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A Comparative Cost-Benefit Analysis of Conventional and Organic Hazelnuts Production Systems in Center Italy

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Abstract: In this study, the economic profitability of hazelnut production in central Italy using conventional and organic farming systems was evaluated using the cost–benefit analysis methodology. Viterbo's province is the leading province in Italy in terms of quantity produced. Three indicators were calculated for both farming systems: net present value, payback time, internal rate of return. The analysis was conducted utilizing primary data collected by means of interviews and surveys with local farmers and organizations of producers. The collected production data refer to the decade 2008–2018; a global area of 100.34 ha and 76.14 ha were considered for conventional and organic cultivation, respectively. Sensitivity analysis was carried out considering different discount rates, price variability, and inflation rates. The net present value is equal to 92,800 €/ha and to 3778 €/ha, the payback time is 10.47 years and 42.94 years, while the internal rate of return is 12.2% and 1.1% for the conventional and organic production systems, respectively. The conventional production system performs significantly more remuneratively, considering that the price premium paid by the market for the organic product and the subsidies granted to organic farmers are not sufficient to balance the lower yield.

Keywords: organic and conventional production; hazelnuts; cost-benefit analysis; net present value; internal rate of return; payback time

1. Introduction

There has been a strong interest in hazelnuts over the last few years, which is driven by a growing request, especially by multinational confectionery firms (e.g., Ferrero), on the demand side, and by growing economic profitability on the supply side [1].

Hazelnut production is highly geographically concentrated over the world. Turkey is the world's leading producer, accounting for over 70% of world production. Italy is the second highest world producer, accounting for 15% of world production [2].

Viterbo's province is the leading province in Italy in terms of quantity produced. Here, production is mostly concentrated in the area of the Monti Cimini [3,4]. The surface cultivated in the area with hazelnuts has continuously increased over the last few years, and many of these new orchards are farmed with an organic production system. This interest in organic farming has been mainly driven by the reform of the European Common Agricultural Policy, which grants subsidies for organic hazelnut plantations in the first five years. In this study, the farms are intended as organic if they have been certified as organic by the MIPAAF (Ministry of Agricultural, Food and Forestry Policies) in compliance of European Regulations n.834/2007 and n.889/2008.

Organically farmed cultivations usually achieve significantly lower production yields [5–7]. Therefore, the economic sustainability of organic hazelnuts cannot be taken for granted [8–10] even if the market pays a premium price for organic products.

To the best of our knowledge, no analyses have been made to compare the economic profitability of conventional and organic hazelnuts farming systems. Some studies have been performed to compare organic and conventional economic performances of other crops, usually utilizing a cost–benefit analysis [11–13]. On the other side, related to hazelnut cultivation in other geographical areas, some attention has been paid to the environmental performance of this crop [14–16] or similar ones (e.g., pistachio, almonds) [17].

This study aims to evaluate and compare the economic performances of the conventional and organic hazelnut production systems in the area of Monti Cimini with a cost–benefit analysis. The objective of this study is to evaluate and compare the economic remunerability of the conventional and organic production systems of the hazelnut. The geographical area considered in this study is the province of Viterbo, more specifically the Monti Cimini (42°21′29.52″ N, 12°10′39.72″ E) area, where hazelnut production is concentrated. The intended audience of this study is the confectionary companies that represent the demand for hazelnuts, the various producer organizations of the area, all the numerous landowners in the region, and the public in general.

2. Materials and Methods

2.1. Description of the Crop Cycle

The economic assessment was carried out by considering all the field operations of the crop cycle, from the preliminary soil tillage performed before the planting to the different crop management operations until the harvesting and transport of hazelnuts to the storage point.

The length of the crop cycle is 50 years; starting from the sixth year, the orchard becomes productive. The average produced quantity over the whole lifecycle is 2363 kg/ha for conventional orchards and 954 kg/ha for organic orchards.

In the case of conventional farming, the field operations are the following:

(1) Soil Preparation (Year 0):

- (a) Soil ripping: This preliminary operation is carried using a ripper and aims to prepare the soil for the subsequent tillage. During the ripping, soil crusts are broken, stones and roots are removed from the soil surface, and the deeper soil layers are tilled and aerated.
- (b) Stone crushing: On average, in 33% of new implantations, after ripping, the soil breaks into blocks of rock or big stones. In these cases, stone crushing is necessary to crush the blocks of rock into little pieces in order to prepare the soil for planting.
- (c) Heavy harrowing: this operation is performed in 1/3 of hazelnut orchards when the soil is too tophaceous after the ripping.
- (d) Leveling: In 33% of new plantings, in soil with few stones, stone crushing and heavy harrowing are not performed. In these cases, leveling is performed.
- (e) Installation of an irrigation system: This system is installed only in conventional orchards of hazels located in areas where the rainfall level does not reach a certain value (about 60% of the farmed area considered in this study).

(2) Planting (Year 0)

- (a) Only for organic hazelnut cultivation, organic fertilization using 50 t/ha of cow manure is performed.

