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WEED HARROWING IN SEEDED ONIONS

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Summary Three experiments with weed harrowing to reduce the number of in-row weeds in seeded onions were carried out in 1994.

In the first experiment, pre-emergence harrowing was compared with pre-emergence flaming. Both methods reduced weed number by 60-70% at the first weed count 23 days after sowing, but later counts revealed that some subsequent emergence of weeds had taken place. In contrast to flaming, harrowing reduced marketable yield by 15% and the method needs to be improved before it can become an alternative to pre-emergence flaming.

In the second experiment, 5 harrows were compared for their applicability for post-emergence harrowing. The implements were working at the same intensity and none of them reduced yield significantly but the effects on *Stellaria media* varied between the harrows.

In the third experiment, the prospects of weed harrowing at later onion growth stages in July were studied. None of the treatments reduced yield and the method show promise for controlling late emerging weeds.

Zusammenfassung *Unkraut Eggen im Saat-Lauch.* Drei Versuche mit Eggen im Saat-Lauch zur Bekämpfung von Unkraut in der Reihe wurden im 1994 durchgefürht.

Im ersten Versuch wurde Vorauflauf-Eggen mit Vorauflauf-Abflammen vergleichen. Am ersten Zählung des aufgelaufenden Unkraut, 23 Tage nach der Aussaat, hatten beide Methoden das Unkraut mit 60-70% reduziert. Nachfolgende Zählungen zeigten jedoch, dass ein gewisser Nachauflauf von Unkräutern stattgefunden hatte. Im Gegensatz zur Abflammen hatte das Eggen den Ertrag mit 15% reduziert und deshalb sollte die Methode verbessert werden um eine realistische Alternative zur Vorauflauf-Abflammen zu werden.

Im zweiten Versuch wurden 5 verschiedene Eggen über ihrer Verwendbarkeit für Nachauflauf-Eggen vergleichen. Die Geräte operierten mit gleicher Intensität und keins von den Geräten hatten den Ertrag der Lauch signifikant reduziert, aber die Bekämpfungseffekte gegen *Stellaria media* waren zwischen den Eggen verschieden.

Im dritten Versuch wurden die Möglichkeiten für das Eggen im Juli auf grösseren Entwicklungsstadien der Lauch untersucht. Keine von diesen Behandlungen hatten den Ertrag reduziert, und die Methode könnte einen wertvollen Beitrag für der Bekämpfung spät aufgelaufenden Unkrauts sein.

INTRODUCTION

Seeded onions require a high degree of weed control over most of the growing season, as they develop slowly with little competitive ability against weeds. This is needed not only to avoid reductions in crop yield and quality, but also to reduce shedding of weed seeds and consequent build up of the seed bank (BAUMANN, POTTER & MÜLLER-SCHÄRER, 1993).

Non-chemical control of inter-row weeds can usually be done by means of mechanical inter-row cultivation. However, in-row weeds are much more difficult to control mechanically. In organic farming, hand-weeding is still the primary method for controlling in-row weeds and the time consumption for this method may reach 300 hours per hectare on particularly weedy fields (ASCARD, 1990). Thus, improving the mechanical control of in-row weeds has high priority for organic growing of row crops, as well as growing systems aimed at reducing pesticide usage.

In-row weed harrowing could have potential for this purpose, although there is very little documentation on this method in row crops. BAUMANN (1992) achieved more than 90% weed control without damaging the crop with post-emergence harrowing in maize in the cotyledon-stage of the weeds, but the treatments had to be repeated every time new weeds had emerged.

The objectives of this study were to make preliminary investigations on the possibilities for minimizing the number of in-row weeds in seeded onions by: pre-emergence harrowing, comparing different implements for their applicability for post-emergence harrowing, and post-emergence harrowing at later growth stages.

MATERIALS AND METHODS

Three field experiments were conducted in seeded onions (cv. 'Hyton') in 1994 on a sandy loam at the Department of Weed Control and Pesticide Ecology, Flakkebjerg. The onions were sown 2.5 cm deep on April 20 with a spacing of 50 cm between the rows and 2.5 cm in the row. The experiments were set up as randomized block designs with 4 replicates. Plot size was 2.5 m x 7.5 m, of which 4.5 m of the central rows was harvested by hand. The onions were pulled out of the soil on September 12 and dried for 16 days. Finally, they were counted and weighed and graded into two classes: marketable (40-80 mm diameter and good shape) and other not marketable onions (small and misshapen).

Both in experiment 1 and 3 harrowing was done with an *Einböck I,* (for description see experiment 2), parallel to the direction of sowing.

