GROWTH AND REPRODUCTION OF YUCCA ELATA [1]

R. S. CAMPBELL AND J. G. KELLER

U. S. Forest Service

Yucca elata, Engelm., locally called soapweed, is a long lived perennial of the Liliaceae. Wooton and Standley ('15) describe the plant as follows: " Stems conspicuous in old plants, reaching a height of 3 to 4 meters, naked below, clothed with a tuft of leaves above; inflorescence a much branched panicle, leaves 10 mm. wide or less." Average plants in southern New Mexico vary from three to six feet in height, but specimens as tall as thirty feet have been observed. The slender, sharp pointed leaves forming the green

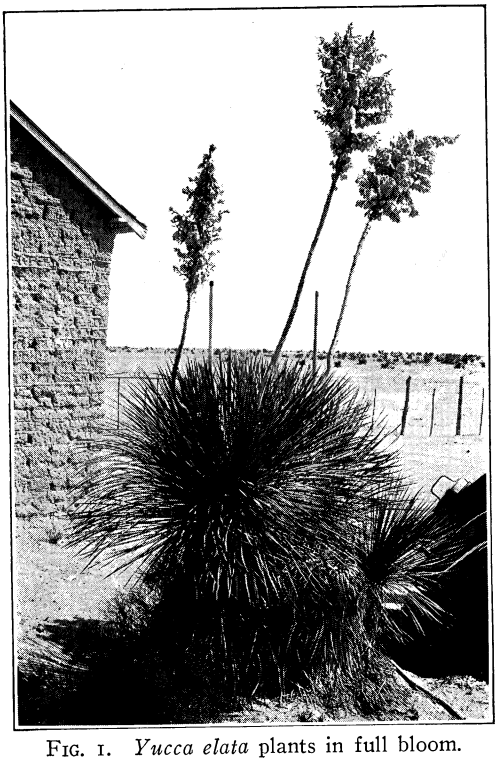

FIG. 1. *Yucca elata* plants in full bloom.

[1] The work upon which this paper is based was done on the Jornada Experimental Range, located about 50 miles north of the Mexican boundary near Las Cruces, New Mexico. It is a branch of the Southwestern Forest and Range Experiment Station, which is under the jurisdiction of the Forest Service, U. S. Department of Agriculture, and is conducted in cooperation with the University of Arizona, with headquarters at Tuscon, Arizona.

crown may vary from 12 to 36 inches in length on different plants. Figure 1 shows some thrifty specimens in full bloom.

On the dry plains and mesas from western Texas, through southern New Mexico to southern Arizona, and into Mexico, scattered specimens of *Yucca elata* are found on every soil type, but it is particularly conspicuous on the more compact sandy soils, where its principal associated species are the grasses; *Bouteloua eriopoda, Sporobolus cryptandrus, S. flexuosus,* and *Aristida* spp. The stand may vary from a few to as many as 300 plants per acre in the *Bouteloua* association. As a rule, it is not abundant in the loose windblown soils of the *Prosopis* sand dune association, but occasionally occurs even there in stands nearly as dense as in the *Bouteloua* association.

Little detailed information is available concerning the fauna associated with *Yucca elata,* but field observations have shown that a great variety of species is found on or near the plant. Specific determinations of much of the material from studies now in progress have not yet been completed, but the following were either collected or observed in 1931:

Order	Species	Where found
	INSECTA	
Homoptera	*Cicada* sp. *Tibicen* sp.	Flowerstalks and leaves
	Aphididae	Flowers
Heteroptera	2 species	" and leaves
Lepidoptera	1 "	Leaves
Diptera	1 "	Flowers and leaves
Coleoptera	26 "	Various species on all parts of plant
Hymenoptera	*Formicoidea*—2 species	All parts of plant
	Apoidea— 1 "	Flowers
	Vespoidea— 3 "	"
	REPTILIA	
Lacertilia	1 species	All parts of plant
Serpentes	1 "	Stem
	MAMMALIA	
Rodentia	*Neotoma albigula albigula*	Stem and leaves Nests at base of plant
	Lepus californicus texianus	Feeds on leaves within reach
	Sylvilagus auduboni minor	Feeds on leaves within reach and inhabits deserted Neotoma burrows at base of plant.

VALUE OF YUCCA ELATA

Even in scattered stands, *Yucca elata* has a definite economic value. In the semi-desert southwest, every plant plays at least some part in bringing about soil stability and improvement. Since it is a very long lived perennial, it is one of the few plants which continually help protect the soil from both

wind and water erosion. The leafy crown and the thick stem intercept rainfall, and check its flow; the numerous lateral roots bind the soil, protecting it from washing or blowing away; and the old dead leaves and material added by the dead bodies of fauna associated with the plant improve the organic content of the adjacent soil enough to increase materially its water holding capacity. If the herbaceous vegetation on the range becomes badly depleted, the Yucca plants obstruct considerable soil during wind storms.