(b) Planting: This operation is performed by a transplanter machine equipped with GPS (global positioning system). The orchards have a plant density of 500 plants per hectare and a plant layout of 5 m × 5 m between rows and on the row.
(c) Harrowing: After planting, an inter-row harrowing is carried out using a rotary harrow in order to control weeds.

(3) Cultivation (from Year 1 to Year 50):

(a) Harrowing and heavy harrowing: Each of these operations is performed once per year from Year 1 to Year 5.
(b) Hoeing: Performed twice per year from Year 1 to Year 5, this operation is manual and takes place until the hazels become productive. It aims to remove weeds around each plant to help them grow better and faster.
(c) Fertilization: Performed twice per year from Year 1 to Year 50, with an increasing quantity of fertilizers applied in the first 5 years. It provides the soil with nutrients to adequately support plant growth and productivity. Fertilization is carried out using a broadcaster spreader coupled with a tractor. In conventional hazelnut cultivation, 150 kg/ha of diammonium phosphate 18-46 and 50 kg/ha of N30 are applied from Year 1 to Year 5, and then, from Year 6 to Year 50, 550 kg/ha of 20-10-10 is applied. In organic hazelnut cultivation, besides the basal fertilization in the year of planting, from Year 1 to Year 5, 150 kg/ha of Bio Enne (12% N) is applied, and then 800 kg/ha of Bio Enne and 200 kg/ha of phosphonature (26% P_2O_5) are applied from Year 6 to Year 50;
(d) Breeding pruning: This operation is performed manually once only in the third year of life of the hazel, and it aims to reach the selected form of breeding ("bushy", "a cespuglio").
(e) Pruning: This operation is performed manually from Year 4 to Year 50.
(f) Removal of basal shoots: This operation takes place from the third year. In conventional farming systems, in half of the cases, the operation is performed manually, and, in the other half of the cases, it is carried out by an herbicide (3.75 L/ha) applied using a sprayer equipped with bell spray nozzles for local application on the row. In the case of organic cultivation, the operation is always performed manually.
(g) Pest control: Insecticide and fungicide treatments are carried out using a sprayer. In the case of conventional farming, the following products are applied: deltamethrin (0.250 g/ha), lamba-cyhalothrin (0.250 g/ha), thiophanate-methyl (0.90 L/ha), boscalid + pyraclostrohin (0.50 L/ha); the operations are performed on average three times per year, and the quantities applied on average per year are indicated. In the case of organic orchards, the insecticide and fungicide treatments do not use any kind of synthetic chemical substances. The substances utilized on average per year as insecticide and fungicide treatments are 15 L of water/ha with a composition of 13 g per liter of "Cuthiol by Mormino", whose composition is 20 g of copper and 14 g of sulfur on 100 g of product, and 6 kg/ha of a leaf stimulant called "Blackjak".

(4) Harvesting (from Year 6 to Year 50):

(a) Shredding: This operation is performed three times per year starting from the sixth year when the hazel enters into the productive phase. It substitutes the harrowing and milling as the "surface cleaning" operation. It is performed with a lateral mulcher machine coupled with a tractor.
(b) Weeding preharvesting: It aims to clean the soil in order to facilitate the mechanized harvesting operations, and it is performed once per year.
(c) Harvesting: The hazelnuts that have fallen on the soil are gathered using a self-propelled machine. This harvesting solution is, by far, the most applied in the studied area [18].

The hazelnuts that have fallen to the ground are windrowed by two contrarotating brushes. The harvester is equipped with a lateral blower, which, using the aspiration air, collects the hazelnuts near the plant stems. The fruits are moved by the brushes to an aspirating pipe. Once aspirated in a depression chamber, they are separated from heavier materials (soil, stones). Finally, the product is collected in a conveyor, where, thanks to the airflow generated by a ventilator, leaves and other impurities are removed.

(5) Postharvesting Phase (from Year 6 to Year 50):

(a) Transportation: Using farm trailers coupled with tractors, the hazelnuts are transported to the collection center; the average distance between the hazels and the collection centers is 10 km. An empty return was considered in this study.

(b) Drying: Using a dryer, the moisture content of the hazelnuts is reduced from 13% to 6%.

Table 1 reports all the operations and utilized machinery in the crop-cycle.

Tables 2 and 3 report the average data regarding the type and quantity of utilized products.

2.2. Cost-Benefit Analysis

In this study, the economic performances of conventional and organic hazelnut production were evaluated using the cost-benefit analysis. This is a widespread technique for evaluating a project or investment by comparing the economic benefits and economic costs of an activity [19]. The economic assessment performed takes into consideration the case of a farm that outsources all the field operations foreseen during the crop cycle and buys all the production factors. The only production factor owned by the entrepreneur is the land. The analysis covers the whole length of the crop-cycle: 50 years. The economic assessment aims to determine the following indicators:

- Net present value (NPV) of the investment. NPV is the discounted sum of all cash flows, positive and negative, in a certain time horizon and is calculated as

$$NPV = \sum_{t=1}^{N} \frac{R_t - C_t}{(1+r)^t}$$

where

t = the time period (year);
R_t = revenues of the year t (€/ha);
C_t = costs of the year t (€/ha);
N = 50;
r = discount rate (%).

