Implementation of control strategies against yellow nutsedge (*Cyperus esculentus* L.) into practice

Einführung von Bekämpfungsstrategien gegen Erdmandelgras (Cyperus esculentus L.) in der Praxis

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DOI 10.5073/jka.2018.458.027

Abstract

Yellow nutsedge (*Cyperus esculentus* L.) is one of the most dangerous weeds in agriculture because of its high multiplication potential, its high risk of tuber dispersal with vehicles and machines and because of its limited control options. Yellow nutsedge control must always aim to prevent the formation of new tubers. Our control strategy is adapted to various infestation levels, which we distinguish "initial infestation", "small infested zone" and "infested field". In the case of "infested fields" questions arise on adaptation of the rotation or even on abandonment of crops. Our experiences showed that only s-metolachlor had good efficacy in reducing considerably the number of tubers. Less effective herbicides left back a number of surviving plants, themselves forming at least a reduced number of new tubers. The proposed control strategies are currently tested in a nationwide network of pilot fields in Swiss agricultural practice. The tuber numbers counted after the first year of control measures did not change dramatically. We observed a slight increase in tuber numbers in almost a third of the fields. The reduction of tuber numbers in the rest of the fields was lower than expected. Inaccurate estimation of the infestation level is always very likely, because the young shoots visible don't give a reliable image on the real number of tubers in the ground. For improving the control strategies in regard to the reduction of tuber numbers, we recommend the combination of herbicide treatment, soil cultivation and competition by cover crops.

Keywords: Cover crop, herbicide, number of tubers, soil cultivation, yellow nutsedge

Zusammenfassung

Erdmandelgras (*Cyperus esculentus* L.) ist wegen seines hohen Vermehrungspotentials, der großen Verschleppungsgefahr von Wurzelknöllchen und den eingeschränkten Bekämpfungsmöglichkeiten als gefährliches Unkraut einzustufen. Das Ziel der Bekämpfung muss immer die Verhinderung der Neubildung der Knöllchen sein. Die Bekämpfungsstrategie ist an verschiedene Verseuchungsgrade angepasst. Wir unterscheiden zwischen „Erstbefall", „kleinem Befallsherd" und „verseuchten Feldern". In den verseuchten Feldern stellen sich Fragen zur Anpassung der Fruchtfolge oder zur Sanierung von Feldern. Unsere Erfahrungen zeigen, dass nur S-Metolachlor bezüglich der Reduktion der Knöllchenbildung gut wirksam war. Schlechter wirkende Herbizide lassen viele überlebende Erdmandelgräser zurück, die – wenn auch reduziert – weiter Knöllchen bilden. Mit einem Schweiz-weiten Netz von Pilotfeldern im Rahmen eines vierjährigen Praxis-Versuches sollen die vorgeschlagenen Strategien in der Praxis getestet werden. Die Knöllchenzahlen nach 1 Jahr zeigen, dass auf unseren Versuchsparzellen in den Pilotfeldern die Menge der Knöllchen zwar kaum zunimmt, sich aber langsamer als erwartet verringert. Die auf dem Feld sichtbaren Erdmandelgras Triebe lassen nur beschränkt Rückschlüsse über den Befallsgrad mit Knöllchen zu, was leicht zu Fehleinschätzungen führen kann, wie ein praktisches Beispiel zeigt. Zur Erhöhung der Wirksamkeit hinsichtlich der Reduktion der Knöllchenzahlen, empfehlen wir die Herbizidwirkung mit der Bodenbearbeitung und der Ansaat einer Gründüngung zu kombinieren.

