Yield losses in vegetable and arable crops caused by yellow nutsedge (*Cyperus esculentus*) in farmers fields in Switzerland

Ertragsverluste durch Erdmandelgras (Cyperus esculentus) in Feld- und Gemüsekulturen in der Schweiz

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Abstract

Cyperus esculentus has become a serious weed in Switzerland. Despite intensive awareness training unaffected farmers tend to underestimate the consequences of *C. esculentus* infestation, especially the potential yield losses. Hence, countermeasures are often taken hesitantly.

Yield loss data from abroad is widely available. However, this data was of limited value to raise awareness in Switzerland, because its transferability to our production systems was questioned. To close this gap yield losses caused by *C. esculentus* were determined for different crops in farmers' fields in Switzerland (2013-2016).

Yield was assessed with and without *C. esculentus* infestation and its coverage was estimated. Standard herbicides had been applied in the fields. For sugar beet and potatoes average, actual yield losses of 67% and 34% were detected at *C. esculentus* coverages of 68% and 44%, respectively. High infestation (80-100%) in leek, onions and Brussels sprouts caused losses of 86%, 90%, 93%, accordingly. In carrots: A high infestation led to 61% yield loss. At these infestation levels yield quality was also negatively affected.

In Switzerland, these figures are employed to further train farmers. The findings are presented here to make this more recent yield loss data available to colleagues facing the same problem in their countries.

Keywords: Brussels sprouts, carrots, interference, leek, onions, potatoes, sugar beet

Zusammenfassung

Cyperus esculentus ist zu einem Problemunkraut in der Schweiz geworden. Trotz Sensibilisierungsanstrengungen werden die drohenden Ertragsverluste von noch nicht betroffenen Landwirten oft unterschätzt. Dementsprechend wird den Auswirkungen eines Erdmandelgrasbefalls zu wenig Beachtung geschenkt und Eindämmungs- und Bekämpfungsmaßnahmen werden oft nur zögerlich ergriffen.

Ertragsverlustzahlen aus dem Ausland sind breit verfügbar. Diese Zahlen erwiesen sich aber nur als bedingt hilfreich, um Schweizer Landwirte zu sensibilisieren. Die Übertragbarkeit auf Schweizer Anbausysteme wurde bezweifelt. Um diese Datenlücke zu schließen, wurden entsprechende Ertragsdaten für verschiedene Kulturen auf Schweizer Praxisflächen erhoben (2013-2016).

Erträge mit und ohne Besatz von *C. esculentus* wurden erhoben und dessen Deckungsgrad geschätzt. Auf den Flächen war eine praxisübliche, chemische Unkrautbekämpfung erfolgt. Für Zuckerrüben und Kartoffeln betrugen die Ertragsverluste durchschnittlich 67 % und 34 %, bei einer *Cyperus*-Bedeckung von 68 % respektive 44 %. Bei einem hohen Besatz (80-100 % Deckungsgrad) betrugen die Ertragsverluste in Lauch, Zwiebeln und Rosenkohl 86 %, 90 % and 93 %. In Karotten führte ein starker Befall zu einer Ertragsreduktion von 61 %. Bei so hohen Dichten war auch die Qualität des Ernteguts beeinträchtigt.

Die Ergebnisse sollen dazu dienen, Schweizer Landwirte weiter zu sensibilisieren. Die Ergebnisse werden zudem Forschungsinstituten bzw. landwirtschaftlichen Beratungsinstitutionen in anderen Ländern zur Verfügung gestellt, die mit der gleichen Problematik konfrontiert sind.

Stichwörter: Karotten, Kartoffeln, Konkurrenz, Lauch, Rosenkohl, Zuckerrüben, Zwiebeln

Introduction

Yellow nutsedge (*Cyperus esculentus*) is considered one of the worst weeds worldwide (HOLM et al., 1991). It was observed for the first time in Switzerland about 30 to 40 years ago. Meanwhile it has spread and can be found in all vegetable growing and arable farming areas. Despite its reputation as one of the worst weeds worldwide and its rapid spread, farmers took and still tend to take the weed not seriously enough. This may be due to the fact, that they underestimate the consequences of *C. esculentus* infestations and especially the resulting yield losses.

