Air-propelled abrasive grit can damage the perennial weed quackgrass

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

Published By: Canadian Science Publishing

URL: https://doi.org/10.1139/cjps-2017-0291

NRC Research Press

SHORT COMMUNICATION

Air-propelled abrasive grit can damage the perennial weed quackgrass

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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.

Résumé : On a besoin de nouvelles techniques pour lutter contre le chiendent dans les cultures biologiques. Au moins 2 applications abrasives de semoule de rafles de maïs propulsée par l'air (800 kPa) sur des talles de chiendent de 15 cm de haut entraînent une repousse minime après 5 semaines de traitement. La semoule abrasive pourrait également s'avérer efficace pour combattre d'autres mauvaises herbes dans les cultures biologiques. [Traduit par la Rédaction]

Mots-clés : semoule propulsée par l'air, semoule de rafle de maïs, *Elytrigia repens*, chiendent, lutte contre les mauvaises herbes.

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).

A new technique for controlling in-row weeds in row crops involves the use of abrasive grit propelled at high air speeds (Forcella 2012). A wide assortment of agricultural residues and fertilizers can be used as abrasive grits (Pérez-Ruiz et al. 2016). Importantly, grit applications can provide selective weed control in a variety of agronomic and horticultural row crops (Forcella 2012; Wortman 2015; Erazo-Barradas et al. 2017). To date, however, abrasive grit has only been tested on seedlings of annual weeds (e.g., Forcella 2017), which likely are easier to kill than plants whose aboveground stems arise from rhizomes or tubers. The effects of abrasive grits on perennial weeds are unknown. The goal of the research reported here was to explore the potential for repeated applications of abrasive grit to damage tillers and rhizomes of quackgrass.

Quackgrass rhizomes were excavated from a home vegetable garden in Morris, MN, (45.57°N, 95.89°W) in April 2017. Single tillers attached to 5-cm-long rhizome segments were transplanted into pots

Received 28 September 2017. Accepted 27 November 2017.

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Fig. 1. Portable abrasive grit applicator showing the air compressor, grit tank, battery-powered auger, air and grit hoses, and trigger-operated single-nozzle wand. [Colour online.]

(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.

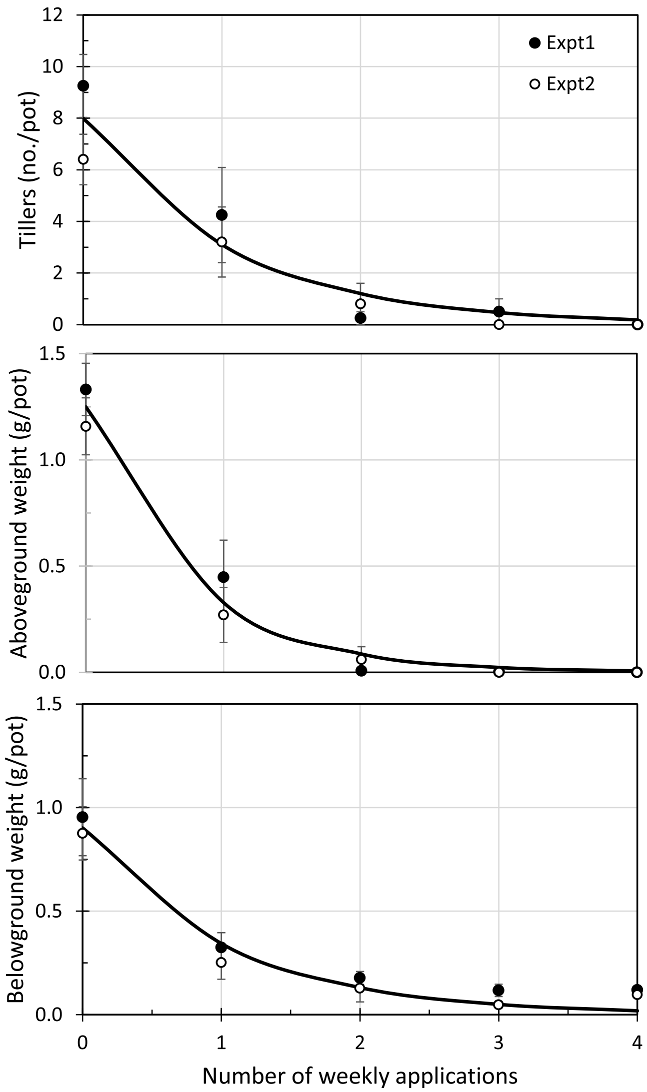
At the end of each experiment, the number of tillers in each pot was counted, their heights and leaf blade lengths measured, and tillers were clipped at the soil surface. Rhizomes and roots in each pot were washed free of potting soil. All tissues were dried at 65 °C for 48 h and then weighed. Statistix 10 software was used for all analyses, which included nonlinear regression; specifically, exponential decay models; $y = a^{*}\exp(-b^{*}x)$, 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 ± 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 ± 1.4 cm in Experiment 1 and 13 ± 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 ± 0.7 and 9 ± 2.4 cm, whereas the heights of the control tillers were 13 ± 2.0 and 16 ± 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

