Weed Science, 1996. Volume 44:622–628

Economic Evaluation of Field Bindweed (*Convolvulus arvensis*) Control in a Winter Wheat-Fallow Rotation[1]

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Abstract. **Field bindweed infests millions of hectares in the Great Plains greatly reducing productivity and value of land. The standard practice for field bindweed control is sweep tillage at 3 wk intervals combined with one or two annual 2,4-D applications during the 14 mo fallow period in a winter wheat-fallow crop rotation. This was compared to tillage and 2,4-D in conjunction with dicamba or a mixture of picloram+2,4-D applied once during the first October of the first 14 mo fallow period. Also, three no-tillage systems were included using glyphosate+2,4-D at monthly intervals. Two of the treatments were supplemented with dicamba, or picloram+2,4-D as in the sweep tillage system. All treatments controlled field bindweed in two fallow periods and two winter wheat crops, and increased winter wheat yields to about twice the control. Sweep tillage at 3 wk intervals combined with 2,4-D resulted in $36 ha^{-1} profit for an owner-operator compared to $15 ha^{-1} loss with no herbicide or tillage treatment. On average no-tillage lost $35 ha^{-1}. Other treatments, although controlling field bindweed, lost from 35 to $186 ha^{-1}. To determine if long-term benefit after control was achieved, average yields for the area were used to calculate profits using normal farming practices. Profits were 136, 78, and $–50 ha^{-1}, respectively, for sweep tillage and 2,4-D, no-tillage, and the untreated check. In a standard 33:67 owner-tenant rental, profits to the owner for the control period were 90, -33, and $43 ha^{-1}, respectively for tillage and 2,4-D, no-tillage, and untreated check. The tenant lost from $24 to 69 ha^{-1} for the three systems indicating owners must modify rental agreements during a field bindweed control program. Nomenclature: Dicamba, 3,6-dichloro-2-methoxybenzoic acid; 2,4-D, (2,4-dichlorophenoxy)acetic acid; glyphosate, *N*-(phosphonomethyl)glycine; picloram, 4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid; field bindweed, *Convolvulus arvensis* L.#[3] CONAR; winter wheat, *Triticum aestivum* L. 'TAM 200.'**

Additional index words. **Sweep tillage, CONAR.**

INTRODUCTION

Field bindweed is a creeping herbaceous perennial weed native to Europe and western Asia that was introduced to North America along the Atlantic seaboard about 1790 (11). The weed has spread coast to coast and has become a serious problem in wheat growing areas in the western United States. It is prolific because of an extensive perennial root system and seed that can remain viable up to 50 yr (1).

Research in the 1930s and 1940s indicated sweep plowing at 2 to 3 wk intervals for 3 to 5 yr controlled large infestations of field bindweed by gradually reducing root reserves (12, 21). In the late 1940s, it was demonstrated that 2,4-D was toxic to field bindweed (6, 9). In humid areas, the greatest control was achieved by applying 2,4-D when plants were budding. However, this did not hold true for dry areas like the southern Great Plains where drought often limits plant growth and vigor. Under dry conditions, most consistent control with 2,4-D was obtained when runners were 15 to 25 cm long and plants were growing vigorously. By the budding stage, plants usually were out of soil water and growing poorly, if at all (20). Although 2,4-D was effective, repeated applications alone did not eliminate the weed (10, 17, 18). The most effective use of 2,4-D was in conjunction with tillage at 2 to 3 wk intervals during fallow periods between crops that are competitive to field bindweed (2, 10, 13, 15, 16, 17, 21). Combining 2,4-D applications with tillage reduced control cost by decreasing the number of tillages per yr and the number of yr required to control the weed. Also if rain delayed tillage, 2,4-D treatment of large weeds prevented build up of root reserves (22). In addition to 2,4-D; dicamba, glyphosate, picloram, and mixtures of some of these herbicides have been effective against field bindweed (5, 7, 14, 19) and may be useful when combined with repeated tillage.

Conservation compliance requirements are another dimension that affects field bindweed control programs and may prevent tillage at 2 to 3 wk intervals because of erosion potential (3). Consequently, no-tillage cropping systems need to be developed that will control field bindweed while retaining crop residues on the soil surface to minimize erosion.

