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TOURISM AS A POSSIBLE MEANS OF DEVELOPMENT OF THE DISADVANTAGED SETTLEMENTS, ON THE EXAMPLE OF ÓPUSZTASZER VILLAGE

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ABSTRACT
The alternative source of income for those people who are living in rural settlements is the creation of services and basic infrastructure for rural tourism. The tourism contributes to the creation of new jobs, therefore increases the rural employment and also supports the local cultural and natural heritage. The reduction of unemployment and the expansion of services and incomes for the local people can help raise the living standards and maintain the rural way of life. In our study, we examined the touristic offers of Ópusztaszer and the role of local tourism service providers. We searched for the man-made and natural values of the settlement and in connection with this, we made a SWOT analysis to assess the local tourism potential. Many forms of rural tourism have developed in Ópusztaszer, including equestrian tourism, rural tourism, cultural tourism and ecotourism. The town has many untapped tourist opportunities; rethinking and exploiting them could contribute to sustainable tourism in the settlement in the long run. Rethinking the values would allow the development of further new forms of tourism, which would attract a wider range of tourists to the settlement.
Keywords: tourism, tourist offer, SWOT analysis, natural and man-made values

INTRODUCTION

The intensification of globalization, the appreciation of environmental paradigms, and the changes in agriculture are shedding new light on the opportunities and chances of the countryside. The emergence of rural tourism can provide a solution to the challenges of the rural economy and society. Rural tourism can be interpreted as an opportunity to diversify the rural economy (KOVÁCS, 2002). The tourism offers measurable positives for rural development. Tourism can be a tool for exploring local resources and thereby has a dynamic effect on the rural economy, as tourism can utilize resources that would result in more modest economic benefits or fall into deprivation, such as national parks and nature reserves. In this way, the intact natural environment and the surviving traditions of the regions can be explored as an attraction that can be interpreted as a developmental energy. Therefore, tourism becomes an important factor in regional and settlement development (LENGYEL, 1997; FATOSZ, 2007).
Natural and environmental factors alone are not an attraction in a specified area, as they are not able to endorse their function, so they are only present as a potential advantage and a possible opportunity. In order to natural and environmental factors become a resource, it is absolutely necessary to have certain basic infrastructure (KIS AND TÓTH, 2016). Elements of the tourism potential have an impact on the local economic and social life, as well as suitable for strengthening the development and competitiveness of the region by closely linking tourism and regional development. The tourism sector has a significant multiplier effect on other activities and sectors (MICHALKÓ, 2005; FATOSZ, 2007).
Demand and supply are the two subsystems of tourism, or in other words, the main components of the market. The relationship between supply and demand is created by marketing and the flow and stay of tourists (LENGYEL, 1997). There are three basic conditions OF touristic demand: motivation, disposable income, and leisure time. We speak about realized tourism demand if all the three conditions meet. The system of tourism is

Review on Agriculture and Rural Development 2020 vol. 9 (1-2) ISSN 2677-0792
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changing dynamically and as an open system interacts with the natural, political, economic technological and social environment, all of which have an impact on the forming of demand (NAGY, 2007; KALMÁRNÉ, 2018). The touristic offer means the total of the tourism services and attractions of the destinations, such as accommodation, hospitality and programs for tourists (VÁSÁRHELYI, 2009). The touristic offer includes elements that are important for tourists during their trips. The elements of supply are the destination receptivity, the attitude of the local population and managers towards tourism, as well as the organization of civil society and local entrepreneurs. The basic infrastructure elements, such as accessibility routes, are also included (VÁSÁRHELYI, 2009; KALMÁRNÉ, 2018).

Tourism can be considered an economic, social and natural phenomenon at the same time. There is a correlation between tourism and its environment, the development of tourism is influenced by certain factors of the environment, and tourism has an impact on its environment. The interaction can be both positive and negative (PALANCSA, 2005). The most important component of the tourism's economic impact is on spending money on tourism, for example, on hotels, restaurants, and means of transport, museums and shops, which spills over into the economy and other sectors as well. It creates jobs, income and attracts capital investments to the specified area, so it has a multiplier effect (LENGYEL, 1997; PALANCSA, 2005). On the other hand, tourism has a significant impact on the economic environment through the development of tourism, as it involves the development of infrastructure, the construction and operation of restaurants and hotels (LENGYEL, 1997). The socio-cultural effects of tourism on tourism destinations mean changes in the daily quality of life of the population, while the transformation of values, norms and identities can be interpreted as a cultural effect (GLASSON ET AL., 1995 QUOTED IN XIAOPING AND YONG, 2019). In this case, tourism is the cause of the environmental and cultural damage, or the initiator of the positive changes (RÉGI, 2017).

MATERIALS AND METHODS

As part of the primary research, a questionnaire interview was conducted with owners of restaurants and accommodations in Ópusztaszer. We conducted a structured in-depth interview with the marketing director of the Ópusztaszer National Historical Memorial Park, the owner of the Csillagösvény Labyrinth, a member of the Cseppentő family and the head of the local Tourinform Office about the basic data on service providers and the demand and supply of Ópusztaszer tourism. In addition to the questionnaires, we also had informal conversations with the managers of the hoteliers and restaurants, and during the personal meetings we also had the opportunity to visit the field. Nine accommodations and two restaurants were involved in the research. However, the opinions of nine persons were relevant, because two accommodations had one owner and the owner of Szeri Csárda and Szeri Kemping was also one person. We used literature and internet sources as well to prepare the study.

Ópusztaszer is located in Csongrád-Csanád County, in the neighborhood of Baks, Kistelek and Dóc in the Kistelek district. In Ópusztaszer, agriculture and tourism provide a livelihood for the people living here. The population of Ópusztaszer has been steadily declining since 2010 (TEIR, 2020). According to the 105/2015. (IV. 23.) Regulation of the Government, the settlement is considered to be beneficiary from a social, economic and infrastructural point of view. There are three large tourist service providers in Ópusztaszer. As a result, restaurants and accommodations operate in the settlement throughout the whole year, thus creating the tourist infrastructure which is suitable for receiving tourists.