<u>*Experiment 1 - pre-emergence harrowing*</u>.

Experimental treatments:

1. Untreated.

2. Pre-emergence flaming at the same time as early harrowing, gas dosage approx. 60 kg ha^{-1} at a driving speed of 6 km h^{-1}.

3 a) Early harrowing, 12 days after sowing, and low intensity (4 km h^{-1}) and approx. 2 cm working depth of tines. The onions with the cotyledon tip approx. 0.5 cm below the soil surface.
  b) As 3 a) but at high intensity (6 km h^{-1}).

4 a) Late harrowing, 16 days after sowing, and low intensity as in 3 a). The onions with the cotyledon tip 0.5 to 1 cm above the soil surface.
  b) As 4 a) but at high intensity as in 3 b).

Weeds were counted 23 and 31 days after sowing in 4 fixed quadrates (0.25 m^2) per plot placed randomly. The weeds were also weighed (fresh weight) 31 days after sowing. In each plot, the area for yield assessments was kept weed free by hand-weeding from crop emergence until harvest.

<u>*Experiment 2 - comparisons of harrows*</u>

Experimental treatments:

1. Untreated
2. *Scönberger Kress* (EN 2,6 LL 2,6 L), 3 km h^{-1}.
3. *Einböck I* (FZ HE 300), 6 km h^{-1}.
4. *Einböck II* (FZ HE 150, specially equipped), 6 km h^{-1}.
5. *Rabewerk* (SE 300), 6 km h^{-1}.
6. *Jacobs*, 9 km h^{-1}

The *Scönberger Kress* is a flexible chain harrow consisting of medium and lightweight netlike parts. The *Einböck I, Einböck II, Rabewerk* and *Jacobs* are all spring tine harrows with tines of different elasticities. The *Einböck I* has relatively short and stiff tines, while the others have quite long and more flexible tines. The *Jacobs* has particularly 'soft' tines.

The harrowings were carried out 50 days after sowing the onions and were done parallel to the direction of sowing. Both pre- and early post-emergence flaming had been applied before harrowing to prevent weeds from becoming too big at the time of harrowing. At the time of harrowing, the crop plants had developed one 10-14 cm high true leaf and on some plants the second true leaf was visible. On all harrows, tines were working to a soil depth of 2-3 cm. Tractor driving speed and implements were adjusted so that approximately the same crop covering with soil was achieved with all harrows. By doing that, it was assumed that the harrows were working at the same intensity according to the work of RASMUSSEN (1991, 1992). Immediately after the treatments, the crop coverage with soil was assessed by visual scores expressed as a percentage of crop biomass covered.

In each plot, weeds were counted 2 days before treatment and again 5 days after treatment in 6 x 0.1 m^2 fixed quadrats, 1 m long and 10 cm wide. Each quadrat was placed randomly in the crop row and centred, so that the 5 cm wide and 1 m long zones at each side of the crop plants were counted. The percentage of weed control was calculated according to the reduction in plant density relative to the weed density before treatment. After having finished the weed counts, all plots were kept weed free by hand-weeding until harvest.

Experiment 3 - late post-emergence harrowing.

Experimental treatments:

1. Untreated.

2 a) First harrowing, 75 days after sowing, and low intensity (6 km h^{-1}), approx. 2 cm working depth of tines and a tine position perpendicular to the soil surface. The onions with 3 true leaves 15-20 cm high, and a fourth true leaf 3-5 cm high.
b) As 2 a) but at high intensity (9 km h^{-1}), and with the tines angled forward at 32°.

3 a) Second harrowing, 92 days after sowing, and low intensity as in 2 a). The onions with 5 true leaves 30-35 cm high.
b) As 3 a) but at high intensity as in 2 b).

2+3 Harrowing both 75 and 92 days after sowing at the two intensities mentioned.

All plots were kept weed free by pre- and early post-emergence flaming and after that by hand-weeding until harvest.

Seeds of *Sinapis arvensis* were sown 14 days before each harrowing in order to evaluate the weed control effect on emerged *Sinapis arvensis* seedlings. The seedlings were counted 1 day before and 5 days after treatment in 3 x 0.1 m^2 quadrats, 1 m long and 10 cm wide, placed similarly as in experiment 2. The percentage of weed control was also calculated as in experiment 2. Immediately after the treatments, crop coverage with soil, leaf damage, and inversion of crop plants were assessed by visual scores expressed as a percentage of crop biomass being covered with soil or damaged by the tines.

