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Sod Control when Rotating Back to Cropland, Guided by Plant Biology

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Perennial grasses and legumes are present on pastures, haylands, and Conservation Reserve Program (CRP) land. As economic conditions change, these lands may be converted to cropland. To maintain protective residue cover on the soil surface, producers may choose to control perennial species in these lands with herbicides, thus minimizing tillage.

To evaluate perennial grass conversion to cropland, we compared three strategies for vegetation control at Akron CO: 1) **sweep plow**, with tillage starting in May; 2) **reduced-till**, where one or two sweep plow operations in May were followed by Roundup (glyphosate) applications as needed; and 3) **no-till**, consisting only of Roundup applications as needed, with the first application in May. The site's vegetation was approximately 80% crested wheatgrass (Agropyron cristatum), a cool season grass, and 20% blue grama (Bouteloua gracilis), a warm season grass. Winter wheat was planted in September, with the study being repeated three times.

The strategies with tillage (sweep plow and reduced-till)

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controlled perennial grasses. However, with the no-till strategy, 23% of the plot was still infested with perennial grasses at wheat planting (Table 1). These remaining grasses reduced no-till grain yield 21% compared to the strategies with tillage.

Table 1. Grass control and surface residue levels at winter wheat planting, and grain yields for three CRP take-out strategies at Akron CO. Data averaged over three years.

Strategies	Grass control[1]	Residue cover[2]	Grain yield
	----------(%)----------		bu/acre
Sweep plow	100	18	40.0
Reduced-till	99	45	38.2
No-till	77	73	30.7
LSD (0.05)	5	12	6.9

[1]Values represent land area in plot that was weed-free.
[2]Values based on the line transect method.

Ineffective control of perennial species by systemic herbicides such as Roundup, Banvel (dicamba) or 2,4-D[2] in no-till systems has been observed elsewhere (1, 7, 8). This paper examines why systemic herbicides may be ineffective, and suggests strategies to improve their performance.

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[2]Provided for information only, and does not imply endorsement by the USDA-ARS.

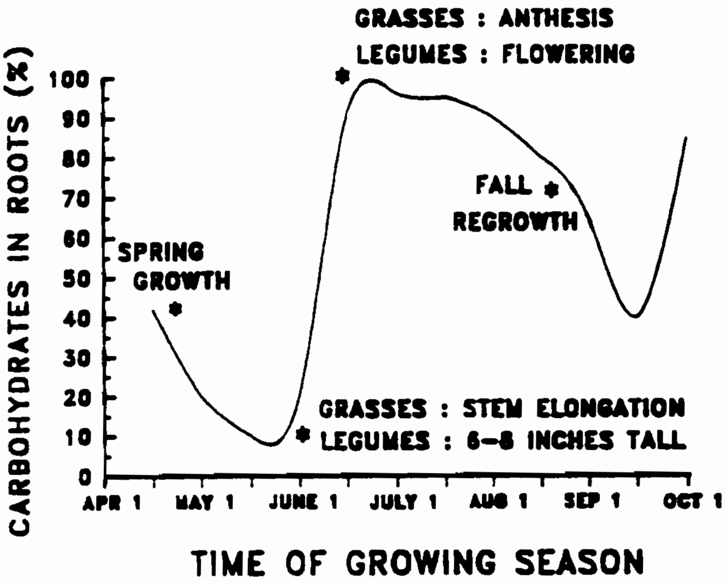
PERENNIAL PLANT STRUCTURE

Perennial species store carbohydrates in plant organs such as roots, stolons, rhizomes, and stem bases. Carbohydrates supply energy for plants to initiate growth in the spring and fall, and to ensure plant survival during periods of dormancy in summer and winter. These storage organs also have buds, which contain dormant shoots. If released from dormancy, these buds will initiate growth and re-establish plant stands. Therefore, to control perennial species, producers need to use systemic herbicides, such as Roundup, that translocate from leaves to buds (2, 4, 11). Herbicide translocation in plants, however, can be altered by several plant or environmental factors, reducing species control.

