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# Wheat gluten meal inhibits germination and growth of broadleaf and grassy weeds[1]

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**Abstract:**

The herbicidal activity of wheat gluten meal (WGM) was evaluated on 17 species of monocotyledons and dicotyledons. Treatments included WGM at 0, 1, 2, 3, 4, 6, and 9 g•dm$^{-2}$. Germination, shoot and root lengths, and root numbers were recorded. Treatments reduced germination and root extension in nearly all species. Leafy spurge (*Euphorbia esula* L.), redroot pigweed (*Amaranthus retroflexus* L.), shepherd's purse [*Capsella bursa-pastoris* (L.) Medik.], henbit (*Lamium amplexicaule* L.), quackgrass [*Agropyron repens* (L.) Beauv.], annual bluegrass (*Poa annua* L.), Canada thistle [*Cirsium arvense* (L.) Scop.], orchard grass (*Dactylis glomerata* L.), purslane (*Portulaca oleracea* L.), annual ryegrass (*Lolium multiflorum* Lam.), and snap bean (*Phaseolus vulgaris* L.) were particularly sensitive. Germination of curly dock (*Rumex crispus* L.) and common lambsquarters (*Chenopodium album* L.) was suppressed at the higher rates. Germination of black medic (*Medicago lupulina* L.), spotted knapweed (*Centaurea maculosa* Lam.), mustard (*Brassica* sp.), and corn (*Zea mays* L.) were not substantially affected at any rate. Shoot growth of all species was inhibited at rates >2 g•dm$^{-2}$, and at the highest rates no shoots developed. In nine species, shoot extension was stimulated at 1 g•dm$^{-2}$ WGM. The herbicidal activity of WGM was not due to a "mulching" effect, since growth characteristics were also altered in bean seeds barely covered by the treatments.

**Additional Index Words:**

Herbicide, *Agropyron, Amaranthus, Brassica, Capsella, Centauria, Chenopodium, Cirsium, Dactylis, Euphorbia, Lamium, Lolium, Medicago, Phaseolus, Poa, Portulaca, Rumex, Zea.*

Nonspecific growth inhibitors of plant origin have been studied for years (Bonner, 1950; Nielsen *et al*., 1960). Many of these were especially inhibitory to growth of plants of the same species from which they were extracted (Cox *et al*., 1945). Evenari (1949) reported that *Beta* excretes substances that inhibit germination of *Agrostemma githago* L., and that the seed coats and fruit of wheat (*Triticum* sp.) and the seed coats and embryo of sunflower (*Helianthus* sp.) also inhibit germination in some species. Mosheov (1938) reported that water extracts of wheat seeds inhibited germination and growth of plants. More recently, Bingaman and Christians (1995) reported that corn gluten meal inhibited growth in a number of weed species. Further research showed that several hydrolysates, including those of corn gluten, wheat gluten, and soy gluten, strongly inhibited plant growth (Liu and Christians 1994, 1997; Liu *et al*., 1994).

Highly elastic gluten is formed when two proteins contained in grain, gliadin and glutenin, are mixed with a liquid and kneaded (Ensminger *et al*., 1994); gluten entraps carbon dioxide produced during fermentation, causing the bread to rise. Wheat flour averages 12% protein, which is composed of gliadin and glutenin.

## Materials and Methods

Three tests were conducted during the summer of 1997 to determine the influence of WGM on plant growth. All tests were conducted in clear plastic boxes with lids and a base area of 9 $dm^{-2}$. Box bottoms were covered with two layers of blotter paper saturated with distilled water. Seeds were sprinkled on the paper and WGM was dusted over the seeds. Boxes were closed and placed in a growth chamber with photoperiods of 8-hours night (15° C) /16-hour day (25° C, 750-1250 1x) in a completely randomized design. All boxes were randomly rearranged every 3 days. There were three replications of each treatment per test.

In tests 1 and 2, 20 seeds of annual ryegrass were placed in each box and 1, 2, 3, 4, 6, or 9 g•$dm^{-2}$ WGM were dusted over the seeds. Thirty drops of Vitavax/Thiram (carboxin/ thiram) (Gustafson, Dallas, Texas) were sprinkled over all treatments, including the controls, to reduce mold growth. Measurements were taken 6 days after seeding.

