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Weed Management on Military Storage Gravel Lots

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Various commercial chemicals were tested to control visually obstructive weed populations abundant in the graveled storage areas on the Fort Riley Military Reservation. Several herbicides applied at lower amounts than the historical treatment were effective in reducing weedy plants. The chemicals Oust and Telar + Karmex provided the best long-term control. Arsenal could be added to a tank mix to provide greater control of field bindweed and tumble windmill grass. A change to these chemicals as part of the integrated pest management strategy would thus help to meet the United States Department of Defense directive to reduce pesticide usage.

INTRODUCTION

All United States military installations have been mandated to reduce pesticide use by 50% by the beginning of this century (United States Department of Defense directive Memorandum of Merit #2, Instruction 4150.7). Historically, chemicals have been used to control unwanted vegetation, but large amounts of herbicide usually were applied. Today, with greater sensitivity to the environment, more rational use of pesticides is the commonsense practice promoted.

A study to assess the effectiveness and environmental impacts of an array of vegetation management tools that could be employed at the Fort Riley Military Reservation in Kansas was initiated by Ft. Riley, USGS-National Biological Service, and Kansas State University. One of the areas under investigation is the many parking lots on the fort. It is important for safety purposes that the graveled storage (parking) areas be free of vegetation. Lowering the rate of pesticide use and using more active chemicals are being considered.

Integrated pest management (IPM), initiated in the early 1960s, is a program that uses multiple tactics to maintain pest damage below the economic injury level and at the same time provides protection against hazards to humans, animals, plants, and the environment (Edwards, Thurston, and Janke, 1991). One approach is to identify the least hazardous chemical that can be used with minimal dosages and the appropriate cultural and biological techniques that can be integrated into a management strategy. An IPM program targets containment rather than eradication. In a previous study we reported a reduction in herbicides of 90% by using appropriate chemicals for weed reduction on military artillery ranges (Geyer, Carlisle, and Fick, 2000).

For the years 1993 to 1996, an average of 1200 lbs (545 kg) of the herbicide bromacil, Hyvar XL, (6% of the total pesticide usage at Ft. Riley) was applied to numerous gravel parking and maintenance yards to control mixed broadleaf weeds, grasses, and a few woody plants. Typically, a single ground application of Hyvar XL at 16 lbs/acre (17.9 kg/ha) at greater than 30 gallons spray volume/acre (280 l/ha) is made during April or May each year. We report here the testing of alternate herbicides in an effort to identify those that are effective in controlling the target species, require minimal amounts of active ingredient, have low toxicity, are economical, and are approved for commercial application.

Methods and Materials

A vacated parking area in Camp Funston, Ft. Riley (39° 5′ 30″ N, 96° 43′ 30″ W) was selected as a surrogate to the many graveled lots. The site was vegetated with mostly herbaceous weedy plants; *Melilotus officinalis* (L.) Lam. (yellow sweetclover), *Erigeron strigosus* Muhl. ex Willd. (rough fleabane), *Convolvulus arvensis* L. (field bindweed) and *Chloris verticillata* Nutt. (tumble windmillgrass), and *Setaria viridis* (green foxtail). Less abundant species from the Poaceae, Compositae, Leguminosae, Verbenaceae, Cruciferae, Euphorbiaceae, Chenopodiaceae, and Onagraceae families were also present.

Six chemical treatments were applied and an additional plot served as the untreated control. Treatments were: (1) bromacil (Hyvar XL), at 16 lbs active ingredient/acre (pai/a) or 17.9 kg/ha, (2) chlorsulfuron + diuron (Telar + Karmex DF) at 0.05 + 4.0 pai/a + (0.06 + 4.5 kg/ha), (3) prometon (Pramitol 25E) at 2.0 pai/a (2.2 kg/ha), (4) ametryn (Evik 80W) at 2.0 pai/a (2.2 kg/ha), (5) imazapyr (Arsenal) at 1.0 pai/a (1.1 kg/ha), and (6) sulfometuron (Oust) 0.28 pai/a (0.31 kg/ha) were applied and control plots were not sprayed. For convention, trade names of chemicals are used in this report (Humburg, 1989). Herbicides were selected using cost, toxicity and efficacy ratings (Regehr and others, 2001). Rates of application were determined from chemical label guidelines and typically were in the middle to upper third of the labeled range for the intended use and targeted pest. The selected rates were considered sufficiently concentrated to significantly reduce or stunt the target species in one application. The acute oral toxicities (LD_{50}) for the herbicides (Table 1) ranged from 1750 mg/kg (Evik) to greater than

Table 1. Herbicides used in 1998 ground spray trials.

