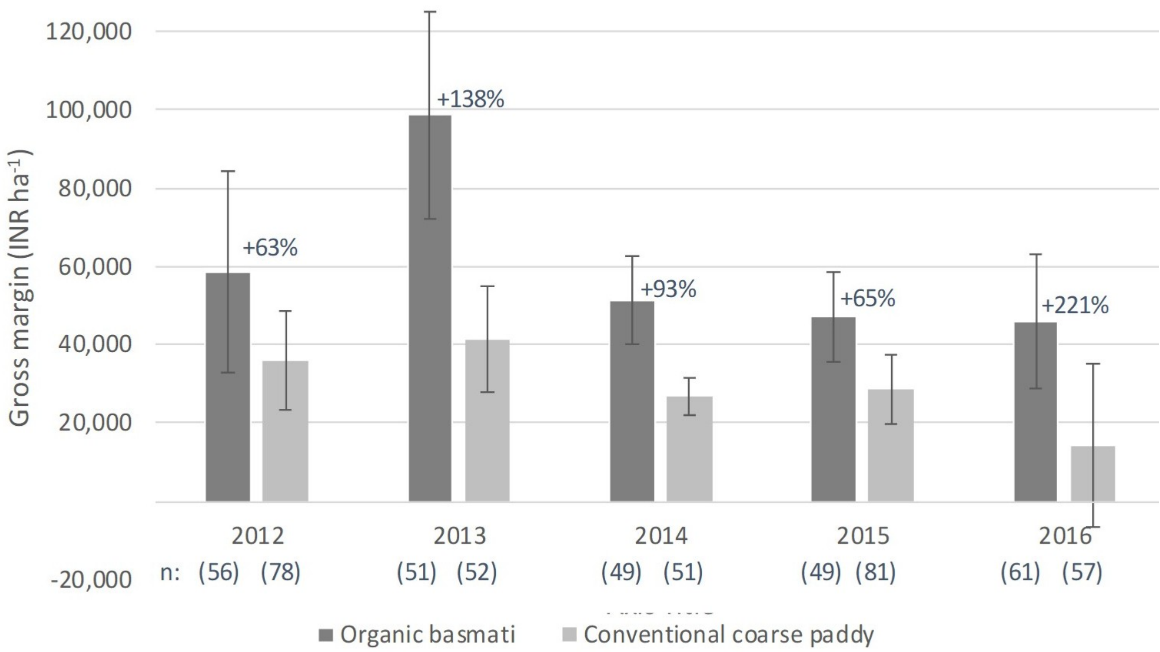

Figure 2. Gross margins (in Indian Rupees per ha, CPI adjusted) in organic basmati compared to conventional coarse paddy. Percentages indicate increase over conventional ($p < 0.01$). Error bars depict standard deviation, figures in brackets indicate sample size.

The price spike of 2013 resulted in a higher variability of gross-margins—as measured by the farm-level coefficients of variation—for organic basmati than for conventional paddy (Table 4). However, this difference is not statistically significant, even at the 10 percent level. Moreover, the difference is caused by an upward singularity, whereas farmers are mainly concerned about downward risk. This indicates that organic basmati cultivation is economically not riskier than conventional coarse paddy cultivation.

4. Discussion

4.1. Productivity of Rice-Based Organic Systems

The result that yields do not differ between organic and conventional farms is surprising. Organic farmers replaced synthetic fertilizers and pesticides with organic means, which usually results in lower yields [22]. However, farmers in the study area operate under sub-optimal conditions concerning available soil types, irrigation and inputs. Fertilizer input in conventional farms is therefore relatively low in cereal and pulses. Since coarse paddy, wheat and pulses are important staple crops partly produced for household consumption, this finding suggests that conversion to organic farming does not jeopardize food security of smallholders in marginal production regions. Field experiments conducted at GB Pant University for Agriculture and Technology from 2012–2014 in the same region but under optimized conditions have also shown that organic cultivation methods can achieve the same or even higher yields in basmati and rotation crops compared to the conventional system, provided that sufficient quantities of organic manures are applied [14]. The partial shift to basmati for export also did not affect food security of the farm families since they continued cultivating coarse paddy and wheat at least to the extent required for their own consumption.