- Payback time (PBT). PBT is a time measure. It is the moment in the time horizon where the NPV becomes positive; it is calculated as

$$PBT = A + \frac{B}{D}$$

where

A is the last year number with negative cumulative cash flow;
B is the absolute value of discounted cumulative net cash flow at the end of Period A;
D is the total discounted cash inflow during the period following Period A. Discounted cumulative net cash flow is the discounted difference between flows and inflows over time;

Table 1. Operations and machinery.

Operation	Year	Nn	Tractor	Operating Machine	Notes
Ripping	0	1	235 kW	Ripper	Crawler tractor
Implanting Harrowing	0	1	235 kW	Heavy Rotary Harrow	Crawler tractor; it is performed, on average, on 30% of the cases
Stone crushing	0	1	235 kW	Crusher	Crawler tractor; it is performed, on average, on 30% of the cases
Leveling	0	1	70 kW	Rotary harrow	It is performed, on average, on 30% of the cases
Installation of Irrigation system.	0	1	n/a	n/a	Foreseen in 60% of the conventional area. Not installed in organic hazel
Planting	0	1	70 kW	Transplanter	
Planting Fertilization	0	1	70 kW	Spreader	It is performed only in organic farming
Manual Hoeing	1–5	2	n/a	n/a	Performed manually around the plants
Harrowing and Heavy Harrowing	0–5	1	70 kW	Disc harrow	
				Rotary harrow	
Fertilizing	1–50	2	70 kW	Spreader	One per year from 1st to 5th year in organic farming
Breeding Pruning	3	1	n/a	n/a	It is performed manually
Pruning	4–50	1	n/a	n/a	It is performed manually
Shredding	6–50	3	70 kW	Shredder	
Removal of basal shoots (suckering)	3–50	1	70 kW	Sprayer	In 50% of cases, it is performed manually without any machinery. In organic farming, it is always performed manually
Weeding preharvesting	6–50	1	70 kW	Disc Ripper	
Treatments	6–50	3	70 kW	Atomizer	
Harvesting	6–50	1	n/a	Self-propelled harvesting machine	
Transport	6–50	1	70 kW	Farm trailer	Average distance: 10 km
Drying	6–50	1	n/a	n/a	From 13% to 6% of moisture content

Nn = number of repetitions per year.

Table 2. Fertilizing and treatment products—conventional farming.

Commercial Product or Active Substance	Operation	Amount
Diammonium Phosphate 18-46	Fertilizing (Years 1 to 5)	150 kg/ha
Fertilizer (30% N)	Fertilizing (Years 1 to 5)	50 kg/ha
Fertilizer (20-10-10)	Fertilizing (from Year 6)	550 kg/ha
Herbicide	Removal of Basal Shoots	3.75 L/ha
Insecticide (Deltamethrin)	Insecticide Application	0.250 g/ha
Insecticide (Lambda-cyhalothrin)	Insecticide Application	0.250 g/ha
Fungicide (Thiophanate-Methyl)	Fungicide Application	0.90 L/ha
Fungicide (Boscalid + Pyraclostrobin)	Fungicide Application	0.50 L/ha

Table 3. Fertilizing and treatment products—organic farming.

Product	Operation	Amount
Cattle Manure	Basal Fertilization	50,000 kg/ha
"Bio Enne" (12 N)	Fertilizing (Years 1 to 5)	150 kg/ha
"Bio Enne" (12 N)	Fertilizing (from Year 6)	800 kg/ha
"Fosfonature" (26 P)	Fertilizing (from Year 6)	200 kg/ha
"Cuthiol" by "Mormino" (20% copper + 14% sulfur)	Treatments	13 g/L of water 15 L of water/ha
Leaf stimulant "Blackjak"	Treatments	6 kg/ha

- Internal rate of return (IRR) is the discount rate that determines NPV equal to zero, and it is calculated as

$$\frac{\sum_{t=1}^{N} \frac{R_t - C_t}{(1+r)^t}}{(1 + \mathrm{IRR})^t} = 0$$

The discount rate r is equal to 2%; the discount rate was selected by taking into account the return rate of the BOT, the Italian 12-month zero-coupon bond, whose rate of return in the last year has floated around 1%, with a yearly inflation rate of 1%.

The prices in this study are considered fixed throughout the year for simplicity, even if they usually vary during the year. The organic farmers benefit, for the first five years of our time horizon, from a yearly subsidy of 900 €/ha, as governed by the European Common Agricultural Policy. The entity of the receivable subsidy may vary on the basis of several parameters. In this study, the maximum subsidy was assumed.