Winter wheat-fallow, where one crop is grown in 2 yr, is a good crop rotation for field bindweed control in dry areas because of ample time for repeated tillage or other controls during the 14 mo fallow periods. Winter wheat is the most competitive crop to use in a field bindweed control program because it grows during the late fall, winter, and early spring when field bindweed foliage is frozen and cannot compete for limited precipitation and stored soil water. When field bindweed emerges in late spring, winter wheat is 15 cm tall, has an established root system, is tall enough to shade the weed, and is able to compete strongly for soil water.

The profitability or cost of various systems for field bindweed control has never been evaluated. This research was conducted in a winter wheat-fallow crop rotation. Field bindweed control as well as profitability of combining 2,4-D, dicamba, or picloram

[1]Received for publication May 12, 1995, and in revised form November 13, 1995.

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[3]Letters followed by this symbol are a WSSA-approved computer code from Composite List of Weeds, Revised 1989. Available from WSSA, 1508 West University Ave., Champaign, IL 61821.

with either sweep plowing at 3 wk intervals or in a no-tillage system was determined during fallow periods.

MATERIALS and METHODS

This study was conducted on Pullman clay loam (fine, mixed, thermic, Torrertic Paluestoll) having 1.5% organic matter and pH 7.7 near Bushland, TX, in the southern Great Plains on a field solidly infested with field bindweed. Two identical experiments during fallow periods in a winter wheat-fallow rotation were initiated June 1985 and February 1986. In this rotation, there is normally a 14-mo fallow period from wheat harvest in late June of one year to wheat planting in September the following year. Starting treatments in June and February resulted in fallow periods shorter than 14 mo. TAM 200 winter wheat was planted in 25 cm rows at 33 kg ha^{-1} with a drill having 2.5-cm-wide chisels in 8 by 18 m plots. Each experiment was started during a fallow period and was continued for a total of two fallow periods and two crops of wheat.

Herbicides used were butoxyethyl ester formulation of 2,4-D, atrazine, [6-chloro-*N*-ethyl-*N'*-(1-methylethyl)-1,3,5-triazine-2,4-diamine], dicamba, commercial formulation of isopropylamine salts of 2,4-D + glyphosate[4], chlorsulfuron, {2-chloro-*N*-[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]-benzenesulfonamide}, and 2,4-D tank mixed with the potassium salt of picloram. Herbicides were applied broadcast with a tractor plot sprayer in 240 L ha^{-1} spray mixture at 210 kPa using fan tips. Sweep tillage was 10 cm deep with an implement having five V-shaped blades each 0.8 m wide.

Details of the seven treatments, including herbicide rates, are outlined in Table 1. The basic operations in the first three treatments were sweep tillage at 3 wk intervals. This schedule was changed with application of 2,4-D at 1.1 kg ha^{-1} to 5 wk old field bindweed whenever enough rain fell to promote vigorous plant growth. In other words, if the soil was too wet to plow at the scheduled time, 2,4-D was applied 2 wk later. One of the three treatments was modified with an application of dicamba at 2.2 kg ha^{-1} to 5 wk old field bindweed during October of the first full 14 mo fallow period regardless of growing conditions. Another received picloram+2,4-D at 0.28 + 0.6 kg ha^{-1} at the same time. Only one application of dicamba or picloram + 2,4-D was made during the two fallow periods. The remaining three control treatments were not tilled, and weeds including field bindweed, were controlled with applications of a glyphosate-2,4-D mixture at 0.28 + 0.5 kg ha^{-1} every 4 wk. If grass weeds were not present, 2,4-D at 1.1 kg ha^{-1} was used instead of glyphosate + 2,4-D to reduce cost. Dicamba and picloram + 2,4-D were applied to two of the treatments the same as with sweep tillage. The untreated check was sweep tillage at 6-wk intervals. This controlled annual weeds and allowed field bindweed to flourish without competition. If needed, 2,4-D at 0.5 kg ha^{-1} was used to control flixweed [*Descurainia sophia* (L.) Webb. ex Prantl] in

Table 1. Tillage and spray treatments utilized for field bindweed control in a winter wheat-fallow-winter wheat crop rotation.

