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Environmental and social value of agriculture innovation

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Abstract: New requirements regarding agriculture production together with the increased pressure on environmentally friendly practices leave almost no space for the routine agriculture production. Innovations that include environmental changes are therefore essential. Agricultural research faces various challenges associated with the quality and effectiveness of agriculture production and recently also with the environmental and sustainability issues. The paper provides a case study focused on the environmental and social evaluation of a biological asset that constitutes an agricultural innovation. This paper also shows a concrete example of how the social and environmental reporting can be constructed and implemented by providing an evaluation of a Bumblebee Nest. As a result, the total value consisting of the market, ecosystem and aesthetic value is provided. Although the market value comprises the largest proportion of the total value, it does not exceed 64%.

Key words: bumblebee nest evaluation, case study, sustainability reporting

Economic competitiveness has become closely connected with technological changes (Verhaeghe and Kfir 2002), and the sustainable competitive advantage is based on knowledge and the capability to innovate (Papalexandris et al. 2005; Švejda 2007). Even as the today's highly competitive economic environment in combination with climate change has put a great pressure on farmers, agriculture researchers can play a significant role by developing technological innovations to satisfy the demands that the farmers face (Blazy et al. 2010). Agricultural research, therefore, should respond to various challenges associated with the quality and effectiveness of the agricultural production and recently also with the environmental and sustainability issues (Raclavska et al. 2011; Spoelstra 2013). New requirements on agriculture production together with the increased pressure on the environmentally friendly practices leave almost no space for the routine agriculture production. Innovations that include environmental changes are, therefore, essential (Galan et al. 2007; Guo et al. 2014), and eliminating the negative environmental impacts has become crucially important (van der Werf and Petit 2002).

Diagnosing the environmental impacts of agriculture constitutes the first step in the overall assessment of sustainability in the agricultural production (Payraudeau and van der Werf 2005), and evaluating agricultural innovations is vital to both the farm management and the policy assessment (Janssen and van Ittersum 2007). Natural agricultural capital is a source of energy (for both human nutrition and production) as well as of the recreation and leisure (Pretty 2008; Sykorova et al. 2012). Consequently, it has the economic, environmental, and social value (Zhang et al. 2009) and any assessment of biological assets should reflect all such sources of value. Value can be described as an objective aspect of an item that is often defined by its function (Drozen 2003, 2008). Mařík et al. (2003) describe the value of a concrete item as a utility and a transferable function, with the latter representing the market value.

Growing global awareness of sustainable development together with the increasingly competitive global economy accentuates the need for the holistic environmental assessment tools for the managers and decision makers (Hyršlová and Hájek 2005; Hyršlová 2012; Curran 2013). Therefore, policy makers, managers, and other decision makers have begun to broaden their economic assessments to include the associated social and environmental aspects and impacts (Hyršlová et al. 2006).

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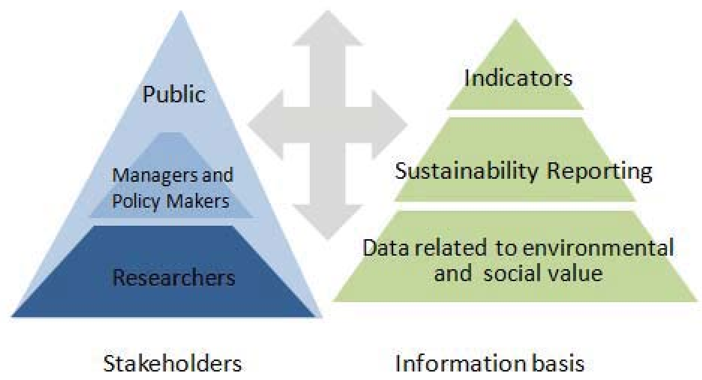

Figure 1. Information bases for sustainability reporting

Source: Adapted by van Dijk et al. (2014)

A review of the relevant literature has revealed that a great variety of environmental impact models has been created (Heijungs et al. 2010), as have the indicators to assess the agriculture's environmental impacts on the scale of a farming region (Payraudeau and van de Werf 2005) or at the individual farm level (van de Werf and Petit 2002). Although many studies have been published which focus on the social and environmental reporting (Hyršlová 2009; Tregidga et al. 2014.), the practical construction and implementation of social and environmental reporting has been neglected by researchers (Contrafatto 2014). According to van Dijk et al. (2014), the information for sustainability assessments can be structured as in Figure 1.