The production is sold only at the wholesale level. Costs and revenues are estimated per hectare, and then, knowing the yearly production, per kg of produced hazelnuts. Taxes and VAT were not considered.

Revenues are derived only from sales at the wholesale market and from the subsidies that only organic farmers receive for the first five years after planting. The average production quantities and quality factors of the last ten year of the hectares analyzed are the values utilized in our model in our time horizon of 50 years.

The revenues, expressed as €/ha, for conventional hazelnuts (R_{CONV}) and organic (R_{ORG}) production are calculated as

$$R_{CONV} = DUH \times E_P \times P_{CONV}$$

$$R_{ORG} = (DUH \times E_P \times P_{ORG}) + S$$

where

- DUH (dry unshelled hazelnuts, kg/ha) represent the mass of dry and cleaned (by removal of unwanted materials such as stones and pieces of wood and leaves) unshelled nuts harvested at the farm and transported to the collection center;

- E_P (processing efficiency) is achieved by shelling a sample of DUH, removing all shells and all the bugged and rotten nuts, and, finally, weighing the remaining dry shelled hazelnuts (DSH, kg). It is expressed as a percentage and can be calculated as

$$E_P = DSH/DUH$$

- P_{CONV} and P_{ORG} (selling price, €/kg of DSH) are the selling prices for conventional and organic dry shelled hazelnuts; the prices are the average wholesale prices of the last ten years;
- S (subsidy, €/ha) is the subsidy granted for organic hazelnut farming in the first 5 years of the crop cycle.

Table 4 reports the average values considered during the crop cycle regarding DUH yield, the processing efficiency, and the selling prices for both organic and conventional hazelnuts.

Table 4. Average yield, efficiency, and prices.

Farming Systems	Dry Commercial Unshelled Yield (DUH)	Processing Efficiency (E_P)	Price (P)
Conventional	2363 kg/ha	42.25%	5.9 €/kg_{DSH}
Organic	954 kg/ha	43.25%	7.5 €/kg_{DSH}

To the test the sensitivity of the different economic indicators to the assumptions made, as well as to the different parameters, a sensitivity analysis was carried out regarding (i) the discount rate utilized (r, %), (ii) the price increase rate (%), and (iii) the presence of inflation (%). Table 5 reports, more specifically, the different scenarios evaluated in the sensitivity analysis.

Table 5. Summary framework of the sensitivity analysis.

Scenario	Discount Rate	Yearly Price Increase	Yearly Inflation
Baseline Scenario	2%	1%	0
Scenario 2	2%	2%	0
Scenario 3	2%	2%	1%
Scenario 4	2%	3%	0
Scenario 5	2%	3%	1%
Scenario 6	4%	0	0
Scenario 7	4%	2%	0
Scenario 8	4%	2%	1%
Scenario 9	4%	3%	0
Scenario 10	4%	3%	1%

2.3. Data Collection

The information related to the cultivation practice (e.g., sequence of field operations, type and characteristics of the machinery utilized, fuel consumption, typology, and amount of fertilizers and pesticides applied) were directly collected by means of surveys and interviews to different employers of local organizations of producers and farmers. In total, two organizations of producers and 20 farmers were involved in the surveys. Based on this information, the typical cultivation practices for conventional and organic hazelnut cultivation were identified. Regarding the quantity produced, data were taken from the database of one of the most important organizations of producers, from the Province of Viterbo. The collected data regarding the production quantities refer to the decade 2008–2018.

Regarding the costs of the different field operations and the different production factors, besides the interviews with local farmers, information was also retrieved from the regional price list of contractors. Contractor tariffs for the different field operations carried out during the whole crop cycle of hazelnut orchards are reported in Table 6.

Table 6. Tariff of contractors for different field operations.

Operation	Cost	Source
Ripping	2000 €/ha	Interview
Heavy harrowing	535 €/ha	
Stone crushing	535 €/ha	
Leveling	535 €/ha	
Planting	600/ha	
Irrigation system installation	1650 €/ha	Producer
Postplanting fertilization	100 €/ha	Interview
Breeding and pruning	500 €/ha	
Pruning	300 €/ha	
Hoeing	200 €/ha	
Harrowing	200 €/ha	
Milling	200 €/ha	
Fertilizing	35 €/ha	
Shredding	200 €/ha	
Manual and chemical (herbicide) removal of basal shoots	300 €/ha	
Weeding preharvest	240 €/ha	
Treatments	100 €/ha	
Harvesting	25 € × 100 kg unshelled nuts	
Transport and drying	10 € × 100 kg unshelled nuts	
Land cost opportunity	500 €/ha	

The tariffs of the harvesting, transport, and drying are expressed per unit of collected nondry unshelled nuts (between the fresh and dry unshelled nuts, there is a 10% weight difference), while all the other tariffs are expressed per unit of area. Table 7 reports the wholesale prices of the utilized production factors.

Table 7. Unitary cost for the different production factors.

