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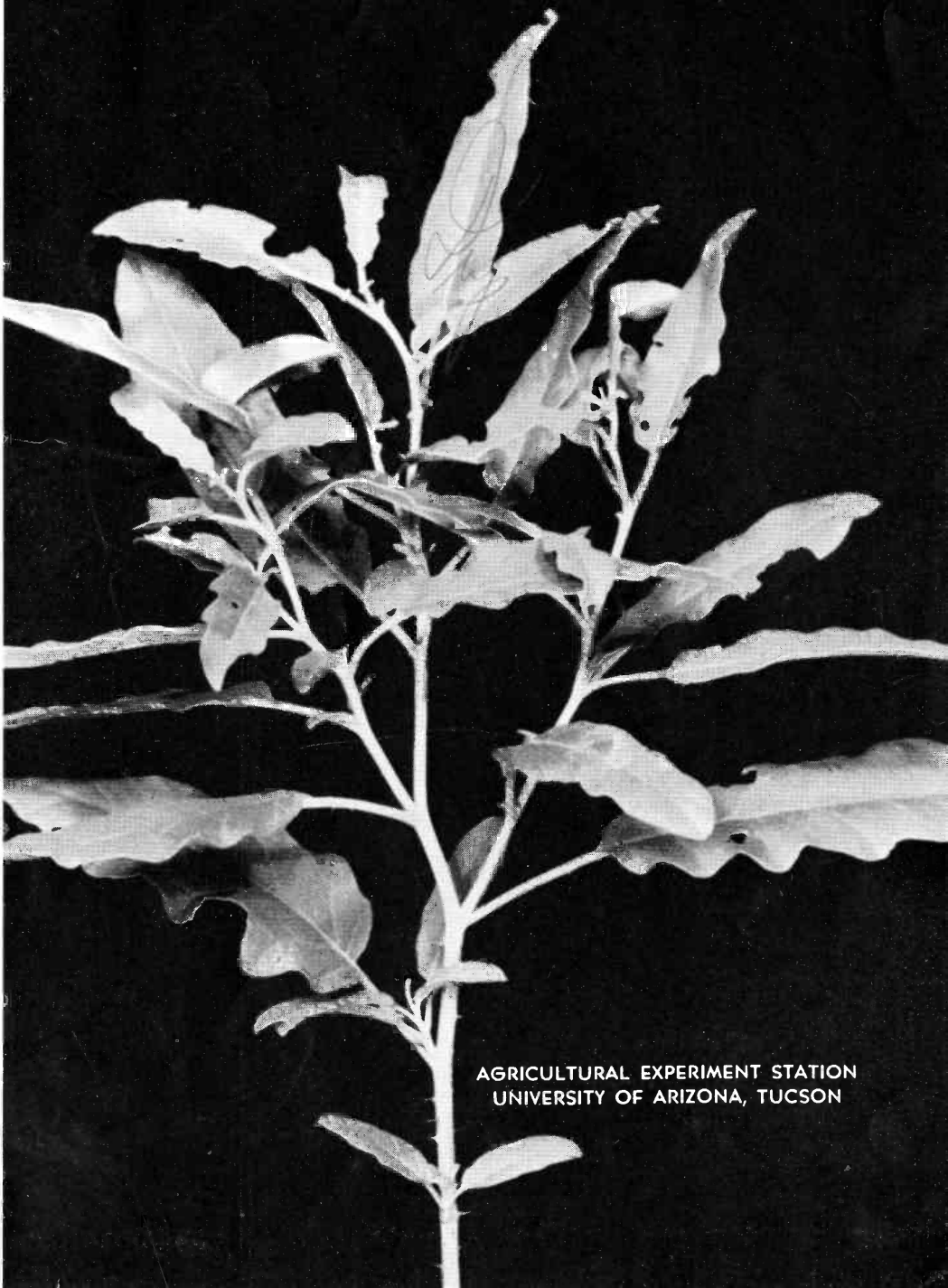
ERADICATION OF WHITE HORSE NETTLE IN SOUTHERN ARIZONA



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*Resigned March 8, 1944.