The figure shows the aggregation provided by sustainability indicators that demonstrate the health of a natural asset (Jones 2003) and seems entirely appropriate for both the decision-making process (Janssen and van Ittersum 2007) and sustainability reporting (Jones 2010). A single indicator is a proxy or measure of something in which one has an interest but which is difficult to monitor precisely (Rigby et al. 2001) and it provides an aggregated comparable information (van der Werf and Petit 2002). Indicators should provide a proper assessments in accordance with their purposes and their underlying methods should be clear and simple, preferably using the real-world data (van der Werf and Petit 2002), to provide information for the stakeholders. Researchers have a crucial role to play in the data selection, the indicator construction, and the sustainability reports provision.

This paper is a response to the call of Tregidga et al. (2014) for academics to be more intensively engaged with the organization of sustainability reporting and the appeal by Spoelstra (2013) for an interdisciplinary approach to be taken in the sustainability research. The main aim of our research is to construct a social and environmental evaluation of a biological asset constituting an innovation in the farm pollination. Our research includes a concrete example of how the social and environmental reporting can be constructed and implemented.

MATERIALS AND METHODS

Case study approach

We want to reflect the growing interest in the practice theory approaches within management and organization studies (Jørgensen and Messner 2010). We therefore decided to use the case study method for a concrete company – the Research Institute for Fodder Crops, Ltd. Troubsko (hereinafter referred to as the "RIFC") – wherein the object of evaluation was an innovation in the farm pollination resulting from the research and development. The evaluation was of a biological asset in the form of a bumblebee nest.

An initial search of the case study layouts and topics led to several papers being examined in detail. Payraudeau and van der Werf (2005) had analysed 11 case studies to compare the methods for assessing the environmental impact of a farming region. Blazy et al. (2010) had proposed a simple mechanistic model for a new agro-ecological management system at one case company. Stevanov et al. (2013) had provided a new model of the science-based policy advice at two case organizations. Jørgensen and Messner (2010) had examined the relationship between strategy and accounting at one case company. This research was concluded over 16 months. The aforementioned research was analysed, three main phases of case studies were identified, and each phase was divided into concrete steps. The main goal of the first phase was to select a concrete object for the evaluation as well as an evaluation scheme. The second phase involved conducting a survey in order to determine

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the social and environmental value of one bumblebee nest. Finally, the social and environmental reporting of the bumblebee nest was designed in the last phase. Two members of the research team were researchers employed in this company. Their internal perspective, which might introduce biases, was balanced by the remaining member of the research team (Woods et al. 2012).

First phase – selecting the object for the evaluation and an evaluation scheme

We presented our project to the general manager, who supported our plan and was involved in the research. The general manager introduced us to the manager of the bumblebee R&D team as well as to the financial manager, both of whom were available during the research. A scheduled interview was conducted with the manager of the bumblebee R&D team on the following topics:

(1) the portfolio of the bumblebee nest products,
(2) the bumblebee market situation, and
(3) the bumblebee nest function – in the nature and for the recreation and leisure.

Notes were taken during each interview and were approved by the interviewee.

Cairns (2006) discusses conflicts in using prices in the environmental evaluations and concludes that prices provide an appropriate information basis for making decisions. The International Valuation Standards define the market value as the estimated amount for which a property should be exchanged on the date of valuation between a willing buyer and a willing seller reasonably and without coercion (Mařík et al. 2003). Janssen and van Ittersum (2007) define the environmental value as an impact assessment of agricultural practices and social value, mainly representing attitudes, values, or culture. Pearson (2000) defines the ecosystem function as a value of the indirect positive impact for the ecosystem, such as an improvement in the climate regulation, nutrient cycling, or the hydrologic system. Šišák and Pulkrab (2008) use an ecosystem function to evaluate the nonmarket value of forest, doing so using the ratio of the nonmarket value to market value wherein the average ratio is set by experts.

This approach could be described as the preference-based evaluation, where the market price provides the basis, thus meeting with the Klöpffer's (2003) requirement for using equal and consistent system boundaries for the environmental, economic, and social assessment.