Treatment no.	Fallow treatment designation	Planned tillage and sprays
1	Tillage and 2,4-D	Three wk sweep tillage supplemented by one or two applications of 2,4-D at 1.1 kg ha^{-1} to 5-wk-old field bindweed that was vigorous because of ample precipitation; 2,4-D at 0.6 kg ha^{-1} to wheat as needed.
2	Tillage and dicamba	As Treatment 1, plus dicamba at 2.2 kg ha^{-1} once to 5-wk-old field bindweed during October of the first 14 mo or longer fallow period.
3	Tillage and picloram + 2,4-D	As Treatment 1, plus picloram + 2,4-D at 0.28 and 0.5 kg ha^{-1} once to 5-wk-old field bindweed during October of the first 14 mo or longer fallow period.
4	No-tillage	No-tillage; field bindweed and annual weeds controlled with 4 wk applications of glyphosate + 2,4-D at 0.4 + 0.6 kg ha^{-1} and atrazine 1.7 kg ha^{-1} immediately after harvest; chlorsulfuron at 0.034 kg ha^{-1} to wheat.
5	No-tillage and dicamba	As Treatment 4, plus dicamba at 2.2 kg ha^{-1} once to 5-wk-old field bindweed during October of the first 14 mo or longer fallow period.
6	No-tillage and picloram + 2,4-D	As Treatment 4 plus picloram + 2,4-D at 0.28 + 0.6 kg ha^{-1} once to 5-wk-old field bindweed during October of the first 14 mo or longer fallow period.
7	Check	Sweep tillage at 6 wk intervals.

the winter wheat crop where sweep tillage was the basic treatment, and chlorsulfuron at 0.034 kg ha^{-1} was used in wheat with no-tillage. Chlorsulfuron, which persisted in the soil, helped control weeds in the subsequent no-tillage fallow.

To harvest wheat each year, both phases of the rotation were started the first year of the experiment. Consequently, there were a total of 14 treatment plots in each of three replications. The fallow period where wheat was planted the first year in the 1985 and 1986 experiments was less than the normal 14 mo. The part of the rotation planted to wheat the first year in each experiment is designated Field A and the second year Field B. Consequently, there are Fields 85A, 85B, 86A, and 86B listed in tables. The 1985 experiment was initiated June 19, 1985. The A part of the 1985 experiment was planted to wheat October 25, 1985, after a 4-mo fallow period. The B part was not planted to wheat until a year later on October 17, 1986, after a 16-mo fallow period. The 1986 experiment was started February 28, 1986, and the A part planted October 17, 1986, giving a 7-mo fallow period. The B part of the study was planted a year later on October 12, 1987, making a 19-mo fallow period. The second fallow periods were all the normal 14 mo. It was planned that each part of the experiments be continued until two crops of wheat were harvested. The plan did not materialize because, in 1989, wheat after

[4]Landmaster BW, Monsanto Agricultural Co., (100 gL^{-1} glyphosate and 182 gL^{-1} 2,4-D) 800 N. Lindberg Blvd., St. Louis, MO 63167.

Table 2. Field bindweed control after one and two fallow periods.[a]

	Field bindweed control after									
	One fallow period on fields					Two fallow periods on fields				
Fallow treatment	85A	85B	86A	86B	Avg.	85A	85B	86A	86B	Avg.
	% control									
Tillage and 2,4-D	80 a	56 d	40 ab	100 a	69 A	100 a	100 a	100 a	93 a	98 A
Tillage and dicamba	78 a	68 cd	43 ab	99 a	72 A	100 a	100 a	100 a	91 a	98 A
Tillage and picloram + 2,4-D	63 a	86 ab	50 a	100 a	77 A	100 a	95 a	99 a	93 a	97 A
No-tillage	52 a	58 d	13 c	94 a	54 A	100 a	95 a	100 a	98 a	98 A
No-tillage and dicamba	52 a	92 a	33 b	97 a	69 A	100 a	97 a	100 a	100 a	99 A
No-tillage and picloram + 2,4-D	53 a	78 abc	53 a	97 a	70 A	100 a	100 a	99 a	99 a	100 A
Check	0 b	0 c	0 d	0 b	0 B	0	0 b	0 b	0 b	0 B
Fallow period, mo	4	16	7	19		14	14	14	14	
Precipitation, actual, mm	340	805	405	993		805	805	808	823	
Precipitation, normal, mm[b]	250	693	350	790		693	685	685	653	

