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CONTROL OF WILD MORNING GLORY OR BINDWEED BY CULTURAL METHODS\*

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An experimental program for the eradication of wild morning glory or bindweed was started in the spring of 1939. The experimental field of 160 acres is located in the southeastern section of Umatilla County, approximately five miles southeast of the Pendleton Branch Experiment Station. The land is Indian-owned and located within the Umatilla Indian Reservation. The infestation of bindweed or wild morning glory on this field at the beginning of the program was uniformly heavy. The stand may be termed "old" as it is reported the plants appeared on this field 30 to 35 years ago. Crop production on the field has been intermittent for a period of years and had practically been abandoned at the time this experiment was started. A portion of the field was seeded to barley during 1938 and approximately 40 acres were seeded to wheat during the spring of 1939. It is reported that yields for both these crops were so low as to be considered as failures.

Summary and Conclusions

The most economical method of morning glory control and eradication, and at the same time the most practical, is to alternate one year of properly timed cultivations and one year of crop rather than to cultivate continuously and keep the land out of production until all the bindweed or morning glory plants are killed. The most effective and inexpensive combination of cultural practices as measured in terms of extent of weed destruction and yield of grain crops during the period is outlined as follows:

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\* Note: This is a progress report on the weed control project which has been conducted under the cooperation of the Umatilla County Court, the United States Indian Service, the U.S. Bureau of Plant Industry, Soils and Agricultural Engineering.

1. Plow infested fields in early spring by the time of first emergence of morning glory plants or within a few days afterward.
2. Destroy all growth by cultivation throughout the season. Cultivations are most effective if made 8 to 12 days after each emergence of the plants following the previous cultivation.
3. Seed to winter wheat or winter rye after one season of such cultivated fallow. The rate of seeding should be increased above the normal rate so that a vigorous, dense stand of crop plants will be obtained.
4. Use a nitrogen-carrying fertilizer preferably early in the spring in order to stimulate an early and rapid growth of the crop plants before the weeds begin to grow and compete with the crop. The use of fertilizer has not produced outstanding yield increases but has stimulated early vegetative growth of the crop, thus increasing shading and competition.
5. A relatively deep tillage shortly before planting time has assisted in delaying growth of the weeds the following spring, but has not materially decreased the roots found in the soil. To date this method has been more in the nature of a control measure than one of eradication.
6. Cultivation of surviving plants should begin again immediately after grain is harvested. Cultivations made in the fall should be done with a blade weeder or other implement that will disturb stubble and topsoil as little as possible to prevent erosion during the winter.
7. The most satisfactory implement used during the fallow period was the duckfoot field cultivator. The rod weeder with the duckfoot attachments is satisfactory in soils that are not too rocky. The rod weeder and duckfoot cultivator used for alternate operations are satisfactory.

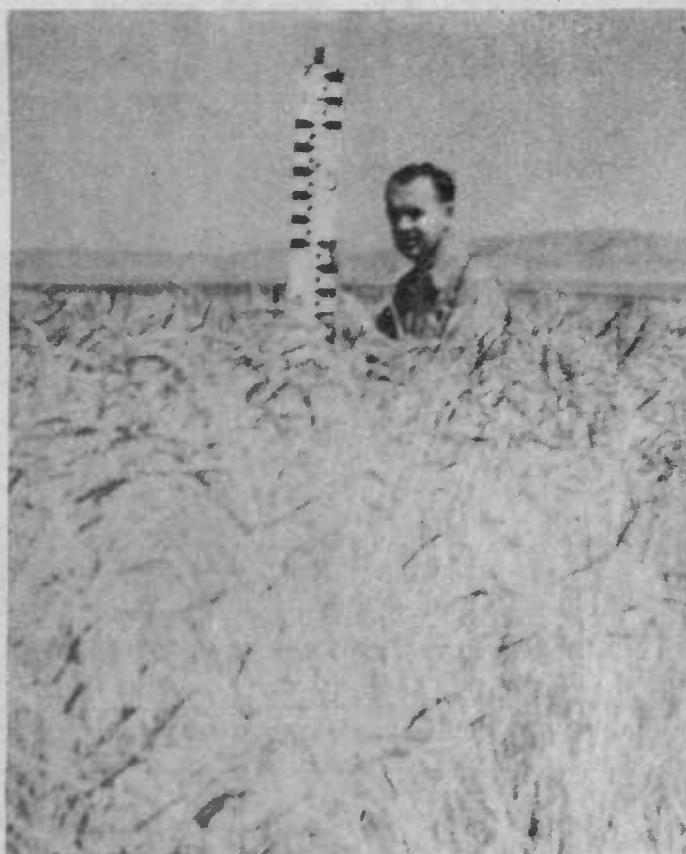
The extra cost for one season of cultivation and fertilizer as outlined above has averaged approximately \$5.75 per acre above the average cost of preparing fallow on non-morning glory land and normal wheat yields have been obtained.

