COMBINATION OF DIFFERENT METHODS FOR DIRECT CONTROL OF *VICIA HIRSUTA* IN WINTER WHEAT

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Abstract

Combinations of three different direct methods for controlling *Vicia hirsuta* (kainite application, flame weeding and harrowing) were investigated in field experiments. They were based on different strategies at early growth stages of *V. hirsuta* and standardised harrowing at late growth stages. The highest efficacy of kainite application and flame weeding was achieved at the one leaf stage of *V. hirsuta*. Winter wheat regeneration from damage caused by both kainite and thermal control was satisfactory when treatments were applied at early growth stages (GS 23). *Vicia hirsuta* plants that survived kainite application or flame weeding were successfully controlled by repeated harrowing at later crop growth stages; crop growth was not affected. Seed production of *V. hirsuta* declined with increasing harrowing in all treatments; however the strongest and most reliable reduction was achieved when flame weeding had been previously applied. All combinations of direct measures reduced winter wheat grain-yield losses and enhanced thousand-grain weight more efficiently than the use of a single method only. The highest wheat-grain yield was gained after repeated harrowing (3 times) both with and without kainite application.

Introduction/Problem

Under organic farming conditions in Germany, hairy tare (*Vicia hirsuta* (L.) S. F. Gray) is a very common weed, especially in low-competitive winter cereals. Heavy infestation with this climbing legume can cause serious problems at harvest, resulting in reduced crop yield and product quality. Indirect control measures are often not sufficient to suppress it efficiently (Eisele 1996). Results of former investigations (Lukashyk *et al.* 2004) show that a single direct weed control using either kainite or flame weeding at early growth stages was not sufficient to reduce seed production of *V. hirsuta* when the infestation level was high. Moreover, *V. hirsuta* plants surviving the treatment were able to produce a higher amount of biomass and a larger number of seeds. Consequently, there is also an urgent need to control *V. hirsuta* at later growth stages. During 2001 and 2003, the efficacy of single applications of the three measures kainite application, flame weeding and harrowing were compared in field trials. The main aim of the investigations presented here was to test combinations of the different direct methods to reduce *V. hirsuta* density in early crop growth stages (kainite, flame weeding) and to control residual surviving *V. hirsuta* plants by harrowing in later growth stages.

Methodology

A one-factorial field experiment combining kainite application, flame weeding and harrowing as control measures was conducted in winter wheat with four replications and plot sizes of 1.5 x 9 m. The trial site was located at the Organic Research Farm 'Wiesengut' in North-Rhine Westphalia, Germany (50°48’N, 7°17’O). Kainite application and flame weeding were performed on the basis of former experiments in the years 2002 and 2003. The treatments with flame weeding (Reinert Company, A 311 HB, 3 burners SB 500/i) and kainite (59 % NaCl, 17 % KCl and 16 % $MgSO_4$, Kali & Salz GmbH 2002) were applied once at growth stage (GS) 23 of winter wheat under dry weather conditions. The concentration of the kainite solution was 350 g l^{-1} (230 kg kainite ha^{-1} = 21 kg K ha^{-1}, 660 l ha^{-1}). Flame weeding was conducted at low speed (1.5 km h^{-1}, gas consumption 41 kg ha^{-1}) in order to ensure sufficient damage to the weeds. The crop ground cover at GS 23 was relatively high at about 50-55 %. The spring-tine harrow (Einböck) was applied at GS 32, 47 and 61 of the crop once,

repeatedly and in combination with kainite or flame weeding, respectively. Winter wheat was harrowed with soil contact at GS 32 and combed (10-15 cm above soil surface) at GS 47 and 61. Harrowing speed was 5 km h^{-1} (speed limit of equipment). Hand-weeded control plots were used to estimate the influence of *V. hirsuta* on grain yield. The parameters assessed were plant density and seed production of *V. hirsuta*, crop ground cover, crop damage, and regeneration and yield of winter wheat.

Results and brief discussion

The efficacy of the kainite application was substantially lower than that of the thermal weed control (42 and 88 %, respectively). This was probably due to the poor adhesion of the kainite solution. The optimal application of kainite solution still requires further investigation. Growth stage of *V. hirsuta* at treatment time strongly influenced the efficacy. The highest reduction of *V. hirsuta* plants was achieved at the one-leaf stage of the weed, with an efficacy of 76 and 96 % after kainite application and flame weeding, respectively (Figure 1). The higher kainite and thermal sensitivity of younger plants was also found in investigations of Vasters & Remy (1914), Ascard (1994) and Leroux *et al.* (2001), which are in agreement with our results. The younger plants are more susceptible, mainly due to thinner leaves, thinner layers of hairs and wax, lower biomass and less well protected meristems compared with older plants (Lien *et al.* 1967, Parish 1990, Vester 1990).