Fig. 2. Number of tillers (top), aboveground dry weight (middle), and belowground dry weight (bottom) of quackgrass in pots one week after the fourth weekly exposure to corncob grit. Bars represent ± 1 standard error. Levels of belowground mass <0.2 g pot^{-1} reflect the presence of discolored root and rhizome tissues, which likely were dead. Curves represent two-parameter exponential decay models fit to aggregate data from both experiments, as confidence intervals for each parameter overlapped with separate models for each experiment.



(Fig. S1).[1] 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.

Aboveground and belowground plant parts were harvested 5 wk after the initial grit application (1 wk after the 4th and last application). At that time, the number of tillers per pot was nil for pots receiving four applications, <1 for pots treated with two or three applications, three to four tillers for one application, and seven to nine for controls (Fig. 2). Aboveground biomass (dry weight) of quackgrass tillers was near zero for any pot receiving two or more grit applications and increased exponentially to >1 g pot^{-1} with fewer applications. Results for belowground biomass were nearly identical to those for aboveground biomass. Dry weights of rhizome and roots were about 1 g pot^{-1} for controls and decreased exponentially to 0.3, 0.2, 0.1, and 0.1 g pot^{-1} for 1, 2, 3, and 4 grit treatments, respectively. The lowest belowground dry weights (≤0.2 g pot^{-1}) depicted in Fig. 2 for treatments with 3 or 4 grit treatments were for dead rhizome and root material that was brown and limp, and did not have time to decompose by the sampling date. (Dry weights of originally transplanted 5-cm-long rhizomes were 0.07 ± 0.005 g [N = 25]. Thus, all treatments gained belowground weight over the course of the experiments.)

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

Boström, U., Andersson, L., Forkman, J., Hakman, I., Liew, J., and Magnuski, E. 2013. Seasonal variation in sprouting capacity from intact rhizome systems of three perennial weeds. Weed Res. **53**: 387–398. doi:10.1111/wre.12035.

Degenhardt, R., Martin, R., and Spaner, D. 2005. Organic farming in central Alberta: current trends, production constraints, and

[1]Supplementary Fig. S1 is available with the article through the journal Web site at http://nrcresearchpress.com/doi/suppl/10.1139/cjps-2017-0291.

research needs. J. Sustain. Agric. **27**: 153–173. doi:10.1300/J064v27n02_10.

Erazo-Barradas, M., Friedrichsen, C.N., Forcella, F., Humburg, D., and Clay, S.A. 2017. Propelled abrasive grit applications for weed management in transitional corn grain production. Renew. Agric. Food Syst. 1–8. doi:10.1017/S174217051700031X.

Forcella, F. 2012. Air-propelled abrasive grit for postemergence in-row weed control in field corn. Weed Technol. **26**: 161–164. doi:10.1614/WT-D-11-00051.1.

Forcella, F. 2017. Spent coffee grounds as air-propelled abrasive grit for weed control in organic production. Weed Technol. **31**: 769–772. doi:10.1017/wet.2017.42.

Melander, B., Mathiassen, S.K., Nørremark, M., Kristensen, E.F., Kristensen, J.K., and Kristensen, K. 2011. Physical destruction of the sprouting ability of *Elytrigia repens* rhizome buds. Weed Res. **51**: 469–477. doi:10.1111/j.1365-3180.2011.00855.x.

Pérez-Ruiz, M., Slaughter, D.C., Fathallah, F.A., Gliever, C.J., and Miller, B.J. 2014. Co-robotic intra-row weed control system. Biosyst. Eng. **126**: 45–55. doi:10.1016/j.biosystemseng.2014.07.009.

Pérez-Ruiz, M., Brenes, R., Rodríguez-Lizana, A., Urbano, J.M., Slaughter, D.C., and Forcella, F. 2016. Laboratory test to assess optimal agricultural residue traits for an abrasive weed control system. CIGR—AgEng Conference, Aarhus, Denmark, 26–29 June 2016. [Online]. Available from https://idus.us.es/xmlui/bitstream/handle/11441/71099/laboratory.pdf.

Ringselle, B., Bergkvist, G., Aronsson, H., and Andersson, L. 2015. Under-sown cover crops and post-harvest mowing as measures to control *Elymus repens*. Weed Res. **55**: 309–319. doi:10.1111/wre.12144.

Wortman, S.E. 2015. Air-propelled abrasive grits reduce weed abundance and increase yields in organic vegetable production. Crop Prot. **77**: 157–162. doi:10.1016/j.cropro.2015.08.001.