[a]Means within columns followed by the same letter are not different at P = 0.05 using Duncan's Multiple Range Test.

[b]Average precipitation for 40 yr at Bushland, TX for the months involved in the fallow period.

the second fallow period on Fields 1985B and 1986A were destroyed by hail. Lease on the land was lost before the last crop of wheat on 1986B could be harvested. Consequently, the only wheat crop harvested after two fallow periods was from Field 85A. Experiments were split plots with main plots being either wheat or fallow. Sub-plots were the six control treatments and the check. ANOVA was used to analyze data from each main plot as a randomized complete block. Means were separated using Duncan's New Multiple Range Test at the 0.05 level of probability. Field bindweed percent control was visually estimated at the end of each fallow period just before wheat planting. Gravimetric soil water content at 0.3 m increments to 1.2 m was determined at wheat planting on some experiments, and wheat was harvested with a plot combine from a 1.3 by 18 m area. Grain moisture was corrected to 13%.

Average grain yield following either one, two, or both fallow periods was used to calculate short-term economic analyses. The analyses considered crop income and all production costs including herbicides, tillage, sprayer, planting and seed, interest, along with cost of harvesting and hauling grain to the elevator. Management, land, and machinery depreciation were not considered. Analyses were made for an owner-operator with yields from this experiment and a 33:67 owner-tenant lease. Long-term benefits for an owner-operator using yield averages (8) for the area also were calculated. Custom charges for spraying and sweep tillage were \$7.50 and \$12.50 ha^{-1}, respectively (4). Herbicide costs to farmers in \$ kg^{-1} were obtained from a local cooperative elevator in June 1994 and were: atrazine, 7; glyphosate, 36; 2,4-D, 7; dicamba, 45, chlorsulfuron, 684; and picloram, 107. Wheat price used was \$0.15 kg^{-1} or about the average growers received in 1994.

RESULTS AND DISCUSSION

Field bindweed control at the end of the first fallow period increased with length of fallow, which was determined by starting date of experiments (Table 2). The first fallow period for the 1985 study, Field 85A, was short because wheat was planted 4 mo after study initiation. Control with sweep tillage and 2,4-D was only 80%. Dicamba and picloram were not applied because they would have injured wheat; consequently, control was the same for the three treatments with sweep tillage. Control was 53% or less after the 7-mo first fallow on Field 86A. When wheat was planted the second year in each experiment on Fields 85B and 86B, and the fallow periods were 16 or 19 mo, control was higher than for the short fallow periods. In the long first fallow in the 1985 experiment, Field 85B, picloram + 2,4-D increased control over 2,4-D in both sweep tillage and no-tillage. Dicamba used with no-tillage also resulted in greater control than no-tillage alone. In the long first fallow of the 1986 experiment on Field 86B, precipitation was above normal. This resulted in lush growth of field bindweed, and control with herbicides was excellent with all treatments. Field bindweed control averaged for the four fields after the first fallow period ranged from 54 to 77%, indicating that more than one fallow period was needed for control (Table 2).

Field bindweed control was 90% or more after the second 14-mo fallow period with all treatments and in all fields. Control was 97% or more regardless of treatment when all fields were averaged. From a practical standpoint, field bindweed had been eliminated with all treatments, and only maintenance control for seedlings would be required in the future.