The largest tourist service provider in Ópusztaszer is the Ópusztaszer National Historical Memorial Park, which is one of our most significant historical monuments. Its history

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dates back to the 1880s. The Memorial Park was completed in 1995, which was dreamed up by Ferenc Erdei in 1970 (SZABÓ, 2005). The Memorial Park seeks to familiarize our past, traditions and history with the visitors via memorial sites, buildings and exhibitions. Its wide range of services and diverse events allows it to receive visitors all year round. The historical site of the Hungarian conquest inspired the Cseppentő family, who moved to Ópusztaszer in 1985 and started breeding horses here, with the historical horse breed, Akhal Teke, which at that time was the only such breed in Hungary. Today, the Cseppentő family primarily organizes equestrian programs and activities. The Csillagösvény Eco Adventure Park is located next to the Ópusztaszer National Historical Memorial Park, which is unique in Central Europe, because the labyrinth theme park is built from the nearby natural ingredients. On the other hand, the Csillagösvény Labyrinth is the largest hedge maze in Europe and it creates a really exciting atmosphere via Hungarian history, geography and wildlife [1].

There are nine accommodations and two restaurants in Ópusztaszer. The type of accommodation is guest house which also known as holiday house, apartment, as well as yurt accommodation, camping and youth hostel. Both types of restaurants are inns. The accommodation providers in the settlement can accommodate about 400-420 people in total, while the inns can seat 580 people.

RESULTS

Ópusztaszer has many man-made and natural values, most of which are still present in the settlement as untapped opportunities. We made an inventory of the values of Ópusztaszer (*Table 1*), in which the websites of the interviewees and the tourism service providers also helped us.

Table 1: Man-made and nature values of Ópusztaszer

Man-made values		Natural values
Religious places	***Events organized by the Historical National Park***	***Flora and fauna***
Kisboldogasszony Chapel	Pünkösdölő, Szeri Easter, Hungarian Christmas, Szobori Farewell, National Assembly of Hungarians, Melon Day, St. Michael's Wine Filter, Harvest, Craftsmen's Day, St. Stephen's Day	Bird and flora of Ópusztaszer (Pusztaszeri) forest
Magyarok Nagyasszonya Church		Akhal Teke Stud
Ecumenical Chapel		***Protected areas***
Ányási Pallavicini Chapel		The village and its surroundings are part of the Pusztaszer Landscape Protection Area
Szeri Monastery		
Historical places, monuments	***Events and Festival organized by the Cseppentő Family***	
Ópusztaszer National Historical Memorial Park	Hello “Ugar” Music Festival, Equestrian Camps and Tours, Cattle Herding on Horseback	***Water***
Pallavicini Palace		Tisza River and floodplain, thermal water
Csontospart Ópusztaszer		
Monument to the Seven Arrows of Hungarians	***Events organized by the Municipality***	
Hantházi Croft	Village Day	
Monuments	***Folk culture***	
Csillagösvény Labyrinth	Works of local craftsmen (basket weaving, saddle making, felting)	
Cseppentő farm		
Hiking Trail		
Alföldi Kék Tour route		

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Based on the natural and man-made values of Ópusztaszer, the forms of tourism were written in a table supported by examples (*Table 2*). Historic sites are the basis of cultural tourism, natural values and the hedge maze can be linked to ecotourism, cattle herding is part of agro-tourism, Akhal Teke stud and equestrian tours belong to equestrian tourism, while pilgrimage sites to religious tourism, types of accommodation and preservation of traditions and events are related to rural tourism.

Table 2: The specific appearance of the forms of rural tourism in Ópusztaszer

Rural tourism					
Cultural tourism	***Ecotourism***	***Agro-tourism***	***Horse tourism***	***Religious tourism***	***Village tourism***
Historic sites: Ópusztaszer National Historical Memorial Park	The services of the Cseppentő family's business: horse riding tours	Cattle herding, Akhal Teke Stud	The services of the Cseppentő family's business: horse riding tours and demonstrations	Ecumenical religious routes, Places of pilgrimage: Szeri Monastery	Cottages, Local artisans

In order to map the touristic situation of Ópusztaszer, we performed a SWOT analysis (*Table 3*), which helps to map the strengths and opportunities that result in the sustainability of Ópusztaszer tourism. We have drafted the weaknesses and threats that are the biggest risk factors for the future.

Strength: In Ópusztaszer, natural and man-made values have a prominent role among the strengths. The village also offers unique attractions in the world, such as the Feszty panorama, the Csillagösvény Labyrinth and the Akhal Teke stud. One of our most significant historical monuments is the Ópusztaszer National Historical Memorial Park, so the name Ópusztaszer is known throughout the country. On the impact of these famous sights, local accommodation and new restaurants opened that can admit a significant number of tourists. Building on the values of the settlement, several forms of tourism have developed, which offer an experience and attraction available to a wide range of tourists.

Weaknesses: Regarding the weaknesses, I would like to highlight the lack of cooperation among tourism service providers in the settlement. The local Tourist Destination Management organization does not perform its function, so it does not play a role in strengthening the collaboration either. Accessibility to Ópusztaszer is difficult due to the lack of transport infrastructure. The unfavorable location of the Tour inform Office only provides information on travel and attractions for guests who visit the Memorial Park.

Opportunities: The utilization of natural and man-made values should be rethought so that new forms of tourism could develop in the settlement, which could contribute to attracting a wider range of tourists. For example, the operation of the castle as a hostel could provide a basis for the development of conference and incentive tourism, the thermal water supply under the settlement would provide an opportunity to build a spa. New forms of tourism would attract a larger proportion of not only domestic but also foreign guests to the settlement. The cooperation among local service providers ensure an opportunity for joint marketing activities and the development of joint program packages, which would increase the number of nights spent in the settlement and the area. The active operation of the local Tourist Destination Management organization should be promoted, which would

Review on Agriculture and Rural Development 2020 vol. 9 (1-2) ISSN 2677-0792
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strengthen the cooperation among the tourism service providers and could also play an important role in the development of joint marketing activities.

