# Plant and Environmental Factors Affecting Systemic Herbicide Performance

R.L. Anderson[1]

Conservation Reserve Program (CRP) lands may be converted back to cropland when contracts expire. Perennial grasses and legumes, established on CRP lands, improved the health and structure of the soil. By using no-till or minimum-till systems where systemic herbicides control vegetation, producers can retain improvements in soil health as well as maintain protective residue cover on the soil surface. However, ineffective control of perennial species by systemic herbicides such as Roundup (glyphosate) or Banvel (dicamba) occurs occasionally, especially in semi-arid regions (1, 2, 7). Lack of vegetation control leads to grain yield losses in CRP-conversion-to-cropland studies (1). This paper examines perennial plant structure, its interaction with herbicide performance, and possible environmental causes of ineffective herbicide activity, with the goal of devising strategies to improve vegetation management.

## PERENNIAL PLANT STRUCTURE

Perennial species store carbohydrates in plant organs such as roots, stolons, rhizomes, and stem bases. Carbohydrates from these organs 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 that translocate from leaves to buds (3, 5, 10). Herbicide translocation in plants, however, can be altered by several plant or environmental factors, which subsequently reduces species control.

## PLANT FACTOR: GROWTH STAGE

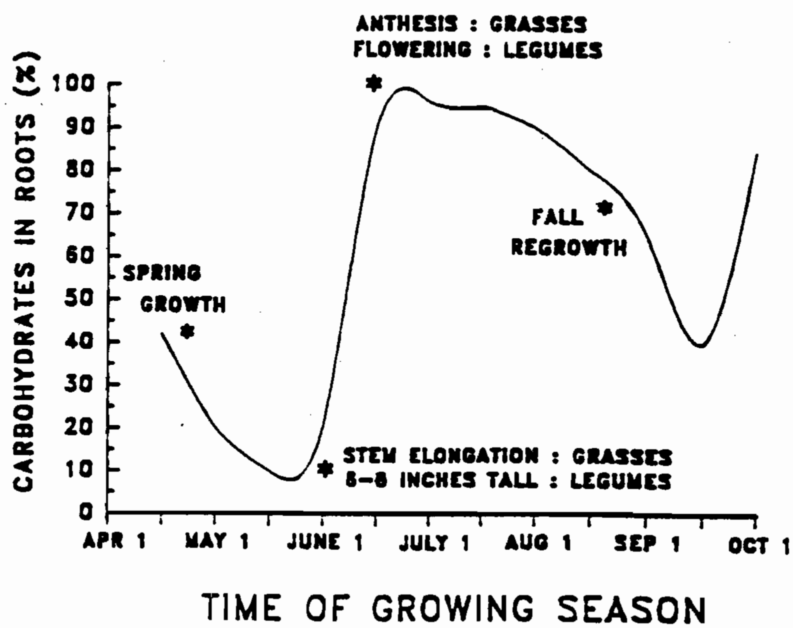
Inside the plant, herbicides move with leaf carbohydrates being translocated to roots (10, 13).

---

[1]USDA-ARS, Central Great Plains Research Station, Akron CO.

However, movement of carbohydrates to roots varies with stage of plant development (11). 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 the herbicide kill the leaves, root buds will break dormancy and establish new plants. However, if herbicides are applied to grasses when stems begin to elongate, then maximum movement of herbicides to root buds occurs, 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.**



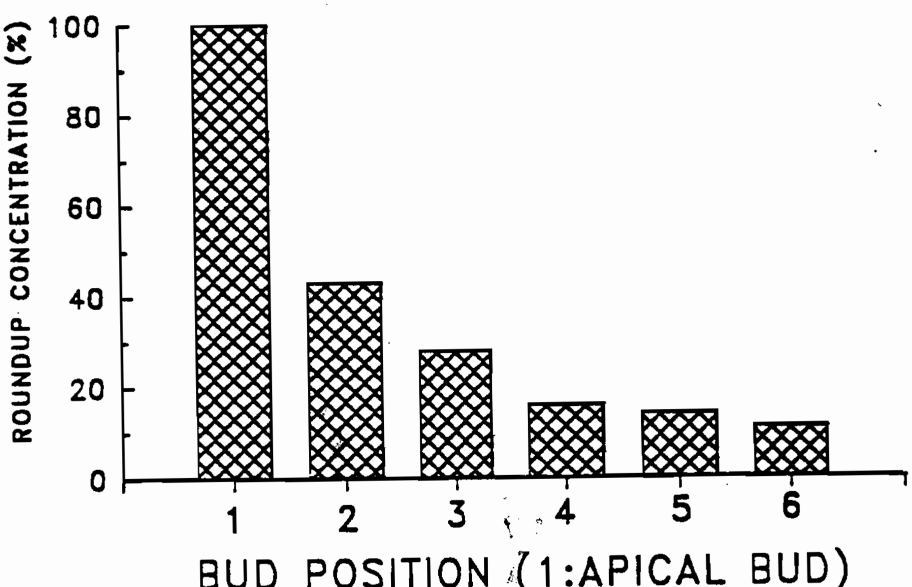

Seasonal carbohydrate movement varies among plant species. For example, cool season and warm season grasses can differ by four weeks in initiating carbohydrate translocation to roots. Thus, if the CRP plant community is a mixture of cool and warm season species, multiple applications of herbicides will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

Fall applications of herbicides have been effective in controlling the cool season species alfalfa (Medicago sativa) and quackgrass (Elytrigia repens) (2, 6, 12). 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 (10), which leads to differences in herbicide concentration among buds. 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).