The first phase resulted in selecting:

(1) a concrete object for evaluation – one developed bumblebee nest from a laboratory colony in Troubsko was selected as the unit for evaluation, with the said developed bumblebee nest consisting of one single female bumblebee plus female bumblebee workers as well as a hive (hereinafter referred to collectively as a "Bumblebee Nest"); and
(2) an evaluation scheme – in line with Šišák et al. (2010), we differentiated the market and non-market value based on different socioeconomic (or environmental and aesthetic) functions. In accordance with Drozen (2003), we based the environmental and social value on the bumblebee's function in the nature; in line with Janssen and van Ittersum (2007), we considered the aesthetic function essential for the social value; and following the lead of Cairns (2006), we based the environmental and social value on the market value.

Second phase – method for determining the environmental and social values

In order to determine the environmental and social value, another scheduled interview with the manager of the bumblebee R&D team was prepared on the following topics:

– the Bumblebee Nest production capacity dedicated to pollinating crops for which the nest was acquired (economic crops),
– the residual nest capacity directed to crops other than those for which it was acquired,
– the aesthetic function as perceived by the public (a representative population sample), and
– assembling a questionnaire to research the aesthetic function.

The RIFC researchers recommend to farmers the number of the Bumblebee Nests needed to pollinate crops depending on the type of the economically important crop and sown area. These recommendations are freely available on a website from the RIFC (see Appendix 2). The environmental value of a Bumblebee Nest was set as the proportion of the said Bumblebee Nest's life that is used for the ecosystem function (i.e., the nest's "free capacity" dedicated to pollinating economically unimportant crops other than those for which it was acquired).

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This second phase resulted in:

(1) establishing the method of constructing the environmental value as the bumblebee's production capacity ratio, and

(2) constructing a questionnaire for surveying (see Appendix 1) a representative population sample.

Third phase – constructing a social and environmental evaluation of the Bumblebee Nest biological asset

In this phase, the STEM/MARK agency surveyed a representative population sample by questionnaire in order to establish the social value of a Bumblebee Nest. Those interested in bumblebee keeping were then asked in two steps to state the amount they would be willing to pay for one Bumblebee Nest. In the first step, the respondents spontaneously proposed an amount, while in the second research step, the respondents were asked a question offering 13 consecutive amounts. For one half of respondents, these amounts were given from the lowest to the highest, and for the other half, from the highest to the lowest. The respondents were to state for each amount whether they would be willing to pay it for a Bumblebee Nest.

Van Dijk et al. (2014) describe an environmental report as an interpretative form summarizing the environmental trends, events, and consequences. One of the ways a company can report the value it creates not only for its owners, but also for other interested parties (the state, employees, the public), is an expanded value added statement (EVAS), which also accounts for the environmental and social impacts from business activities (Hyršlová 2009). In order to compile an EVAS, it is necessary to consider (value) the direct and indirect outcomes and other (subsequent) impacts from business activities. The statement contains not only the economic value defined as by financial transactions but also environmental and social impacts expressed in monetary terms (Hyršlová 2009).

We prepared another scheduled interview with the financial manager to obtain the information required for an EVAS on the following topics:

– the total Bumblebee Nest production for 2013, and
– the total production costs per 1 Bumblebee Nest.

This third phase resulted in the selection of a specific form of sustainable development reporting – EVAS – as well as an analysis of financial accounting data to create the statement.

RESULTS AND DISCUSSION

Bumblebee keeping in Troubsko

As pollinators of many cultured and wild plants, bumblebees are very important for protecting the cultural landscape. They are irreplaceable in many cases, in particular for the pollination of flowering plants during the periods when honey bees are unable to fly, such as during an inclement weather (Velthuis and van Doorn 2006). Bumblebees are exclusive pollinators of the long tubular flowers. Recent years have seen a wide-scale collapse of the honey bee colonies. Under these circumstances, the importance of bumblebees has increased (Carreck and Williams 1998). If a landscape lacks the honey-producing bees, even temporarily, it will not remain completely without pollinators so long as the bumblebees and solitary bees live there.

The bumblebee has its functions in the landscape, which can be categorized as follows:

– a market function resulting from pollinating the economically important crops,
– an environmental function resulting from pollinating the economically unimportant plants, and
– an aesthetic function resulting from the popularity of the bumblebee and its aesthetic operation in the landscape.