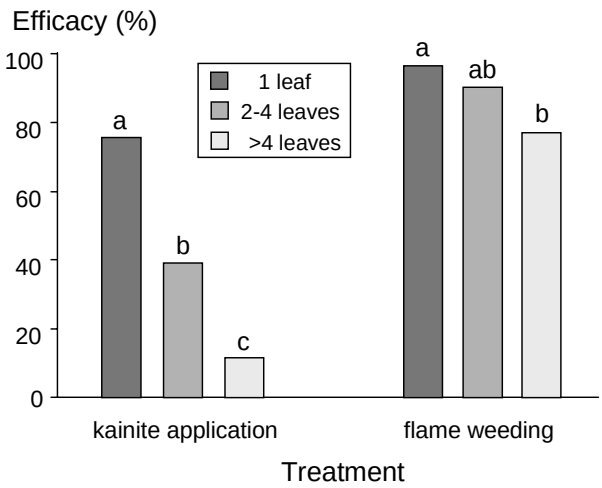

Figure 1: Efficacy of kainite application and flame weeding on density of *V. hirsuta* in winter wheat (GS 23), 8 days after treatment. Weed density of control (no weed control) = 47 plants per m^2. Different letters within treatments indicate significant differences (Tukey test, $\alpha = 0.05$).

Treated *V. hirsuta* plants with more than 4 leaves were able to regenerate even after complete desiccation of the shoots. The ability of these damaged plants to regrow was likely due to a larger amount of assimilates in the roots, higher water availability, and low competition by neighbouring plants.

Leaf area of winter wheat was reduced by 20 % and 60 % after kainite application and thermal weeding, respectively. Wheat stands recovered rapidly from theses injuries. Three and 6 weeks after the application of kainite and flame weeding, crop ground cover in the treated plots was not significantly different compared to that of the untreated plots. These findings confirm the results of Ascard (1995). Monocots like winter wheat with protected growing points that are located near the soil surface were able to reproduce shoots rapidly after damage.

Two weeks after kainite application and flame weeding, a considerable number of *V. hirsuta* plants germinated (average 16 plants per m^2). Surviving and newly germinated *V. hirsuta* plants were successfully controlled by single or repeated harrowing, which damaged the plants especially by

breaking off branches or pulling out the stems. The winter wheat was not affected by repeated harrowing.

Single harrowing at both GS 32 and GS 47 was also able to control *V. hirsuta* sufficiently. However, the efficacy was lower than that of a combination of different direct control methods, because a high number of entwining *V. hirsuta* plants were not reached by the tines. The winter wheat was sometimes injured by the harrow, which frequently pressed down the crop stand.

Both kainite application and flame weeding significantly reduced *V. hirsuta* biomass and seed production (Figure 2). Weed seed production in plots treated with kainite was higher than in the plots treated with flame weeding. This can be explained by the lower efficacy of the kainite application with respect to *V. hirsuta* density compared with that of flame weeding (Figure 1). Seed production of *V. hirsuta* generally declined with increasing harrowing intensity due to higher efficacy in reducing biomass, e.g., broken off branches of *V. hirsuta* resulted in a decline in photosynthesis (Kemball *et al*. 1992). The severest decline of seed production (95 %) compared to the untreated control was achieved by the highest intensity of combined weed control (3 times harrowing + flame weeding) (Figure 2).