In test 3, 25 seeds of each of 15 common weed species, except where noted, and seeds of sweet corn ('Early Sunglow') and snap bean ('Red Rum') were placed in boxes and treatments of 1 and 3 g•dru-2 WGM dusted over the seeds. Fifteen seeded boxes remained as controls. Vitavax/Thiram was applied as described above. Growth measurements were recorded 16 days after seeding for the weed seeds and 13 days after seeding for the corn and bean. At the end of the test, trays were removed from the growth chambers, the root and shoot lengths of each seedling recorded, and the percent germination was calculated. For this experiment, radical emergence was considered the sole criterion for germination. In addition, the number of roots was recorded in Tests 1 and 2 and the number of secondary roots on the bean seedlings in Test 3.

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Data were analyzed using a separate analysis of variance, followed by Student-Newman-Keul mean separation for each species, since comparison of differences among species was not meaningful (Snedecor and Cochran, 1980).

## Results and Discussion

In preliminary tests with six rates of WGM, the percent seed germination generally decreased as rate increased (Table 1). No annual ryegrass seeds germinated at 9 g•dm$^{-2}$.

**Table 1. Effects of seven rates of wheat gluten meal (WGM) on germination of annual ryegrass seed. Combined data from Expt. 1, with rates of 0, 2, 4, and 6 g•dm$^{-2}$ and from Expt. 2, with rates of 0, 1, 3, and 9 g•dm$^{-2}$.**

| | WGM concn | | | | | | |
|---|---|---|---|---|---|---|---|
| | Control[z] | 1 | 2 | 3 | 4 | 6 | 9 |
| | | | | *Germination (%)* | | | |
| Total | 98 | 95.0 | 65.0 | 35.0 | 10.0 | 5.0 | 0.0 |
| Total with: | | | | | | | |
| Roots ≤ 5mm | 98 | 50.0 | 5.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Shoots | 98 | 100.0 | 70.0 | 45.0 | 10.0 | 25.0 | 0.0 |
| | | | | *Mean length (mm)* | | | |
| Of longest root | 35.87 | 7.0 | 2.5 | 1.1 | 0.4 | 2.0 | 0.0 |
| Of longest shoot | 33.21 | 47.7 | 24.3 | 3.3 | 5.3 | 0.0 | 0.0 |
| Mean no. roots | 1.85 | 1.2 | 0.8 | 0.7 | 0.1 | 0.05 | 0.0 |

[z]Means for controls are averages for two trials.

Germination was suppressed by 50% or more of the control in 12 species receiving 3 g•dm$^{-2}$ and in eight species treated with 1 g•dm$^{-2}$ (Table 2). Leafy spurge, pigweed, shepherd's purse, henbit, quackgrass, annual bluegrass, Canada thistle, orchard grass, and beans appear particularly sensitive; germination was <65% at the lowest rate of WGM. Germination of curly dock and lambsquarters *(Chenopodium album* L.) was not suppressed at the lower rate but dropped substantially at the higher rate. Germination of black medic and corn was not reduced.

Treatments reduced root length in nearly all species; the results resembled those reported by Bingaman and Christians (1995) for corn gluten meal, except that WGM may be as effective as the former at one-third the rate (Tables 1 and 2). In fact, WGM itself was similar in activity to that of corn gluten hydrolysate (Liu and Christians, 1997), although the tests are not directly comparable.

Primary root length was ≥5 mm in 88% of the control plants (mean = 22 mm), but in only 35% receiving the lowest rate of WGM (1 g•dm$^{-2}$) (mean = 17.5 mm) (Table 2), and only 23% in those receiving 3 g•dm$^{-2}$. In preliminary trials, root length was ≥5 mm in only 50% of the annual ryegrass plants treated with 1 g•dm$^{-2}$ WGM and in only 5% of those treated with 2 g•dm$^{-2}$ (Table 1). No annual ryegrass plants receiving higher rates had roots ≥5 mm.