Yield loss data for Cyperus species (*C. esculentus* and *C. rotundus*) from abroad is widely available (e.g. STOLLER et al. 1979, STOLLER, 1981; FELIX and BOYDSTON, 2010). KEELEY (1987) provided an overview of yield losses in various crops due to *C. esculentus* infestation. In a recent study, FOLLAK et al. pointed out that yield losses were mainly determined in North America and that quantitative data of yield losses from Europe is scarce (2016). They also stressed that the transferability of data from North America is limited due to different climate and cropping practices (FOLLAK et al., 2016). In Switzerland, we experienced the same criticism against yield loss data from abroad. It became clear, that for our extension work, yield loss data from Switzerland is a key element. Thus, the aim of this study was to determine yield losses caused by *C. esculentus* for different crops in farmers' fields in Switzerland.

Materials and Methods

Actual yield losses caused by *C. esculentus* were determined in Swiss fields from 2013 to 2016. Infested fields were chosen according to infestation levels, crop and possibility to sample. Per field 3 to 5 samples were taken, when possible from different *C. esculentus* patches. Infestation levels were estimated as coverage (%) and when feasible *C. esculentus* density was assessed (plants m^{-2}). 3 to 5 samples from field areas with none too little infestation were collected as well (Tab. 1). In the fields standard weed control had been carried out, which was mainly chemical and can be characterized as intensive. The same had been the case for pest control in general. Thus, we assumed that the average yield without *C. esculentus* (actual yield) was similar to the attainable yield for the field in the corresponding year. As a consequence we could calculate the actual yield loss (%) due to *C. esculentus* infestation (OERKE, 2006):

$$actual\ yield\ loss = 100 \times (1 - \frac{average\ yield_{with\ C.esculentus}}{average\ yield_{without\ C.esculentus}})$$

For summer onions (2015) and carrots (2015) samples over a wider range of infestation levels could be collected (onions: 8 samples; carrots: 9 samples in total). In onions, an area of 0.6 m^{-2} was harvested per sample. In carrots, a ridge length of 0.5 m was harvested per sample. These samples allowed modeling a nonlinear yield loss curve employing the drc package in R (RITZ et al., 2015; R CORE TEAM, 2016). The 3 parameter Michaelis-Menten model was used (RITZ et al., 2015).

Results

For potatoes we found actual yield losses of 39 and 28% in 2013 and 2014 (Tab. 1). For sugar beet actual yield losses were 62% and 71% for 2013 and 2014. In sugar beet the infestation level was on average higher. In vegetables the observed infestation levels and thus effects of *C. esculentus* were even higher compared to the arable crops: Infestation levels from 80 to 100% coverage in leek, onions and Brussels sprouts caused losses of 86%, 90% and 93%, accordingly (2014, 2015 and 2016). An intermediate infestation of *Cyperus esculentus* (40%) resulted in a yield loss of almost 62% in the Brussels sprout field. This field was heavily infested. Thus, we had to take samples for the "non-infested" group also in spots where some *C. esculentus* plants were growing (coverage < 10%). The stems of Brussels sprout plants exposed to intermediate and high *C. esculentus* competition were considerably smaller compared to the plants with no to little competition: 0.38 m and 0.40 m compared with 0.65 m (data not shown). The number of sprouts was reduced by roughly one and two thirds at an infestation level of 40% and 80-90%, correspondingly (data not shown). Sprouts' size in the samples of the no to low and the intermediate infestation groups were 1 cm to 2.5 cm, whereas sprouts' size in 3 samples of the high infestation group was ≤ 1 cm (data not shown).

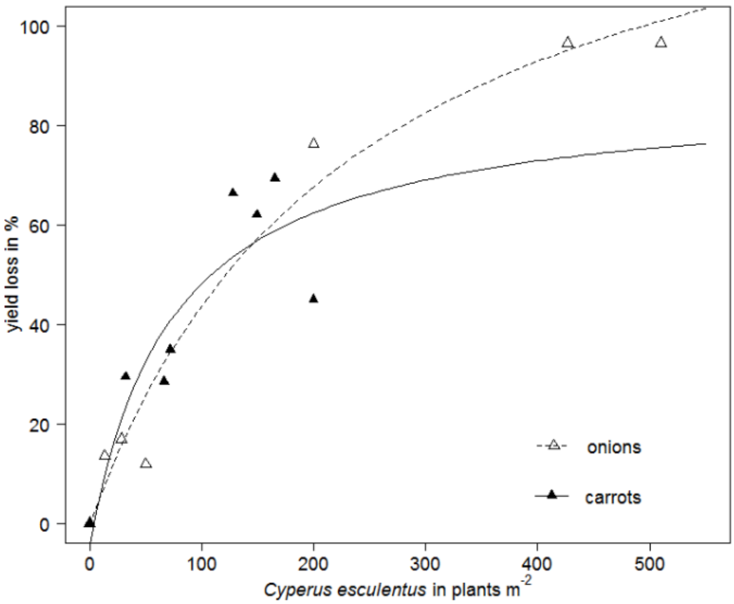

Fig. 1 Yield loss caused by Yellow nutsedge (*C. esculentus*) in summer onions and carrots in 2015.