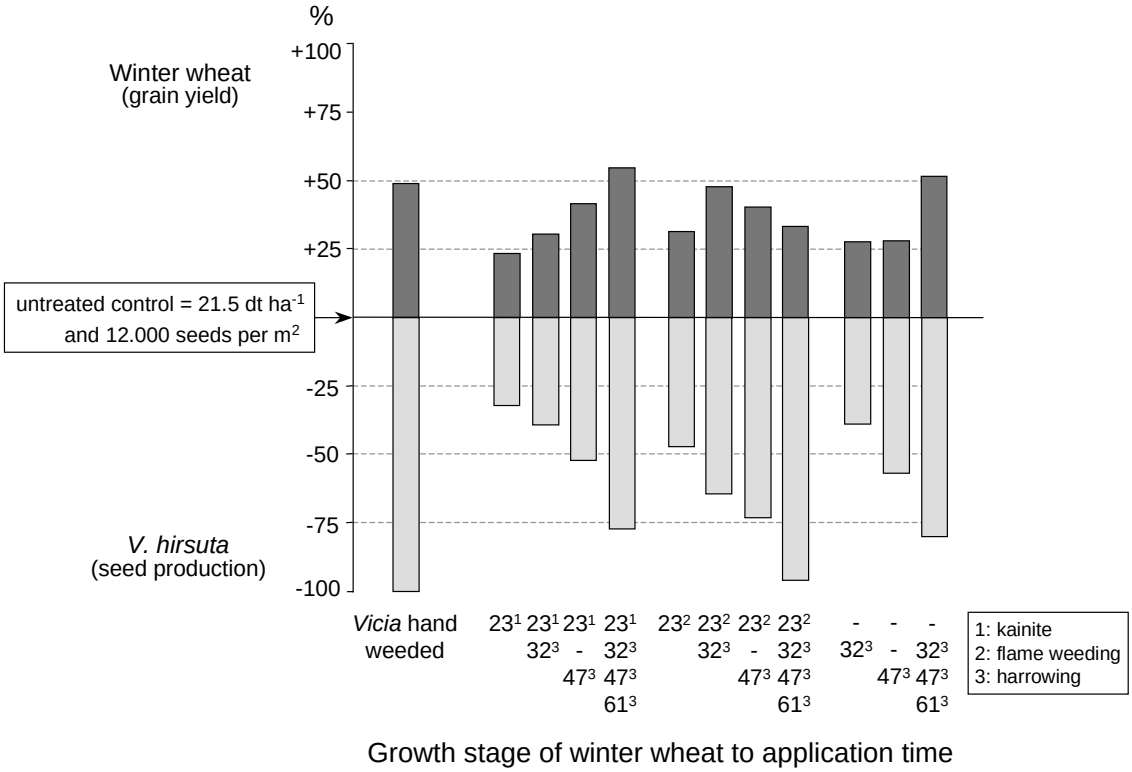

Figure 2: Relative increase of grain yield (winter wheat) and decrease of seed production (*V. hirsuta*) after weed treatments at different crop growth stages in relation to untreated control.

In the presented study, a high infestation of *V. hirsuta* in a low competitive winter wheat stand caused a high reduction of grain yield in the case of missing direct control at all. Hand weeding of *V. hirsuta* reduced crop grain yield losses by 49 % compared with the untreated control (Figure 2). All direct control methods resulted in reduced yield loss and enhanced thousand-grain weight (data not shown). Grain yield losses declined with increasing harrowing intensity.

The highest grain yield (33.3 dt ha^{-1}) in our experiment was achieved after kainite application combined with repeated harrowing (3 times). This effect was caused by the successive reduction of weed biomass due to harrowing. On the other hand, in plots previously treated by kainite this high grain yield could be the result of the fertilising effect of kainite (21 kg K ha^{-1}) on the crop. The yield of the kainite + three times harrowing treatment was significantly higher (55 %) than that of the untreated control and even 10 % higher than in the hand-weeded control (not significant).

According to Wehsarg (1931), kainite can be used for both weed control and overhead potash fertilisation of the crop. However, kainite broadcasted for fertilisation purposes only (53.5 kg K ha^{-1}) resulted in a reduction of the crop yield due to enhanced growth of *V. hirsuta* (Lukashyk *et al*. 2004).

Conclusions

Results show that a combination of different direct weed control methods (kainite application, flame weeding and harrowing) can significantly increase the efficacy of controlling the density and seed production of *V. hirsuta* when compared to the single or repeated use of single methods only. In early crop growth stages, the effect of kainite application or flame weeding on *V. hirsuta* density is higher than that of harrowing. However, in later crop growth stages, harrowing (combing) is much more effective in reducing the number of surviving and newly emerged *V. hirsuta* plants than kainite application or flame weeding. Nevertheless, three times harrowing/combing resulted in nearly the same grain yields and the same efficacy in reducing weed seeds as when this treatment was combined with flaming or kainite application. Kainite application as well as flame weeding is recommended for patches with high infestation of *V. hirsuta* in early spring, whereas harrowing/combing can be used efficiently in later growth stages and on larger areas.

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