It is striking to see that fertilizer input in conventional paddy substantially decreased over time. Several conventional farmers reported that they reduced fertilizer input when observing that organic farmers in their village got similar yields with organic manures. However, current manure application rates in organic farms seem insufficient to replace nutrient export through crop harvest, and therefore may lead to soil degradation and reduced productivity in the long term [23]. Improvements in manure collection, storing and application as well as increased use of in situ grown green manure can remedy this situation. Since basmati produces more straw than coarse paddy varieties and therefore increases the availability of fodder, its cultivation may enhance stocking rates and therefore production of manure to some extent [24].

While yields of coarse paddy showed a positive correlation with external input costs both in organic and conventional farms, no such correlation was observed in basmati or other crops. This finding raises doubts regarding the effectiveness of the biocontrol and bio-fertilizer inputs used on these crops.

4.2. Conversion to Organic Farming as a Livelihood Strategy

The results of the agronomic performance assessment confirm the finding of Crowder and Reganold [3] that organic farming is more profitable than conventional systems, but contradicts their conclusion that due to 10–18% lower yields, organic crops need a premium of at least 5–7% to be competitive with conventional production. Even without a premium price, organic rotation crops achieved the same profitability as conventional crops. This is in line with other studies in India showing that organic farming reduces the cost of cultivation without affecting net margins, particularly in less intensively cultivated hill regions [25,26]. Other studies comparing organic and conventional paddy systems in Uttarakhand also found that organic farms achieve the same yields but substantially higher net profits due to lower costs of cultivation and the availability of an organic premium [27,28]. Another study comparing (conventional) basmati with coarse paddy in Uttarakhand found that cultivating basmati is more profitable than non-basmati rice varieties [21]. The improved profitability of organic basmati cultivation in our study is therefore a result of both the conversion to organic agriculture and the shift from coarse paddy to basmati.

From a farmer's perspective, the main questions are whether basmati production is sufficiently lucrative as a cash crop compared to other options, and whether the conversion to organic management altogether makes their farms more profitable. Of the three main crops grown in the Kharif season (coarse paddy, basmati and soy bean), organic basmati had the highest gross margin in all years. Additional data collected in 2013 and 2014 show that only vegetables like tomato and spices like ginger and turmeric achieve higher gross margins, but also involve considerable investments and risks (crop failure, market fluctuations). These findings suggest that organic basmati is an interesting cash crop for farmers, combining good profit margins with relatively low risk. It is, therefore, not surprising that shares of land allocated to basmati cultivation were positively correlated with basmati gross margins in the previous year ($p < 0.001$).

However, organic farms allocated only an average of 15% of their arable land to basmati cultivation, and no clear upwards trend was observed over the five years. 22–33% of the organic farmers who registered with the project did not even grow any basmati. Interviews with farmers point out various reasons why they do not increase the basmati share. Delayed rains often force them to grow coarse paddy that has 25–30 day shorter crop cycles compared to traditional basmati varieties, or switch to soybean or millet if rains are further delayed. Farmers also assess what crop-to-field combination they expect will be best. Such decisions may be based on crop preferences, for example prioritizing the production of food crops for home consumption over cash crops. Also, labor and risk aversion play a role. Farmers typically grow cash crops on fields close to the compound, making it easily accessible for crop management, including protecting the field from being invaded by wild boar, monkeys and other wildlife [29]. Due to land fragmentation, available acreage close to the compound is limited in size, limiting the expansion of basmati cultivation.