Threats: The biggest threat is the municipality's lack of interest in local tourism. During the research we could not contact the local authorities, we did not find any information about the local tourism on the website of the settlement. The local tourism service providers also thought that the local government was not interested in cooperation, joint marketing or development.

Table 3: SWOT analysis of Ópusztaszer tourism

Strength	**Weaknesses**
Natural features Traditions and built heritage Diverse events Unique attractions Familiarity and attendance Existing and operating tourism businesses Development of a significant number of forms of tourism	Weaknesses in transport infrastructure The unfavorable location of the Tourinform Office Seasonality of tourism Lack of cooperation among local tourism providers Demographic problems: declining population, aging Lack of joint marketing Untapped human and natural values Formal operation of a local Tourist Destination Management organization Lack of higher category accommodation and restaurants
Opportunities	**Threats**
Expanding the tourism product portfolio by rethinking the use of natural and man-made values Strengthen cooperation between local tourism providers Development of joint program packages and marketing activities in the settlement Facilitate the active operation of the local Tourist Destination Management organization Reception of foreign guests in the village	Lack of interest of the local population and local government Economic crisis phenomena

CONCLUSION

The main aim of the study was to examine the touristic offer of Ópusztaszer, taking into account the man-made and natural values of the settlement, as well as the local tourism service providers. We made a SWOT analysis to map the tourist situation of the settlement, in which we summarized the strengths, weaknesses, opportunities and threats for the future. Many forms of tourism have developed in the settlement, including equestrian tourism, village tourism, cultural tourism and ecotourism. During the inventory of man-made and natural values, we found that the settlement has many untapped opportunities. By rethinking their use they could become later a strength of the settlement, contributing to sustainable tourism in the settlement. Rethinking the values of the settlement promotes the

Review on Agriculture and Rural Development 2020 vol. 9 (1-2) ISSN 2677-0792
DOI: 10.14232/rard.2020.1-2.3-8

development of further forms of tourism which contributes to attracting a wider layer of tourists to the settlement.

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EFFECT OF WEED MANAGEMENT PRACTICES ON WEED COVER IN FIELD PEA (*PISUM SATIVUM L.)*

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ABSTRACT
Field pea (*Pisum sativum L.*) are planted on small area in Hungary, although it is a precious source of protein (22-28%), and it also plays a significant role like a component in fodder mixture and green forage. It is a great part in crop rotation as a short growing-season legume. Furthermore, it has beneficial effects of nitrogen-fixing nodules being able to obtain N derived from air. One of the most critical limiting factors is to find out weed management practise for control of weeds in field pea.
Our field experiment was carried out on site of the National Agricultural Research and Innovation Centre, the Department of Field Crops Research in Öthalom for comparing weed management strategies by evaluate their efficacy and weed flora. We used 6 herbicides or herbicid combination and observed weed density in 5 times during the growing season.
The most important weeds were: common chickweed (*Stellaria media*), wild mustard (*Sinapis arvensis*), branching lackspur (*Consolida regalis*), meldweed (*Chenopodium album*). Among the treatments the highest weed cover was the weedy check, followed by Stomp Super, obtained maximum weed control and long lasting effect. With the application of Basagran 480 SL and Pulsar 40 SL have a significantly lower weed density was recorded than preemergence applications. In case of Corum application, it was the lowest weed cover of all even at harvesting time. According to our experiments use of Dash does not control weeds considerably.

KEYWORDS: field pea, weed management, weed cover, herbicidal effect

INTRODUCTION

Field pea in both sowing time has very high level of protein (22-28%) and it also plays a significant role like a component in fodder mixture and green forage. Field pea (*Pisum sativum L.)* are harvested 14 million tonnes from about 7,6 million hectares worldwide in 2016 (FAOSTAT, 2018). In Hungary the total area under filed pea were in small size: the complete harvested area was 15,4 thousand ha in 2017, with 2,75 t/ha yields (BÁBÁNÉ, 2017).
Plant protection is an extremely important part of the crop management in the case of field pea. It has numerous pathogens and pests, but reducing weeds infestation has become one of the challenging aspects in agriculture in the last few years. Because of the importance of weed effects research is needed to use suitable integrated weed management (HARKER ET AL, 2001, WOZNIAK AND SOROKA 2014). We have to choose chemical weed control with the knowledge of the environment effect of seed placement (abiotic and biotic effect), cultivation purpose and the kind of trait (KÁDÁR, 2016).
An early sowing date of field pea in March has determinated the weed species in the area (WÁGNER AND NÁDASYNÉ, 2008a, WÁGNER AND NÁDASYNÉ 2009). According to NÁDASYNÉ (2015) the weed suppression ability of field pea depends on the structure of the weed, the foliage size, which means how fast as it can shade the soil. There are 2 critical

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period of weed control in spring field pea. The first critical period is the first month after planting. Because of its early sowing date, weeds, such as red poppy (*Papaver rhoeas* L.), cleavers (*Galium aparine* L.), field chamomile (*Anthemis* spp.), wild chamomile (*Matricaria* spp.) emerge early in the season (REISINGER, 2000). Afterwards appear weeds in the area, which is germinating in spring, and flowering in summer including wild mustard (*Sinapis arvensis* L.), wild radish (*Raphanus raphanistrum* L.), black oats (*Avena fatua* L.). The second critical period of weed control is at the end of the growing season, after the lower leaves dried (GYULAI, 2014). Then emerged prickly grass (*Echinochloa crus-galli* L.P.B.), *common amaranth (Amarathus retroflexus* L.), meldweed (*Chenopodium album* L.) (REISINGER, 2000). Volunteer sunflower (*Helinathus annuus* L.) and perennials: field bindweed (*Convolvulus arvensis* L.), creeping thistle (*Cirsium arvense* L. SCOP.), Johnson-grass (*Sorghum halepense* L. PERS.) are important also in the arable land. Dicotyledon weeds are the highest problem in the weed control of field pea (WÁGNER AND NÁDASYNÉ, 2008a, WÁGNER AND NÁDASYNÉ, 2008b). Mostly dicotyledon weeds which has germinated from deeper parts of soil are the most difficult to eradicate (SZENTEY, 2003), where the basic treatment are not effective (NAGY, 2017). Furthermore these weeds have only 2-3 days in optimal phenological phase to maximize weed control against them.