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ERADICATION OF WHITE HORSE NETTLE IN SOUTHERN ARIZONA

By C. H. Davis, T. J. Smith, and R. S. Hawkins

INTRODUCTION

White horse nettle, *Solanum elaeagnifolium* Cav., is also known as silver nightshade and trompillo. White horse nettle seldom exceeds a height of 2 feet when growing undisturbed in the open, but it has been seen as high as 4 feet or more in cotton and hegari crops. The bright blue flowers are about 1 inch in diameter and are so numerous that a patch of the weed will have a distinctly blue and silver appearance in midsummer. White horse nettle has been called blue weed because of the numerous blue flowers, but some white horse nettle plants have white flowers; therefore, the name is a poor one. The leaves are covered with fine hairs, and glandular spines occur along the stems and the midribs. The fine hairs give the characteristic silvery white color to the leaves, and the spines give the nettle characteristic from which the common name is derived. The small green tomatolike seed pods can be seen soon after the flowers drop. Ripe yellow seed pods about ¾ inch in diameter are present after early June. Some of the flat brown seeds are viable the same season.

The seedlings appear in August and September in flooded areas. The plants are killed to the ground by frost each year and reappear from the roots the next spring. A large proportion of the fleshy roots penetrate to great depths. Figure 1 shows the root distribution by percentages in each foot of soil for white horse nettle dug from Gila fine sandy loam in which the tenth foot of soil was wet by capillarity from the water table. A similar distribution was found in Pima silt loam which was sandy below the 18-inch depth. The water table was 27 feet deep in the Pima soil. The roots were dug to only 10 feet, although roots extended below 10 feet virtually undiminished in size in both soils.

The distribution of tubers of nut grass (*Cyperus rotundus*) as previously determined was found to be radically different from the distribution of the fleshy roots of white horse nettle. Over 99 per cent of nut grass tubers were in the top foot of soil as compared with only 45 per cent of the fleshy roots of white horse nettle. It was necessary to dig down over 9 feet to excavate 99 per cent of the white horse nettle roots. The wide dissimilarity in the distribution of the underground storage organs of these two weeds greatly influences eradication procedure as reported in *Univ. of Ariz. Agr. Exp. Sta. Bull. 189*, entitled, "Eradication and Control of Nut Grass," and in this bulletin on white horse nettle.

White horse nettle is commonly seen throughout Arizona and is a noxious weed of irrigated fields in southern Arizona. It is

