Air-propelled abrasive grit can damage the perennial weed quackgrass

Authors: Forcella, Frank, Humburg, Daniel, Wortman, Samuel E., and Clay, Sharon A.

Source: Canadian Journal of Plant Science, 98(4) : 963-966

Published By: Canadian Science Publishing

URL: https://doi.org/10.1139/cjps-2017-0291
Air-propelled abrasive grit can damage the perennial weed quackgrass
Frank Forcella, Daniel Humburg, Samuel E. Wortman, and Sharon A. Clay

Abstract: New techniques are needed to control quackgrass in organic crops. With ≥2 applications of abrasive air-propelled (800 kPa) corncob grit to 15-cm-tall quackgrass tillers, regrowth was minimal at 5 wk after treatment. Abrasive grits may be effective tools to help manage perennial weeds in organic row crops.

Key words: air-propelled grit, corncob grit, Elytrigia repens, quackgrass, weed control.

Perennial and rhizomatous weeds often are serious problems in horticultural crops. One of the worst of these weeds in temperate regions is quackgrass [Elytrigia repens (L.) Nevski] (Degenhardt et al. 2005). Although quackgrass can be controlled effectively with some postemergence herbicides, it remains an important weed, especially where such herbicides cannot be used.

Tillage and mowing typically are the tools of choice for nonchemical control of quackgrass (Boström et al. 2013); however, tillage unearths buried seeds of other weeds, stimulates oxidation of soil organic matter, and facilitates soil erosion. In contrast, no-till systems encourage soil health and increase the many other benefits provided by intact agricultural soils. Moreover, tillage and mowing cannot be performed within rows in row crops, except with highly specialized equipment (Pérez-Ruiz et al. 2014). Hence, methods for controlling quackgrass that do not involve tillage or mowing are needed (Melander et al. 2011).

Received 28 September 2017. Accepted 27 November 2017.
F. Forcella. North Central Soil Conservation Research Laboratory, United States Department of Agriculture – Agricultural Research Service, 803 Iowa Avenue, Morris, MN 56267, USA.
D. Humburg. Department of Agricultural and Biosystems Engineering, South Dakota State University, Brookings, SD 57007, USA.
S.E. Wortman. Department of Agronomy and Horticulture, University of Nebraska, Lincoln, NE 68583, USA.
S.A. Clay. Department of Agronomy, Horticulture, and Plant Science, South Dakota State University, Brookings, SD 57007, USA.

Corresponding author: Frank Forcella (email: frank.forcella@ars.usda.gov).

This work is free of all copyright and may be freely built upon, enhanced, and reused for any lawful purpose without restriction under copyright or database law. The work is made available under the Creative Commons CC0 1.0 Universal Public Domain Dedication (CC0 1.0).
(5 cm × 5 cm × 10 cm) filled with potting soil comprised of peat, loam, and perlite. As new tillers appeared, the original tillers were removed. All experiments were performed on 2nd and 3rd generation tillers whose heights averaged 15 cm (range, 6–49 cm) when grits first were applied. Twenty-five of the 5-cm-long rhizomes (without tillers) were washed, dried at 65 °C for 48 h, and weighed to determine initial dry weights of transplanted rhizomes.

Plants were grown in a greenhouse from April to July 2017. They were watered daily and fertilized weekly with a complete nutrient solution. Greenhouse conditions included natural day lengths (14.1–15.3 h), maximum light intensity of about 400 μmol m⁻² s⁻¹, and day/night temperature settings of 25 °C/15 °C; however, maximum air temperatures during sunny days often exceeded 30 °C.

The standing height of tillers and length of leaf blades were measured for all tillers immediately prior to grit applications. Pots then were mounted in a wooden frame to prevent movement during application. The middle of a pot was 56 cm from the nozzle of the grit applicator (50 cm horizontal distance), which was held at a 60° angle from the horizontal. Grit was applied at 7 g s⁻¹ for 3 s. Grit was commercially available corncob residue (20–40 mesh sieve size) with individual particles being about 0.5 mm in diameter. One week after treatment (WAT) with grit, the heights and leaf lengths of all tillers were measured again.