Our aim to examine the effect of different weed management of field pea to the cultivated plant and its weed flora.

MATERIALS AND METHODS

The research was established in the Department of Field Crops Research of National Agricultural Research and Innovation Centre, in Szeged-Öthalom. The research farm has a flat relief, salt meadow chernozem soil, humus content: 2.8-3.2 %, pH value: 7.9, liquid limit (K_A): 42, nutrient supply capacity: N medium, P_2O_5 good, K_2O good. The variety is Impulse, which is a middle-maturated, white flowered, afila type, high fertiliy and protein content spring shelling pea. Preceding crop was winter wheat. After the winter wheat has been harvested we made shallow stubble stripping, then loosened area with a middle deep brush weeder (25-30 cm deep) and smoothed down. Later the loosened stubble was disking, and supplied 280 kg ha^{-1} NPK (15:15:15) multinutrient fertilizer. In the last 5 years, we coun't use organic fertilizer, and there's no possible to irrigate the area. Seedbed preparation was made by cultivator and combinator. Sowing was made in 14th of March in 2018, the row width was 12 cm, sowing depth was 5 cm, seed quantity was 250 kg ha^{-1} (1 million germ ha^{-1}). Filed pea was emerged in 23th of March in 2018. We designated random layout plots for 8 treatments in 4 repeats. Each plot has 10 m^2 area. Weed survey was made by the method of Balázs-Ujvárosi in 19th of March, 2nd and 21th of April, 4th of May and 12th of June in 2018. Based on the weed surveies we calculated the measure of the weed cover and effect of the weed control.

Applications were in *Table 1*, meteorogical datas on the date of applications were in *Table 2*.

Review on Agriculture and Rural Development 2020 vol. 9 (1-2) ISSN 2677-0792
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Table 1: Applications

Number of applications	Pesticide	Active substance/agent	Dose (l ha^{-1})	Phenological phase of field pea
1	weedy check control			
2	Stomp Super	*pendimetalin*	4.5	Preemergens
3	Basagran 480 SL	*bentazon*	2	6-8 leaves
4	Stomp Super + Basagran 480 SL	*pendimetalin+ bentazon*	4.5+ 2	Preemergens and 6-8 leaves
5	Corum	*imazamox + bentazon*	1.25	6-8 leaves
6	Pulsar 40 SL	*imazamox*	1	6-8 leaves
7	Corum + Dash HC	*imazamox + bentazon + metiolelát, metilpalmitát*	1.25+ 0.5	6-8 leaves
8	hand weed control			

Table 2: Meteorological datas on the date of applications

Meteorological conditions		
Parameters	19th of march in 2018	21th of April in 2018.
Air temperature (ºC)	12	21
Relative humidity %	75	65
Wind speed (m/s)	2	1
Cloud cover (%)	50	50
Precipitation (mm) 2 weeks before the application	47.5	0.9
Precipitation(mm) 2 weeks after the application	30.1	0
The first >5 mm precipitation after the application	21th of March in 2018	15th of May in 2018
Weather on the last week before the application	moderately chill and wet	warm and dry
Weather on the next week after the application	chill and wet	warm and dry

RESULTS AND DISCUSSION

In *Table 3* we can see the weed cover of weedy check control/ date of weed survey. In the first 2 times we made only a few experiences, then on the third weed survey we got 10%. In this time persian speedwell (*Veronica persica*), chickweed (*Stellaria media*), shepherd's purse (*Capsella bursa-pastoris*), wild mustard (*Sinapis arvensis*), cleavers (*Galium aparine*), corn poppy (*Papaver rhoeas*), branching lackspur (*Consolida regalis*) and volunteer wheat (*Triticum aestivum*) were on the plots. On the next weed survey in the 4th of May we can see secondary weed period, where black nightshade (*Solanum nigrum*), meldweed (*Chenopodium album*), common ragweed (*Ambrosia artemisiifolia*), and giant sumpweed (*Iva xanthiifolia*) were appeared. By the last weed survey weed cover of the weedy check plot was reached 34.25 %.

Review on Agriculture and Rural Development 2020 vol. 9 (1-2) ISSN 2677-0792
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On the *Table 4* we can see the effect of the applications compared with the results of weedy check plot. In the year of 2018 circumstances were ideal to examine both the effect of pre-, and postemergence herbicides.

Table 3: The average weed cover of the weedy check plot

Weed	Bayer code	Weed cover (%)				
		19th of March	2nd of April	21th of April	4th of May	12th of June
Persian speedwell	**VERPE**	0	1.75	0	0	0
Common chickweed	**STEME**	1.25	2	2	1.5	0
Shepherd's purse	**CAPBP**	0	1	1	1	0
Wild mustard	**SINAR**	0	1	2	5.35	2
Common fumitory	**FUMSC**	0	0	2	3.5	0
Cleavers	**GALAP**	0.2	0.5	1	2	1.5
Corn poppy	**PAPRH**	0.1	0.1	0.5	1	4
Branching lackspur	**CONRE**	0.5	0.5	0.5	1	3
Black nightshade	**SOLNI**	0	0	0	1	5
Meldweed	**CHEAL**	0	0	0	5	15
Common ragweed	**AMBEL**	0	0	0	0.2	1
Giant sumpweed	**IVAXA**	0	0	0	0.3	1.75
Volunteer wheat	**TRZAX**	1	1	1	1	1
All		**3.05**	**7.85**	**10**	**22.85**	**34.25**

Table 4: Evaluation of the herbicidal effect (weed cover %)

