Crop Protection xxx (2017) 1–9

Contents lists available at ScienceDirect

Crop Protection

journal homepage: www.elsevier.com/locate/cropro

When herbicides don't really matter: Weed species composition of oil pumpkin (*Cucurbita pepo* L.) fields in Hungary

Gyula Pinke [a, *], Péter Karácsony [a, b], Bálint Czúcz [c], Zoltán Botta-Dukát [c]

[a] Faculty of Agricultural and Food Sciences, Széchenyi István University, H-9200, Mosonmagyaróvár, Hungary
[b] Department of Economics, University of Selye János, SR-94501, Komárno, Slovak Republic
[c] MTA Centre for Ecological Research, Institute of Ecology and Botany, H-2163, Vácrátót, Hungary

ARTICLE INFO

Article history:
Received 27 February 2017
Received in revised form
12 June 2017
Accepted 23 June 2017
Available online xxx

Keywords:
Agroecology
Arable fields
Alternative crops
Weed flora
Weed management

ABSTRACT

Oil pumpkin is a major emerging alternative crop with several unresolved weed management questions in central-eastern Europe, one of the focal regions of oil pumpkin production worldwide. This study aims to assess the importance of three groups of factors: environment, non-chemical management (all management excluding herbicides), and chemical weed management, in determining the weed species composition of oil pumpkin crops in Hungary. We surveyed the weed flora of 180 oil pumpkin fields across the country, along with 32 background variables. Applying a minimal adequate model consisting of 18 terms with significant net effects, 30.8% of the total variation in weed species data could be explained. Most variation in species composition was determined by environmental factors, with climatic conditions (precipitation and temperature) being most influential. The net effects of seven non-chemical management variables (preceding crop, N and P fertilisers, seeding rate, crop cover, cultivating tillage, and manual weed control), and two herbicides (S-metolachlor and linuron) were also significant. Variation partitioning demonstrated the dominance of environmental factors, and it also showed that non-chemical management practices accounted for five times more variance than herbicides. Within non-chemical management, the relative impact of cultural variables was nearly five times larger than that of mechanical weed management. Among the abundant weeds, *Chenopodium polyspermum* and *Ambrosia artemisiifolia* were positively associated with precipitation, *Datura stramonium* and *Hibiscus trionum* correlated with higher temperature, and *Chenopodium album* favoured larger potassium content of the soil. High seeding rate and crop cover suppressed *Amaranthus retroflexus*, cultivating tillage reduced *Ambrosia artemisiifolia* and *Setaria pumila*, while conspicuous tall weeds like *Abutilon theophrasti* and *Chenopodium album* were most vulnerable to manual weed control. Although the short stature of pumpkin with its poor weed-suppressive ability could unfavourably influence the results of some cultural practices, our findings suggest that the weed vegetation of oil pumpkin fields can be efficiently managed also with environmentally benign methods.

1. Introduction

Edible oils are produced from various *Cucurbita pepo* L. cultivars throughout the World. One of these plants is “Styrian oil pumpkin” or *Cucurbita pepo* L. subsp. pepo var. *styriaca* Greb., which is grown in numerous varieties/hybrids in many countries of south-eastern part of Europe (mainly in Austria, Hungary, Slovenia and Serbia) and its special oil is increasingly used in food and pharmaceutical industry (Fruhwirth and Hermetter, 2008; Lelley et al., 2009). Oil pumpkin is eligible under the EU agricultural ‘greening programme’ as an option for crop diversification, and it is considered as an excellent preceding crop very beneficial for soil structure. Furthermore and most importantly, the cultivation of oil pumpkin has proven to be highly profitable (Madai and Lapis, 2016; Niedermayr et al., 2016). In Hungary, its annual growing area is approximately 20 000–25 000 ha, with average seed yields ranging between 0.4 and 1.2 ton ha^{-1} depending on weather conditions (Madai and Lapis, 2016).

Weed control is the most critical element of management practice in Cucurbits production worldwide. At the beginning of their vegetation period pumpkins have only a weak competitive

* Corresponding author.
E-mail address: pinke.gyula@sze.hu (G. Pinke).

http://dx.doi.org/10.1016/j.cropro.2017.06.018
0261-2194/

ability against weeds. Consequently, early weed infestations can result in high yield losses. Developed pumpkin vegetation will provide some shading and weed suppression, but in turn, its vining habit makes cultivation difficult later in the season. Moreover, there are only a limited number of registered herbicides applicable, which also come with potential crop injury risks, high costs, and insufficient efficacy (Brown and Masiunas, 2002; Kammler et al., 2008; Marr et al., 2004; Walters and Young, 2010). In addition to herbicide sensitivity issues, the main target markets (health and wellness industries) also suggest that the weed management of oil pumpkin crops should rely on non-chemical practices as much as possible (Farkas, 2015).