Stichwörter: Bodenbearbeitung, Erdmandelgras, Gründüngung, Herbizid, Knöllchenzahl

Introduction

One of the world's worst weeds

Yellow nutsedge (*Cyperus esculentus* L.) is listed in Switzerland on the black list of invasive neophytes (INFOFLORA, 2017). It is an annual monocotyledon of the *Cyperaceae* family – also known as sedges – producing numerous root tubers for its multiplication in one year. Worldwide it has been ranked as the 16th worst weed (FOLLAK et al., 2016; HOLM et al., 1991). The small tubers, which are frost tolerant hibernating propagules contribute primarily to its dispersal. Due to their

longevity they provide a perennial character to the annual grass. Tuber producing plants rarely grow from seeds (LAPHAM and DRENNAN, 1990). As an exception among other invasive alien species, yellow nutsedge invades solely agricultural areas with all type of crops.

Often undiscovered until it becomes dominant

The risk of confusion with millets is high in the early stage of development. Typical characteristics for yellow nutsedge are the greenish yellow color and the strong leaf tips (SCHMITT and SAHLI, 1992). The weed remains often undiscovered until somewhere in the field dense populations occur. In such places in the second year after the infestation numerous pin head to pea sized tubers may be found. One single tuber can form several shoots, but not every tuber germinates in spring. A tuber can remain dormant for several years in the soil. A shoot starts forming daughter shoots in spring. A small trial in big pots gave a multiplication rate of 1/746 tubers in one year in undisturbed conditions (BOHREN and WIRTH, 2015). Unintentional spread of tubers starts from the very first infestation. Because tubers cannot be mechanically destroyed in the soil, all control measures must aim the green parts and the roots of the plant in order to prevent the formation of new tubers. Conventional graminicides don't show any efficacy against yellow nutsedge, therefore the choice of herbicides with its limited crop selectivity diminishes dramatically the number of control options.

The control strategies – an overview

The goal is always to prevent the formation of new tubers. The strategies include preventive measures for stopping the unintentional spread of tubers as well as a step by step approach adapted to the infestation level. Together with specialists from the cantonal plant protection services Agroscope has developed a technical data sheet about yellow nutsedge control (BOHREN, 2016).

Listed below are terms used for describing the step by step approach according to the infestation levels:

- „*initial infestation*" – single plants are visible
- „*small infested zone*" – parts of the field covered with a dense population
- „*infested fields*" – single plants or dense populations all over the field
- „*adapting crop rotation*" – choice of crop allowing to control yellow nutsedge
- „*restoration*" – abandonment of crop during ongoing control measures
- „*prevention of unintentional tuber spread*" – requires particular attention to all material and vehicles entering and leaving the field
- „*patience and endurance*" – consciousness and awareness that yellow nutsedge demands long term and precise control measures

Materials and Methods

Task force yellow nutsedge

The agricultural consulting organization Agridea (lead), advisors of cantonal plant protection services and Agroscope founded in 2012 a "Task Force Yellow Nutsedge" in order to offering a platform to exchange information with farmers. Based on the above mentioned strategies a four years project was launched in 2016 for introducing the control strategies into agricultural practice (Beratungsprojekt Erdmandelgras). The work is done by the cantonal plant protection services and Agroscope. It is financed by the Federal Office for Agriculture (Foag) and partially by marketing organizations (MO). The participating MO's are: the Swiss farmers union (SBV), the Swiss sugar beet producers (SVZ) and the specialist unit for sugar beets (SFZ), the Swiss potato growers (VSKP), the Swiss Cereal Growers (SGPV), the Swiss vegetable growers (VSGP), BioSuisse Basel, SwissTabac Posieux and the association of agricultural contractors (SVLT).

The project has two main goals: 1) the proposed strategies are tested within a nationwide network of pilot fields. 2) Workshops run by the cantonal plant protection services and Agridea present information on yellow nutsedge control to farmers. Print media articles, internet pages and special initiatives such as financial contribution to a sugar beet harvester to be exclusively used in infested fields should attract attention of farmers to the yellow nutsedge problem.

On farm pilot fields

Farmers provided a total of 15 pilot fields (Tab. 1 and 2) to the project in the cantons Bern, Fribourg, Neuchâtel, Solothurn, St. Gallen, Ticino and Zürich. The pilot fields 1A and B, 8A and Bas well as 14A and B are in fact on the same plot. In close collaboration with cantonal advisors the farmers adapted their cultivation methods with regard to better efficiency of yellow nutsedge control.