#### Weather Data

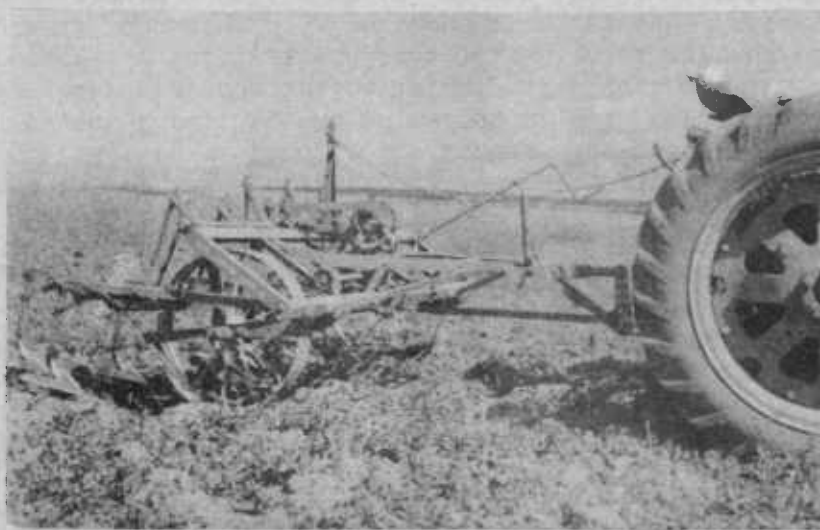
Both precipitation and temperature were favorable for crop production during the past three years (1941-1943). These years show above normal rainfall during the fall, relatively low during the winter months and exceptionally high during the critical months of May and June. The mean monthly temperature was also favorable during the last three years. Although the minimum temperatures during the winter of 1942 and 1943 were lower than the normal, there was



Crop growth on morning glory land following cultivation as ordinary summer fallow



Crop growth on morning glory land following cultivation 8 days after weed emergence throughout the season



Duckfoot field cultivator with 14 inch "shovels" or "sweeps"

no appreciable winterkilling. The mean temperature during May and June for the three years was from 2 to 6 degrees lower than normal. The cooler temperatures combined with higher than normal rainfall were favorable for crop yields. The relationship of rainfall and temperature was particularly favorable for the 1943 crop and is reflected by the high yields for that year, as shown in Tables 1 and 4. Of the four crop-years since the experiment was started, only one year (1939-40) shows rainfall below and the mean temperature above normal. The May and June rainfall during 1940 was particularly light, with the mean temperature higher than normal.

### Destruction of Root Reserves Essential

Success in morning glory eradication by cultivation depends upon the destruction of reserves of food in the roots. The quantity of these reserves is indicated by the fact that one acre-foot of soil may contain more than half a ton of bindweed roots, consisting largely of starch and other carbohydrate plant food reserves. Cultivation for eradication is successful only if it forces the plants to use or draw on these root reserves faster than they are replenished and stored. During normal growth the low point of root reserves of morning glory is reached in early spring before the plants reach the flower bud stage. It is essential, therefore, to begin cultivation in early spring to take advantage of the low point in food reserves.