PLANT FACTOR: GROWTH STAGE

Inside the plant, herbicides move with leaf carbohydrates being translocated to roots (11, 14). Movement of carbohydrates to roots varies with stage of plant development (12). When plants first initiate growth in the spring, roots supply carbohydrates to the leaves, thus translocation is out of roots (Figure 1). Leaves return carbohydrates to roots after stem elongation begins. Therefore, herbicides, if applied when roots are supplying carbohydrates to leaves, will remain in the leaves. After leaves die, root buds will break dormancy and establish new plants. However, if herbicides are applied to grasses when stems begin to elongate or to legumes when six to eight inches tall, then maximum movement of herbicides to root buds will occur, subsequently increasing control.

Figure 1. Seasonal movement of carbohydrates between leaves and roots for a cool season species, as shown by varying levels of carbohydrates in roots over time. Warm season species movement occurs later, with no fall regrowth.



Seasonal carbohydrate movement varies among plant species. For example, cool season and warm season grasses can differ by four weeks in initiating carbohydrate translocation to roots. Thus, if the CRP plant community is a mixture of species, multiple applications of herbicides may be needed for vegetation control.

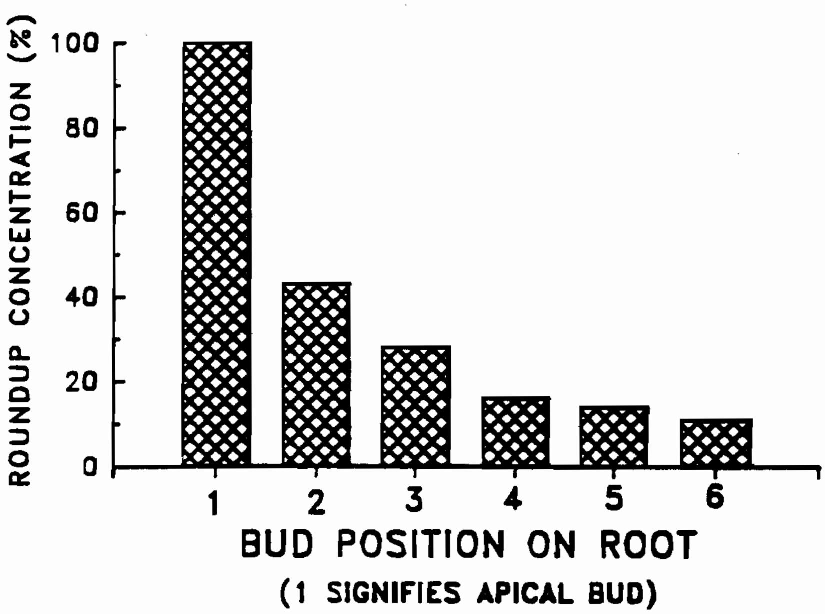
Fall applications of herbicides have been effective in controlling the cool season species alfalfa (Medicago sativa) and quackgrass (Elytrigia repens) (1, 7, 13). Effectiveness of fall applications also is related to seasonal carbohydrate movement between leaves and roots, as cool season plants store carbohydrates in the fall in preparation for winter survival (Figure 1). If applied in conjunction with carbohydrate movement to roots, Roundup will be distributed to root buds, subsequently disrupting winter survival and spring growth. Fall applications are not effective with warm season species, as they are dormant in the fall.

PLANT FACTOR: APICAL BUD DOMINANCE AND BUD AGE

Carbohydrates are not evenly distributed among root buds (11), which leads to differences in herbicide concentration. For example, Roundup concentration may be 80% less in older, dormant buds than in actively-growing tip buds, thus leading to non-lethal concentrations in older buds (Figure 2). This concentration difference is related to apical bud dominance. The youngest and most active growing bud (apical) exerts dominance over older buds by hormonal signals and by depriving these buds of carbohydrates (10). This dominance also leads to older bud dormancy. Because the apical bud accumulates most of the carbohydrates, it also stores herbicide moving with the carbohydrates. If the apical bud dies, axillary buds break dormancy and produce new shoots to re-establish the plant stand.

Producers can disrupt bud dominance and stimulate dormant bud growth by either mowing or tilling (9, 10, 12). Mowing eliminates leaf production of carbohydrates while tillage severs roots, both of which stimulates growth of dormant buds. As more buds produce shoots, this increases the above-ground to belowground biomass, which increases translocation of systemic herbicides after application (11).