Tab. 1 Overview on cultivation methods differing from the "late maize drill strategy" proposed by Agroscope.
Tab. 1 *Übersicht über Anbaumethoden, welche von der von Agroscope empfohlenen Strategie "späte Maissaat" abweichen.*

pilot-field	crop	strategy	specialities	main sector
1a	maize	late maize drill	incorporation of 2 l/ha Dual Gold® (720 g/l S-metolachlor) before late maize drill	arable farming
1b	maize	late maize drill		arable farming
2	lettuce, fennel	on farm	intensiv soil cultivation before crop and hand-weeding in crop; 0.5 l/ha Linturon® (450 g/l linuron) post in fennel and lamb's lettuce	vegetables
3	maize	late maize drill	incorporation of 2 l/ha Dual Gold® before late maize drill	vegetables
4	maize	late maize drill		arable farming
5	maize	late maize drill		arable farming
6	maize	late maize drill		arable farming
7	maize	late maize drill		arable farming
8a	maize	early maize drill	1.4 l/ha Frontier X2® (720 g/l dimethenamid-P)	vegetables
8b	maize	early maize drill	2 l/ha Dual Gold®	vegetables
9	maize	late maize drill	incorporation of 2 l/ha Dual Gold® before late maize drill	arable farming
10	maize	late maize drill		arable farming
11	zucchini	on farm	intensiv soil cultivation before crop and handweeding in crop; no herbicide	vegetables
12	soya org.	on farm	1x cultivator and 2x disc harrow pre, 1x tined weeder and 3x finger weeder post emergence	arable farming
13	w.wheat org.	on farm	no measures	arable farming
14a	maize	on farm	maize drilled end of April after incorporation of 2 l/ha Dual Gold®	arable farming
14b	maize	late maize drill	maize drilled end of May after harrowing mid-April and incorporation of 2 l/ha Dual Gold® before drill	arable farming
15	w.wheat	on farm	April and July 25 g/ha Monitor® (80% Sulfosulfuron)	arable farming

The strategy "late maize drill" developed from Agroscope was applied on 9 of 15 farms participating to the project. In early spring a stale seedbed is prepared, followed by an additional soil cultivation to destroy yellow nutsedge at the 2-5 leaf stage. Immediately before late sowing (end of May) a herbicide (2 L/ha Dual Gold®, 960 g/L s-metolachlor) is incorporated. Post emergence control – mechanical or chemical at farmer's option – follows in consideration of getting the best possible efficacy against yellow nutsedge.

The farmer of pilot field 2 cultivated the soil intensively before each crop sowing (fennel, head lettuce and lamb's lettuce), weed control in crop was done mechanically and by hand and finally

linuron was applied on fennel and lamb's lettuce. On farm 8 two different herbicides were used. On 8A 1.4 l/ha Frontier X2® (720 g/L dimethenamid-P) was incorporated before sowing and on 8B it was 2 l/ha Dual Gold®. On farm 11 the zucchini crop was weeded by hand only after intensive soil cultivation without applying a herbicide. The farmers of the organic farms with pilot fields 12 and 13 harrowed the soya crop (12) three times post emergence with a finger weeder; the winter wheat (13) was not weeded at all in spring 2016. Pilot field 14 was divided into two parts: 14A maize was drilled by end of April after incorporation of 2 L/ha Dual Gold®, in 14B the same was done but one month later, after having in the meantime harrowed the soil following the "late maize drill" method. The farmer of pilot field 15 treated the wheat in April 2016 with 25 g/ha Monitor® (80% sulfosulfuron) and repeated the same treatment at the end of July with an additional wetting agent. Winter rye was installed as green cover in August after harvesting the wheat.