Table 1. Summary of winter and spring wheat yields from plots infested with Morning Glory (bindweed) following cultivation started at three different stages of plant growth. Pendleton 1940-43.

Time of Seeding and Cultivation Practice	TIME OF STARTING CULTIVATION		
	Emergence of Morning Glory in spring	Morning Glory in flower bud stage	Morning Glory in full bloom
BUSHELS PER ACRE - 4-YEAR AVERAGE			
Fall Seeding			
Average all cult. plots	48.2	40.1	28.6
*Checks	21.8	21.6	15.1
Spring Seeding			
Average all cult. plots	32.1	30.5	21.0
*Checks	15.9	15.1	15.7
*Checks cultivated as ordinary summer fallow			



Crop growth on morning glory infested plots that were alternately cultivated - Cropped for four seasons. Left: Cultivated as ordinary summer fallow. Right: Cultivated 8 days after weed emergence throughout the season



Morning glory plants in bloom in wheat crop on plots cultivated as ordinary summer fallow

Early cultivation serves an additional purpose in conserving soil moisture. This is important because morning glory plants become dormant during the summer if the soil moisture becomes too low. While dormant the plants do not grow and nothing is gained by cultivating. If, on the other hand, the soil moisture is conserved the morning glory continues to send out new growth after each cultivation and continues to draw on its root reserves, thus hastening its eradication.

Soil nitrates, as well as moisture, will be more favorable for crop production during average years if plowing is done early. Early plowing and subsequent properly timed cultivations during the season not only result in more rapid destruction of the morning glory roots but also produce greater yields of wheat, as shown in Tables 1 and 4. The decrease in dry weight of morning glory roots from the surface acre-foot of soil is also more rapid when cultivation is started early than when started at later periods during the season.

The percentage decrease of roots as compared to the uncultivated checks is shown for two different seasons in Table 2. The dry weight of roots from uncultivated plots for a two-year average was 1,029 pounds in the surface acre-foot of soil. When plots were plowed in early spring and subsequent cultivations were made 8 days after weed emergence for two different seasons and followed with a crop of wheat, the average dry weight of roots was 185 pounds per acre. This is a decrease of 82.1 percent. When the plowing was delayed until the plants were in the bud and full bloom stages, with similar cultivations, the decrease in dry weight of roots was 66.7 percent and 15.5 percent respectively.

Table 2. Dry weight of morning glory (bindweed) roots in surface acre-foot of soil following cultivation started at different stages of plant growth. Pendleton 1939-41. (Cultivated 8 days after each plant emergence for one season and followed with crop of wheat.)

Stage of weed growth at beginning cultivation	Average No. cultivations		Dry weight of roots after one year cultivation		Average pounds per acre	Percent decrease of roots		
	1939	1940	1940	1941		1939	1940	Ave.
			lbs.	lbs.				
First emergence in spring	11	11	169	201	185	83.6	80.5	82.1
Bud stage	8	9	383	304	343	62.8	70.5	66.7
Bloom stage	3	5	880	801	870	14.5	22.2	15.5
*Checks								
No cultivation	0	0	1029	1029	1029	0	0	0
*Checks determined from uncultivated plots and are the average of 62 samples taken during two-year period.								

Proper Timing of Cultivation Necessary

Thorough cultivation after the initial plowing should be made 8 to 12 days after each emergence of the morning glory plants throughout the season in order to deplete or destroy root reserves. The percentage decrease in total carbohydrate root reserves for 4-day, 8-day, and 12-day intervals of cultivation has been rapid during one season as compared to the uncultivated checks. Twelve days approach the maximum interval that should be allowed for growth between weed-plant emergence and the succeeding cultivation. Although the trend is generally downward for this interval throughout the season, there are periods between cultivations in which the decrease of food reserves was relatively small and increased slightly during some periods.