4.3. Available Strategies to Further Improve Household Income

Surveys conducted among organic and conventional farms in the project region in 2011, 2014 and 2016 indicate that total annual household income (including income from agriculture, employment, labor and small-scale businesses) has been relatively stable over time (on average approximately USD 1000 per household of 4–5 persons, ranging from USD 200 to 4500). However, the share of agricultural income has declined from 60% in 2011 (baseline) to 43% in 2016. One reason for this is that all main crops except lentils have shown declining profitability over the years when adjusted by consumer price index. Another reason is that off-farm incomes strongly increased. In 2016, the share of agricultural income was higher in organic farms (49%) compared to conventional farms (35%). In that year, conventional farms had 3.5 times higher income from employment, leading to 2.5 times higher total income compared to organic farms. Since this result is mainly due to 10 conventional farm households who obtained more than USD 3000 annual income from employment, it may not be representative, though. The higher share of income from agriculture in organic farms along with the larger average farm size could be an indication that households that primarily rely on agriculture are more likely to convert to organic farming.

Even if organic farmers achieve considerably higher gross margins in basmati, this alone does not enable them to substantially increase their household income, since land holdings and the share of organic cash crops are too small. Only if additional rotation crops can be marketed with an organic premium, particularly vegetable and spice crops that generate higher margins, organic farmers will be significantly better off compared to conventional farmers. A crop diversification strategy would also enable farmers to maintain the cash flow throughout the season [24]. The project partners are therefore taking efforts to establish organic value chains for these crops linking organic farmers in the project region to the increasing demand for organic products in nearby cities, including the Delhi metropolitan market. Another viable strategy to make a living from farming may be to manage larger areas of land (e.g., by buying or renting land from households that give up farming) and increase the use of agricultural machinery and tools. Increased mechanization of field preparation, sowing and weed management would enable farmers to reduce labor input. It also enables them to optimize manure application and increase the utilization of green manure [23]. If farmers shifted from transplanting to direct sowing of paddy, this could reduce work load, but at the expense of somewhat lower yields [30].

While diversification and mechanization strategies have obvious advantages, they also have disadvantages. They both require specific skills, infrastructure and market linkages, and therefore may not be available to all households. More research is needed into these aspects before providing valid recommendations in a specific local context.

4.4. Environmental Benefits

The environmental benefits of organic compared to conventional agriculture have been widely discussed in the scientific literature [22,31–34]. Notable differences between organic and conventional agriculture relate to the strategies for pest and nutrient management. Organic farmers rely on organic pesticides that typically have lower toxicity and often lower persistence in the environment compared to most pesticide formulations used in conventional agriculture [31]. Organic farmers in the project presented here only used botanical extracts (mainly neem, which is of low toxicity) for pest management both in basmati and in the rotation crops, eliminating exposure to synthetic pesticides and consequently the risk of adverse effects on human health and of contamination of water sources.

Nutrient management has an important effect on various sources of nitrogen (N) pollution: Nitrate leaching can contaminate ground and surface water; volatilization of ammonia leads to air pollution ($PM_{2.5}$) and eutrophication of natural ecosystems; and emissions of the potent greenhouse gas and ozone depleting nitrous oxide (N_2O) adversely affect climate change and human health [35]. Averaged across geographic locations and cropping systems, N pollution on a per unit area basis is lower in organic compared to conventional systems [31,34,36,37].

Because organic certification standards prohibit the use of synthetic fertilizers, organic agriculture solely relies on alternative fertilizer sources such as animal manure, compost and green manures (plants that fix N from the atmosphere). The variety of nutrient management strategies observed across organic farms; however, is not always well reflected in field experiments, an issue that was criticized as a design flaw in the evaluation of comparative organic and conventional systems [38]. Indeed, when inspecting individual studies, the type and management of animal manure or green manures plays an important but incompletely understood role with respect to both the magnitude and direction of the N pollution response [39,40]. In this project, various organic nutrient management strategies were promoted through outreach and extension, including the use of farmyard manure, vermi-compost, biogas slurry, and the green manure Sesbania. A parallel field trial indicated that the organic management options reduced N leaching and NH_3 volatilization in many of the treatment by year combinations compared to the conventional control, whereas the effect of the organic management on greenhouse gas emissions was mostly insignificant (unpublished data). Beyond effects observed at the field scale, however, one needs to consider that widespread reduction in the use of synthetic pesticides and fertilizers would reduce greenhouse gas emissions associated with the production of these compounds at the regional or global scale [8,31].