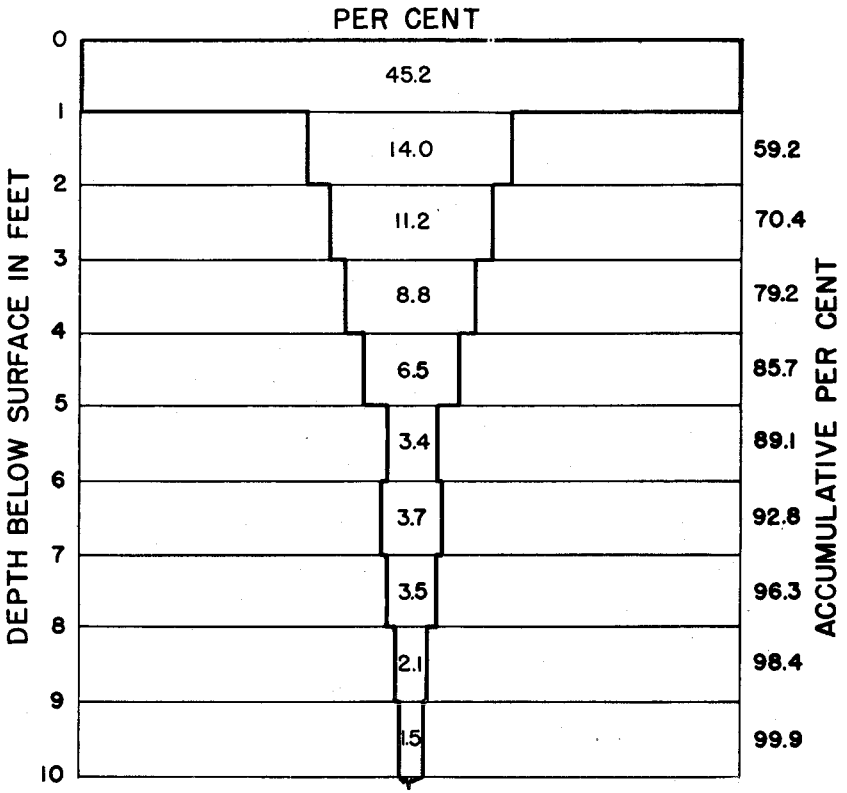

Figure 1.—Distribution of white horse nettle roots in Gila fine sandy loam—Tucson.

particularly troublesome where alkali is also a problem. White horse nettle is most damaging in such low-growing summer crops as cantaloupes, watermelons, and permanent pastures. The weed is very noticeable in alfalfa fields that are pastured, because livestock will not eat it; and the coarse stems and spiny leaves are equally objectionable in the hay. Rapid growth in the spring and/or summer from the stored reserves in the roots gives white horse nettle an early advantage which retards the growth of such crops as cotton, corn, and sorghum. Horse nettle damage is less after a crop is large enough to shade the ground.

METHODS AND RESULTS

USE OF CHEMICALS

The chemical experiments were started on rod-square plots in randomized block experiments of four replicates each. The number of weed shoots per plot was analyzed by variance, and the data are expressed as percentage for convenience in presentation.

Carbon bisulphide was the most effective chemical used in 1937 (Table 1). The carbon bisulphide was applied by two different methods. The common method of injecting 2 ounces in holes 18 inches apart was compared with 2-ounce injections at the base of each plant. The kill was equally good with either method. The treatment of individual plants required more chemical in heavy stands and less in light stands. No white horse nettle appeared in the spring of 1939 after re-treating scattered shoots in August, 1938, but rod-square plots surrounded by untreated infested areas were reinfested in one or two years.

A second experiment begun in 1938 gave complete eradication of small patches of white horse nettle in two treatments with carbon bisulphide. The first treatments were made at different times during the summer of 1938. The scattered shoots were then re-treated in June of 1939. Horse nettle had not reappeared in these isolated patches by 1942. The carbon bisulphide treatments were equally effective at any time during the growing season and on dry as well as moist soil, although it was very difficult and slow to make the applications on dry soil.

The cost of the chemical plus application and the loss of the crops for two seasons limit the use of this chemical to very small isolated plots where its use is justified, for unless it is controlled the weed will spread rapidly from both roots and seed, eventually covering a large area. The high cost of carbon bisulphide eradication for a plot limited in area is small compared with the damage done by white horse nettle on a large area.

Sodium chlorate was applied as a spray in the fall of 1937 at three rates, 1½ pounds, 1, and ½ pound per gallon. Two gallons of each solution were used on a square rod. On other plots, 2 pounds of the dry chlorate were applied to the surface of the soil and the plots were then flooded to carry the chemical into the soil.