Because soil water was not determined on Field 85A, and the 1989 wheat crop was hailed out, no attempt was made to relate available soil water to subsequent wheat yields. Average available soil water at wheat planting from three fields after one or two fallow periods is in Table 3. Precipitation during the fallow periods was above normal. Because two of the first fallow periods were short on fields 85A and 86A, soil water storage was less after one fallow period than after two. There was no stored soil water in the checks after the first fallow period, because field bindweed growth utilized all precipitation. No-tillage alone was

Table 3. Available soil water in 1.2 m of profile; average from three fields at wheat planting after one or two fallow periods.[a]

Fallow treatment	Available soil water after: One fallow	Two fallows
	mm	
Tillage and 2,4-D	45 a	103 ab
Tillage and dicamba	38 a	109 a
Tillage and picloram + 2,4-D	43 a	101 ab
No-tillage	14 bc	88 b
No-tillage and dicamba	36 ab	94 ab
No-tillage and picloram + 2,4-D	25 ab	94 ab
Check	0 c	41 c
Average precipitation during fallow, mm	734	812
Long term precipitation average, mm[b]	610	675

[a]Means within columns followed by the same letter are not different at P = 0.05 using Duncan's Multiple Range test.

[b]Average precipitation for 40 yr at Bushland, TX for the months in the fallow period for each experiment.

the only weed control treatment where soil water was reduced compared to others. After two fallow periods, soil water storage was the same on all treatments except the check, which had less than 50% of control treatments. Where a control program was not used, field bindweed utilized precipitation during fallow periods leaving very little soil water for a subsequent wheat crop.

Average wheat yield on untreated areas after one fallow period was only two-thirds of where bindweed control treatments were used (Table 4). Winter wheat was harvested on Fields 85A, 85B, 86A, and 86B following one fallow period. Precipitation was above normal for all fallow and crop years. However, low yield on Fields 85A and 86B after one fallow period was caused by low rainfall in late April and May when wheat was heading. There were no differences in wheat yield among bindweed control treatments on Fields 85B and 86A the two years when yields were high. Yield on most control treatments was higher than the check. On Fields 85A and 86B yields with no-tillage were lower than with sweep tillage. This probably relates back to lower soil water storage at planting (Table 3) because wheat residue with no-tillage was not adequate to prevent all runoff from hard rains.

Only Field 85A was harvested after two fallow periods. Hail in 1989 destroyed wheat on two fields where two fallow periods of treatment had been applied. The 1986 experiment was discontinued before wheat was harvested from plots on Field 86B, which had been fallowed two times. Wheat yield on Field 85A after two fallow periods was high because of above-average precipitation during the fallow and crop yr (Table 4). There was no difference among control treatments which averaged about 2000 kg ha^{-1}. Check yield was 940 kg ha^{-1}, a little less than 50% of the sweep tillage and 2,4-D treatment.

Wheat yields were markedly increased after field bindweed stand was reduced with control treatments after one or two fallow periods. Yield increase was related to increased soil water storage at planting compared to untreated areas. Tillage at 3-wk intervals or herbicidal controls did not allow field bindweed or other weeds to develop enough foliage to transpire much soil water.

Short-term economic analyses for an owner-operator in Table 5 are for first, second, and both fallow periods. Short-term analyses do not consider machinery depreciation or returns for management and land. Using average yield in Table 4, all control treatments as well as the check lost money after one fallow period and one wheat crop. The check or tillage every 6 wk was the most economical treatment losing only \$9 ha^{-1}. Tillage and 2,4-D was the next best losing only \$18 ha^{-1}. Other control treatments lost more, but using sweep tillage and 2,4-D lost less than no-tillage treatments, because monthly applications of glyphosate + 2,4-D cost more than sweep tillage at 3-wk intervals. Highest loss, \$148 ha^{-1}, was no-tillage and dicamba.