One commonality between all organic nutrient management strategies is that they imply an input of carbon into the soil. This explains the overall increase in soil organic matter content and soil fertility in organic compared to conventional systems across geographic regions and cropping systems [31,32]. Focusing on Northern India or Uttarakhand in particular, studies have found that organic management promoted soil aggregation and increased organic carbon content, biological activity and nutrient availability compared to soils under conventional management [14,27,41]. Within the parallel field trial associated with this project, it was observed that the organic treatments mitigated nutrient mining and soil degradation compared to the conventional control treatment, as a consequence of lower N loss and higher input rates of phosphorus, potassium and sulphur for an equivalent amount of N (unpublished data). One criticism on the feasibility of organic agriculture, especially with respect to smallholder farmers, is the availability of sufficient organic fertilizer sources to meet crop demands [8,42]. To address this concern, a study was conducted in the project area to evaluate the farm-level impacts of subsystem nutrient management actions and to identify locally viable interventions for increased nutrient supply and recycling [23]. Viable interventions including the reduction of nutrient losses through simple and relatively cheap manure management modifications (i.e., using straw bedding to capture livestock urine, covering farmyard manure stockpiles with plastic sheeting, enclosed biogas slurry storage, and using biogas slurry for improved compost production), in situ green manuring, and purchasing farmyard manure identified through this study are now being promoted by extension services.

Organic soil fertility management contributes to increased water infiltration and retention in soils due to elevated soil organic matter content [14,43], thereby contributing to saving irrigation water. In addition, a majority of organic basmati farmers adopted the alternate wetting and drying (AWD) method in irrigating their basmati plots. Field trials conducted in the project in 2017 indicate that this practice leads to 24% lower water input compared to the earlier practice of keeping water stagnant in the field for longer periods, without affecting yields. This is in line with other studies that report 10–78% lower water input due to adoption of AWD and SRI [19,32,44]. The results of research station field trials conducted in the region in 2012–2014 even found 78–84% lower water inputs and 5.3–6.7 times higher water use efficiency in AWD plots [14].

Using available water resources more efficiently in a water-scarce environment can help improve crop productivity and livelihoods while reducing environmental stress. Equally important to applying water saving techniques at the field level is to improve water management and stewardship at the cluster or village level. Facilitated by the project, farmers formed Water User Groups (WUG) that identified and implemented measures to improve irrigation and drinking water infrastructure. Beneficiary contributions and combined funding from the fair trade premium, municipality budgets and project contributions enabled the WUGs to finance these measures [24].

5. Conclusions

The study has shown that conversion to organic basmati farming can provide a viable alternative for smallholders in India. Participation in certified basmati value chains that ensure organic and fair-trade prices enables farmers to substantially improve the profitability of paddy cultivation. Due to 45% lower production costs and higher sales prices, organic basmati cultivation was 105% more profitable than cultivating ordinary rice under conventional management. Contrary to the widespread belief that yields in organic farming are inevitably lower, our study shows that organic smallholder farmers can achieve the same yields in cereals and pulses as conventional farmers, with considerably lower external inputs. Even in the absence of organic and fair-trade premiums, organic management can therefore achieve the same or higher gross margins in cereals and pulses as prevailing conventional farming systems. At the same time, good organic management practices contribute to safeguarding environmental resources. If conversion to organic farming involves switching to a particular crop or variety, its comparative profitability and suitability to the local agro-climatic conditions need to be ensured. However, since land holdings are often too small to make a living from cereal and pulse crops, conversion to organic farming will only result in substantially higher household incomes if it goes along with producing higher-value cash crops like vegetables, fruits and spices for domestic markets. We therefore propose that future efforts to enhance the long-term viability of rice-based organic farming systems in this region focus on diversification involving higher value crops.

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