Soil sampling for determination of tuber numbers

On every pilot field four 6m x 6m test plots were established and their GPS coordinates were registered. The test plots were placed according to the farmer's information in homogenously infested zones in his field. In spring 2016 six soil samples were taken from each test plot which amounted to 24 soil samples per pilot field. For each soil sample three cores were randomly taken with a soil auger (10-cm diameter) to a mean depth of 20 cm as most tubers can be found in this upper soil layer. The three cores were mixed together in the field and 1 liter of that soil mix was washed and sieved (1 mm mesh) in the lab for tuber count. In autumn 2016 the sampling on the same test plots was repeated the same way. The results of the two samplings are presented in table 2. Sampling will be repeated in autumn 2017, 2018 and 2019.

Considering a mean sampling depth of 20 cm in our test plots, one tuber per liter soil represents around 200 tubers per square meter.

Results

Nationwide network of test plots – report from the first year

Table 2 shows the development of the numbers of tubers from the test plots of 18 pilot fields on 15 farms during the first of four years of trials. The nationwide network evaluates the efficiency of a control strategy developed by Agroscope against yellow nutsedge. Beside two exceptions the differences between the tuber counts in spring and in autumn 2016 are not significant.

The Agroscope strategy "late maize drill" with incorporation of Dual Gold® before planting of maize was applied in 10 of 18 pilot fields in 2016. A significant decrease in tuber numbers was observed in two of these pilot fields (8B and 14B) only. In pilot field 10 we did not find any tubers – see discussion. In the pilot fields that were conducted with the farmer's operating methods all fields showed a non-significant change (either decreasing or increasing) in tuber numbers at the end of the first trial period.

The pilot fields 1 A/ B, 8 A/ B and 14A/B allow some special observations: in test plots 1A located in a heavy infested zone of the field 1 more than 10 tubers/liter soil and in test plots 1B of the same field less than 5 tubers/liter soil were counted. The tuber numbers did not change significantly.

The pilot fields 8A and B are situated side by side on the same field 8. The only difference was the choice of herbicide (8A = dimethenamid-P, 8B = s-metolachlor). The incorporation of s-metolachlor, proposed by Agroscope, led to a significant reduction of the tuber number.

Tab. 2 Number of tubers per liter soil (24 samples / pilot field) at the beginning and at the end of 2016, the first count of four during a four years project with pilot fields distributed throughout Switzerland. The crop was selected by the farmer and the advisor of cantonal plant protection service. The strategy "late maize drill" included several passes for soil cultivation and the incorporation of Dual Gold® (960 g/L s-metolachlor) before late maize drill. This and the various "on farm" strategies are explained in the text.

Tab. 2 *Knöllchenzahlen pro Liter Erde (24 Proben/Pilotfeld) zu Anfang und zu Ende des ersten Jahres eines vierjährigen Praxis-Versuches auf Pilotfeldern in der ganzen Schweiz verteilt. Die Kultur auf dem Pilotfeld wurde vom Landwirt zusammen mit dem kantonalen Berater gewählt. Die Strategie „späte Maissaat" beinhaltet mehrere Bodenbearbeitungen und die Einarbeitung von 2 l/ha Dual Gold® (960 g/l S-Metolachlor) vor der späten Maissaat. Diese und die verschiedenen Strategien „Betrieb" sind im Text beschrieben.*