Product	Unitary Cost	Source
Seedlings	1.20 €/plant	Interview
Fertilizer (20-10-10)	0.54 €/kg	Producer
Fertilizer (30-0-0)	0.60 €/kg	
Fertilizer Diammonicum	0.54 €/kg	
"Bio Enne" (12-0-0)	1 €/kg	
"Fosfonature" (0-26-0)	0.60 €/kg	
Herbicide "Basta"	1.88 €/L	
Pesticide with Deltamethrin	40 €/L	
Pesticide with Lambda-cyhalothrin	20 €/L	
Thiophanate-Methyl	30 €/L	
Boscalid Pyraclostrobin	80 €/L	
Sulfur and Copper "Cuthiol"	10 €/L	
Leaf Stimulant "Blackjak"	13.5 €/L	

Table 8 reports the average DUH yield and processing efficiency. Regarding the yield for both conventional and organic farming, the data refer to the period 2009–2018 and, more in detail, were retrieved from the database of the organization of producers. For conventional cultivation, the productive data were collected for a global area of 100.34 ha, while for the organic cultivation, the data refer to an area of 76.14 ha. On average, organic hazelnut cultivation shows a strong reduction (−60%) of yield, while, between the two farming systems, the processing efficiency, as well as the share of nuts that were rotten or damaged by insects, is similar.

Table 8. Hazelnut yield and processing efficiency parameters.

Average Value	Conventional	Organic
Dry Unshelled Hazelnuts (DUH)	2363 kg	954 kg
Damaged by insects (% of DUH)	15.8%	15.5%
Rotten (% of DUH)	1.8%	1.9%
Processing efficiency (% of DUH)	42.25%	43.25%

Besides hazelnuts, during the crop cycle, pruning residues are also produced. Although the interest in pruning residues valorization for energy purposes in growing [20–23], there is no systemic and economic utilization of these byproducts in the Monti Cimini area. In the studied area, pruning residues do not usually represent a saleable product [24]; consequently, no additional income was considered regarding their production.

3. Results

3.1. Cost Analysis

Tables 9 and 10 report the total costs and the contribution of the different field operations and production factors consumed through the whole crop cycle for conventional and organic systems, respectively.

Table 9. Total discounted cost of the conventional system.

Cost Item	Discounted Cost (€/ha)	Share
Preplanting operations and planting	5920	5.38%
Shredding	10,684.06	9.71%
Removal of basal shoots	8844.61	8.04%
Pruning	8561.92	7.78%
Treatments for pest control	8013.04	7.28%
Fertilizing	2199.65	2%
Chemical weed control	2611.18	2.37%
Weeding preharvest	6410.44	5.83%
Harvesting and transport	17,361.60	15.80%
Drying	6944.64	6.31%
Rent opportunity cost	13,355.07	12.14%
Fertilizers	7932.91	7.21%
Pesticides	6009.78	5.46%
Breeding operations	5165.12	4.69%
Total	110,014	100%

Note: Preplanting operations and planting include the following operations and products: ripping, stone crushing, leveling, planting, purchase of seedlings, irrigation system installation, and the different soil tillage operations. Breeding operations include breeding and pruning, harrowing and heavy harrowing, and manual hoeing. Fertilizers include N30, diammonium, and 20-10-10.

For conventional production, the sum of the discounted costs through the whole crop cycle is 110,014 €/ha, while for organic production, it is 107,046 €/ha. The total discounted costs are very similar between the two farming systems (−2.7% for organic production), but a considerably lower yield is achieved (−60%) in the organic system.

For conventional production, harvesting and transport are responsible for the highest cost contribution, accounting for 15% of total discounted cost, followed by the rent opportunity cost. Drying is responsible for 6% of the total discounted costs; this operation is summed-up with harvesting representing about 1/5 of the total discounted cost. For organic production, in contrast, the purchase of fertilizers is the main portion of the total discounted cost. This is due to the fact that organic fertilizers present higher unitary prices compared to the products applied in conventional cultivation. Compared to conventional cultivation, harvesting and transport and drying represent a lower share of the total costs in the organic system due to the lower productivity of organic orchards.

Table 10. Total discounted costs of the organic system.

Cost Item	Discounted Cost (€/ha)	Share
Preplanting operations and planting	4470	4.18%
Shredding	10,684.06	9.98%
Removal of basal shoots	8844.61	8.26%
Pruning	8561.92	8%
Treatments for pest control	8013.04	7.49%
Fertilizing	2199.65	2.05%
Weeding preharvest	6410.44	5.99%
Harvesting and transport	7078.19	6.61%
Drying	2671.01	2.50%
Rent opportunity cost	13,355.07	12.48%
Fertilizers (production phase)	24,573.33	22.94%
Pesticides	4835.00	4.52%
Breeding operations	5348.95	5%
Total	107,046	100%

Note: Preplanting operations and planting include the following operations and products: ripping, stone crushing, leveling, planting, purchase of seedlings (1.2 €/seedling), basal fertilization, and manure. Breeding operations include manual hoeing, harrowing, heavy harrowing, breeding and pruning, and BioEnne fertilizer for the breeding phase applications (from Years 1 to 5).