TABLE 1.—WHITE HORSE NETTLE SURVIVING CHEMICAL TREATMENTS STARTED AT TUCSON IN THE FALL OF 1937

Treatment	Pounds per square rod by season of application			Percentage of 1937 stand remaining in:	
	Fall, 1937	Spring, 1938	Fall, 1938	Spring, 1938	Spring, 1939
Sodium chlorate, dry	2	0	2	136	181
Sodium chlorate, spray 1½ lbs. per gal.	3	3	3	164	139
Sodium chlorate, spray ½ lb. per gal.	1	1	1	168	134
Arsenic, acid 0.5% As.	1	1	1	123	193
Arsenic, basic 0.5% As.	1	1	1	91	121
Carbon bisulphide	2 gal.	½ gal.	..	15	0
Hoed	Weekly	Weekly	..	44	171
Burned	Weekly	Weekly	..	102	102
Check (no treatment)	..	..	..	111	159

Hoeing and burning treatments were begun at the same time in 1937, and continued through the next summer. Sodium arsenite solution containing 0.5 per cent by weight of arsenic was used with two penetrating agents, 5 per cent by weight of concentrated commercial sulfuric acid and 3 per cent by weight of commercial sodium hydroxide flakes. All the spray treatments were repeated the following spring and fall at the same concentrations and rates. The dry chlorate treatment was repeated in the fall. None of these treatments were effective, as is shown in Table 1.

A new series of plots was started in the spring of 1938. Hoeing and burning treatments at intervals of one, two, and three weeks were included. Dry and spray chlorate applications were made at the heavier rate of 4 pounds per square rod. The data in Table 2 show no effective kills, but they do show some reduction in stand.

The entire field was planted to small grain in the fall of 1939, to corn in the summer of 1940, and to cotton in 1941 and 1942. The small grain was killed in all plots to which chlorate had been applied, but the succeeding crops of corn and cotton grew successfully on the chlorate plots. The corn crop was hoed once, and the cotton crop of 1941 was hoed four times. No white horse nettle appeared during the season of 1942 in the treated areas.

CULTIVATION AT TUCSON

A field near Tucson infested with white horse nettle was plowed in October of 1937. Parts of the area were seeded to barley in November; the other parts were cultivated with sweeps until frost had killed all the tops of the horse nettle plants. Cultivation was begun in these fallow plots as soon as the weeds appeared the next spring and was continued through the summer. Similar cultivation treatments were given the winter grain plots, although these were not started until after the grain was harvested each spring.

Four cultivation treatments maintained through each summer for three years were: (1) cultivation weekly on high moisture, (2) cultivation weekly on low moisture, (3) cultivation biweekly on high moisture, and (4) cultivation biweekly on low moisture. The high moisture plots were irrigated each month during the summer. The low moisture plots received no irrigation except for rainfall. Good stands of barley were obtained each year, but the growth was poor on some areas. Soil moisture samples taken in the spring of 1938 showed that water penetration was less than 1 foot where barley was poor, and more than 6 feet on areas of good barley growth. The areas of poor water penetration were originally high spots in the field where salts had accumulated and were found in both irrigated and nonirrigated plots.

Cultivation treatments were continued on all plots until July, 1940, when corn was planted on the continuous cultivation plots. All plots were planted to sorghum in 1941 and 1942. Horse nettle plants were completely eradicated on all plots by 1942.

TABLE 2.—WHITE HORSE NETTLE SURVIVING DIFFERENT TREATMENTS STARTED AT TUCSON IN THE SPRING OF 1938 AND CONTINUED THROUGH 1939

Treatment	Percentage of stand in spring of 1938 remaining in:	
	Fall, 1938	Fall, 1939
Hoed each week	41	25
Hoed each two weeks	64	29
Hoed each three weeks	67	27
Burned each week	57	29
Burned each two weeks	68	29
Burned each three weeks	60	27
Chlorate, spray, 4 lbs. per sq. rod*	73	53
Chlorate, dry, 4 lbs. per sq. rod*	29	50
Check (no treatment)	100	86

*Treated in the spring of 1938 and again in 1939.

No weeds appeared in 1941 on the plots seeded to winter grain except on areas where barley growth had been poor. Three years of winter grain and summer cultivation eradicated the horse nettle, provided good crop growth was obtained. However, on areas of poor water penetration and poor barley growth, an additional year of cultivation with sorghum was necessary for complete eradication.