The decrease of roots as measured by dry weight content following one season of cultivation was rapid for all intervals of cultivation as indicated in Table 3. From the results to date, the 4-day period is slightly superior in root destruction to the 8-day and 12-day periods of cultivation but the advantage

Table 3. Dry weight of morning glory roots in surface acre-foot of soil as influenced by frequency of cultivation for one and two seasons. Pendleton, 1939-40 and 1940-41.

Number of days between plant emergence and cultivation	Ave. number of cult. per season	Average pounds dry matter in surface acre-foot of soil				Percent decrease	
		One season	Two seasons	One season	Two seasons	Average one season	Average two seasons
		1939	1939-40	1940	1940-41		
4 days	14.5	144	56	113	42	87.5	95.8
8 days	11.0	169	67	201	48	82.1	94.4
12 days	9.5	380	74	198	53	71.9	93.8
*Check - No cult.	0	1029	1029	1029	1029	0.0	0.0

\*Checks were determined from uncultivated plots and are the average of 62 samples during 2-year period.

is not enough to compensate for the cost of the extra cultivations. When the plots were cultivated for two successive years the small amount of roots remaining in the soil was similar for all intervals.

The 4-year average yield of winter and spring wheat from plots cultivated at different frequencies for one to three seasons is shown in Table 4. This table indicates the superiority of fall-sown over spring-sown wheat from the standpoint of increased yields. Field observations have also indicated the superiority of fall-sown wheat over spring-sown on the decrease of morning glory plant population.

Table 4. Summary of winter and spring wheat yields from plots infested with morning glory (bindweed) when cultivated at different frequencies throughout season. Pendleton 1940-43.

Time of Seeding	NUMBER DAYS BETWEEN WEED EMERGENCE AND CULTIVATION			
	4 days	8 days	12 days	*Checks
	BUSHEL PER ACRE - 4-YEAR AVERAGE			
Fall	46.1	48.9	49.4	19.9
Spring	32.4	30.6	31.4	15.5

\*Checks cultivated as ordinary summer fallow.

There has been no significant difference in yields of wheat from plots cultivated at 4-day, 8-day and 12-day frequencies. On a cost per bushel basis, the 8-day and 12-day periods are practically identical and are lower than the 4-day interval.

Deep tillage before seeding has been favorable as a control measure during the first and second years of the cultivation program (Table 5). The emergence of weed plants in the spring following deep tillage in the fall has averaged from 15 to 20 days later than where shallow tillage was made. When the optimum cultivation practices are employed for at least four seasons, however, it does not appear desirable or necessary to make a deep tillage before seeding the crop.

Table 5. The effects of deep tillage before seeding on yield of fall-planted wheat on plots infested with morning glory (bindweed). Pendleton 1940-42.

Crop Year	Alternate year Cultivation crop		Two years' cultivation before seeding		Average
	Deep (1) tillage before seeding	Shallow (2) tillage before seeding	Deep (1) tillage before seeding	Shallow (2) tillage before seeding	
	Bu.	Bu.	Bu.	Bu.	Bu.
Cultivation started with weed emergence in spring					
Average					
1940-42	53.3	52.1	50.1	49.9	51.4
*Checks	25.0	20.4	22.5	20.6	22.1
Cultivation started when weeds in bud stage					
1940-42	39.3	37.5	36.8	44.0	39.4
*Checks	24.8	23.1	21.7	22.6	23.1
Cultivation started when weeds in full bloom					
1940-42	32.8	29.2	37.0	34.6	33.4
*Checks	18.0	16.3	18.9	18.0	17.8

\* Checks cultivated as ordinary summer fallow.

(1) Deep tillage = 8 - 10 inches.

(2) Shallow tillage = 4 - 5 inches.



Alternating One Year of Cultivation and Crop

Proper timing of cultivation for one season and seeding to a crop of wheat appears to be the most practical cultural procedure. This alternate fallow crop system is not considered merely as a control measure. The results to date indicate that root depletion will occur over a period of years when alternate fallow-crop is practiced and at the same time crop yields will be maintained with less soil erosion than if cultivated for two successive years before seeding. This type of operation will not only decrease the net cost but the length of period required to destroy the root system will not materially increase. The weight of roots in plots that have received alternate cultivation and cropping for four seasons is as low as in plots that have received two successive years of cultivation and one crop.