Bumblebee keeping in the laboratory at the RIFC had been begun by doc. Ptáček, whose research contributed considerably to the knowledge of bumblebee keeping in laboratories, not only concerning the most frequently kept buff-tailed bumblebee, but also many other bumblebee species (Ptáček 2008; Bučánková and Ptáček 2012). Bumblebee keeping in the laboratory at Troubsko comprises the largest and oldest such operation in the Czech Republic and the only one which allows the acquisition of domestic bumblebees while not endangering biodiversity (see www.ceskycmelak.cz). RIFC offers 2 nest types: an early-development nest for gardeners with the nonspecific pollination needs and an already developed nest for pollinating the specific crops. The RIFC organizes workplace tours for the public as a part of annual events as well as field trips and stays at the workplace for schools and gardening unions. It also uses the Bumblebee Nests to pollinate its own land.

Value of a Bumblebee Nest

Mařík et al. (2003) state that the market value essentially represents usability that is acknowledged

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by the market and essentially represents the price negotiated on a free and competitive market. The market price of a Bumblebee Nest is established as CZK 1070 per 1 Bumblebee Nest, including the hive. As the nests can be acquired on the market from various suppliers, the market price was not adjusted in any way and therefore represents the market value of a Bumblebee Nest. The environmental value constitutes 38% of the Bumblebee Nest's free production capacity dedicated to pollinating crops other than those for which the nest was acquired. The calculated percentage represents the average value of a Bumblebee Nest's free production capacity evaluated for 22 economic crops based on the recommendations from the RIFC researchers (see Appendix 2). The ecosystem value of a Bumblebee Nest therefore amounts to CZK 405.

During the survey, people interested in bumblebee keeping were asked to state the amount they would be willing to pay for one Bumblebee Nest. In the first step, the respondents spontaneously proposed an amount, with only 6% of people stating in these circumstances that they would not be willing to pay anything for a Bumblebee Nest. The average spontaneously stated amount came to CZK 1610. In this specific case, it is better to be guided by the median. The median came to CZK 1000, meaning that one half of all interested people would be willing to pay CZK 1000 for a Bumblebee Nest. Socially weaker population groups as well as the inhabitants of smaller municipalities and towns (up to 19 999 inhabitants) generally stated lower amounts relative to the median. The youngest (up to 29 years of age) and the oldest (over 60 years of age) respondents also stated lower amounts.

In the second research step, the respondents were asked a question offering 13 consecutive amounts. For one half of the respondents, these amounts were given from the lowest to the highest, and for the other half, from the highest to the lowest. The respondents were to state for each amount whether they would be willing to pay that price for a Bumblebee Nest. The results from this question show that only 2% of all interested people would not be willing to pay anything for a Bumblebee Nest. CZK 100 was acceptable for 98% of people, CZK 300 for 77% of the interested people, and CZK 500 for 71% of the respondents. There was still an apparent majority interest for the amounts CZK 700 (59%) and CZK 900 (56%). Half of the interested people would be willing to pay CZK 1100; one-third CZK 1900; and almost one-quarter CZK 2500. The survey confirmed the correct setting of a Bumblebee Nest's market price, which should not significantly exceed the value of CZK 1000.

Table 1. Total value of a Bumblebee Nest

Value component	CZK	% share
Market	1 070	64
Ecosystem	405	24
Aesthetic	199	12
TOTAL	1 674	100

Source: authors

The survey results led to the conclusion that one-fifth of the population would acquire Bumblebee Nests for not-for-profit purposes. No essential statistically significant differences were found in the approach to this topic within the individual socio demographic categories. Differences were recorded only for the entrepreneur category, where an increased interest can be assumed (30%), and the category of people with a lower education, where, by contrast, a lower interest was declared (18%).

In establishing the social value of one Bumblebee Nest, therefore, we must include into our considerations also those respondents who are not willing to pay anything. A total of 79% of respondents were not willing to pay for a developed nest. The resulting value was therefore calculated as it would correspond to a single respondent from the total number of respondents and was derived by the following:

- 21% of the respondents at CZK 1,000 corresponds to 213 respondents × CZK 1000 = CZK 213 000.
- 79% of the respondents at CZK 0 corresponds to 803 respondents × CZK 0 = CZK 0.
- 213 000 CZK/1070 = CZK 199.