3.2. Economic Indicators

Figure 1 shows the net present value for the baseline scenario (2% discount rate, 1% yearly price increase, and no inflation) for the conventional and organic production systems, respectively.

The net present value (NPV) is equal to 92,800 €/ha and 3778 €/ha, the payback time is 10.47 years and 42.94 years, while the internal rate of return is 12.2% and 1.1% for the conventional and organic production systems, respectively. Even if characterized by a higher selling price, organic production shows considerably worst economic performances if compared to conventional production; all the economic indicators are, by far, more favorable for the conventional hazelnut system. Even if a positive NPV is achieved, the payback time is such that the investment is hardly interesting from an economic point of view. The results suggest that the farmers who planted organic orchards will not sell their product on the wholesale market, and they will seek a significantly higher premium price in different markets.

3.3. Sensitivity Analysis

In the baseline scenario, a 2% discount rate, 1% yearly price increase, and no inflation were considered. The discount rate is calibrated with the weighted average cost of capital (WACC), which could vary with an eventual increase in the interest rate (cost of debt). The wholesale market price is strongly dependent on Turkish production. If the production in Turkey increases substantially, the wholesale market price would flatten or even decrease. Finally, it is possible to have slight inflation in a scenario of constant economic growth. Hence, there is much uncertainty regarding the assumptions made. To investigate the influence of these assumptions on the economic indicators, a sensitivity analysis was carried out. Table 11 reports, for conventional hazelnut production, the absolute and relative variation of the three indicators (NPV, payback time, and IRR) due to changes (as indicated in Table 5) in the discount rate, price increase rate, and inflation.

Table 12 reports the results of the sensitivity analysis for the organic production system.