**Figure 2. Concentration of Roundup in buds along one root section of quackgrass, compared to the apical bud (position 1). Roundup was applied to leaves 14 days earlier.**



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 (9). 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 (8, 9, 11). 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 leaf area available to intercept systemic herbicides during spraying, consequently increasing their translocation to the root buds (10).

## ENVIRONMENTAL FACTOR: WATER STRESS

Herbicides are less effective if plants are drought stressed at time of application (7, 8). 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 (7).

## ENVIRONMENTAL FACTOR: TEMPERATURE (FROST)

Roundup effectiveness on cool season 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 (4). 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 (4, 6). Frost enhancement of herbicide activity has not been observed with legumes (4). Timing herbicide application in relation to carbohydrate translocation will be more effective for producers than targeting application to coincide with frost.

## SUGGESTED STRATEGIES TO IMPROVE PERENNIAL SPECIES CONTROL

**Apply herbicides to match carbohydrate movement to roots**

Applying systemic herbicides during an inappropriate growth stage can drastically minimize their effectiveness. If herbicides are applied at the wrong time, only above-ground leaves will be controlled, with root buds reestablishing the plant stand. This decision of when to spray is the most crucial factor related to perennial species control.

**Stimulate dormant buds to initiate growth before herbicide application**

Mowing, grazing, or tilling the plant stand will stimulate root buds to grow. These practices alter the internal plant physiology such that bud dormancy is disrupted, leading to shoot and leaf emergence. These young shoots are more easily controlled than dormant buds, thus overall herbicide performance is improved.

**Fall application of systemic herbicides**

Most effective control of perennial species, especially in semiarid regions, occurs when systemic herbicides are applied in the fall. This practice is dependent, however, on sufficient fall precipitation to stimulate plant growth. Plan the herbicide application to match carbohydrate movement to the roots (Figure 1).

**Drought conditions**

Because of the tendency for dry falls with limited precipitation in this region, lack of fall plant growth may prohibit herbicide application. However, combining one tillage operation with systemic herbicides can improve control in these conditions. Till in late summer with a sweep plow before leaves start translocating carbohydrates to roots (Figure 1). This tillage, by preventing carbohydrate storage, weakens plants' tolerance to winter injury as well as stimulates dormant bud growth. Apply systemic herbicides in the spring, after grasses begin stem elongation (6-8 inches in height). If dry conditions also occur in the spring, include a second sweep plow operation. Later applications of herbicides will control plant escapes and still maintain sufficient residue cover on the soil surface.

## REFERENCES

1. Anderson, R.L. 1996. Strategies for sod control in CRP conversion to cropland. Proc. Colorado Conservation Tillage Association Annual Meeting, Ault, CO. Pages 16-24.

2. Buhler, D.D. and J.C. Mercurio. 1988. Vegetation management and corn growth and yield in untilled mixed-species perennial sod. Agron. J. 80:454-462.

3. Claus, J.S. and R. Behrens. 1976. Glyphosate translocation and quackgrass rhizome bud kill. Weed Sci. 24:149-152.

4. Davis, H.E., R.S. Fawcett, and R.G. Harvey. 1978. Effect of fall frost on the activity of glyphosate on alfalfa (Medicago sativa) and quackgrass (Agropyron repens). Weed Sci. 26:41-45.

5. Devine, M.D. and L.M. Hall. 1990. Implications of sucrose transport mechanisms for the translocation of herbicides. Weed Sci. 38:299-304.

6. Ivany, J.A. 1981. Quackgrass (Agropyron repens) control with fall-applied glyphosate and other herbicides. Weed Sci. 29:382-386.

7. Klevorn, T.B. and D.L. Wyse. 1984. Effect of soil temperature and moisture on glyphosate and photoassimilate distribution in quackgrass (Agropyron repens). Weed Sci. 32:402-407.

8. Majek, B.A., C. Erickson, and W.B. Duke. 1984. Tillage effects and environmental influences on quackgrass (Agropyron repens) rhizome growth. Weed Sci. 32:376-381.

9. Robertson, J.M, J.S. Taylor, K.N. Harker, R.N. Pocock, and E.C. Yeung. 1989. Apical dominance in rhizomes of quackgrass (Elytriga repens): inhibitory effect of scale leaves. Weed Sci. 37:680-687.

10. Shieh, W., D.R. Geiger, and S.R. Buczynski. 1993.

Distribution of imported glyphosate to quackgrass (Elytriga repens) rhizomes in relation to assimilate accumulation. Weed Sci. 41:7-11.

11. Smith, D. 1973. Physiological considerations in forage management. p. 425-436 *in* Heath, M.E., D.S. Metcalfe, and R.F. Barnes (eds.) Forages - The Science of Grassland Agriculture. The Iowa State University Press, Ames, Iowa.

12. Smith, M.A. and P.R. Carter. 1993. No-till systems for corn following hay or pasture. J. Prod. Agric. 6:46-52.

13. Sprankle, P., W.F. Meggitt, and D. Penner. 1975. Absorption, action, and translocation of glyphosate. Weed Sci. 23:235-240.