In 1940, horse nettle plants did not appear on the fallow plots until late July. Rhizomes were traced from these shoots to depths of 3 feet, but they were lost in the hard soil before connections were definitely established with live storage roots found at depths of 3½ to 4 feet. Horse nettle again appeared in 1941 on areas where growth of corn in 1940 was poor, even though cultivations were continued. No horse nettle appeared on areas of good corn growth. Under the conditions of this experiment, continuous cultivation alone does not appear as the most practical means of eradication. The combination of shade from a summer cultivated crop and additional cultivation eradicated horse nettle and also provided an annual income.

CROPPING EXPERIMENTS AT PHOENIX

An 8-acre field near Phoenix which was nearly solidly infested was rented in the fall of 1940 for experiments to determine the effectiveness of the following cropping programs in white horse nettle control: (1) alfalfa used as a hay crop; (2) oats used as a winter crop followed by summer cultivation; (3) cotton and (4) hegari, both planted as summer crops in which the cultivation was supplemented by hand hoeing.

The field was divided into four blocks and these were subdivided into plots each 39 x 100 feet. A randomized block design of three to five replicates was used for each of the four crops planted. The

stand counts were analyzed by variance and then reduced to a square rod basis for ease in comparison.

Alfalfa

Alfalfa was cut for hay at three different stages: at one-fourth bloom, at one-half bloom, and when the horse nettle bloomed. Additional treatments where the alfalfa was not irrigated in August were made for the one-fourth and one-half bloom stages, making five treatments in all.

The average stand of white horse nettle on all plots after two seasons was 101.3 per cent of the stand at the beginning of the experiment, and there were no significant differences between the plots cut at different stages; nor was there any advantage in allowing the ground to dry out in August. The alfalfa plots were planted after the extremely heavy fall rains of 1940, and the soil was in such a puddled condition that the alfalfa production was very low. The poor growth of the alfalfa apparently was due to poor water penetration. The white horse nettle grew well in spite of the puddled soil and poor water penetration, and the alfalfa could not compete with the weed under these adverse conditions.

Winter grain

Oats was planted as a winter crop in the fall of 1940, 1941, and 1942, although barley or wheat would undoubtedly have been equally effective. Since horse nettle does not appear in the fall and winter after oats is planted, the semiprostrate growth of oats during the fall and winter months probably does not have on the weed an effect different from that which would have been produced by the upright growth of wheat or barley.

The different cultural treatments that were used after the stubble was plowed under in the spring were as follows: (1) disced each two weeks, (2) disced each four weeks, (3) sweeps each two weeks, (4) sweeps each four weeks, and (5) plowed each month. Each treatment was repeated in four replicates. The plots were disced the first time to break up the straw and loosen the soil for the sweeps, because the sweeps could not be used effectively immediately after the stubble was plowed. The cultural treatments were repeated the second year with the exception that when no weeds appeared on the plots of a given treatment by the date scheduled for cultivation, the cultivation was delayed until the next scheduled treatment when weeds were present. Cultural treatments on all plots the third summer were limited to one plowing and one discing.

The number of cultivations and the stand counts are shown in Table 3. The counts averaged forty-seven shoots per square rod in the fall of 1940 at the beginning of the experiments after the preceding corn crop had been removed. A significant reduction in number of shoots in all plots except those receiving the monthly discings was shown by the end of the first season of cultivation.

Nearly all the weeds had disappeared by the end of the second year of winter oats and summer fallow, although significantly more appeared on the plots cultivated with a disc each four weeks than appeared on plots receiving the other treatments. The disc failed to cut all the plants, and many of the tops were only partially buried by the disc, so that they were free to continue growth within a few days after treatment. No differences were shown in the effectiveness of the other four treatments, and all resulted in complete eradication by the end of the third season.