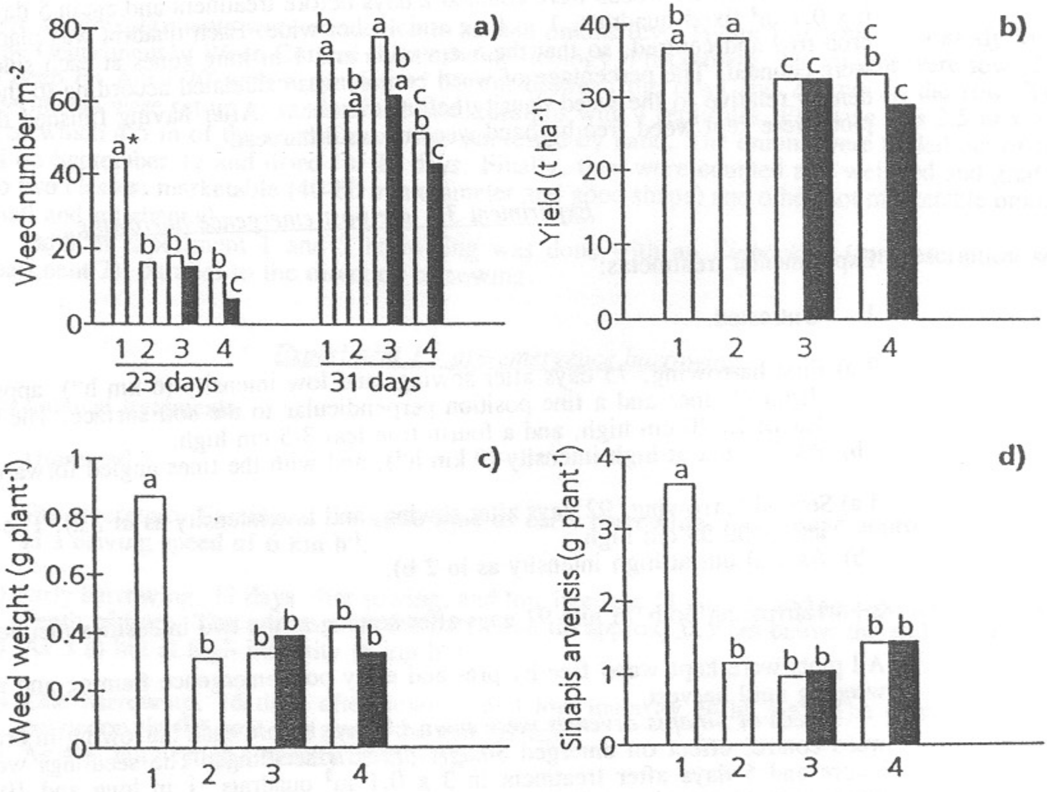
RESULTS

Pre-emergence harrowing, experiment 1

All treatments had significantly reduced the number of emerged weeds 23 days after sowing the onions (Fig. 1a). Weed number was 85% lower compared to untreated following late harrowing at high intensity, while the other treatments had reduced weed number by averagely 64%. The effects were mainly found for *Stellaria media,* as this species was most numerous among the weed species recorded. However, weed counts 31 days after sowing revealed that some subsequent emergence had taken place in all treatments, indicating that the treatments might have had a stimulating effect on seed germination.

The treatments also reduced the average weight per weed plant (Fig. 1c). Plants of *Sinapis arvensis* constituted the major part of weed fresh weight, because the other species were much smaller at the time of weighting. So, the effects shown in Fig. 1c were mainly caused by a reduction in the number of early emerging *Sinapis arvensis* plants (Fig. 1d).

Marketable onion yield was 15% lower on average after pre-emergence harrowing compared to pre-emergence flaming and untreated (Fig. 1b) with a tendency for highest crop damage after



1 = untreated; 2 = pre-emergence flaming; 3 = early harrowing; 4 = late harrowing
* columns with the same letters are not significantly different ($p<0.05$).