Root extension was significantly suppressed in 12 of the 17 species at 1 g•dm$^{-2}$, but not in corn, shepherd's purse, and henbit, although the trend in these species was for

shorter roots at higher rates (Table 2). Bean seedlings developed significantly fewer secondary roots at the higher rates; mean values were 18, 12, and 1 at WGM concentrations of 0.1 and 3 g•dm$^{-2}$, respectively. Necrosis appeared near the apex of secondary roots and developed basipetally along the axis.

**Table 2. Effects of wheat gluten meal (WGM) on seed germination and length of primary roots and shoots of 17 species.**

| | Germination[z] % | | Primary root length (mm) WGM (g dm$^{-2}$) | | | Primary shoot length (mm) | | |
|---|---|---|---|---|---|---|---|---|
| Species | 1 | 3 | 0 | 1 | 3 | 0 | 1 | 3 |
| Annual ryegrass | 75[y] | 71 | 53 a[x] | 8 b | 3 c | 83 ab | 90 a | 60 b |
| Mustard | 96 | 83 | 19 a | 18 a | 8 b | 18 ab | 30 a | 25 b |
| Curly dock | 100 | 30 | 13 a | 3 b | 1 b | 6 b | 9 a | 7 ab |
| Quackgrass | 63 | 50 | 28 a | 2 b | 2 b | 49 a | 44 a | 25 a |
| Black medic | 94 | 94 | 13 a | 6 b | 5 b | 22 a | 17 a | 17 a |
| Leafy spurge | 42 | 0 | 12 a | 3 b | <1 b | 26 a | 4 b | <1 b |
| Lambsquarters | 100 | 36 | 9 a | 4 b | 3 c | 9 a | 17 a | 11 a |
| Spotted knapweed | 75 | 80 | 9 a | 4 b | 2 b | 12 a | 16 a | 7 a |
| Pigweed | 48 | 0 | 9 a | 2 b | 3 b | 5 a | 6 a | 0 b |
| Shepherd's purse | 48 | 0 | 9 a | 2 a | 0 a | 4 a | 12 a | 0 b |
| Henbit | 0 | 25 | 8 a | <1 a | 1 a | 3 a | 0 a | 2 a |
| Purslane | 75 | 17 | 10 a | 7 a | 3 b | 10 b | 15 a | 11 b |
| Annual bluegrass | 1 | 0 | 3 a | <1 b | 0 b | 20 a | 5 b | 1 c |
| Canada thistle | 8 | 0 | 11 a | 3 b | 1 b | 24 a | 4 b | 1 b |
| Orchardgrass | 5 | 2 | 15 a | <1 b | <1 b | 38 a | 12 b | 9 b |
| Corn | 100 | 95 | 64 a | 39 a | 36 a | 43 a | 50 a | 43 a |
| Bean | 31 | 15 | 53 a | 28 a | 11 c | 38 a | 8 b | 3 b |

[z]Expressed as percentage of control.
[y]Mean for three replications.
[x]Mean separation within species and parameter by Student-Newman-Keul test, $P \leq 0.05$.

The influence of WGM was less dramatic on shoot growth than on root growth (Tables 1 and 2). Shoot growth occurred in some annual ryegrass plants treated with all rates except the highest, though <50% of the plants receiving rates ≥3-dm$^{-2}$ developed shoots. None of these plants had roots ≥5 mm (Table 1).

Shoot length in annual ryegrass plants was substantially inhibited at rates >2 g•dm$^{-2}$ (Table 1). There were no shoots >1 mm in length at the highest two rates. The lowest rate appeared to stimulate shoot extension in nine species, although the difference was significant in only two species (Table 2). This effect may be attributable to nutrients contained in WGM. A similar effect and explanation was reported by Evenari (1949). Shoot extension in leafy spurge, pigweed, shepherd's purse, annual bluegrass, Canada thistle, orchardgrass, and bean was reduced significantly at the higher concentrations, but shoot extension in black medic, quackgrass, lambsquarters, spotted knapweed, henbit, and corn was not significantly affected by the treatments.

On the basis of preliminary tests in a growth chamber, WGM may have herbicidal activity on germinating seeds. If WGM proves herbicidally effective at practical concentra-

tions in field trials, it could be developed as a safe organic alternative to commercial herbicides presently used in home gardens and small commercial plantings.

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