Chemical	Application rate	Toxicity*	Cost**
Oust (Sulfometuron)	@0.28 pai (0.31 kg/ha)	500 mg/kg	$77.40/A ($191.18/ha)
Hyvar (Bromacil)	**@16 pai (17.9 kg/ha)**	**5200 mg/kg**	**$424/A ($1,047/ha)**
Telar (Chlorsulfuron)	@0.05 pai (0.06 kg/ha)	5545 mg/kg	
+ Karmex (Diuron)	@4.0 pai (4.4 kg/ha)	3400 mg/kg	$49.19/A ($121.54/ha)
Arsenal (Imazapyr)	@1 pai (1.1 kg/ha)	>5000 mg/kg	$128.64/A ($317.74/ha)
Pramitol (Prometron)	@2.0 pai (2.2 kg/ha)	2276 mg/kg	$224/A ($554/ha)
Evik (Ametryn)	@2 pai (2.2 kg/ha)	1750 mg/kg	$16.18/A ($40/ha)

Historical treatment in bold.
* LD50 (acute oral).
** Approximate retail cost from 2001 Chemical Weed Control for Field Crops, Pastures, Rangeland, and Noncropland SRP 867, Kansas State University Agricultural Experiment Station and Cooperative Extension Service; 2000 Guide for Weed Management in Nebraska EC 00-130-D, Nebraska Cooperative Extension; Ken Carlson (personal communication) BASF.

5000 mg/kg (Hyvar, Telar, Arsenal, Oust). All of the herbicides are federally classified as slightly toxic (LD_{50} above 500). For additional information refer to Material Safety Data Sheets (MSDS) and product labels as published by industrial chemical firms and to Humburg (1989).

Costs of the chemicals ranged from about $16 to $424 per acre. Herbicides were applied in 42 gallons/acre spray volume (392 l/ha) using a CO_2-powered backpack sprayer and a 4-nozzle boom equipped with flat-fan nozzles (TeeJet #8006).

Two dates of application were used to test the effect of plant stage of development on treatment effectiveness. Herbicides were first applied on May 1. Winds were out of the north at 0 to 4 mph (0 to 2 m/s), temperature was 52–62°F (11 to 17°C), and the relative humidity was 77 to 94%. Vegetation averaged < 6 inches (15 cm) in height. The second application occurred on May 21. Winds again were from the north at 5 to 8 mph (2 to 4 m/s), the temperature was 77–80°F (25 to 27°C), and the relative humidity was 79 to 82%. Vegetation heights averaged > 12 inches (0.30 cm) and many plants were blooming. Precipitation after the first application occurred 5 days later, May 6, (0.39 in or 9.9 mm). Three days elapsed after the second application before 0.04 in (1 mm) of rain fell. Plots were evaluated visually as to the percent of bare ground with a range of 0 to 10. Ten represented 100% bare ground.

The experimental design was a split-split plot, with treatment as the whole plot, date of application the subplot, and evaluation date as the sub-subplot. Date of application was not significant, thus, the data were pooled over the two application dates for subsequent analysis. Data were analyzed using ANOVA at $P \leq 0.05$. Treatment means were separated using LSD. Analysis

Table 2. Percent weed control (pooled for dates of application) on graveled lots at Ft. Riley, Kansas.

Herbicide	Months after treatment (MAT)[1]			
	1 MAT	2 MAT	3 MAT	4 MAT
Oust	75a	83b	78b	69a
Hyvar	**68b**	**76c**	**71bc**	**62a**
Telar + Karmex	73a	82bc	73b	62a
Arsenal	77a	94a	86a	50b
Pramitol	77a	85b	67c	45bc
Evik	58c	64d	56d	42c
Control	0d	0e	0e	0d

Historical treatment in bold.
[1] Values in the same MAT column followed by different letters are significant at $P \leq 0.05$.

was performed separately at each evaluation date using time series model. Each treatment and time of application were replicated three times. Plots were evaluated visually as to the amount of bare ground with values ranging from 0 to 100. One hundred being 100% bare ground. Spray strips were 6.7 ft (2 m) by 50 ft (15.2 m), each separated by a 6 ft (1.5 m) no spray buffer. Evaluations were made at 30-day intervals. Vegetation remaining four months after treatment (MAT) also was noted.

Results and Discussion

Differences existed among herbicide treatments (P < 0.05) but not between dates of application (P > 0.05) (Table 2). All treatments except Evik provided control equal to or greater than Hyvar XL 1 to 3 MAT. Hyvar was the standard, currently used treatment. One month after application, treatments were 58 to 77% effective in reducing weeds. When evaluated 2 MAT, most treatments gave at least 76% control with Arsenal providing 94%. At three months after application, effectiveness decreased slightly for all treatments. There was a further decline in effectiveness after four months. Green foxtail was invading all treatments, but especially Arsenal plots (Fig. 1). Only Oust and Telar + Karmex gave control equivalent to Hyvar XL at 4 MAT.

Field bindweed and tumble windmill grass were most effectively controlled by Arsenal (Fig. 1) Including Arsenal in a tank mix with Oust may provide season long control of these hard-to-kill perennial weeds.