			tuber numbers per liter soil (t-Test)				
pilot field	crop	strategy	spring 2016	s.error	autumn 2016	s.error	estimated tuber numbers from spring to autumn 2016 per m^2 and 20 cm depth (=200 l soil)
1a	maize	late maize drill	10.71	1.9	10.96	1.8	2142 - 2192
1b	maize	late maize drill	4.25	0.8	4.08	0.7	850 - 817
2	lettuce, fennel	on farm	0.63	0.2	0.29	0.2	125 - 58
3	maize	late maize drill	0.50	0.2	0.71	0.2	100 - 142
4	maize	late maize drill	10.75	1.7	8.63	1.4	2150 - 1725
5	maize	late maize drill	0.79	0.2	0.33	0.1	158 - 67
6	maize	late maize drill	0.42	0.1	0.33	0.2	83 - 67
7	maize	late maize drill	0.08	0.1	0.00	0.0	17 - 0
8a	maize	early maize drill	8.13	1.6	6.17	1.5	1625 - 1233
8b	maize	early maize drill	4.13	0.6	2.08 **	0.3	825 - 416
9	maize	late maize drill	0.58	0.2	0.75	0.3	117 - 150
10	maize	late maize drill	0.00	0.0	0.00	0.0	0 - 0
11	zucchini	on farm	0.92	0.2	0.96	0.4	183 - 192
12	soya org.	on farm	1.04	0.4	0.50	0.2	208 - 100
13	w.wheat org.	on farm	3.83	0.7	5.29	0.7	767 - 1058
14a	maize	on farm	0.17	0.1	0.25	0.2	33 - 50
14b	maize	late maize drill	4.04	0.7	1.58 **	0.3	808 - 316
15	w.wheat	on farm	0.46	0.2	0.63	0.3	92 - 125

The pilot fields 14A and B are as well situated side by side. The efficiency of the farmer's strategy (14A, early maize drill) and the Agroscope strategy (14B) can be compared. The first harrowing was done on 14A and 14B at the end of April; the herbicide Dual Gold® was incorporated and maize was drilled immediately after the first harrowing in 14A. After the first harrowing in 14B by end of April the Agroscope strategy allowed the yellow nutsedge in a stale seedbed to develop 2-5 leafs before a second harrowing was added by mid-May. Again after two weeks yellow nutsedge was a second time severely disturbed with the incorporating the herbicide Dual Gold® before maize drill. A significant reduction of tuber numbers resulted from the application of the Agroscope strategy (14B).

Winter wheat on pilot field 15 was treated two times with Monitor®. No reduction of tuber numbers was observed. The effect of the rye green cover sown in autumn 2016 will be observed with the sampling in autumn 2017.

The farmers of the pilot fields 2, 11-13 and 15 were not prepared to adapt their rotation proposed by the cantonal advisor. Some had no use for maize silage or maize grain (2, 11-13). For some farmers yellow nutsedge is not a problematic weed (11-13) and one had other reasons for keeping to his planned rotation (15).

The mean tuber numbers differed in all pilot fields in spring 2016 between 0.00 and 10.71 per liter soil even though the farmers selected the most infested zones on their fields for the establishment our test plots. The tuber numbers within the 24 samples of one pilot field differed most in field 8A, in spring between 30.00 (1 sample) and 0.00 (2 samples) and in autumn between 35.00 (1 sample) and 0.00 tubers (2 samples) per liter soil. This indicates an important heterogeneity in the tubers distribution within the fields.

Discussion

A short history on yellow nutsedge in Switzerland

Three locations with stands of yellow nutsedge were known in Switzerland thirty years ago: the arable zones south of the Alps in the canton Ticino and two small locations in the cantons Bern and Zürich (SCHMITT and SAHLI, 1992). In the last 10 to 15 years yellow nutsedge expanded tremendously in the farming areas north of the Alps. This increase had several reasons. Since around 30 years Swiss agriculture is undergoing drastic structural changes. In the last decade of the previous century we recorded around 90 000 mainly versatile farms, today around 50 000 increasingly specialized farms are counted. The labor force on farms decreased drastically. Nowadays 4 of 5 field operations are done by contractors or machinery rings (LID). Soil and harvest residues containing weed seeds or propagules sticking to machines and wheels find their way further and further beyond the range of an individual farm. This is due to the increasing mechanization and the lack of time accorded to the attention to the details. Around 10 years ago yellow nutsedge appeared as a problematic weed in regions with intensive vegetable production (BOHREN and WIRTH, 2013). Today the weed is present well outside of these regions (INFOFLORA).