Application	Date	Name of the weed												
		VERPE	STEME	CAPBP	SINAR	FUMSC	GALAP	PAPRH	CONRE	SOLNI	CHEAL	AMBEL	IVAXA	TRZAX
2. Stomp Super	04.02.	71	50	100	50	100	0	0	50	100	100	100	100	100
	04.21.	100	50	50	87,5	100	0	0	50	100	100	100	100	100
	05.04.	100	11	0	81	43	50	50	50	50	65	100	0	100
	06.12.	100	100	100	88	100	67	50	67	35	73	60	43	100
3. Basagran 480 SL	05.04.	100	100	100	100	71	100	100	0	100	100	50	100	50
	06.12.	100	100	100	100	100	100	100	33	100	80	75	100	100
4. Stomp Super + Basagran 480 SL	04.02.	71	50	100	50	100	0	0	50	100	100	100	100	100
	04.21.	100	50	50	87.5	100	0	0	50	100	100	100	100	100
	05.04.	100	100	100	100	100	100	100	50	100	100	100	100	100
	06.12.	100	100	100	100	100	100	100	66.7	100	86.7	70	100	100
5. Corum	05.04.	100	100	100	100	71.4	100	50	100	100	100	100	100	100
	06.12.	100	100	100	100	100	100	100	100	100	86.7	100	100	100
6. Pulsar 40 SL	05.04.	100	100	100	100	71.4	100	50	0	100	100	100	100	100
	06.12.	100	100	100	100	100	100	87.5	66.7	80	80	100	100	100
7.Corum + Dash HC	05.04.	100	100	100	100	71.4	100	50	100	100	100	100	100	100
	06.12.	100	100	100	100	100	100	100	100	100	87	100	100	100
8. hand weed control	04.02.	100	100	100	100	100	100	100	100	100	100	100	100	100
	04.21.	100	100	100	100	100	100	100	100	100	100	100	100	100
	05.04.	100	100	100	100	100	100	100	100	100	100	100	100	100

Review on Agriculture and Rural Development 2020 vol. 9 (1-2) ISSN 2677-0792
DOI: 10.14232/rard.2020.1-2.9-14

	06.12.	100	100	100	100	100	100	100	100	100	100	100	100	100

By the results of our experiments preemergence herbicids itself (in application 2 and 4) were less effective than postemergence herbicides. By using Stomp Super in filed pea in the early stage of development we reduced winter annual weeds, and has long last effect. Then field pea presumably could be able to overshadow the soil, which increased its weed supression ability. However the effect of Basagran 480 SL with *bentazon* was much better than preemergence herbicide (3. application). Combination of these two herbicides (4. application) had obviously better values than the unmatched. Weed cover of the Corum handling plot (5. application) has the lowest values from all even 5 days before harvesting. Compare with Corum and Corum with Dash HC combination in this year there was no significant difference between the effect of applications (7. treatment). Pulsar 40 SL which contains only *imazamox* was significantly worse herbicidal effect than the application with Corum. Examining the efficiency of herbicides the best choice were Corum, and Corum with Dash HC combination.

CONCLUSIONS

In our experimental field the biggest number were common chickweed (*Stellaria media*), wild mustard (*Sinapis arvensis*), branching lackspur (*Consolida regalis*), meldweed (*Chenopodium album*). Probably the warming climate late summer annuals were the most in filed pea.

The highest values of weed cover were the hand weed control plot and the preemergence herbicid handling parcel with pendimetalin. But the number of weeds during the whole growing season was the lowest by Stomp Super application. It is probably causes the faster development and higher overshadow of field pea, which is the same results as DÁVID AND KISS (2015). According to their opinion preemergence application is very important against strict requirements of postemergence application (for example: development of cultivated plant and weed, temperature criteria). In contrast in our experiments the herbicidal effect of preemergence application was weaker than the posztemergence application, as VARGA AND GARA (2004) have determined it formely. Basagran 480 SL with *bentazon* active substance has a short residual action, because of the increased number of weeds which emerged at the end of the growing season. According to DÁVID AND KISS (2015) *imazamox* is a wide spectrum active substance, which proves to be true, but combination with *bentazon* was much more effective. There were no significant diferrences between the herbicidal effect of Corum and Corum with Dash HC combination.

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INVESTIGATION OF BIOLOGICAL PLANT PROTECTION IN PROTECTED CULTURE OF PEPPER

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ABSTRACT

The aim of the study was to determine the effectiveness of regularly applied biological control by continuous monitoring of pests with the help of color traps (sticky sheets) and flower tests with joint species identification of the useful insects to determine the extent to which native useful insects can settle next to the introduced predatory ones. The latter process is to be facilitated by growing a flowering mixture of annual plants at one of the experimental sites, which provides adequate feeding and hiding place for beneficial insects.

The experiment was carried out in Szentes. The peppers in protected cultivation were grown in two unheated polytunnels. The color traps were laid out in three different places in politunnels. A total of 11 color traps were collected from the experimental area (from April till September). During the experimental period, the main pests damaging peppers were western flower thrips (*Frankliniella occidentalis*) and tobacco thrips (*Thrips tabaci*). The highest thrips number (*F. occidentalis*, 40 pieces) was counted on 9th June in 2020. Useful insects in the experiment: predatory mites (*Amblyseius spp*.), predatory flower bugs (*Orius laevigatus*) and the banded thrips (*Aeolothrips spp.*). The highest useful insect's number (*Aeolothrips spp.*, 11 pieces) was counted in the 20th September in 2020.

Keywords: sweet pepper (*Capsicum annuum*), polytunnel, biological plant protection, western flower thrips (*Frankliniella occidentalis*), microscope

INTRODUCTION

Pepper (*Capsicum annum* L.) is one of the most popular vegetable plants, it is of great nutritional importance and its popularity is growing worldwide. Consumption in fresh and processed form is significant on the one hand for its pleasant taste and on the other hand due to its high vitamin C content. With an annual production of 180-200 thousand tons, Hungary is one of the most important pepper-growing countries in the European Union. About 80% of the quantity of Hungarian peppers currently comes from protected cultivation. Its peculiarity is that more than 20 types are grown, 50-55% of the greenhouse surface is provided by the so-called *Cecei* types. This is the only forced vegetable species that is grown predominantly with Hungarian varieties, which can compete with foreign varieties in terms of quality and disease resistance. Soilless protected cultivation introduced in the 1990s provided an opportunity for long-term cultivation, with which the average yield of cone-shaped varieties reaches 25 kg / m^2 / year (ZATYKÓ, 1993; TERBE AND SLEZÁK, 2019).