TABLE 3.—WHITE HORSE NETTLE STAND AFTER WINTER CROPPING WITH OATS FOLLOWED BY SUMMER CULTIVATION—PHOENIX

Cultural treatments	Fall, 1941		Fall, 1942		Fall, 1943	
	No. of cultivations	Shoots per sq.rod	No. of cultivations	Shoots per sq.rod	No. of cultivations	Shoots per sq.rod
Disced each two weeks.....	8	35.6	5	1.34	2	0
Disced each four weeks....	5	49.4	5	5.57	2	0
Sweeps each two weeks....	8	30.4	5	0.09	2	0
Sweeps each four weeks..	5	30.0	4	0.12	2	0
Plowed each four weeks..	5	23.4	3	0.05	2	0

Note: All plots averaged 47 shoots per square rod in the fall of 1940.

Summer cultivated crops

The summer crop series was divided into two parts, with one half used for cotton and the other for hegari. Pima cotton was grown in 1941 and 1943 and Acala in 1942. Three hoeing treatments were set up in the cotton series with three replicates of each as follows: (1) hoed before each irrigation, (2) hoed after each irrigation, and (3) hoed when horse nettle bloomed. All the plots were irrigated each two weeks after the cotton was established. The irrigation interval was set at a regular time to fit in with the cultivations, and the hoeing program was so outlined that the cultivations in preparation for irrigation or after irrigation would cut the weeds between the rows and leave weeds to be hoed in the rows only. The original plan was to hoe each two weeks, but white horse nettle was slow in reappearing under the shade of the cotton plants, and the intervals were extended to four weeks. The intervals between hoeings were somewhat irregular in 1942, and the plots were hoed only once in 1943. Intervals longer than four weeks were permitted where the weeds did not grow. Cotton was planted in 1941 in 90-foot rows running north and south in each plot, leaving a 10-foot turnrow at one end between the cotton and the alfalfa. The second year the cotton rows were run east and west and the area used as a turnrow in 1941 was planted to cotton.

The survival of only one to three shoots per square rod after the second year of cultivation (Table 4) represents a significant reduction in the weed population. No significant differences in the effectiveness of weed eradication were shown between hoeing

at regular intervals or hoeing when weeds bloomed. The regular cultivations given these plots and the stands of cotton obtained were poorer than the average for this district.

TABLE 4.—WHITE HORSE NETTLE STAND AFTER THREE HOEING TREATMENTS IN COTTON—PHOENIX

Cultural treatments	Fall, 1941		Fall, 1942		Fall, 1943	
	Number of hoeings	Shoots per sq. rod	Number of hoeings	Shoots per sq. rod	Number of hoeings	Shoots per sq. rod
Hoed after irrigation	4	12.8	4	1.32	1	0.18
Hoed before irrigation	4	19.2	5	1.32	1	0.00
Hoed when weeds bloom	4	37.4	4	3.68	1	0.18

Note: All plots averaged 47 shoots per square rod in fall of 1940.

The turnrow mentioned above was cultivated monthly in 1941 with a disc, and in addition was hoed with the cotton. The weeds grew much more prolifically in the cotton planted on the turnrows in 1942 than they did in the areas which had been in cotton in both 1941 and 1942. Apparently the lack of shade in 1941 allowed the white horse nettle to make heavier growth than did plants which were shaded in 1941 as well as in 1942.

The second part of the summer crop series was devoted to hegari, the common feed sorghum grown in the Salt River Valley. The area was plowed in the spring at the same time the cotton land was plowed; the weeds were then kept down by discing each month until the hegari was planted about July 15. Three cultural methods of controlling the weeds in the hegari were used: (1) normal cultivation, which included no hoeing; (2) an extra plowing just before planting the hegari; and (3) one hoeing at the time the hegari shaded the centers between the rows. There were a few open spaces in the stand of hegari, and some white horse nettle bloomed in these open areas each year. A study of Table 5 shows that there was little or no reduction in the stand of white horse nettle after one year of hegari, a reduction to 6 per cent after two years, and complete eradication after three years. There were no statistical differences among the three cultural treatments.

