RETURNING CONSERVATION RESERVE PROGRAM LAND TO CROP PRODUCTION: WEED MANAGEMENT CONSIDERATIONS

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INTRODUCTION

The conservation reserve program (CRP) was formulated in the 1985 Food Security Act and established to help prevent soil erosion on more than one third of the crop acres in the United States (USDA, 1986). Soil erosion represents the greatest threat in agriculture to the environment. Nationally, an estimated 750,000,000 tons of soil have been conserved as a result of CRP representing an estimated annual savings of $2 billion in off-farm clearing of eroded soil. Other benefits of CRP wildlife enhancement, improved water quality, and income support to participants. Iowa has 33,490 growers enrolled in CRP as of 1991 and a total of 2,107,871 acres in the program. Unless CRP continues, most of these acres will be returned to production agriculture and soil erosion may potentially increase dramatically. Grower concerns about weed management will likely result in tillage systems that enhance erosion. However, there are significant concerns about the management of weeds without the use of tillage. This paper will review weed management in CRP and present concepts that will improve the growers ability to develop environmentally and economically acceptable weed management strategies in CRP.

EFFECT OF CROPPING HISTORY ON SOIL WEED SEED BANK

The composition and density of the soil weed seed bank varies dramatically with the cropping history (Holt, 1988). Kelly and Bruns (1975) compared the weed seed bank of grasslands with adjacent fields where there had been five years of crop production. They reported that the weed seed population was four times greater in the cropped land compared to the grassland. Weed seed banks in arable land may be quite large and have been reported to range from 1,000 to 20,000 seeds m^{-2} (Kropac, 1966) and as large as 496,000 seeds m^{-2} (Froud-Williams et al., 1983).

Crop and weed management programs influence changes in the weed seed bank (Wilson, 1988). Roberts (1970) reported that the number of weed seeds in the soil could be maintained 25,000,000 ha^{-1} or less with appropriate herbicide use, tillage and crop rotation. Crookston et al. (1981) reported that the soil seed bank for continuous corn production systems was twice as large as other crop rotation systems. It is assumed that where vigorous stands of perennial grasses, either cool season species such as bromegrass (*Bromus inermis* Leyss.) and orchardgrass (*Dactylis glomerata* L.) or warm season species such as switchgrass (*Panicum virgatum* L.), were established in CRP, there would be little addition to the annual weed seed bank. However, by minimizing disturbance, the general ecology of field would likely change and other species would increase in population. These species include native prairie grasses and forbs, perennial thistles, brambles and early invading trees. Thus, while the annual weed seed bank would not increase and potentially could decline, other species would contribute to the seed bank.

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WEED SEED SURVIVAL IN THE SOIL

The fate of the soil seed bank reflects factors such as germination, dormancy, predation and loss of viability and are influenced by the physiological status of the seeds and the environmental conditions of the soil (Schafer and Chilcote, 1970). Weed seeds eventually become associated with the soil structural units and the size of the structural unit reflects tillage history; larger structural units are found in undisturbed fields (Pareja et al., 1985).

Weed seed germination is affected by moisture and oxygen levels in the immediate vicinity of the seed (Pareja and Staniforth, 1985). Dormant seeds persist in the soil because the germination requirements are not met in the soil-seed microsite. Further, weeds are very prolific seed producers and a high percentage of these seeds are viable thus increasing the probabilities of survival in the seed bank (Holt, 1988). It was estimated that 12 years would be required to deplete the soil seed bank of viable velvetleaf (*Abutilon theophrasti*) seeds to 99% of the original level (Egley and Chandler, 1983).

Roberts (1970) suggested that the rate of weed seed loss from the seed bank followed an exponential decay curve. However, the rates of decay vary for different species (Roberts and Feast, 1972). Seed germination, predation, and infection by soil microorganisms affect the loss of seeds from the soil seed bank (Cavers and Benoit, 1989).

There are a number of crop management factors that influence soil microorganism populations. Notably, higher levels of plant residue resulting from no tillage systems increased microbial populations in the topsoil compared to conventional tillage (Norstadt and McCalla, 1969). Higher microbial populations in the zone of weed seed germination enhances the depletion of the active seed bank through increased microbial infection of weed seeds (Pitty et al., 1987). Kremer and Spencer (1989) reported that *Fusarium spp.*, *Alternaria alternata* and *Cladosporium cladosporioides* were the most prevalent fungi associated with velvetleaf seeds in the soil.

Pitty et al. (1987) observed that the same fungi were associated with the deterioration of green foxtail (*Setaria viridis*) and giant foxtail (*Setaria faberi*) seeds in the soil. The colonization was higher in reduced tillage compared to conventional tillage and colonized seeds were located shallower in the soil profile.