Peppers are very sensitive to precise control of heating, the minimum equipment required for cultivation is the heating and ventilation system. In unheated houses, only summer cultivation is possible, as it is sensitive to low temperatures, which cause a high degree of flower dropping and crop deformation. From the point of view of cultivation and climate control, large-air equipment is suitable in which, in cold weather during ventilation, the

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cold air does not come into direct contact with the plants. In summer, however, the upper leaves are not exposed to strong radiation. The planting requires a support system height of at least 2.5-3 m (SZŐRINÉ, 2007).

In the case of cultivation without soil, it is particularly important to observe optimal conditions in the root zone. For pepper production, the capacity of the irrigation system is 1-2 l / hour / drip, and the annual water demand is 800-900 l / m^2 / year. The transpiration water requirement of the adult plant is 1.6-2.6 ml / m^2 at 1 J / cm^2 and the dosage is 2.0-3.5 ml / m^2 per Joule. Peppers do not tolerate airless, aqueous media, high salinity and the accumulation of certain harmful elements in the root zone. In case of poor water quality, desalination of water is recommended. Humidity control in summer is greatly facilitated by a humidification system that also performs cooling functions (RESH, 1998; TERBE *ET AL.*, 2004; TERBE AND SLEZÁK, 2019).

Peppers are very demanding of the medium. It does not inhibit its development if it has the following characteristics:

- air capacity: 35-40% by volume
- water capacity: 45-50% by volume
- pore volume: 75-85% by volume.

For soil-less cultivation, stone wool, perlite and very good quality coconut husks are best.

In Hungary, two types of cultivation methods can be used:

- long-term cultivation (8-11 months in the cultivation equipment)
- short-term cultivation (4-6 months in the cultivation equipment)

One of the major issues in plant protection of peppers in protected cultivation is the solution of thrips control. The introduction of non-native predatory mites (*Amblyseius spp*.) and predatory flowering bugs (*Orius laevigatus*), which are commercially available in Hungary, offers a more efficient option than the use of pesticides. In addition to efficiency, biological control has a number of beneficial properties, one of the outstanding factors being that the abandonment of insecticides allows the settlement of native arthropods into shoots.

Settling animals from the paprika grower's point of view may be:

- useful: predators
- pests: animals feeding on peppers
- neutral: they do not feed on peppers or pepper pests

Of the "useful" group, native flower bugs are of outstanding importance, which, like *Orius laevigatus*, are able to regulate the number of thrips. They can eat 4-5 adults or 8-15 larvae a day. In addition to thrips, they can also feed on aphids, mites, moths or butterfly eggs. The largest number of specimens has the common flowering bug (*Orius niger*), which is common on flowering plants that provide it with prey, such as cultivated (e.g. alfalfa, corn, sunflower) or roadside plants (e.g. spotted burrs, nettles) in the vicinity of polytunnels from where it can migrate into the protected cultivation area. The first specimen can be observed as early as the end of May, but they do not grow en masse in peppers until June, where they are found continuously until the end of September.

Also, a common predatory species found in forced peppers is the banded thrips (*Aeolothrips intermedius*), which feeds mainly on phytophagous thrips and mites. It can eat 2-3 western flower thrips (*Frankliniella occidentalis*) or tobacco thrips (*Thrips tabaci*) larvae per day, while during its full development it can prey on up to 100 thrips or 300 spider mite larvae.

Western flower thrips (*F. occidentalis*) can reproduce both sexually and by

Review on Agriculture and Rural Development 2020 vol. 9 (1-2) ISSN 2677-0792
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parthenogenesis (AVAR AND DÉRI, 1989; JENSER, 1998). Females use their egg tubes to lay 20-40 eggs under the epidermis of the plants. The most ideal laying place for them is the flower. The first stage larva is still moving freely on the plant, the second stage larva is hiding. In forced peppers at 25 ºC it takes 16 days for the pest to develop. It can achieve the highest reproduction in a flowering plant producing abundant pollen at a temperature of 20-21 ºC and a relative humidity of 80-90%. (AVAR AND DÉRI, 1989; DELIGEORGIDIS *ET AL.*, 2006a). The number of annual generations is 12-15.

The female of the tobacco thrips (*Thrips tabaci*), after 2-5 days of embryonic development, places 40-100 eggs under the epidermis of the plant and then takes 5 days for the larvae to develop. These larvae are later found in flowers, leaves, mostly on the back of the leaf, along the leaf veins, and in the leaf sheath or other hidden place. Interestingly, the duration of generation development is a function of temperature (GUZMAN *ET AL.*, 1996; BOZSIK, 1997; JENSER, 1998; JENSER, 2003; DELIGEORGIDIS AND IPSILANDIS, 2004; JENSER AND SZÉNÁSI, 2004; ARRIECHE *ET AL.*, 2006; DELIGEORGIDIS *ET AL.*, 2006b). The higher the temperature, the shorter each stage will be: the time before laying; the chance of larvae surviving and laying their eggs decreases (DELIGEORGIDIS *ET AL.*, 2006b). Several generations can develop each year. In the open field, 4-5 generations and in the greenhouse up to 8-12 generations can develop in one year.

MATERIAL AND METHOD

The polytunnels experiment was set up in Szentes. Pepper planting time was early April 2020. The peppers in protected cultivation were grown in two unheated polytunnels with areas of 500-500 m^2.

One flower box containing annual plants was placed in front of and behind the first polytunnels (treated) to lure pest insects away from the sprouted peppers, the second polytunnels was assigned as control. Flower sampling was collected twice from the crates, dated 1st July and 3rd August 2020, respectively. In the polytunnels, color traps were laid out in three different places: at the beginning of the, in the middle of the, and at the end of the polytunnels.