The high wheat yield on the Field 85A harvested after two fallow periods increased income about \$100 ha^{-1} compared to

Table 4. Winter wheat yields after one or two fallow periods.[a]

Fallow treatment	After one fallow period: 85A	85B	86A	86B	Avg.	After two fallow periods: 85A
	kg ha^{-1}					
Tillage and 2,4-D	940 a	1950 a	1810 a	1080 a	1450 A	1950 a
Tillage and dicamba	740 b	1950 a	1610 a	940 ab	1310 AB	1810 a
Tillage and picloram + 2,4-D	940 a	1810 ab	1750 a	870 b	1340 AB	1810 a
No-tillage	600 c	1480 ab	1610 a	740 bc	1110 CD	2240 a
No-tillage and dicamba	600 c	1550 ab	1480 a	670 bc	1080 D	2020 a
No-tillage and picloram + 2,4-D	600 c	1750 ab	1880 a	810 bc	1260 BC	2150 a
Check	400 d	1280 b	1080 b	470 d	810 E	940 b
Precipitation, fallow period and wheat crop, mm	583	1165	768	1372		1122
Precipitation, average, mm[b]	490	945	700	1068		950

[a]Means within columns followed by the same letter are not different at P = 0.05 using Duncan's Multiple Range Test.

[b]Average precipitation at Bushland, TX, for 40 yr for the mo involved with the fallow period and wheat crop.

Table 5. Short term economic analyses for an owner-operator that do not consider machinery depreciation, or returns for management and land using various fallow treatments for control of field bindweed in a wheat-fallow-rotation.[ab]

	Economic return for treatments						
	1	2	3	4	5	6	7
	$ ha^{-1}						
Analysis After First Fallow Period							
Income:							
Wheat @ $0.15 kg^{-1}[c]	218	197	201	167	162	189	122
Expenses:							
Herbicides	43	88	53	135	180	145	5
Tillage	100	100	100	0	0	0	68
Sprayer	25	25	28	60	58	60	5
Planting and seed	12	12	12	12	12	12	12
Interest @ 10%	18	23	18	20	25	20	8
Harvest and haul	38	35	35	35	35	35	33
Total variable costs	236	283	246	262	310	272	131
Returns	(18)	(86)	(45)	(95)	(148)	(83)	(9)
Analysis After Second Fallow Period							
Income:							
Wheat @ $0.15 kg^{-1}[d]	292	272	272	342	303	323	141
Expenses:							
Herbicides	23	83	40	145	198	160	5
Tillage	125	125	125	0	0	0	85
Sprayer	20	20	25	60	63	63	0
Planting and seed	12	12	12	12	12	12	12
Interest @ 10%	18	23	20	20	25	23	10
Harvest and haul	40	40	40	45	43	43	35
Total variable costs	238	303	262	282	341	301	147
Returns	54	(31)	10	60	(38)	22	(6)
Analysis For Both Fallow Periods							
Total Income	510	469	473	509	465	512	263
Total Expenses	474	586	508	544	651	573	278
Total Returns	36	(117)	(35)	(35)	(186)	(61)	(15)

[a]Treatment numbers are detailed in Table 1.
[b]( ) indicate negative returns or losses.
[c]Average yield for one fallow period from Table 4.
[d]Yield from field 85A from Table 4 after two fallow periods.

income from average yield after one fallow period. Profit with tillage and 2,4-D, tillage and picloram+2,4-D, and no-tillage was 54, 10, and $60 ha^{-1}. Other treatments were not profitable.

When income and expenses for both fallow periods were added together, tillage and 2,4-D was profitable returning $36 ha^{-1}. The check treatment lost less than other control treatments, $15 ha^{-1}. Losses ranged from 35 to $186 ha^{-1} for the other treatments. The least profitable was when dicamba at 2.2 kg ha^{-1} was used with tillage or no-tillage.

When low wheat yields from Field 85A after one fallow period (Table 4) were added together for two crops and expenses for both fallow periods shown in Table 5 were used to calculate returns to an owner-operator, losses for the check, tillage and 2,4-D, and no-tillage were 152, 192, and $364 ha^{-1} (Table 6). This indicates that cost of control on marginal land with low yield potential is not justified, and a possible alternative would be to use annual crops of winter wheat or summer annual forage crops for grazing, thus using low inputs to minimize risk.

Long-term benefits for a field bindweed control program were calculated from results of a 10 yr experiment on the same soil type that was conducted 5 mi from these field bindweed studies (8). Using the long-term yield level there was a $136 ha^{-1} profit from two fallow periods and two wheat crops using sweep tillage and 2,4-D compared to $50 ha^{-1} loss in the check (Table 6).