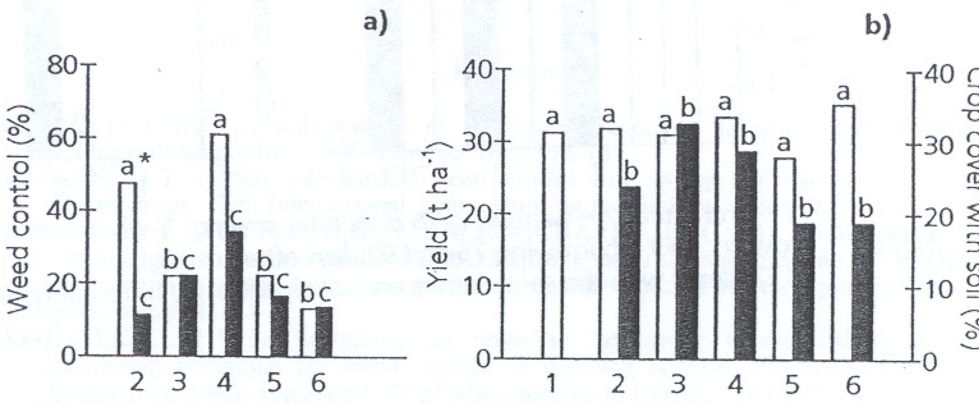
Fig. 1: Effects of pre-emergence harrowing and flaming in seeded onions on a) number of emerged weeds 23 and 31 days after sowing, b) marketable onion yield, c) fresh weight per weed plant (averaging all species) and d) fresh weight per *Sinapis arvensis* plant 31 days after sowing. □ low intensity harrowing, ■ high intensity harrowing.
Wirkungen von Vorauflauf-Eggen und Vorauflauf-Abflammen im Saat-Lauch auf a) die Dichte von Unkräutern 23 und 31 Tage nach dem Aussaat, b) Handelsfähigem Ertrag, c) und d) Gewicht pro Unkrautpflanze (Durchschnitt von allen Arten) und Gewicht pro Sinapis arvensis *Pflanze 31 Tage nach dem Aussaat.* □ *niedrige Intensität des Eggens,* ■ *hohe Intensität des Eggens.*

late harrowing at the high intensity. This yield loss following harrowing was caused by a reduction in the mean weight per onion and also to some extent in the number of onion plants.

Comparisons of harrows, experiment 2

Stellaria media was the commonest weed species recorded and the control of this species was different between the harrows (Fig. 2 a). The *Einböck II* was most effective with 60% control, while the *Jacobs* only controlled 16%. Most *Stellaria media* plants had developed 2 true leaves at the time of harrowing. There was no obvious relationship between control of *Stellaria media* and crop cover with soil. The control of the other weed species in the experiment was not significantly affected by the harrows tested and therefore the results are pooled over species (Fig. 2 a). The majority of these weed species had developed from 2 to 4 true leaves, while *Sinapis arvensis* had developed from 2 to 6 true leaves at the time of treatment. As with *Stellaria media,* the *Einböck II* tended to be more efficient than the other harrows.

Marketable onion yield was not significantly affected by any of the harrows in spite of 20 to 30% crop coverage with soil (Fig. 2 b). No significant differences in crop cover with soil were recorded between the harrows. Some crop plants were uprooted, but soil coverage appeared visually to be the main effect of crop damage. Generally, there was a tendency for a lower plant number and higher weight per onion after harrowing, indicating that plant kill was compensated by an increased growth among remaining plants due to an increase in space.



1 = untreated; 2 = Scönberger Kress; 3 = Einböck I; 4 = Einböck II; 5 = Rabewerk; 6 = Jacobs.
* Columns with the same letters are not significantly different ($p<0.05$).

Fig. 2: Comparisons of the performance of 5 different harrows. The percentage control of a) *Stellaria media* (☐) and other weed species (■) after harrowing. Marketable onion yield (☐) and crop cover with soil (■) following harrowing in b).
Vergleichen von das Verwendbarkeit von 5 verschiedenen Eggen für Nachauflauf Anwendung im Saat-Lauch. Bekämpfungseffekt gegen a) Stellaria media (☐) *und übrigen Unkräutern* (■). *b) Handelsfähiger Ertrag* (☐) *und das Zudecken* (■) *den Kulturpflanzen mit Erde nach dem Eggen.*

Late post-emergence harrowing, experiment 3

Harrowing at the first time and the low intensity controlled 23% of the *Sinapis arvensis* seedlings, whilst 47% were controlled at the high intensity. The *Sinapis arvensis* seedlings were mainly at the cotyledon stage, but some were beginning to develop the first 2 true leaves. No records on weed control were obtained for harrowing at the second time, because of inadequate germination among the sown *Sinapis arvensis* seeds.

None of the late post-emergence harrowings reduced yield significantly (Fig. 3a). On the contrary, there was an indication of an yield increase following harrowing. Visual scores of crop damage shown in Figure 3b were only high at the first harrowing and highest intensity. At that time crop damage was mainly seen as soil coverage of onion leaves, whereas at the second time of harrowing crop damage was primarily seen as a breakage of leaves and inversion of crop plants. Nevertheless, the onions have recovered from these visual symptoms of crop damage and it seems that harrowing at relatively late growth stages can be performed without any severe crop damage or loss of yield.