Yellow nutsedge control requires high precision

The high multiplication potential, the high risk of displacing tubers by field works and the limited control options are the main reasons to declare yellow nutsedge as a dangerous weed. All control measures must always aim precisely in preventing tuber formation and the reduction of the tuber numbers in the soil.

If it is detected at early stages an "initial infestation" can be controlled by uprooting single plants with their roots. Plants, roots and soil containing tubers need to be disposed in a way that tubers never develop new plants again. In subsequent years the infested zone need to be periodically controlled for the emergence of new shoots.

It is important to mark "small infested zones" and exclude them from further cultivation in order to prevent unintentional spread of tubers. These zones have to be treated with herbicides (single plant treatment) or sterilized with hot steam deeper than the standard ploughing depth. Also here the control for new shoots in subsequent years is absolutely mandatory.

Considering "infested fields" the question arises whether the normal crop rotation should be interrupted or not. If yes, the strategy "late maize drill" is the best because it allows at least a reduced maize yield. The date of maize sowing is delayed for 3-4 weeks for enabling yellow nutsedge to develop. An additional harrowing and the incorporation of an herbicide before drilling is very efficient in destroying the young plants. In that case root crop production (potato, sugar beet, celery, carrots etc.) has to be rejected. Another possibility is to treat winter wheat in spring with 25 g/ha Monitor® and immediately after the harvest sowing a cover crop such as oil radish (e.g. *Raphanus sativus* var. *oleraceus*) in order to establish quickly a dense competition to weeds.

On heavy infested fields the option "restoration" should be considered as an objective. This option includes the abandonment of crop cultivation in order to enable precise yellow nutsedge control in spring. In this case yellow nutsedge can be repeatedly destroyed in the 2-5 leaf stage during spring and early summer. This is done in the absence of crops allowing full-surface field works. A

further option would be to abandon cropping in spring and re-allow cropping from early autumn. "Restoration" includes combining the positive effects of soil cultivation, herbicide treatment and competition of cover crops. To date no farmer in our network was prepared to restore his field envisaging the abandonment of crop as the loss of income is a heavy burden.

Farmers in a difficult situation

News from the professional vegetable branch about increasing yellow nutsedge problems initiated a couple of years ago Agroscope to develop control strategies. An herbicide screening in the greenhouse and in the field preceded field trials which combined soil cultivation, competition effects from cover crop and herbicide treatment (BOHREN und WIRTH, 2015). In the meantime news about new infestations from many parts of the country reached us. The "task force yellow nutsedge" offers a nationwide platform for information exchange. Early on an obligation to announce and to control yellow nutsedge was considered desirable. Accompanied by a monitoring the obligation to announce would allow the contractors to separate their machinery for work exclusively on infested fields. The obligation to control would motivate the farmer to take measures at an early stage. Until now both obligations face resistance, on the one side from the farmers and on the other side from the authorities. The discussion around these obligations revealed some interesting details: Some farmers are ashamed to announce infestation of yellow nutsedge because they fear being accused of bad agricultural practices and may have problems selling their products. An official obligation to control yellow nutsedge would entail compensations due to the additional work requested. Township, cantonal and even federal administrations demonstrate actually a reluctant attitude towards possible compensation payments of unspecified amounts. Nevertheless each and every farmer concerned should feel himself responsible for avoiding the unintentional spread of tubers within his farm and beyond.

It is all about the tubers

From June on small white bulges are formed at the end of rhizomes. These bulges may form white tubers becoming brownish until August. Very young and still white tubers are able to germinate in a petri dish. The brown and later black tubers cannot easily be detected in the field because their skin is covered with soil dust. Tubers are visible only in heavy infestations (let's say > 1000 tubers/m^2) and under the rain after ploughing. Mechanical destruction or sieving of tubers in the soil is not feasible as many soil particles have similar dimensions.