Conclusions

Not all treatments utilized in the trials were highly effective in controlling the vegetation in the gravel study plots. Maximum bareground conditions were recorded 2 MAT for all herbicides. Arsenal at 1 lb/a (1.1 kg/ha) pro-

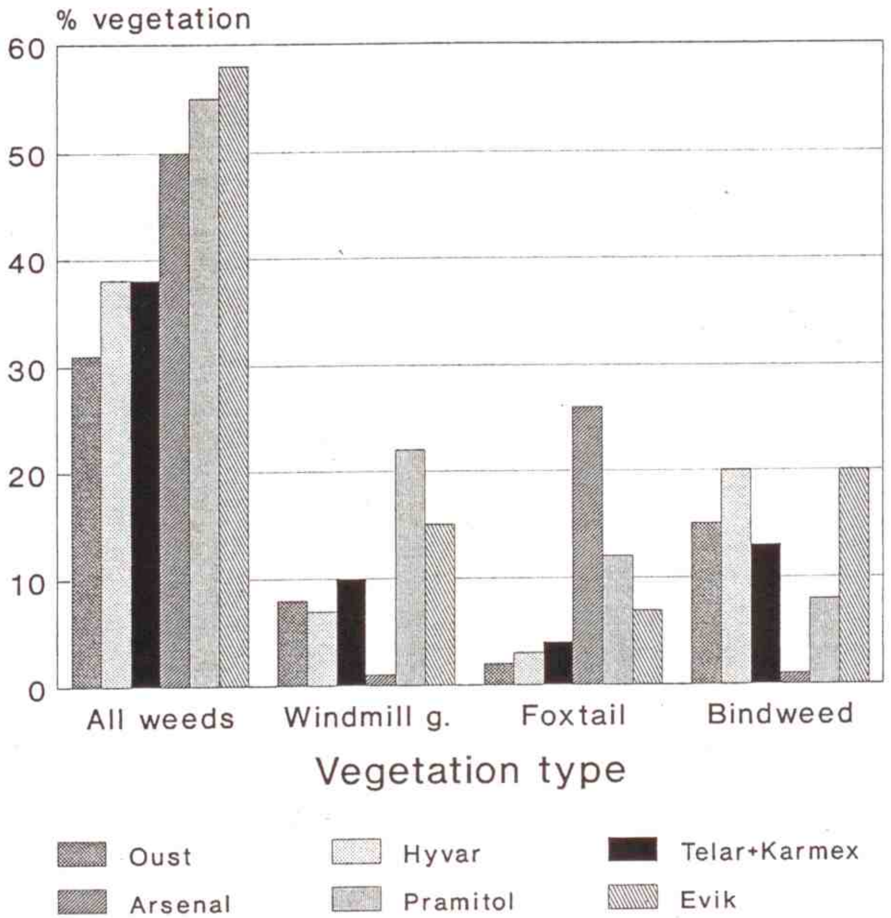

Figure 1. Remaining vegetation four months after treatment.

vided 94% bareground. At the end of the growing season, 4 MAT, only Oust and Telar + Karmex provided control equal to the treatment historically used, Hyvar XL. Time of application did not have a significant effect on the results. Field bindweed and tumble windmill grass were present in all plots at 4 MAT but were minimal in the Arsenal treatment.

Oust herbicide offered the lowest pounds of active ingredient and was priced considerably less then the historical treatment, Hyvar. If conditions experienced in the field trial were typical, substitution of Oust at 0.28 pai/a (0.31 kg/ha) for Hyvar XL would reduce the amount of active ingredient of herbicide by more than 98% in the graveled lots at Fort Riley. Use of Oust in lieu of Hyvar XL would provide a substantial contribution in reducing pesticide use at Ft. Riley. Using Telar + Karmex at the rates used in this study would reduce costs even more and reduce pounds of active ingredient by 75%. Thus, the IPM management technique of using minimal dosages of chemicals could help to reduce the amount of alien (manmade) substances in the environment.

Recommendations

Our studies have shown that the use of Oust on gravel storage areas provided the best weed control with the least amount of ingredient at attractive cost levels. Adding Arsenal enhances control of tumble windmill grass and field bindweed, two difficult-to-rid vegetation pests. Utilization of these herbicides would reduce the amount of pesticides used at military installations. Thus, the IPM management technique of using minimal dosages of chemicals could help to reduce the amount of manmade substances in the environment.

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References

Edwards, C. A., H. D. Thurston, and R. Janke. 1991. Integrated pest management for sustainability in developing countries. Pages 109–133, in Towards Sustainability. National Academy Press, Washington, DC.

Geyer, W. A., J. Carlisle, and W. H. Fick. 2000. Weed management on military artillery ranges. Kansas Acad. Science Trans. 103(1–2): 58–63.

Humburg, N. E., chm. 1989. Herbicide handbook of the Weed Science Society of America (6th ed.): Champaign, IL., 301 pp.

Regehr, D. L., D. E. Peterson, P. D. Ohlenbusch, W. H. Fick, P. W. Stahlman, and R. E. Wolf. 2001. Chemical weed control for field crops, pastures, rangeland, and noncropland, 2001. Rept. of Prog. 867. Kansas St. Univ. Agr. Expt. Sta. and Coop. Ext. Ser., Manhattan, 72 pp.