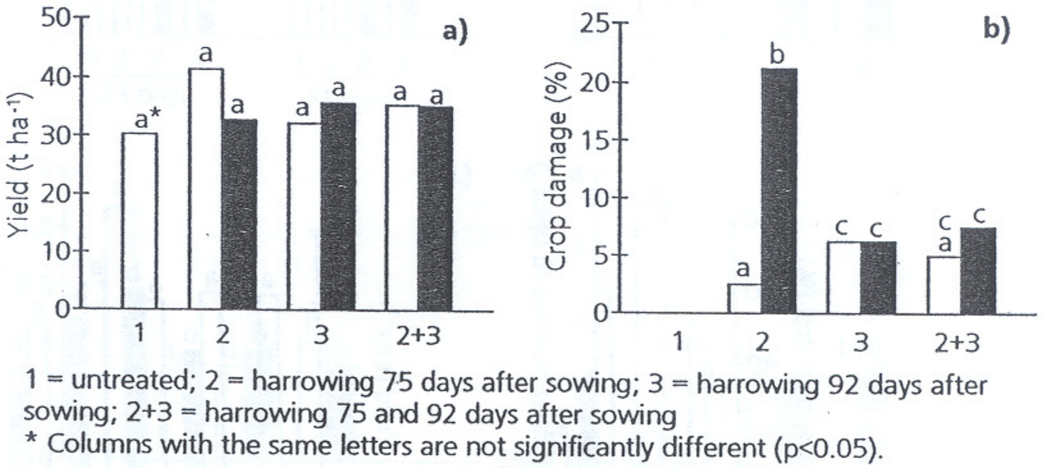


Fig. 3: Effect of late post-emergence harrowing on a) marketable onion yield and b) visual scores of the associated crop damage. □ low intensity harrowing, ■ high intensity harrowing.
Die Wirkung von spät eingesetztem Eggen im Saat-Lauch auf dem a) Handelsfähigen Ertrag und b) die visuelle Beurteilung des nachfolgenden Schäden an der Kulturpflanzen. □ niedrige Intensität, ■ hohe Intensität.

DISCUSSION

Pre-emergence harrowing controlled the weeds to the same extent as pre-emergence flaming and the level of control tended to increase when harrowing was done close to crop emergence. Pre-emergence harrowing delayed weed emergence, as did pre-emergence flaming, and emerged weeds were markedly smaller than in the untreated plots which can be very important for the success of mechanical treatments later on. It seems that pre-emergence harrowing might be an alternative to pre-emergence flaming, but more experiments and a better understanding of the impact on crop yield are certainly needed.

Both this study and those of VESTER (pers. comm.) demonstrated the sensitivity of the onions to pre-emergence harrowing. Apparently, the risk of significant crop damage from pre-emergence harrowing is particularly high in the period just before crop emergence.

Also harrowing at early crop growth stages within the first two weeks after crop emergence might damage the onions severely (ASCARD, pers. comm.; VESTER, pers. comm.). However, weed control in this period is very important in order to prevent the first flush of weed seedlings becoming too big for subsequent treatments. BAUMANN (1992) suggests on the basis of his work in maize, peas, and beans that gentle harrowing (low driving speed and tine pressure) should be done at the cotyledon-stage of weeds and repeated every time new weeds emerge. This strategy should minimize the risk of crop damage, but whether such a strategy would be appropriate in seeded onions is an open question.

The comparisons of harrows were not so successful, as equal intensities of harrowing, which were assessed from the crop cover with soil, were not fully achieved. However, the results for *Stellaria media* indicate that there might be some differences in the selective mode of operation between harrows. This is in contrast to the conclusions for weed harrowing in cereals by RASMUSSEN (1992). More work is required to study this aspect.

The weed control levels obtained with post-emergence harrowing were generally low in this study. The intensities of harrowing used were not high enough to adequately control weeds that obviously had become too big. However, onion yield was not reduced and it seems possible to further increase the intensity of post-emergence harrowing at the growth stages studied. Probably, the concept of selective harrowing introduced for cereals by RASMUSSEN & SVENNINGSEN (1994) could also be relevant for weed harrowing in onions. However, there is a need for a better description of the actual intensity of harrowing when the harrow is operating in the field. Visual scores by different individuals of soil coverage, leaf breakage, and inversion of plants appear to be very subjective. Thus, better quantification of what the harrow is actually doing to the crop when operating are worth considering in future research.

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