Yucca elata furnishes shade for livestock and has a certain value as forage, especially as emergency feed for cattle during prolonged drought periods. When other range feed is short during the winter or spring months, cattle take the green leaves. The sharp points of the leaves discourage grazing, but when forced to do so, cattle learn to chew the leaves from the stem out toward the sharp ends. Forsling ('19) states that: "In the fall of 1917, a herd of cattle in southern New Mexico was maintained for at least two months on a range where the green soapweed leaves furnished 50 per cent or more of the feed." The young leaves which start growth at the center of each leaf cluster in the spring are especially relished by cattle. The succulent flower stalks, and large flowers, also are quite palatable, and furnish considerable forage during May and June, when other vegetation usually is dormant.

Yucca elata was used extensively in southern New Mexico for supplemental feeding during drought from 1916 to 1919. Forsling ('19) reports from work done on the Jornada Experimental Range during this period, that Yucca plants were cut and chopped for ensilage, after the dead leaves were burned off. The stems are fibrous, but very pulpy, and he concluded that the feeding of chopped soapweed, with a supplemental ration of cottonseed meal or other similar concentrate, is a practicable means of maintaining range cattle during severe drought.

The large caudex of *Yucca elata*, called "amole," is saponaceous. It is used locally, and according to Dayton ('31), to some extent commercially for soap. The stem and leaves of the plant contain abundant fibers which are considered of potential economic value. The fibrous strands laid down by the growing point of the stem are much branched, and are continuous with those of the leaves. The stems make a very small annual addition of secondary fibers.

Wooton ('13) recommends *Yucca elata* as a hedge or windbreak because of its thick heads. However, he reports that because of its deep tap root, which often must be cut in excavating the plant, twenty-five per cent or more of the transplants usually are lost, depending somewhat upon the amount of water supplied at transplanting and during the first season.

Growth and Reproduction of Yucca elata

Because *Yucca elata* is an important range shrub, studies of its growth and reproduction were started on the Jornada Experimental Range in 1925. In that year, several plants were selected for study with various methods of

treatment; and in 1931, height measurements were made on the sprouts from plants cut for ensilage in 1915. Special studies of seedling growth and behavior also were made in 1931.

In November, 1925, two Yucca plants in an area protected from grazing were selected, and the growing point of each was measured for height above the soil surface. Leaf and flower stalk measurements also were made, and all measurements were repeated in October or November every year, including 1931. The two plants showed some individual variation in height growth each year, but taken together followed rather closely the precipitation for certain seasons of the year, as shown in table 1. The data indicate that the greatest height growth is the result of high rainfall, well distributed throughout the nine months preceding the measurement in October. The direct effect of extreme rainfall during any one season of the year upon stem growth is not shown conclusively from the records available, although the effectiveness of summer rainfall is indicated. Furthermore, measurements made in 1926 showed that practically all of the stem growth that year was made during the summer.

TABLE I. *Precipitation by seasons and average annual growth of Yucca elata, 1925 to 1931*

Year	Precipitation					Average Height
	Jan.–Feb.–Mar. Inches	Apr.–May–June Inches	July–Aug.–Sept. Inches	Oct.–Nov.–Dec. Inches	Total Inches	Growth of Yucca Inches
1925	.36	1.00	3.76	1.81	6.93	
1926	2.19	3.13	7.89	4.40	17.61	1.12
1927	.77	.08	6.41	.50	7.76	1.00
1928	.72	1.21	3.62	3.95	9.50	.88
1929	.79	2.19	7.55	1.92	12.45	1.00
1930	0.	.22	2.52	1.25	3.99	.50
1931	2.51	2.17	5.42			1.25

The average annual growth of the two plants during the six years was 0.96 inch. The maximum growth of a single plant in one year was 1.50 inches, while the minimum was 0.50 inch. Growth of as much as two inches has been measured on other plants during a year with exceptionally high rainfall. In order to obtain a more representative figure for the average annual growth of *Yucca elata,* 25 sprouts from plants which were cut down in the autumn of 1915, were measured in 1931. The highest was 31 inches, the shortest was 8 inches, with an average height of 16.08 inches. Since the plants were 15 years old, the average annual growth was 1.07 inches, which checks very closely with the growth of the two more mature plants measured from 1925 to 1931.