Much of the land in the southern Great Plains is operated by tenants. Yields for both fallow periods from Table 4 and a standard 33:67 rental agreement were assumed for an analysis. With this rental agreement, the tenant gets two thirds of the crop and pays for 50% of herbicide and harvest costs. The tenant also performs or pays for tillage and spraying. The costs used and split up between owner and tenant come from the bottom of Table 5. Economic analysis of this arrangement for two crops and two fallow periods indicates the owner has $90 ha^{-1} profit with tillage and 2,4-D, and the tenant lost $64 ha^{-1} (Table 6). No-tillage lost 33 and $24 ha^{-1} for owner and tenant, respectively. The check treatment resulted in profit for the owner and loss for the tenant.

Table 6. Economic analyses for tillage and 2,4-D, no-tillage and 2,4-D and the check treatment with different yields and rental arrangements for a total of two fallow periods and two winter wheat crops.

Fallow treatment	Total for two fallow periods and two crops			
	Wheat yield	Income @ $0.15 kg^{-1}	Expenses	Returns
	kg ha^{-1}	$ ha^{-1}		
Low Wheat Yield as in Field 85A[a]				
(Owner-operator)				
Tillage and 2,4-D	1880	282	474	(192)
No-tillage	1200	180	544	(364)
Check	800	121	272	(152)
Long Term Benefit Analysis[b]				
(Owner-operator)				
Tillage and 2,4-D	3160	474	338	136
No-tillage	3180	477	399	78
Check	1520	228	278	(50)
33:67 Lease Agreement[c]				
Owner share				
Tillage and 2,4-D	1133	170	80	90
No-tillage	1116	167	200	(33)
Check	586	88	45	43
Tenant share				
Tillage and 2,4-D	2267	340	404	(64)
No-tillage	2234	335	359	(24)
Check	1174	176	245	(69)

[a]Low yields from field 85A after one fallow period in Table 4 and multiplied by two because of two crops. Expenses taken from Table 5 and totaled for two fallow periods.

[b] This analysis determines the benefit to an owner-operator after field bindweed control has been achieved. Yield is a 10 yr average from an experiment comparing sweep tillage and no-tillage on the same soil type about 5 miles from these field bindweed control studies (8). In the tillage and 2,4-D treatment it was assumed that tillage could be reduced to once every 6 wk or the same as the check and herbicide and sprayer cost were reduced 50%. In the no-tillage and 2,4-D treatment, herbicide and spray cost were reduced 33%. The check yield were reduced 52% which was the same as the reduction between the tillage and 2,4-D treatment after two fallow periods and the untreated check in Table 4.

[c]Expenses and yields taken from Table 5 and totaled for both fallow periods and two crops. Owner and tenant share chemical and harvest cost. Tenant applies chemical and does the tillage. Owner receives 33% of yield and tenant 67%.

Using the expenses and income from this study, the tillage and 2,4-D treatment would give about $10 ha^{-1} profit to owner and tenant if the owner paid 33% of tillage cost in addition to sharing chemical and harvest cost (data not shown). There are many possible lease arrangements, and the economic consequences of control costs or no control at different yield levels and wheat prices must be considered in arriving at equitable rental contracts. In another study, the winter wheat-fallow rotation was the least profitable of several rotations evaluated (8). The most profitable was winter wheat-fallow-sorghum-fallow. This indicates control may be more profitable for both owner and tenant with a different crop rotation.

These experiments were conducted in years with above average precipitation; consequently, 2,4-D was very effective (22). When the experiments were initiated, dicamba and picloram + 2,4-D treatments were included because they were more effective than 2,4-D alone for fall application under normal dry conditions (18) that usually prevail in the western part of the southern Great Plains. Above average precipitation during these experiments prevented evaluation of these herbicides under "normal" weather conditions. Because dicamba and picloram + 2,4-D treatment were more expensive than 2,4-D, economic evaluation favored 2,4-D. In general, no-tillage cost more than sweep tillage. However, using glyphosate + 2,4-D at monthly intervals was reasonably economical and could be used on fields where government conservation programs dictated a no-tillage system.