Grit was reapplied to random pots at weekly intervals. These weekly applications constituted the experimental treatments: 0 (control, no exposure to grit), 1, 2, 3, and 4 grit applications at weekly intervals. The entire experiment was performed twice. The sole difference between the experiments was the number of replications. In Experiment 1, the control had eight replications and all other treatments had four. In Experiment 2, all treatments had five replications except the 4-grit application treatment, which had 10. Pots were arranged in completely randomized designs on greenhouse benches. In addition, pot arrangements were re-randomized after each weekly grit treatment.

At the end of each experiment, the number of tillers in each pot was counted, their heights and leaf blade lengths measured, and tillers were clipped at the soil surface. Rhizomes and roots in each pot were washed free of potting soil. All tissues were dried at 65 °C for 48 h and then weighed. Statistix 10 software was used for all analyses, which included nonlinear regression; specifically, exponential decay models; \[ y = a \cdot e^{(-b \cdot x)} \]

where \( y \) is the value for plants in a treated pot, \( a \) is the value of control plants, \(-b\) is the rate of decay (decrease), and \( x \) is the number of weekly grit applications.

A portable, wagon-mounted, single-nozzle grit applicator (Fig. 1) was designed and built by engineering students at South Dakota State University as part of their senior design project. The applicator consisted of a small gasoline-powered air compressor, a grit tank with a motorized auger, a 12-volt battery, a hand-held wand tipped with a single cone-type nozzle, and two sets of flexible tubes that separately connected the auger to the nozzle and the compressor to the nozzle. The wand had a biphasic trigger that opened air flow to the nozzle first and secondly grit flow to the nozzle. The battery powered a small motor that governed auger speed (i.e., the “duty cycle”). With air pressure set at 800 kPa (116 psi) and the duty cycle set at 50 rpm, the delivery rate of corncob grit was \( 6.6 \pm 0.35 \) g s⁻¹ \((N = 3)\), which affected a circular area with a 5 cm diameter at a 50 cm distance. (All settings and rates were determined through a series of preliminary trials.)

Initial tiller heights were \( 16 \pm 1.4 \) cm in Experiment 1 and \( 13 \pm 1.6 \) cm in Experiment 2. Upon abrasion by grit, most tillers were severed at the soil surface, or their tillers were weakened and then lodged. One week after the first grit application, tiller heights of treated plants in the two experiments were \( 7 \pm 0.7 \) and \( 9 \pm 2.4 \) cm, whereas the heights of the control tillers were \( 13 \pm 2.0 \) and \( 16 \pm 2.3 \) cm. The decrease in average heights of control plants represented the emergence of young tillers during the intervening week rather than a loss of height of older tillers. Young tillers also emerged in the treated pots. Consequently, average tiller height did not capture fully the effects of abrasion. A more sensitive variable was cumulative leaf blade length.

A single application of corncob grit reduced cumulative leaf lengths by 65%–80% compared with control plants 1 WAT. However, these single-treatment plants slowly began to recover, and by 5 WAT leaf length reductions were 59%–66% compared with control plants.
Two applications of grit reduced leaf lengths by >90%, and three and four applications effectively eliminated new leaf growth. Thus, cumulative leaf length appeared to be a sensitive and nondestructive indicator of initial quackgrass damage, recovery, and sustained damage. The results for both experiments mimicked one another closely.

Repeated defoliation of quackgrass to deplete rhizome and root reserves is a well-known control technique. For instance, in field experiments in Sweden, two mowings (3–5 cm height) spaced at 20-d intervals after cereal grain harvest reduced quackgrass tiller dry weights by 75% (Ringselle et al. 2015). Such mechanical control may be helpful for organic crops that subsequently are sown into cereal stubble infested with quackgrass. Immediate in-crop control of quackgrass, however, remains a conundrum for organic growers. Because air-propelled abrasive grit can be used for selective control of annual weeds within crop rows (Forcella 2012; Wortman 2015; Erazo-Barradas et al. 2017), and because it shows potential for damaging quackgrass, it represents a possible tool for nonchemical management of this important perennial weed in row crops.

Acknowledgements

Development of the portable grit applicator was made possible by USDA–NIFA grant 2014-51300-22233. Engineering students D. Brugman, J. Peterson, and B. Schrankler contributed to its design and construction.

References