The social value was thus set at CZK 199 per 1 Bumblebee Nest.

The Bumblebee Nest's total value is therefore the sum of all the three bumblebee functions and its final calculation is given in Table 1.

Although the market value comprises the largest proportion of the total value, it does not exceed 64%.

CONSTRUCTING THE EVALUATION

The case study resulted in constructing an evaluation of a biological asset – an agricultural innovation consisting of a Bumblebee Nest – while considering the environmental and social aspects of sustainable development. The evaluation scheme is presented in Table 2.

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Table 2. Evaluation of a biological asset – Bumblebee Nest

Value	Basic function	Application to Bumblebee Nest
Economic	Market function. Value is based on market price (Mařík et al., 2003)	Pollination of economic crops (i.e., crops for which the nest was acquired)
Environmental	Nonmarket function. Value is expressed as the ratio of the capacity of the market and nonmarket functions as established by expert estimate (Šišák and Pulkrab 2008)	Pollination of crops other than those for which the nest was acquired
Social	Aesthetic function according to Janssen and van Ittersum (2007)	Contribution to feelings of beauty and pleasure

Source: authors

The final phase of the case study resulted in compiling an EVAS with the main objective being to express the total added value created by the RIFC in producing 100 Bumblebee Nests, including the identified benefits for the stakeholders. We focused primarily on the crucial stakeholders EVAS (Table 3), those being the ones with the largest stakes (i.e., the greatest "interest") in the organization (such as the managers or board members) and those with a high degree of power to support (or to sabotage) the firms' strategies (such as the donors or the government) (Drozen and Kubáňková 2014). In addition, organized field trips and stays enabled primarily such local organizations as schools and gardening unions to visit the department, and, given that the department uses the bumblebee pollination on its own lands, Troubsko bumblebees help the landscape to flourish.

The first part of the EVAS presents the environmental, economic, and social values of a Bumblebee Nest, while the second part quantifies the added value from the created production.

This EVAS indicates that the total value added created by the RIFC's producing Bumblebee Nests in 2013 was CZK 94 500. The ratio of this created value to the resources consumed is interesting, as the production value based upon the complex concept of economic, environmental, and social value is 1.27 times the resources consumed. If we consider the added value to be generated only by the financial returns (i.e., the total revenues), then the added value is CZK 33 000 or 45% of the resources spent.

Jørgensen and Messner (2010) conducted the research of new product development evaluation and concluded that a relatively high degree of ambiguity in evaluation can be expected as a natural consequence of the complex and uncertain setting. Rigby et al. (2001) stated that constructing a single indicator that would evaluate the economic and social impacts

Table 3. Expanded value added statement for a Bumblebee Nest

EVAS	CZK/nest	Beneficiaries
Market value of a Bumblebee Nest	1 070	
Environmental	405	
Aesthetic	199	
Total	1674	
Total number of nests sold	100	
Total revenues	107 000	Managers, shareholders
Environmental value created	40 500	Local community
Aesthetic value created	21 000	Local community
TOTAL VALUE	168 500	
Production costs	74 000	
Added value	94 500	
Ratio of added value to production costs	**127.70%**	

The EVAS reported was adapted by Hyršlová (2009b)

Source: authors

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on sustainability could be problematic. Gluch and Baumann (2004) stated that measuring environmental problems within a one-dimensional monetary unit may oversimplify the reality. Curran (2013) discussed reporting both the qualitative information and the quantitative data and the difficulties with the rather hidden qualitative information. We are fully aware that the constructed evaluation is a simplification and that other approaches can be used to assess the environmental or social value, such as the life cycle assessments, the balanced scorecard methodology, the social compatibility analysis, the qualitative and quantitative reporting. The implementation of the aforementioned methods and approaches might provide an interesting comparison and current topics for the perspective further research.

The evaluation presented here is based on the fair market price and shows the proportions of the economic, environmental, and social values within the overall assessment. Blazy et al. (2010) reassured researchers that an ex-ante assessment can be a starting point for implementing innovations in agricultural practice. The present evaluation also can be used for the ex-ante assessment of a Bumblebee Nest introduced as an innovation in pollination for an agriculture producer. The producer can use it to quantify the environmental and social values that the newly acquired Bumblebee Nest will bring.