TABLE 5.—WHITE HORSE NETTLE STAND AFTER THREE CULTURAL TREATMENTS IN HEGARI—PHOENIX

Cultural treatment	Shoots per square rod		
	Fall, 1941	Fall, 1942	Fall, 1943
Hoed after crop shaded middles	50.3	3.1	0.0
Check, three cultivations but no hoeing	49.9	1.53	0.0
Plowed before planting hegari	49.3	4.51	0.0

Note: All plots averaged 47 shoots per square rod in fall of 1940.

DISCUSSION

White horse nettle is a drought-resistant, deep-rooted, widespreading plant which is very difficult to control in the open. A

good soil moisture level for ordinary crop growth in the presence of a shade crop had more effect in reducing the stand of this plant than cultivation or chemicals in the open. Three successful systems of eradication were based on the weak points indicated in the earlier experiments. One system utilized the land for a grain crop in the winter dormant period of the weed, with clean cultivation during the summer growth period. The grain received at least one heavy irrigation in the winter which thoroughly saturated the soil, and another in the spring which wet the soil to encourage weed growth in the summer. Horse nettle was eradicated by eleven cultural treatments in three seasons, using sweeps each month after one plowing each spring. Plowing each month required ten treatments through the same period for complete eradication. Cultivating with sweeps was the cheapest means of eradication used in the winter grain series.

The second successful system utilized the dense shade of the cotton crop in the late summer. The number of hoeings was not excessive under the conditions encountered in this experiment. Although the intervals between hoeings during the different seasons and treatments varied somewhat, they were usually about a month in duration. Hoeing each month from thinning to laying by, and then each six weeks until frost, is a more definite schedule than is one based on the date the weeds bloom, and it is equally effective. Since white horse nettle rarely infests a field solidly, the amount of labor per acre should not be great even though all the field were covered by the hoeing crew at each treatment.

The use of shade from sorghum in late summer following early summer fallow with cultivation also eradicated white horse nettle in three years. Normal cultivation of the sorghum, or cultivation plus one hoeing, gave equally good results. Under most conditions it would be advisable to hoe the sorghum once, particularly if the stands were poor in any areas in the field. The success of shading is dependent upon having little or no growth of white horse nettle at the time the sorghum plants begin to shade the ground. Any growth of the weed after this time will use storage reserves, and the shade will not permit additional reserves to be manufactured and stored in the roots.

The field where these cultural experiments were conducted was planted to hegari in 1944. No white horse nettle plants reappeared on areas where weeds were not present in the fall of 1943. However, the area originally planted to alfalfa, where cotton had been grown in 1943, was solidly infested with horse nettle. The growing on this area of cotton and hegari, both shade crops, for two seasons without sufficient cultivation failed to reduce the weed population. Shading the white horse nettle in late summer is an important factor in the summer cultivation experiments, but shading alone is ineffective in its eradication.

Combinations of the various crops were not tried in these experiments because of the limited area and the field complications of handling such experiments. There is a possibility, however, that in fields badly infested with white horse nettle, the cost of hoeing, particularly for the first two times the first season, might not be offset by the increased return from cotton over the return from oats or other grain. The weeds could be weakened by winter grain plus summer cultivation so that the time and cost of weed control in the succeeding cotton crop would be materially reduced. A rotation worthy of serious consideration for solidly infested fields is to: (1) plow in the fall and seed to small grain; (2) harvest the grain; (3) plow under the stubble; (4) irrigate; (5) disc; (6) cut all weeds with sweeps each four weeks until frost; (7) the second year, plow, winter irrigate in preparation for cotton; (8) plant cotton and bring to thinning in the usual way; (9) thin the cotton and hoe the weeds; (10) hoe each month after thinning until laying by; (11) hoe the weeds at bloom stage or six weeks after laying by; (12) continue the cotton and the hoeing for two or more years until the horse nettle disappears.