The yields of wheat for both fall-sown and spring-sown have been as high on plots that received alternate cultivation and cropping as on plots that had received two successive years' cultivation before planting to a crop. The average yield of fall-sown wheat for all plots for a three-year period (Table 6) is 44.8 bushels per acre for the alternate cultivation crop and 44.0 bushels

Table 6. Comparison of alternate tillage - crop and two successive years of tillage before seeding as measured by yields of fall and spring sown wheat on plots infested with morning glory (bindweed). Pendleton 1941-43.

Length of Cultivation Period	TIME OF STARTING CULTIVATION			Average
	Emergence of morning glory in spring	Morning glory in flower bud stage	Morning glory in full bloom	
BUSHELS PER ACRE - 3-YEAR AVERAGE				
Fall Seeding				
Alternate cult. - crop	55.1	40.7	38.7*	44.8
2 yrs. cult. before seeding	54.8	43.7	37.6*	44.0
Spring Seeding				
Alternate cult. - crop	38.8	33.4	33.6*	35.3
2 yrs. cult. before seeding	38.5	37.8	35.1*	37.1

\* These plots cultivated for two seasons as indicated and then cultivation started with first emergence of morning glory in spring for following two seasons.

per acre from plots having two years' cultivation before seeding. For spring-sown wheat the average yield from plots receiving alternate cultivation crop was 35.3 bushels per acre and 37.1 bushels per acre on plots receiving two years' cultivation before seeding.

### Choice of Crop

During the course of these trials, crops of fall-sown wheat, barley and rye have been of approximately equal value in competing with morning glory or bindweed. Fall-sown wheat, however, is preferred for most areas in eastern Oregon due to its economic importance. During the early part of the growing season, barley affords more competition than the other cereal crops used because of the higher percentage of leaves. Most of the barley varieties, however, have weak stems and lodging is generally severe. When this occurs the morning glory plants grow up above the crop and have little competition the remainder of the season. Another factor that will limit the use of barley as a competitive crop in areas of low winter temperatures is lack of winter-hardiness. During dry seasons or in areas of low rainfall, rye has certain advantages as a competitive crop. Because of the volunteer problem, however, rye is undesirable for seeding in the wheat-growing sections.

### Cultivation of Land Immediately After Crop Harvest

Morning glory plants that are growing with a crop will have a long period of growth after harvest if left undisturbed the remainder of the season. Good results have been obtained by cultivating 6 to 8 inches deep with a blade weeder immediately after a crop is harvested. Top growth and roots to the depth of cultivation are destroyed by this operation. At harvest time the soil is usually very dry and cultivation during that period substantially delays regrowth during the remainder of the season even though moisture may fall later during the season. Additional cultivation whenever regrowth occurs, however, is a necessary aid in further weakening of plants that may otherwise fully recover by the end of the growing season.

### Nitrogen Fertilizer Applications

Ammonium sulfate applied as a top dressing on winter wheat in the spring and with the seed when planted in the fall has stimulated vegetative growth of the crop which has prevented most of the morning glory plant seedlings from becoming established during the year of the crop. The fertilizer has also produced some increase in wheat yields. The greatest effect of nitrogen fertilizer applications on control of morning glory plants, however, is during the first and second years of the cultivation program. After the second year, proper timing of cultivation appears to have more effect than nitrogen fertilizer on the amount of bindweed found in the crop at the time of harvest. As shown in Table 7, a more pronounced effect of the fertilizer is shown in the plots that were cultivated one year and cropped the next.

Table 7. The effect of nitrogen fertilizer on the number of morning glory (bindweed) plants at time of winter wheat harvest on plots with varying tillage practices. Pendleton 1939-42.