Jones (2010) emphasized the demand for a comprehensive accounting that would report environmental impacts to stakeholders. The EVAS presented here shows the value created for the company shareholders as well as the value created for the society. Acquiring new Bumblebee Nests supports the pollination of the surrounding wild plants and the nest increases the feelings of pleasure and aesthetic experiences. We believe that the present case study could encourage other companies to communicate their responsibility for sustainable development (Jones 2010).

Spoelstra (2013) called for an interdisciplinary approach to the sustainability research. Bebbington and Lahrinaga (2014) concluded that accounting for the sustainable development craves a "bigger picture" approach. The present research demonstrates how economic analysis from the perspective of sustainable development can be used to evaluate a concrete agricultural innovation and evaluate a biological asset, one Bumblebee Nest, from an economic, environmental, and social perspective. We therefore hope that our research will move other researchers to investigate the environmental and sustainability reporting and overcome the frustrations with the environmental accounting to which Bebbington and Lahrinaga (2014) refer.

CONCLUSION

Measuring the performance of agricultural practice from a complex economic, environmental, and social perspective is essential to a further agricultural development. The sustainable development of agricultural practice is based on innovations. This paper demonstrates the evaluation of an agricultural innovation, the biological asset that is a Bumblebee Nest. We provided a framework wherein the environmental and social values are based on the real market data following the requirements of van der Werf and Petit (2002) as well as the concrete calculations about the case company. The market price of a Bumblebee Nest is established as CZK 1070 per 1 Bumblebee Nest and it demonstrates 64% of the total value. The environmental value constitutes 38% of the Bumblebee Nest's free production capacity dedicated to pollinating crops other than those for which the nest was acquired, therefore, it amounts to CZK 405. The social value was set at CZK 199 per 1 Bumblebee Nest.

Even as the researchers focus primarily on the negative environmental impacts (Rigby et al. 2001; Payraudeau and van de Werf 2005; Blazy et al. 2010), the chosen biological asset – a Bumblebee Nest – has in fact a positive environmental impact. We hope that our research will inspire an additional research focused on measuring the positive impact of agriculture innovations such as to value the growing of intermediary crops to preserve the soil quality and maintaining proper agro technical procedures.

In conclusion, the results of this study constitute a positive example for how to report about sustainability and how to translate the sustainability demands into the economic ones, which is crucial if sustainability is to be included within decision making (Spence and Rinaldi 2014). Cabello-Medina et al. (2011) examined innovation performance in three Spanish industries. They concluded that although the companies are complex entities and a practice that works well in one firm may not produce the same results in another, it is nevertheless important to establish sets of the best practices, as these practices may work well in a broad variety of firms and can be adapted to a wide range of environments. Similarly, we believe that providing sustainability reports of concrete agricultural products

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or farms can contribute to the identification of the best practices that can be implemented in practice by agricultural entrepreneurs while inspiring other researchers.

APPENDIX 1

(1) Would you purchase a bumblebee nest? YES/NO

(2) If yes, would it be because you like bumblebees and their presence in the landscape or a garden has a positive effect on you (i.e., not for commercial or other economic reasons)? YES/NO

(3) If yes, how much would you be willing to pay for one nest (female and workers)? (e.g., CZK 100, CZK 200, CZK 500, CZK 2000)

APPENDIX 2

No.	Plant species	Minimum number of nests per ha	Flowering period	Note	Flowering period duration in months	Total nest life in months	Percent of time dedicated to plants for which the nest was purchased
1	Almond *Amygdalus communis* L.	3–4, depending on orchard type and number of flowers in area	First flowering, March.	At least two trees are necessary for pollination. Bumblebees can contribute crucially to yield.	1	3	33.33%
2	Peach *Prunus persica*	4–6 or more	March/April. Trees blossom for about 14 days when individual blossoms flower – ensuring harvest even in case of short-term inclement weather	The number of hives can be consulted according to the actual situation – status of stand, honey bee hives in vicinity, etc. Even a small number increases yields.	2	3	66.67%
3	Apricots *Prunus armeniaca*	3–5, according to stand character	March/April	Pollen transfer between plants can increase fruit yield and quality	2	3	66.67%
4	Gooseberries *Ribes uva-crispa Grossularia uva-crispa*	2–3	April	Frequently flower in cold. Bumblebees considerably boost yields.	1	3	33.33%
5	Currants *Ribes sp.*	2–3	April. Ca 1 week after gooseberries	Red and white currants are partially self-pollinating, while black currants are mostly cross-pollinated and preferred by bumblebees.	1	3	33.33%
6	Sweet cherries *Prunus avium*	4–6, according to status of stand and number of flowers in area	April	For sweet cherries, pollination of all flowers brings benefits. Even a small number of bumblebees increases yields	1	3	33.33%
7	Sour cherries *Prunus cerasus*	3–4, according to stand character	April	Bumblebees can contribute to yield increase by pollinating among trees, especially among varieties.	1	3	33.33%