Another combination worthy of trial under certain conditions would be to start the weed eradication in the spring by plowing and irrigating, clean cultivating with sweeps until sorghum planting, then following the sorghum crop with cotton the next year and continuing as above. In solidly infested fields the cheaper cost of cultivating before planting sorghum as compared to hoeing of cotton would tend to offset the lower return from sorghum over the return from cotton.

CONTROL MEASURES

I. Combination of cultivation and shade cropping
   1. Winter oats
      (a) Plow before planting the first fall.
      (b) Plow after harvest the next spring.
      (c) Irrigate.
      (d) Double disc as soon as soil is sufficiently dry.
      (e) Use sweeps to cut all weeds each month from June until October.
      (f) Plant winter oats.
      (g) Irrigate for oats as necessary.
      (h) Repeat above measures each year. Eradication should be complete after the third summer.
   2. Cotton
      (a) Plow and preirrigate to fill soil with water to depth of 5 or 6 feet.
      (b) Plant, irrigate, cultivate, and thin as usual.
      (c) Cultivate and hoe each month all weeds missed by cultivator.
      (d) Hoe six weeks after cotton is laid by.

(e) Repeat above measures each year. Complete eradication can be effected in three years. Hoeing will not be required so frequently the second year, and probably not more than once or twice the third year.

3. Hegari
   (a) Plow in early spring.
   (b) Disc or use sweeps each month until time to plant hegari.
   (c) Plant.
   (d) Cultivate and irrigate as needed.
   (e) Hoeing once or twice may be needed, although complete eradication was effected in three years without it.
   (f) Plow as soon after harvest as possible, irrigate, and repeat above procedure, eliminating (a).

II. Use of chemicals

Small patches of white horse nettle on areas not suited to cropping may be eradicated by injecting two ounces of carbon bisulphide in holes 18 inches apart, or at the base of each weed if the stand is too thin to make the above plan feasible. One treatment will eliminate most of the weeds. A second treatment must be given the following year to kill the few weeds which escape the first treatment.

SUMMARY AND CONCLUSIONS

White horse nettle is exceptionally deep rooted, extending more than 10 feet in depth in Gila fine sandy loam and Pima silt loam soils.

No reduction in density of population was effected with alfalfa cut for hay at one-fourth and one-half bloom stages, and cut when the white horse nettle bloomed.

The planting of winter oats followed by summer cultivation with sweeps each four weeks reduced the weed population from an original count of forty-seven shoots per square rod to thirty at the end of the first year and to 0.12 shoot per square rod at the end of the second year. Complete eradication was effected by the end of the third year.

The stand of white horse nettle in cotton was reduced from forty-seven shoots per square rod to 12.8 at the end of the first year when hoed after each irrigation, to 19.2 when hoed before each irrigation, and to 37.4 when hoed each time weeds were in bloom. The numbers of weeds per square rod at the end of the second year were 1.32, 1.32, and 3.68 for these respective treatments. No weeds remained at the conclusion of the third year in cotton with the exception of a few on areas where skips occurred in the cotton.

No reduction in weed stand was effected by growing one crop of hegari preceded by early spring plowing and succeeding discings

(monthly) until planting time. The stand was reduced to 6 per cent of the original by the end of the second year in hegari, and complete eradication was obtained by the end of the third year except on areas where skips occurred in the stand of hegari.

Complete eradication of small patches of white horse nettle was obtained with two annual treatments of carbon bisulphide applied at the rate of 2 ounces injected into holes 18 inches apart in heavily infested areas and injected at the bases of widely scattered plants. The high cost of this treatment limits its use to very small isolated areas.

Two annual treatments of sodium chlorate applied at varying rates either dry or as spray did not eradicate white horse nettle.

Burning with a weed burner and hoeing each week, each two weeks, and each three weeks during the growing seasons of two years did not give satisfactory control.