Our earlier studies showed that due to their large gradient length, environmental factors were the most important drivers in determining the weed species composition in Hungarian summer arable weed vegetation (Pinke et al., 2012) and also in soybean fields (Pinke et al., 2016). Hungarian oil pumpkin production is generally concentrating in three different regions in the western, south-eastern and northern part of the country. Because of the contrasting soil and weather conditions, environmental variables are expected again to play the largest role in determining weed species composition of these fields. Nevertheless, in our recent study in soybean crops, where chemical weed management are regarded as an indispensable element of the production, herbicides turned to be more important than cultural practices (Pinke et al., 2016). Oil pumpkin crops after all, where herbicides are generally considered only as supplemental tools along the much more important cultural practices and mechanical weed control (Farkas, 2015), offer a good opportunity for studying the assumed relevance of non-chemical weed management. The main goal of this study was to assess whether non-chemical weed management can be really more important predictor than herbicides in the weed species composition of pumpkin crops? Measuring and ranking the role of different variables might provide new information about the assembly rules of weed communities and could be used to optimise weed control strategies.

2. Materials and methods

2.1. Data collection

First, we searched for oil pumpkin-growing farmers who permitted access to their fields and were willing to be interviewed about management factors. This operation yielded 180 arable fields throughout Hungary (Fig. 1). According to our sampling strategy, each main oil pumpkin-growing districts in the western, south-eastern and northern part of the country are represented equally with 60 fields. Weed data were recorded in the years 2015 and 2016 at the seasonal peak of summer annual weed vegetation, between the end of July and beginning of September each year. Weed vegetation was sampled in the fields in four randomly selected 50 m^2 plots. One plot was located on the field edge (inside the outermost seed drill line), whereas the remaining three plots were located inside the fields at different distances (between 10 and 200 m) from the edge. Percentage ground cover of plant species in the plots was estimated visually, which method is widely used in arable weed surveys (Kolárová and Hamouz, 2016). In total, 720 plots were sampled (4 plots in 180 fields).

Management information was received directly from the farmers. In order to avoid rare levels of categorical variables, the preceding crop species occurring less than ten times were considered to be 'miscellaneous'. A soil sample of 1000 cm^3 from the top 10 cm layer was collected from each field. Soil analyses were carried out in two laboratories belonging to Synlab Ungarn GmbH and BETA Research Institute accredited by NAT (Hungarian Accreditation System for Testing). Climatic conditions were represented by mean annual temperature values taken from the WorldClim database, and mean annual precipitation values taken from the Hungarian Meteorological Service.

Altogether 32 predictor variables (12 *environmental*: 2 site, 2 climate, 8 soil; 16 *non-chemical management*: 11 cultural, 5 mechanical management; and 4 *chemical weed control factors*) were included in the analysis (Table 1). Management variables were

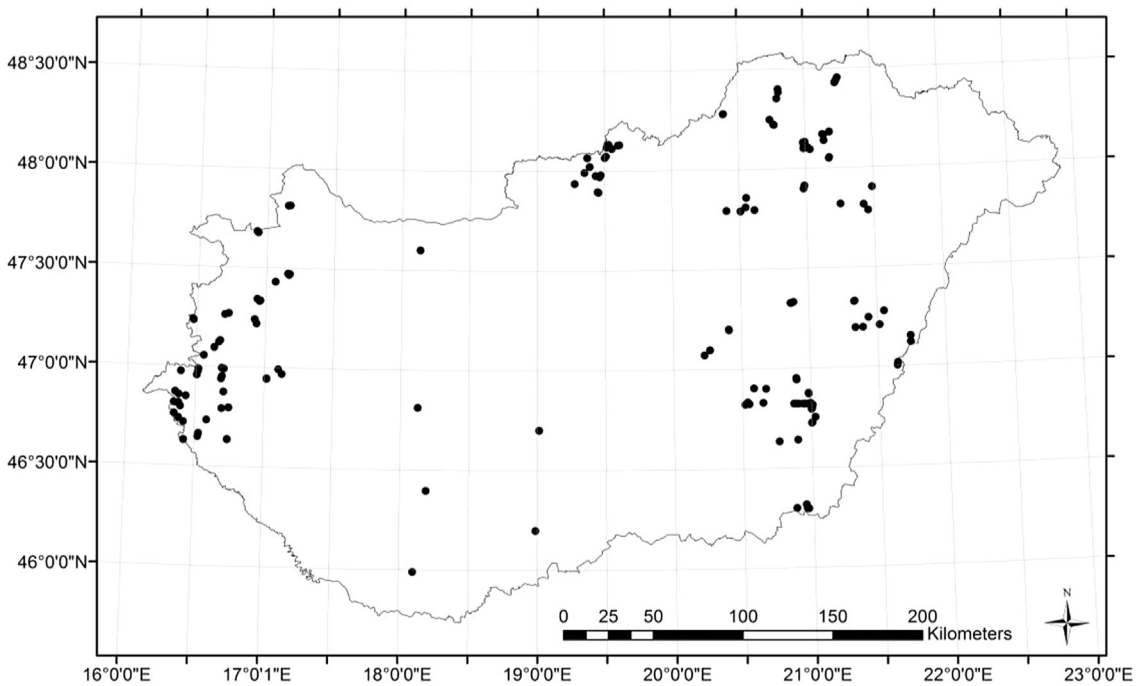

Fig. 1. The distribution of the 180 surveyed oil pumpkin fields across Hungary (a single point may represent multiple fields).

Please cite this article in press as: Pinke, G., et al., When herbicides don't really matter: Weed species composition of oil pumpkin (*Cucurbita pepo* L.) fields in Hungary, Crop Protection (2017), http://dx.doi.org/10.1016/j.cropro.2017.06.018