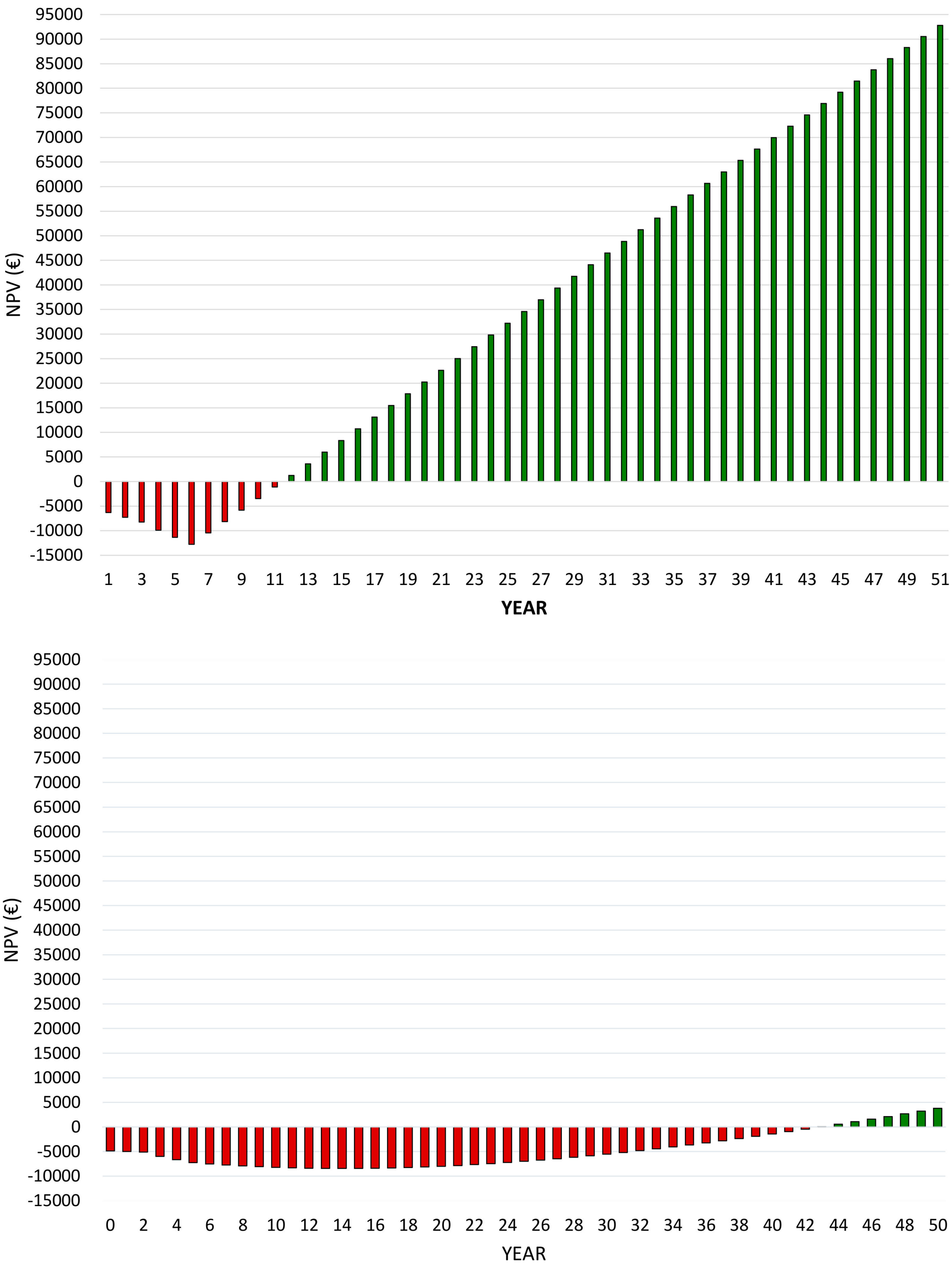

Figure 1. Net present value per unit of area (ha) for conventional (**top**) and organic (**bottom**) hazelnut production (red colour = NPV < 0 €, green colour NPV > 0 €).

Regarding conventional hazelnut production, for none of the considered combinations of discount rate, price variation, and inflation did the NPV and the IRR become negative. As expected, the indicators are positively correlated with increases in price and inflation and negatively with an increase in the discount rate. Scenarios with higher inflation and prices would benefit the investor. Nevertheless, the increase in one of these two parameters can be offset by the growth of the discount rate. Regarding price variability, the sensitivity analysis performed highlights how all the economic indicators are deeply affected by this parameter. With respect to the baseline scenario (where 1% of price increase is considered), with no price increase, the NPV is halved, the PBT increases by more than 1 year, and the IRR is decreased by about 22%. Generally, the absence of a price increase represents the biggest risk for investors. However, it should be considered that in the last 15 years, in the district of Viterbo, the average annual price increase for the most cultivated variety "Tonda Gentile Romana" was higher than 1%. Regarding inflation, applied uniformly both to revenues and costs, its increase has a positive effect on economic performance because, after the 5th year, the revenues are higher than the costs.

Table 11. Sensitivity analysis for conventional production.

Scenario	NPV	PBT (years)	IRR
Baseline r: 2% Price increase: 1% Inflation: 0%	92,800 €	10.47 years	12%
r: 2% Price increase: 1% Inflation: 1%	127,466 € Δ: +37%	10.13 years Δ: −3.2%	13.3% Δ: +10.8%
r: 2% Price increase: 0% Inflation: 0%	47,319 € Δ: -49%	11.77 years Δ: +12.4%	9.4% Δ: −21.6%
r: 2% Price increase: 0% Inflation: 1%	64,484 € Δ: −30.5%	11.29 years Δ: +7.8%	10.5% Δ: −12.5%
r: 2% Price increase: 2% Inflation: 0%	155,053 € Δ: +67%	9.61 years Δ: −8.2%	14.5% Δ: +20%
r: 2% Price increase: 2% Inflation: 1%	214,832 € Δ: +131%	9.35 years Δ: -10%	15.7% Δ: +30.8%
r: 4% Price increase: 1% Inflation: 0%	51,026 € Δ: −45%	11.26 years Δ: −7.5%	10% Δ: −20%
r: 4% Price increase: 0% Inflation: 0%	25,924 € Δ: −72%	12.96 years Δ: +23%	7.3% Δ: −39%
r: 4% Price increase: 1% Inflation: 1%	69,124 € Δ: −25%	10.83 years Δ: −3.4%	11.1% Δ: −3.4%
r: 4% Price increase: 2% Inflation: 0%	84,445 € Δ: - 9%	10.20 years Δ: −2.5%	12.3% Δ: +2.5%
r: 4% Price increase: 2% Inflation: 1%	114,783 € Δ: +23%	9.88 years Δ: −5.6%	13.5% Δ: +12.5%

Δ = [(Scenario Value − Baseline Value)/Baseline Value] × 100.

In the case of organic production, contrary to conventional production, several combinations of discount rate, inflation, and price variation involve negative economic results and an NPV below 0. In particular, with an increase of discount rate to 4%, without the price increase considered in the baseline scenario and with inflation growing from 0% to 1%, the NPV is deeply negative and the PBT is never reached because the revenues are always lower than the costs. Consequently, different from conventional cultivation, inflation is negatively correlated with the economic indicators (where the costs are higher than revenues, the inflation worsens the economic results). Inflation has a positive effect on the economic indicators only if it occurs together with a yearly price increase that is higher than 1%. When the discount rate increases to 4% and no price increase is considered for the hazelnuts, the NPV is negative and the PBT is equal to 61 years, which is longer than the crop cycle. In conclusion, the price variations deeply affect the remuneration of the investment. In three out of four scenarios with no price increase, the net present value of the investment is negative. Conversely, a price increase of 2% would boost the NPV up to 1358% if inflation of 1% also occurs (+840% with no inflation).