Number days between plant emergence and cultivation	Time fertilizer applied (1) and amount per acre	Number plants per sampled area*		Average
		Two years alternate fallow- crop 1939-40	Four years alternate fallow- crop 1939-42	

Cultivation started when weeds emerge in spring

4 days	None	6	2	4.0
4 days	Spring-100 lbs.	3	2	2.5
4 days	Spring-200 lbs.	3	0	1.5
8 days	None	4	0	2.0
8 days	Fall-100 lbs.	5	0	2.5
8 days	Spring-100 lbs.	3	0	1.5
8 days	Spring-200 lbs.	1	0	0.5
12 days	None	7	4	5.5
12 days	Spring-100 lbs.	3	0	1.5
12 days	Spring-200 lbs.	1	0	0.5
Check-cult. as ordinary fallow	None	31	23	27.0

Cultivation started when weeds in bud stage

8 days	None	12	11	11.5
8 days	Spring-100 lbs.	6	2	4.0
8 days	Spring-200 lbs.	4	1	2.5
Check-cult. as ordinary fallow	None	28	12	20.0
Average all fertilized		3.2	0.5	1.8
Average not fertilized		7.2	4.2	5.7

(1) Fertilizer - ammonium sulfate.

\* Counts made on 9 sq. ft. and 3 to 5 samples per plot.

Table 8. The effect of nitrogen fertilizer on yield of winter wheat on plots infested with morning glory (bindweed). Pendleton 1940-43.

Time Fertilizer* Applied	TIME OF STARTING CULTIVATION			Average
	Emergence of morning glory in spring	Morning glory in flower bud stage	Morning glory in full bloom	
BUSHELS PER ACRE - 4-YEAR AVERAGE				
Spring	49.7	39.6	28.2	40.2
No fertilizer	47.6	35.8	24.6	37.1

\*Ammonium sulphate 100 lbs. per acre.

Nitrate fertilizer applied in the spring of the year of the fallow season has not shown any effects on either the yield of wheat or decrease of bindweed plants found in the succeeding crop.

The 4-year average yields of fall-sown wheat (Table 8) from fertilized plots for all types of cultivation is 40.2 bushels per acre, and 37.1 bushels per acre on the unfertilized plots.

#### Implements to Use

For the first or beginning operations in the spring, the plow set at a depth of 6 to 8 inches appears to be the best implement to use. Immediately after plowing, use spring-tooth harrow (deep as possible) to bring straw to the surface. This eliminates most of the "plugging" of the duckfoot cultivator with straw during the first cultivation. For cultivation the remainder of the season, up to the time of preparation for seeding, the duckfoot field cultivator is preferred and should be used for most locations. Frequent use of the rod weeder on many soil types will pack the soil and prevent sufficient penetration to thoroughly cut off all roots. The new duckfoot attachments for rod weeders correct that difficulty but rocky or gravelly soils may break the points on the attachment. Some of the new types of blade weeders are satisfactory if the blades are adjustable so that uniform penetration can be maintained. The blade weeder has a tendency to pack the soil or produce too fine tilth. This increases erosion during the winter or when there is heavy runoff.

For tillage just after crop harvest, a plow or blade weeder is satisfactory. From the standpoint of crop yields or decreased growth of bindweed or morning glory plants, there has been no appreciable difference between the two. The blade weeder is preferred as there is less disturbance to the soil and more stubble is left on the surface as a protection against erosion.

The total number of cultivations will vary with different seasons. Spring work may begin early or late and the date that growth ceases in the fall will also vary. Dry growing seasons with relatively high temperatures

will retard plant growth while moist or wet seasons promote rapid recovery of plants following each cultivation. The number of days between successive cultivations after plowing in the spring until the end of the season for different years has been variable. The number of days between successive cultivations for the three intervals or frequencies of cultivation used have followed the same general trend or pattern throughout the season. There is a long period between the first and second cultivation in the spring. The number of days between the next five cultivations are progressively fewer. The shortest period between cultivations occurs during the latter part of May to early July. The period between cultivations during the latter part of the season gradually increases, with the final interval extending to as much as 30 days between cultivations.