Figure 2. Concentration of Roundup in buds along one root section, in comparison with the apical bud (position 1).



ENVIRONMENTAL FACTOR: WATER STRESS

Herbicides are less effective if plants are drought stressed at time of application (8, 9). Water stress reduces: 1) herbicide entry into leaves because waxes on the leaf surface become thicker, and 2) carbohydrate translocation from leaves to roots. Reduced entry and translocation results in less movement of herbicides to buds, leading to non-lethal concentrations. For example, Roundup concentration in root buds can be reduced by as much as 60% under stress conditions (8).

ENVIRONMENTAL FACTOR: TEMPERATURE (FROST)

Roundup effectiveness on perennial grasses in fall applications have occasionally been enhanced by frost. This enhancement only occurs, however, if Roundup is sprayed within two days after a 25 to 27 °F frost (3). If Roundup is applied before or after this 2-day window, frost does not improve performance. In fact, if Roundup is applied too late (5 to 7 days after frost), frost damage to leaves minimizes Roundup entry and translocation, thus decreasing control (3, 7). Frost enhancement of herbicide activity has not been observed with legumes (3). Timing herbicide application in relation to carbohydrate translocation will be more effective for producers than targeting application to coincide with frost.

ECONOMIC AND ECOLOGICAL CONCERNS WITH NO-TILL STRATEGIES:

Roundup's ineffectiveness in no-till strategies can be costly. For example, at Akron CO, converting perennial grass to cropland with no-till cost two-fold more than the sweep plow strategy (estimated $75 vs $38/acre). The reduced-till strategy cost approximately $45/acre. Even though the sweep plow strategy was effective in controlling perennial species, it left insufficient residue cover at planting (Table 1). Only the reduced-till strategy achieved both perennial grass control and protective residue cover.

Another concern is that perennial grasses proliferate in no-till cropping systems. Examples of this trend are foxtail barley (Hordeum jubatum) in the Northern Great Plains (5), and tumblegrass (Schedonnardus paniculatus) in the Central Great Plains (15). To control these perennial species in cropping systems requires some tillage in conjunction with systemic herbicides (6, 15). This proliferation reflects lack of consistent control by systemic herbicides.

SUGGESTED STRATEGIES FOR PERENNIAL SPECIES CONTROL:

The key to successful vegetation control, whether in humid or semiarid regions, is applying systemic herbicides to plants when carbohydrates are moving to roots.

No-till strategies: (most suited for continuous cropping regions)

Cool season species communities

Consider mowing your CRP plant community in August, to stimulate dormant bud growth. Apply systemic herbicides in the fall, when plants are moving carbohydrates to roots (Figure 1). Roundup is effective if the stand is grass only, but if alfalfa is present, add Banvel or 2,4-D, as alfalfa has some tolerance to Roundup. A second application of systemic herbicides in the spring may be required to control new shoots. If crops are planted that spring, residual herbicides such as atrazine will suppress perennial species growth in-crop. Please note: if plants are growing under drought stress, less herbicide entry will occur and may reduce control.

Warm season species communities

Because warm season species do not initiate fall growth, herbicides will need to be applied in early summer. Carbohydrate movement to roots occurs at similar developmental stages as cool season species, but development occurs later in the growing season. As noted above, severe moisture stress may reduce control.

Reduced-till strategies: (most suited for crop-fallow regions)

Cool season species communities

Because of the tendency for dry falls, less favorable economics, and the need for fallow in these regions, consider combining limited tillage with systemic herbicides. Till in late summer with a sweep plow before leaves start translocating carbohydrates to roots (Figure 1). This tillage, by preventing carbohydrate storage, will weaken plants' tolerance to winter injury as well as stimulate dormant bud growth. Apply systemic herbicides in the spring, after grasses begin stem elongation and legumes reach 6-8 inches in height. If drought occurs in the spring, substitute a second sweep plow operation for the herbicides. Later applications of herbicides will control plant escapes and still maintain sufficient residue cover on the soil surface.

Warm season species communities

Till with the sweep plow before growth is initiated in early summer. This will stimulate bud germination and improve herbicide performance. Apply the herbicide to coincide with the appropriate plant development for carbohydrate movement to roots.

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