A total of 11 x 3 color traps were collected from the experimental area. The dates were: April 26, May 11, May 26, June 9, June 25, July 8, July 22, August 3, August 24, September 6, and September 20.

In addition to collecting color traps, we also collected pepper flower samples in protected cultivation (treated polytunnel). A total of three samples were taken, with dates of 8th June, 1st July, and 3rd August.

RESULTS

The color traps were placed a total of 11 times in the two polytunnels. The first polytunnels was the 1, the second polytunnels was the 2. The insects (thrips) collected by the color traps are shown in *Figure 1.*, *Figure 2.* and *Figure 3.*

Review on Agriculture and Rural Development 2020 vol. 9 (1-2) ISSN 2677-0792
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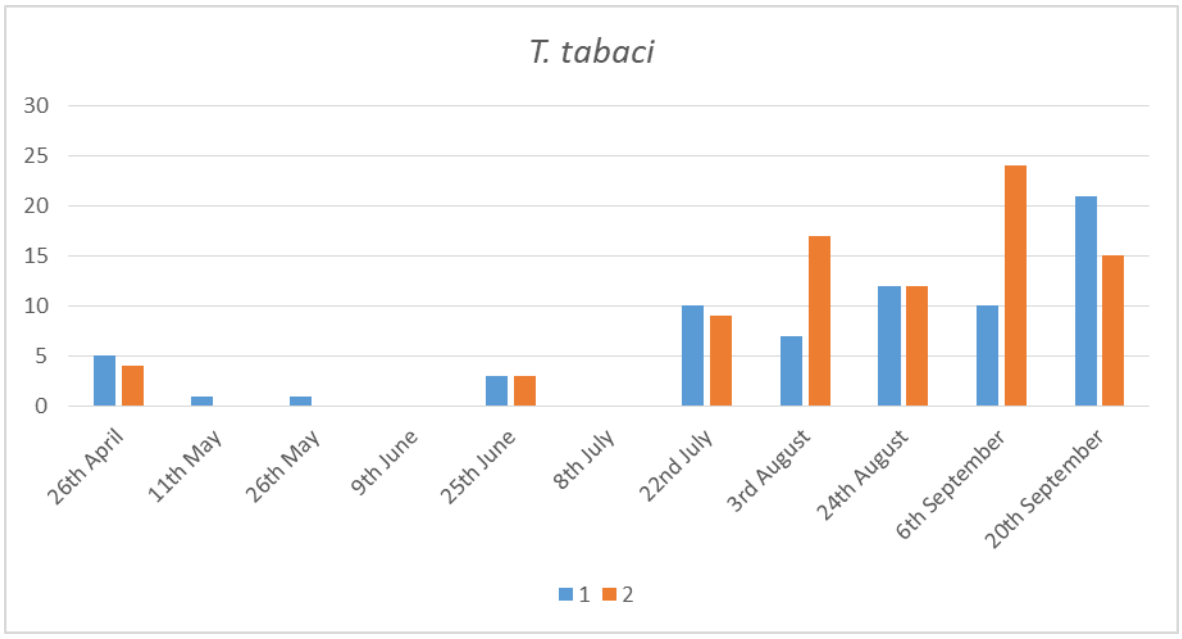

Figure 1. Show are the date of collection and the number of *Thrips tabaci*.

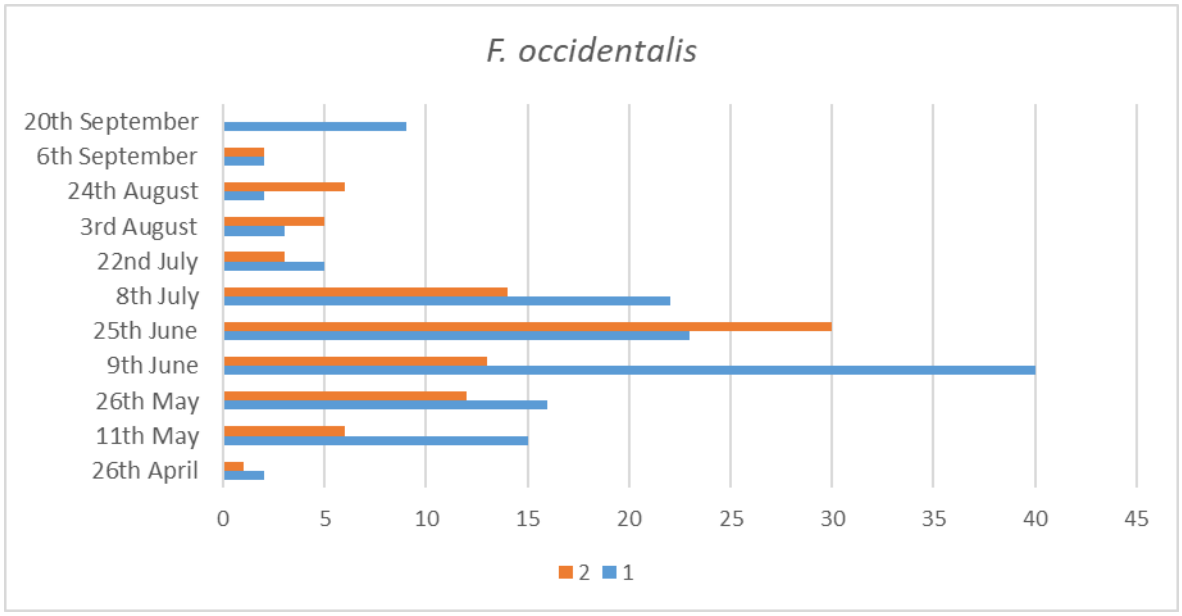

Figure 2. Show are the date of collection and the number of *Frankliniella occidentalis*.