Table 12. Results of the sensitivity analysis for organic production.

Scenario	NPV	PBT (years)	IRR
Baseline r:2% Price increase: 1% Inflation: 0%	3778 €	42.94 years	1.1%
r: 2% Price increase: 1% Inflation: 1%	9177 € Δ: +142%	38.63 years Δ: −10%	2.1% Δ: +90.9%
r: 2% Price increase: 0% Inflation: 0%	−20,147 € Δ: −633%	n/a [1]	n/a [1]
r: 2% Price increase: 0% Inflation: 1%	−23,955 € Δ: −734%	n/a [1]	n/a [1]
r: 2% Price increase: 2% Inflation: 0%	35,535 € Δ: +840%	23.06 years Δ: −46%	6% Δ: +445%
r: 2% Price increase: 2% Inflation: 1%	55,120 € Δ: +1358%	21.75 years Δ: −49%	7.1% Δ: +545%
r: 4% Price increase: 1% Inflation: 0%	−15,321 € Δ: −505%	n/a [1]	n/a [1]
r: 4% Price increase: 0% Inflation: 0%	−2096 € Δ: −155%	61 years [2] +42%	-0.934% Δ: −184%
r: 4% Price increase: 1% Inflation: 1%	343 € Δ: −90.9%	49 years Δ: +14%	0.1% Δ: −90.9%
r: 4% Price increase: 2% Inflation: 0%	15,500 € Δ: +310%	26.53 years Δ: −38%	4% Δ: +263%
r: 4% Price increase: 2% Inflation: 1%	24,372 € Δ: +545%	24.56 years Δ: −42.8%	5% Δ: +354%

[1] Costs > revenues for all the years of the crop cycle and, consequently, the payback time (PBT) will never be reached and the internal rate of return (IRR) is not calculable; [2] PBT is longer than the crop cycle; (Δ = [(Scenario Value - Baseline Value)/Baseline Value] × 100.

4. Discussion

Based on the results reported in the previous sections, organic hazelnut production presents considerably lower performances with respect to conventional production. All the economic measures (NPV, PBT, and IRR) related to organic production processes are less sustainable from a financial point of view than conventional production, even in the presence of public subsidies. The major drawbacks of the organic hazelnut production system are the cost of organic fertilizers, the nonadequate selling price, and the lower yield, which deeply affect the whole economic performance.

Regarding the main organic drawbacks, an additional evaluation was carried out, taking into account the following considerations:

- A reduction of the price (from 10% up to 40%) of the organic fertilizer "Bio-Enne", aiming to assess whether cheaper organic nitrogen fertilizers could enhance the profitability and economic sustainability of organic hazelnut;
- At which level of increase in hazelnut selling price can the profitability of organic cultivation practices be improved to match conventional production performance;
- At which level of increase in organic production yield can the same profitability as in the conventional production system be reached.

Concerning the price of "Bio-Enne" fertilizer (12% of N), which is responsible for about 1/4 of production cost, a reduction of the cost by 10% (to 0.90 €/kg of fertilizer) can improve the NPV by +56% (to 5925 €/ha) and the IRR by 54% (to 1.77%) and can reduce the PBT to 39.56 years (−7%), while larger benefits are achieved with a reduction of 40% (NPV +339% to 16,609 €/ha, IRR +300% to 4.4%, and PBT −42% to 24.78 years). Despite significant improvement of the organic economic results following a decrease in fertilizer cost, the organic system fails to match conventional hazelnut production performances.

Regarding the yield and selling price that allow the organic system to match the profitability of the conventional cultivation system, the analysis was carried out considering the IRR as the main indicator. The IRR of organic production is equal to the conventional system's IRR when the selling price and the yield increases by 54% (selling price equal to 11.55 €/kg and yield equal to 1470 kg/ha). Considering this optimal scenario, the NPV increases to about 61,300 €/ha (+1520%), and the PBT is reduced to 10.34 years (−70%).

5. Conclusions

Organic cultivation is being used worldwide. Concerning hazelnut production in Italy, a similar trend can be recognized. However, the economic profitability of this cultivation system is related to cultivation practices, which are less well-known by the farmers compared with conventional practices, and, above all, to the selling prices.

In this study, a comparison between the economic performances of conventional and organic hazelnuts was carried out in the main Italian area for hazelnut production. The results show how the conventional system performs better than the organic one. Consequently, for a rationale and profitable expansion of organic hazelnut production, different valorization of the products should be identified because the selling of nuts on the market at a price established internationally does not allow adequate remuneration of the different production factors employed. Future perspectives for the organic hazelnut production systems could arise from a combination of agronomic efforts focused on increasing the yield, as well as on the search for cheaper fertilizers and on the exploration for new market opportunities, allowing a better valorization of the product. In this context, the set-up of local markets focused on the production of bakery products, ice cream, and sweets, as well as on the selling of the hazelnuts in small shops (e.g., agritourism) could be a proper solution that should be further explored.

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