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No.	Plant species	Minimum number of nests per ha	Flowering period	Note	Flowering period duration in months	Total nest life in months	Percent of time dedicated to plants for which the nest was purchased
8	Apples *Malus domestica*	4–6, according to stand type	April/May	Pollination is necessary for fruit formation, but too many pollinated flowers decrease fruit quality.	2	3	66.67%
9	Pears *Pyrus communis*	Up to 8, according to stand type	April/May	Pears are sometimes not very attractive, so it is beneficial to place hives evenly throughout the orchard.	2	3	66.67%
10	Strawberries *Fragaria vesca*	2–3	May	Pollination is necessary to create high-quality fruit. However, over-pollination should be avoided, as it leads to fruit deformation.	1	3	33.33%
11	Blueberries *Vaccinium myrtillus* and *V. corymbosum*	3–4. Mainly Canadian varieties are grown in culture.	May	During pollination process, they require a special flower vibration that bumblebees can perform but honey bees cannot.	1	3	33.33%
12	Carrots, onions, brassicas, and borages	3–9, according to stand type and density as well as presence of competing plants.	June/July	Bumblebees are suitable for many species, but case-by-case consultation is necessary.	2	3	66.67%
13	Melons, cucumbers, zucchini *Cucumis* spp.	2–3, adjusted according to stand size and number of flowers in area.	June/July	Bumblebees frequent male flowers for pollen and female flowers for nectar, thereby transferring the pollen necessary for seed creation.	2	3	66.67%
14	Red clover *Trifolium pratense*	3–9, specifically according to the given location	July/August	Species with long proboscises are ideal. All grown buff-tailed bumblebees can reach the nectar, including males. All workers pollinate when collecting pollen.	2	3	66.67%
15	Other clovers *Trifolium* spp.	3–5, according to specific situation	July/August	Buff-tailed bumblebees usually can reach the nectar, except for the cases of *T. alpestre*, *T. medium*, and *T. pannonicum.* For those species, what was said above for *T. pratense* applies.	3	3	100.00%

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No.	Plant species	Minimum number of nests per ha	Flowering period	Note	Flowering period duration in months	Total nest life in months	Percent of time dedicated to plants for which the nest was purchased
16	Legumes: *Lotus* spp., crown vetches, vetches, broad beans, chickpeas, and *Anthyllis* spp.	3–5, according to specific situation	July/August	Bumblebees preferentially visit the flowers of all these species.	3	3	100.00%
17	Beans *Phaseolus* spp.	Must be tried according to stand type and variety grown	July/August	Insect pollination multiplies pod quantity and seed quality.	3	3	100.00%
18	Blackberries, raspberries *Rubus* spp.	3, according to parcel character	May/June	Bumblebees preferentially seek these species.	2	3	66.67%
19	Opium poppies *Papaver somniferum*	Must be selected according to specific situation	June/July	The flowers provide only pollen, but they are very attractive for honey bees and bumblebees.	2	3	66.67%
20	Sunflowers *Helianthus annuus*	Must be selected according to specific situation	July	Pollination with another variety increases seed yield and oil content. Attractive for bumblebees.	1	3	33.33%
21	Tomato *Solanum lycopersicum*	5–10, according to status of stand	All year	Bumblebees can release pollen using a special vibration, and they increase yields by as much as 50%.	3	3	100.00%
22	Peppers *Capsicum* spp.	4–6, according to stand character	All year	Buff-tailed bumblebees seek the pollen of peppers and pollination multiplies fruit yield and size.	3	3	100.00%
Averages		4.37			1.86	3	62.12%

Source: Ptáček and Votavová (2013)

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