The combination of lower-root reserves of the morning glory or bindweed in the spring, relatively deep tillage as made with the plow for the first operation, and lower growing temperatures probably account for the long interval in number of days between the first and second cultivation. The more shallow cultivation after the initial operation and better growth conditions between the second and seventh cultivations favor more rapid emergence of the plants and therefore a shorter interval between cultivations. The gradual decrease in root reserves brought about by previous cultivations, decreased soil moisture and lower temperatures, result in a longer interval between cultivations during the latter part of the growing season. For example, on the plots that were cultivated 8 days after weed emergence throughout the season, the number of days between successive cultivations has varied from 12 during optimum growth periods to 28 days between the last two cultivations for the season. It is, therefore, apparent that careful observations must be made each time growth starts after cultivation if successful results are obtained with the minimum number of operations.

The cost per acre for the minimum operations (excluding fertilizer and deep tillage before seeding) for one season's cultivation when started in the spring and cultivated at 4-day, 8-day and 12-day intervals after plant emergence throughout the season has averaged \$3.84, \$2.56 and \$2.24 respectively per acre more than the average cost of preparing fallow on land that is not infested with morning glory. The total cost per acre and per bushel of producing wheat on these plots and the cost for the average farm in the general locality of the experimental field are shown in Table 9. When cultivated for one season the total cost per bushel was 56 cents for the 4-day plots, 50 cents per bushel for the 8-day plots, and 49 cents per bushel for the 12-day plots. The check plots that were cultivated as ordinary fallow or similar to the cultivation practiced on land not infested with bindweed had an average cost of \$1.10 per bushel. The average cost per bushel on farms in the same locality as the experimental field, as indicated in Oregon Experiment Station Bulletin 373, is 62 cents. When cultivated for two successive seasons before seeding to wheat the average cost from the 4-day plots was 81 cents per bushel, on the 8-day plots 78 cents per bushel, and on the 12-day plots 72 cents per bushel. Check plots that were cultivated as ordinary summer fallow for two successive years had an average cost of \$1.39 per bushel.

Table 9. Cost of producing wheat on plots infested with morning glory (bindweed) when cultivated during season at three different frequencies (cultivation started in spring at time of weed emergence). Pendleton 1939-43.

Cost items	Average farm in locality of experimental field*		Number days between weed emergence and cultivation						Checks--cultivated as ordinary fallow	
	Cost		4 days		8 days		12 days		Cost	
	Per Acre	Per Bushel	Per Acre	Per Bushel	Per Acre	Per Bushel	Per Acre	Per Bushel	Per Acre	Per Bushel
Alternate fallow - wheat										
Fallow operations	\$8.83	\$0.25	\$12.67	\$0.27	\$11.39	\$0.23	\$11.07	\$0.22	\$8.83	\$0.44
Wheat operations	13.13	0.37	13.13	0.29	13.13	0.27	13.13	0.27	13.13	0.66
Total	21.96	0.62	25.80	0.56	24.52	0.50	24.20	0.49	21.96	1.10
Average yield	35-45 bu.		46.1 bu.		48.9 bu.		49.4 bu.		19.9 bu.	
Two years' fallow before seeding wheat										
Fallow operations	\$17.66	\$0.50	\$25.01	\$0.53	\$24.26	\$0.50	\$21.86	\$0.45	\$17.66	\$0.80
Wheat operations	13.13	0.37	13.13	0.28	13.13	0.28	13.13	0.27	13.13	0.59
Total	30.79	0.87	38.14	0.81	37.39	0.78	34.99	0.72	30.79	1.39
Average yield	35-45 bu.		46.2 bu.		46.6 bu.		48.0 bu.		22.2 bu.	

\* From Oregon Experiment Station Bulletin 373, "Land Use and Production Costs on Dry Land Wheat Farms, Columbia Basin, Oregon."