The farmer is obliged to decide on which control options he may implement only on the basis of the visible shoots. Our experience is that the number of shoots does not give a reliable indication as to the number of tubers present in the soil. Therefore the risk of bad decisions gains more weight. This observation was very clear on pilot field 10 (Tab. 2). In 2016 we found in our test plots no tubers, even though we established the plots in a zone where according to the farmer a homogenous infestation was previously observed. The advisor of the cantonal plant protection service reported that the pilot field was ploughed in winter 2015/16 before our sampling and the maize drill in spring. Without ploughing winter barley was sown after maize silage 2016 and harvested in summer 2017. Ploughing after the winter barley brought the tubers back to the surface. The subsequent artificial prairie is actually heavily infested with yellow nutsedge (personal communication M. Jenzer).

The pilot fields 8A and B are situated in Eastern Switzerland's Rhine valley on very heavy silty soils. The farmer would not have been able to apply additional soil cultivation and late maize drill due to usually wet soil conditions in spring. Instead he compared the Dual Gold® with the Frontier X2®. This year's result shows a significant reduction of tuber numbers with Dual Gold®.

The farmer's statements on pilot fields 11 - 13 (12 and 13 belonging to organic farms) with their sandy soils are remarkable. These sandy soils dry up quickly under the hot sun and allow regularly good efficiency with mechanical weeding. The soil falls quickly from uprooted plants and roots and they dry out. The farmer of fields 12 and 13 does not recognize yellow nutsedge as a

problematic weed, therefore he forwent additional control measures against yellow nutsedge. The vegetable farmer of the nearby pilot plot 11 is of the same opinion. Our survey in the first year of the trial period showed a constant amount of tubers on the three fields.

On pilot field 14 A and B the farmers strategy and the Agroscope strategy can be compared. The extra month between early (14A) and delayed (14B) maize drill allowed yellow nutsedge to develop roots and plants which were perfectly destroyed by the soil cultivation and the herbicide, leading to a significant decrease of tuber numbers.

We are looking forward to studying the future development of tuber numbers in this trial period.

Patience and persistence for yellow nutsedge control

Only a few herbicides provide good efficacy against yellow nutsedge. With s-metolachlor incorporated immediately after an application we achieved the best efficacy among the herbicides registered in Switzerland. In herbicide screening field trials sulfosulfuron also worked well when not incorporated (BOHREN and WIRTH, 2015).

Soil cultivation should be done about 20 cm deep using either a disc harrow, rotary harrow, power harrow or a seedbed cultivator to destroy new roots and plants. The major part of tubers is located in the first 20 cm. In appropriate soils and under good conditions harrowing can replace a herbicide treatment. Yellow nutsedge is sensible to shading (LOTZ et al., 1991; SANTOS et al., 1997). Competition by densely growing cover crops such as oil radish suppressed surviving plants and reduced the formation of tubers importantly (BOHREN and WIRTH, 2015).

None of the three control methods "herbicide", "soil cultivation" and "competition" is always sufficiently effective. Therefore we recommend the combination of these methods for the restoration of fields without cultivating a crop. Hoeing in row crops is detrimental because weeds within rows are not sufficiently controlled. Furthermore, there is no effective herbicide available for post emergence band treatments.

To date, there is no obligation to announce and to control C. esculentus in Switzerland. Such an obligation exists already for common ragweed (*Ambrosia artemisiifolia*). The fact of being an invasive neophyte, the increasing workload and diesel consumption and machines and tractor costs for controlling yellow nutsedge was until now (October 2017) not enough to define a common objective against this weed.

Conclusion for the agricultural practice: the control of yellow nutsedge is an endurance test on the farmer's patience and persistence.

Acknowledgements

We express our special thanks to the farmers and all members of the Task Force Yellow Nutsedge, especially Bruno Arnold and Jean-François Vonnet (Agridea), David Brugger (Swiss Farmer's Union), Martina Aeschbacher (Cantonal plant protection Service St. Gallen) and Lutz Collet (Institut agricole de l'état de Fribourg IAG) for their valuable initiatives, and we thank the Federal Office for Agriculture for the financial support.

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