It is assumed that CRP would enhance microbial populations and thus contribute significantly to the decline of the annual weed seed bank. No data currently exists to document this, however no tillage systems demonstrate significant declines in the active weed seed bank over time when replenishment of the seed bank is controlled. Given observations that microbial infection and predation occurs shallow in the soil, the general location of the active seed bank, it seems appropriate to assume that CRP with a competitive perennial plant population has reduced the active weed seed bank.

EFFECT OF TILLAGE ON THE SOIL WEED SEED BANK

The accepted advantages of no tillage crop production systems include reduced soil erosion, energy conservation, reduced soil compaction, reduced soil moisture evaporation, improved water infiltration and less soil temperature fluctuation (Sen, 1987). However, these advantages also potentially place weeds in a superior competitive position (Froud-Williams et al., 1983). Thus, it becomes more critical to manage weeds in no tillage systems than in production systems that include extensive tillage. Tillage ifluences weed seed germination rates and thus future weed populations. Shallow cultivations can induce weed seed germination and dilute the active seed bank by placing seeds in an environment that does not allow germination (Wilson, 1988). However, the population of many weeds may remain stable due to mechanisms such as dormancy and variable germination capabilitities (Shaw and Hainero, 1990). The ecology of weeds changes in response to the indigenous agricultural practices (Knab and Hurle, 1986). Froud-Williams et al. (1983) suggested that perennial grass and broadleaf weeds increase when tillage is reduced. However, perennial weed populations may not chane dramatically in response to reductions in tillage (Buhler, et al., 1993).

Annual weed species do demonstrate significant differences in response to tillage systems (Kotile, 1992). Pollard and Cussans (1976) and Bachthaler (1974) reported that increased tillage resulted in more broadleaf weed seedlings. Froud-Williams et al. (1983) found that weed seed populations declined significantly in plowed compared to no tillage systems, although the percentage of decline varied by site. Annual grasses and small-seeded annual broadleaf weeds demonstated higher populations under no tillage compared to complete tillage systems (Owen, 1992).

Tillage also impacts the physical location of the weed seed bank. Wicks et al. (1971) reported that as the intensity and frequency of tillage declines, the weed seed bank moves closer to the soil surface. Therefore, weed management strategies employed should reflect the weed seed position in order to improve the effectiveness of reduced tillage cropping systems. Wilson (1988) reported that reduced tillage left 50% of the weed seeds in the upper 7 cm of soil, as compared to more intensive tillage systems where weed seeds were evenly distributed throughout the upper 30 cm of the soil. Pareja et al. (1985) found that in Iowa, soils under reduced tillage systems had an average of 24 seeds per 100 g soil and represented a 6X increase in weed seed populations found in conventional tillage systems.

Burnside et al. (1986) reported that plowing reduced the total weed seed populations in the soil and that grass weeds were more affected than broadleaf weeds. However, it was suggest that grower shoudl not reduce weed management strategies despite a significant decline in the weed seed bank; the remaining weed seed population was sufficient to rapidly replenish the weed population. Schweizer et al. (1984) concluded that intensive weed management should be employed for the first few years if a large weed seed bank exists but that less intensive strategies could be successful after the weed seed bank declined. He cautioned, however, if the environment negatively impacted the weed management strategies, new weed seeds introduced or where resistant weeds develop, the weed seed bank will rapidly increase and intensive management strategies will be necessary.

EFFECT OF CRP ON WEED POPULATIONS

There have not been any reported research on the impact of CRP on weed population dynamics. Currently, Iowa State University has a research program funded by the Aldo Leopold Center for Sustainable Agriculture to determine the impact of CRP on weed populations and management systems. The research will be conducted over three growing seasons and will emphasize the weed seed bank dynamics, species shifts and alternative managements strategies. However, only cursory observations are currently available. Another consideration is that the general success of CRP establishment and species composition varied considerably. Thus, any specific remarks about CRP must account for this variability. Where growers established a competitive perennial plant population, the impact on annual weeds will be significant. If poor CRP establishment occurred, there will be minimal impact on CRP. Weed management decisions must reflect the success of the CRP perennial plant population.

Observations suggest that generally, the weed seed bank does not change dramatically where CRP has been successfully managed. Areas where the perennial plants were not successfully established likely have extremely high numbers of weeds. Typically these weeds will be small-seeded annual species and include yellow foxtail (*Setaria lutescens*), pigweeds (*Amaranthus spp.*), common lambsquarters (*Chenopodium album*) and giant foxtail. However, in specific situations, biennial and perennial thistles, curly dock (*Rumex crispus*), smartweeds (*Polygonum spp.*), perennial smartweed (*Polygonum coccineum* Muhl.) and others can increase in population. Species associated with prairies have not become major features of the CRP plant population and generally, brambles, shrubs and invader trees have not increased significantly in CRP.