Fig. 1 *Ertragsverluste durch Erdmandelgras (*C. esculentus*) in Sommerzwiebeln und Karotten 2015.*

In carrots and onions high *C. esculentus* densities resulted in high yield losses (Fig. 1). In onions, a coverage of almost 100% (i.e. 427 and 510 plants m^{-2}) resulted in a yield loss of 97%. Whereas a coverage of about 90% (200 plants m^{-2}) resulted in a yield loss of 76%. For carrots, 128 to 200 *C. esculentus* plants m^{-2} resulted in a yield loss of 61%.

Tab. 1 Actual yield losses caused by yellow nutsedge (*C. esculentus*) in vegetable and arable crops in Switzerland.

Tab. 1 *Ertragsverluste durch Erdmandelgras (*C. esculentus*) in Gemüse- und Feldfrüchten in der Schweiz.*

			Coverage [%]	Density [plants m^{-2}]	Actual yield loss [%]
Potato	2013	3[b]	47	-	39
	2014	5[b]	40	-	28
Sugar beet	2013	3[c]	77	-	62
	2014	5[d]	58	-	71
Leek	2014	3[e]	100	620	86
Brussels sprouts	2016	5[f]	40	-	62
			80-90	-	93

[a] Number of samples taken per category, [b] 2 m of a ridge was harvested per sample, [c] 4 m of a row was harvested per sample (7 plants per sample), [d] 2 m of a row was harvested per sample, [e] 2 m of a row was harvested, [f] 5 neighboring plants were harvested per sample.

Discussion

Actual yield losses were determined in Swiss fields by sampling yields of crops in self-established *C. esculentus* patches and in field areas without infestation. As a consequence, yield differences between infested and non-infested areas caused by other factors such as compacted soil or water logging cannot be ruled out. However, *Cyperus esculentus* thrives generally and especially fields and field areas where the crop suffers also due to the aforementioned factors (common observation). Thus, this data is realistic and relevant to farmers.

Transplanted crops tend to tolerate higher infestation levels than seeded ones. For example, we could not observe any tangible yield loss in transplanted lettuce at *C. esculentus infestation* levels of 40 plants m^{-2} (15% coverage), whereas a slightly lower infestation level in seeded corn salad resulted in complete crop failure (data not shown).

The determined losses were similar or tended to be higher than the yield losses found in North America (e. g. KEELEY, 1987; KEELING et al., 1990; FELIX and BOYDSTON, 2010). The yield loss data reviewed by KEELEY were usually calculated based on untreated control plots (1987). In contrast, our data was derived from fields with intensive chemical weed control, which is comparable to other Swiss regions and other regions in Western Europe. *C. esculentus* is a weed which profits generally from intensive weed control as other weeds are removed and thus competition by shading is reduced (STOLLER, 1981; BRYSON and CARTER, 2008).

Apart from the quantitative actual yield losses, *C. esculentus* caused also qualitative yield losses. For example the Brussels sprouts from heavily infested field areas (coverage 80-90%) were very small and thus not marketable. The same was the case for the leek crop. In contrast, in onions the yield loss calculated based on weight and on marketable onions was similar. In carrots, rhizomes of *C. esculentus* can penetrate and grow through the roots. The same is the case for potatoes. We even observed tuber formation of *C. esculentus* within potato tubers, which had also been reported by FELIX and BOYDSTON (2010).

Apart from the quantitative and qualitative yield losses, *C. esculentus* infestation causes nuisances such as extra costs and extra work to control *C. esculentus* and to prevent its further spread. In addition, high *C. esculentus* infestation levels cause difficulties during harvest (PRATT et al., 2003). On highly infested soils several crops cannot be successfully grown anymore. As a consequence the value of land, especially leasehold, might be substantially reduced due to *C. esculentus* infestation (ANONYMOUS, 2004). Therefore, we strongly advise weed scientists and federal consultants of countries and regions which are not (heavily) affected by *C. esculentus* yet to inform and train farmers, to raise their awareness for the risks which this weed poses, as well as to establish strict control measures.

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