Review on Agriculture and Rural Development 2020 vol. 9 (1-2) ISSN 2677-0792
DOI: 10.14232/rard.2020.1-2.15-21

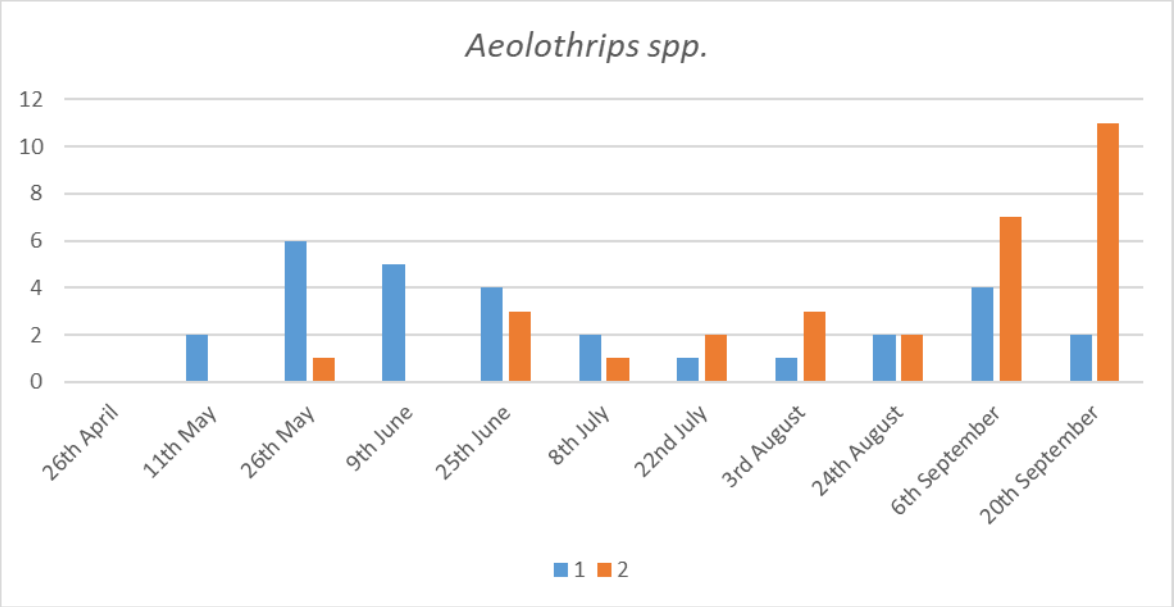

Figure 3. Show are the date of collection and the number of *Aeolothrips spp*.

Pepper flower samples were collected during protected cultivation. A total of three samples were collected: 8th June, 1st July and 3rd August in 2020. The sampling was performed in 3 replicates and 2 samples.

- 1st pepper flower sampling (June 8, 2020): The time of recording was between 8:20 and 10:20. At the first survey, useful insects were not identified on the flower samples. Quantity of harmful insects: *F. occidentalis* 19 ind; *T. tabaci* 1 pc; *M. persicae* 3 pieces.
- 2nd pepper flower sampling (1st July, 2020): The time of recording was between 13:30 and 15:30. At the second survey, no useful insect was recorded after processing the collected flower samples. Quantity of harmful insects: *F. occidentalis* 9 pieces; *M. persicae* 1 pc.
- 3rd pepper flower sampling (03/08/2020): The time of recording was between 14:00 and 16:00. At the third survey, a total of 3 useful insects were detected on the pepper flower samples: *O. niger* 2 pcs; *Aeolothrips intermedius* (banded thrips) 1 piece. Quantity of harmful insects: *F. occidentalis* 6 pieces; *M. persicae* 5 pcs; *A. fabae* 1 pc.

Flower sample results from the flower box:
Sampling of flowers from the flower box in front of the 1st polytunnels (01.07.2020):
- *F. occidentalis* (10 pcs)
- *M. persicae* (1 pc)
- *A. intermedium* (1 pc)

Sampling of flowers taken from the flower box behind the 1st foil (01.07.2020):
- *F. occidentalis* (3 pcs)
- *O. niger* (2 pcs)

Review on Agriculture and Rural Development 2020 vol. 9 (1-2) ISSN 2677-0792
DOI: 10.14232/rard.2020.1-2.15-21

Result of the second flower sampling (03.08.2020) taken from the flower box in front of the 1st polytunnels:

- *H. armigera* worm (1 pc)

Result of the second flower sampling taken from the flower box behind the 1st foil (03.08.2020):

- *M. persicae* (1 pc)
- *O. niger* (2 pcs)

CONCLUSIONS

From the color traps that we collected 11 times, it can be concluded that the number of *Thrips tabaci* individuals ranged from 0 to 5 for color traps 1, 2, 3, and 5. At the collection of color traps 4 and 6, 0 tobacco thrips were detected. In the case of collected color traps number 7 through 11., the highest value of *T. tabaci* varied between 10 and 24 pieces, showing an increasing trend. For the first three adhesive sheets collected, most *Frankliniella occidentalis* data ranged from 1 to 16. In the collected color traps numbered 4-6, the western flower thrips showed a value between 13 and 40 pieces. In the case of collected adhesive sheets 7-11., *F. occidentalis* ranged from 1 to 9. For the first color traps collected, the number of *Aeolothrips spp*. was the lowest, namely 0 (in both replicates). For the collected color traps 2 through 9, values between 0 and 6 were calculated for the banded thrips. In the case of collected adhesive sheets 10 and 11, the highest banded thrips value varied between 7 and 11 pieces.

In the experimental area in the first two samplings, no useful insects (*O. niger, A. intermedius*) were detected, only at the third time. In terms of harmful insects, *F. occidentalis* was the most common pest insect (34 pieces).

T. tabaci was present in small amounts (1 pc) in the experimental areas.

The effectiveness of the lure flower ensemble is inferred from the fact that in the boxes placed in front of and behind the polytunnels, the annual plants lured the harmful insects away from the sprouted peppers. This is especially true for the pest insect *Frankliniella occidentalis* (western flower thrips): a total of 13 pieces were counted in the two flower samples. If more boxes were placed around the polytunnels in larger quantities, the lure efficiency of annuals could be more successful.

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