Thus, returning CRP to crop production will not require major changes as a result of changes in weed species or populations. The exception will be where CRP perennial plant cover was not successfully established and the annual weed population increased dramatically. Typically only the summer annual weeds will be economically important if the CRP goes to corn or soybeans. In these patchy areas, weed pressure may be exceptionally high.

A key, and thus far unanswered question, is whether or not the active weed seed bank has been significantly depleted as a result of microbial infection and predation. Evidence suggests significantly higher micro flora in CRP and research has demonstrated that weed seed viability declines under conditions of high plant residue, presumably a direct response of high and possibly more diverse microorganism populations. Initial observations from ISU research on CRP weed populations would support this idea. CRP returned to crop production without tillage demonstrated lower weed populations than CRP that was tilled prior to crop production. Whether these observations reflect a general trend in CRP is not known. However, where tillage was conducted, the weed species were similar to those prior to the long-term CRP. Tillage moved dormant weed seeds and replenished the active seed bank that presumably had been depleted over the course of the CRP. These observations are consistent with research describing weed seed bank dynamics in long-term no tillage systems. However, it can be assumed that like long-term no tillage, CRP active weed banks can increase dramatically if weeds are allowed to reproduce. Given that most of the seeds will fall into the zone of germination, significant increase in weed populations may be observed the following year.

EFFECT OF CRP ON WEED MANAGEMENT

While weed populations may not be significantly different or may have declined compared to levels prior to CRP, there are key considerations about the impact of CRP on weed management strategies. The most important consideration is tillage. Given that CRP has significantly reduced soil erosion and that much of the land in CRP is highly erodible, restoring crop production without tillage would be desirable. Weed management without tillage can be accomplished, but not without considerable management. If tillage is determined to be necessary, weed management becomes relatively easy. However, ease of weed management may not be the determining factor with regard to tillage.

One of the potentially serious problems resulting from CRP is the topography of the land. Mammals have adapted to CRP readily and the burrows and mounds they have created represent physical barriers to equipment. Tillage may be necessary to eliminate these barriers. It then becomes a consideration as to how severe the tillage must be in order to resolve these problems. With regard to weed population dynamics, the greater the amount and severity of the tillage, the greater the impact on the weed population. Moldboard plowing will likely restore the weed population to pre-CRP levels.

Weed management strategies in CRP that has been tilled are no different than for any other field. Options include soil-applied herbicides, postemergence herbicides, mechanical strategies and cultural control opportunities. Herbicides are available to control a broad spectrum of weeds in either corn or soybeans. The choices can be made to accommodate most infestation levels, soil characteristics and application requirements. It is important to recognize that strategies supplementing herbicidal control are desirable. By initially tilling, there should be no equipment restrictions and timely rotary hoeing and cultivation are excellent options for alternative weed management. Cultural weed management can also be utilized by adjusting planting dates and row widths to make the crop most competitive with weeds.

No tillage crop production in CRP is an excellent option. Again, there are a number of herbicide options available for either corn or soybean production. Application strategies are also similar to those available in tilled CRP, however the relative risks of weed control success are different. Total postemergence strategies are not a good option in no tillage CRP. Residual herbicidal activity is important and many of the postemergence herbicides do not provide this needed component. Preemergence applications are also risky, depending upon the specific environmental conditions.

Early preplant herbicide applications fit extremely well in no tillage CRP weed management. By applying the residual herbicide prior to the germination of annual weeds, the herbicide has a better probability of moving into the active germination zone thus improving potential control. This application systems works more consistently in corn, given the earlier planting date when compared to soybeans. Preemergence herbicides or postemergence applications are likely necessary to supplement the early preplant treatments. A key consideration is that multiple application strategies are likely to provide better and more consistent weed control than single applications.

Mechanical and cultural weed management are extremely important in no tillage CRP crop production. While representing a challenge, rotary hoeing and cultivation can be accomplished in CRP. However, the equipment requirements are somewhat different than in tilled CRP. Newer rotary hoes that are designed to function in high residue are needed and cultivators are typically heavier than those traditionally used in tilled fields. An important consideration is that while many growers who produce crops without tillage are hesitant to control weeds mechanically, considering the options, mechanical weed management is cost effective. Arguments that mechanical control increases soil erosion are not founded in research data. As in all no tillage weed management, the timeliness of mechanical strategies is critical for best performance.

The biggest obstacle to weed management and crop production in CRP is the perennial grass that was established. The perennial cover, while providing excellent protection from soil erosion, becomes a weed problem when the CRP is returned to crop production. The perennial cover represents a physical problem to equipment, either planting or tillage and also may be difficult to control with herbicides. Whether the CRP will be returned to crop production without tillage or with tillage, it is likely that existing residue must be removed. The options are burning or mowing/baling; environmentally burning does not seem to be an appropriate technique. Mowing must be accomplished in a timely fashion allowing enough time for regrowth to improve the activity of the herbicide. Typically, the best time to control existing perennial cover is late summer or fall. This allows the most consistent herbicidal control and does not preclude applications in the spring if fall applications have not been successful.