LITERATURE CITED

1. Brown, E. O. and H. Porter. 1942. The viability and germination of seeds of *Convolvulus arvensis* L. and other perennial weeds. Pages 473–504 in Iowa Res. Bull. 294.
2. Derscheid, L. A., J. F. Stritzke, and W. G. Wright. 1970. Field bindweed control with cultivation, cropping, and chemicals. Weed Sci. 18:590–596.
3. Federal Register. 1987. Highly erodible land and wetland conservation: Final rule and notice of finding no significant impact. 52(180):35193–35208.
4. Findley, D. S. and J. H. Waldrop. 1992. Pages 9, 14, 55 *in* Texas Custom Rates Statistics. Compiled by USDA, National Agricultural Statistics Service, Austin, TX.
5. Gooding, J. R., L. S. Jordan, and W. H. Isom. 1967. Low rates of Tordon for field bindweed control. Down to Earth 22(4):6–7.
6. Hamner, C. L. and H. B. Tukey. 1944. The herbicidal action of 2,4-dichlorophenoxy acetic acid and 2,4-5-trichlorophenoxy acetic acid on bindweed. Science 100:154–155.
7. Heering, D. C. and T. F. Peeper. 1988. Control of field bindweed with imazapyr in winter wheat. Proc. South. Weed Sci. Soc. 41:93.

8. Jones, O. R. and G. L. Johnson. 1993. Page 9 *in* Cropping and tillage systems for dryland grain production. USDA, ARS, Conservation and Production Research Laboratory, Bushland, TX 79012. Research Rep. 93–10.
9. Phillips, W. M. 1950. The effect of 2,4-D on field bindweed. Res. Rep. North Cent. Weed Contr. Conf. 7:30–31.
10. Phillips. W. M. 1961. Control of field bindweed by cultural and chemical methods. U.S. Dept. Agric. Tech. Bull. 1249. 30 pp.
11. Phillips, W. M. 1978. Field bindweed: The weed and the problem. Proc. North Cent. Weed Contr. Conf. 33:140–141.
12. Phillips, W. M. and F. L. Timmons. 1954. Bindweed: How to control it. Kansas Agric. Exp. Stn. Bull. 366. 24 pp.
13. Russ, O. G. and L. W. Anderson. 1960. Field bindweed control by combinations of cropping, cultivation, and 2,4-D. Weeds 8:397–401.
14. Schoenhals, M. G., A. F. Wiese, and M. L. Wood. 1990. Field bindweed (*Convolvulus arvensis*) control with imazapyr. Weed Technol. 4:771–775.
15. Stahlman, P. W. 1978. Field bindweed control in the Central Great Plains: A review. Proc. North Cent. Weed Control Conf. 33:150–152.
16. Schweizer, E. E., J. F. Swink, and P. E. Hiekes. 1978. Field bindweed control in corn and sorghum with dicamba and 2,4-D. Weed Sci. 26:665–668.
17. Swan, D. G. 1982. Long-term field bindweed (*Convolvulus arvensis*) control with two cropping systems. Weed Sci. 30:476–480.
18. Wiese, A. F. and D. Lavake. 1986. Control of field bindweed with postemergence herbicides. Weed Sci. 34:77–80.
19. Wiese, A. F., J. Gibson, and D. Lavake. 1967. Controlling large patches of field bindweed infestations with repeated applications of Tordon. Down to Earth 23(2):2, 37, 38, 39.
20. Wiese, A. F. and H. E. Rea. 1955. Bindweed control in the Panhandle of Texas. Texas Agric. Exp. Stn. Bull. 802. 8 pp.
21. Wiese, A. F. and H. E. Rea. 1959. Bindweed (*Convolvulus arvensis*) control and seedling emergence as affected by tillage, 2,4-D and competitive crops. Agron. J. 51:672–675.
22. Wiese, A. F. and H. E. Rea. 1962. Factors affecting the toxicity of phenoxy herbicides to field bindweed. Weeds 10:58–61.