The best nonselective herbicide treatment currently available is glyphosate. Glyphosate application in the fall requires eight to ten inches of new growth prior to treatment and plants should be actively growing. Application rate is dependent upon the plant species but should be 1.5 to 3 qts/A and include 0.5% nonionic surfactant. The inclusion of 2,4-D will improve the perennial broadleaf weed control. Warm season perennial grasses should be treated earlier in the season than cool season perennial grasses. If tillage is to be included in the management system, allow at least seven days between application and tillage so the glyphosate will adequately translocate into the root system. Typically, applications should be accomplished prior to the end of September. Fall applications to control the perennial cover are appropriate for either corn or soybean production.

Data from ISU research indicates that the cool season perennial grasses can be effectively control, however a single application will not be sufficient to eliminate the problem. Spring and summer applications were not as effective as the fall treatment timing. Spring applications of glyphosate have recommendations similar to the fall applications, however it will likely be necessary to supplement the glyphosate with other herbicides treatments. Given the herbicide options available, soybeans are likely a better choice if a spring glyphosate timing is selected. This will allow the advantage of cultural weed management as well as cost efficient herbicidal weed control. However, if a perennial legume was included in the perennial CRP cover, corn would be the best option.

The use of triazines to control perennial CRP cover does not represent a good option. Similarly, the use paraquat has not demonstrated sufficient control to be considered as an option. There has been some consideration of using other herbicides with efficacy on the perennial CRP cover and eliminate the nonselective application. This should not be considered an appropriate option even when tillage is included in the weed management plan.

HERBICIDE RESISTANT CROPS AND CRP

Recent registration of glyphosate resistant soybean varieties have been promoted to be the answer to weed management problems in no tillage production systems. These varieties do represent an excellent opportunity to management weeds in challenging situations and will provide potentially "worry-free" weed management when CRP is returned to crop production. However there are a few risks that must be considered when evaluating this option. Notably, in the short term, adapted varieties may not be available. Further, the use of glyphosate in a genetically altered crop is not an answer to weed management, but rather a tool in a weed management systems. Application timing and rate selection will be critically important for the success of this strategy. Glyphosate does not have residual activity and grower management will be needed to provide residual to this system, either by multiple applications of glyphosate, supplemental mechanical strategies, the use of residual herbicides in combination with glyphosate, or all of these options. Generally the more options that are included in a weed management strategy, the better, more consistent and cost-effective the weed control.

The last, albeit most important, consideration for the use of glyphosate and the genetically altered soybeans is the potential drift of glyphosate. Other plants typically do not demonstrate good tolerance to glyphosate and very little drift will significantly damage corn. While glyphosate has been used successfully without consistent drift problems when applied as a nonselective burndown treatment prior to planting, the use of glyphosate as a treatment during the growing season represents a very different situation. Considerable caution should be used when making an application decision.

SUMMARY

Weed management is the critical production issue for the return of CRP to crop production. It would be most desirable to maintain the CRP, however if the program is not available, most of the land will be placed in corn or soybean production. Warm season perennial grasses represent a greater challenge than cool season perennial grasses for control. In either case, the plant material must be removed if any crop production system and weed management strategy are to be effective. Tillage may be necessary to eliminate animal-produced barriers to equipment. Tillage will also improve the potential for consistent weed management without significantly changing management decisions. However, the risk from soil erosion may outweigh the benefits of weed control.

The use of a nonselective herbicide treatment such as glyphosate is essential whether the CRP will be returned to crop production with or without tillage. Fall applications will be more effective and consistent than spring applications. Residual weed management is necessary for effective weed management. This can result from multiple glyphosate applications (if the glyphosate resistant soybean varieties are used), residual herbicides, or supplemental postemergence applications. Regardless, the use of mechanical and cultural weed management should be included in all crop production systems.

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NORTH CENTRAL EXTENSION-INDUSTRY

SOIL FERTILITY CONFERENCE

Published for
The North Central Extension-Industry Soil Fertility Conference
by
Potash & Phosphate Institute
2805 Claflin Road, Suite 200
Manhattan, KS 66502
913-776-0273

November 15-16, 1995

St. Louis Westport Holiday Inn
St. Louis, Missouri

Volume 11

Program Chairman and Editor:

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University of Minnesota
Dept. of Soil, Water and Climate
439 Borlaug Hall
1991 Upper Buford Circle
St. Paul, MN 55108-6028