The leaves of *Yucca elata* grow more quickly, but are more short lived than the stem. The leaves remain green throughout the year, but grow very little during the winter. In the spring, usually in May or June, new leaves

in the center of the cluster start growth and lengthen during the summer and early fall. New leaves continue to appear in the center of the cluster during the summer. Leaf measurements made in 1926 show the rapidity with which the growth occurs. On July 27, several young leaves, which were measured and tagged, had an average length of 6.3 inches. On August 3, just one week later, they had an average length of 13.7 inches, an average growth of 7.4 inches, or slightly over an inch each day. On August 24, three weeks later, the same leaves averaged 14.8 inches in length, an increase of only 1.1 inches in 21 days. Thus, the main leaf elongation takes place within a very short time. Measurements to locate the region of growth in the leaves showed that it is almost entirely basal, with practically no measurable elongation of cells after they are over two inches from the stem. At first, the new leaves are vertical and are encased within the center of the cluster of more mature leaves. As each leaf grows, it becomes part of the protecting group for the still younger leaves, and as the stem grows, assumes an acute angle to the stem axis during its first season of growth. During its second year, it comes to a position at about 45 degrees to the stem axis, and by the third year, is either in a horizontal or slightly drooping position. Leaves on many plants begin to die after the third year, gradually point downward and eventually rest against the stem in a nearly vertical position. Some leaves remain alive for as many as five years, but most of them die after the third or fourth year. The dead leaves persist on the stem for many years, until they finally disintegrate and blow away, or are rubbed off by cattle. The fibers in the leaves, continuous with those in the stem, are responsible for this persistence.

Yucca elata reproduces mainly by vegetative means. Any treatment which destroys the growing point means the death of the mature stem, and usually results in the production of sprouts from the base of the plant. The accumulated dead leaves on the Yucca plants burn well, and often are fired by cowboys or travellers during cold weather to furnish a brief warming place, although lightning or accidental grass fires are responsible for the burning of many Yuccas. The fire usually goes clear to the top of the stem. Soon afterward the terminal leaf cluster dies and within one or two years the entire main stem rots away at the base and falls over. Occasionally, if the fire does not reach quite to the top, the growing point is not injured fatally, and the main stem continues to grow. If the stem is cut off, the plant dies back to the first sprout, which may be from 2 to 12 inches under the soil. The caudex of the plant is very persistent and if the first sprouts are killed by rodents or from some other cause, other sprouts come up the next year. Some actual cases of vegetative reproduction will illustrate the variation.

In 1925, a Yucca plant 38 inches high was cut off at 4 inches above the soil surface. In 1926, a sprout came up near the old stump and continued to grow through 1931, with no other sprouts appearing. Another plant, 52 inches high, was cut at the same time, and in the same way. In 1926, two sprouts appeared near its dead stump, but one of these died during the spring

of 1927 and the other during the spring of 1928. Both were damaged badly by rodents. In 1929, a third sprout came up but died the following spring. Then in 1931, two more sprouts appeared, and with the excellent rainfall of that year, developed exceptionally well. As many as five sprouts have been observed near the base of a dead stem. Sprouts often spring up even from the base of a living stem, and grow in a manner similar to the sprouts from cut or injured plants.

The growth rate of sprouts is much the same as that of more mature stems. Three sprouts measured annually from 1929 to 1931 had an average annual height growth of 0.96 inch. These sprouts started in 1926, but required three years to develop a stem high enough to measure. This growth for three years corresponds exactly with the growth rate found on two mature plants from 1925 to 1931, and very closely with the 1.07 inches per year found in 25 sprouts for 15 years. The maximum growth measured on a single sprout in one year was two inches, while the minimum was 0.50 inch. The growth of sprouts followed rainfall as closely as did the growth of mature plants shown in table I. Figure 2 shows a bisect of a Yucca burned in June, 1930,

FIG. 2. Partial bisect of a burned *Yucca elata,* showing caudex, dense lateral root system and new sprouts.

with its sprouts in October 1931, after two seasons of growth. The comparatively rapid growth of sprouts is due very largely to the well developed root systems, in the uppermost 18 inches of soil, of the mature plants which produce them. Cottle ('31) has shown that the caudex of *Yucca elata* ends

abruptly at the calcareous layer, and has poorly-branched main roots running outward to distances of 5 to 10 feet.

When winter and early spring rains are abundant, many *Yucca elata* plants on the range produce flower stalks. Table 1 shows that in 1926, and again in 1931, favorable rainfall occurred during the previous autumn, continuing through the winter and spring periods of the current year, and from 1925 to 1931, these two years were marked for the abundance of Yucca blooms. Every year, a few Yuccas flower, but it is only in the exceptionally favorable year that the majority of the plants bloom.

The flower stalks usually appear during May and June, and come into full bloom during late June and early July. Flower stalks occur sooner or later on nearly all plants taller than 15 inches, and have been found on plants only 6 inches high. Their development is very rapid as is shown by table II. These data show that during their most rapid growth, the two flower stalks observed increased an average of 2.52 inches per day. The height of flower stalks varies considerably on different plants and in different years; the shortest flower stalk observed was only ten inches high in 1928, while the longest was 96 inches high in 1931. The flower stalk grows up through the center of the leaf cluster, and is protected by the leaves during the first several inches of growth. The elongation is largely terminal, with approximately 63 per cent in the uppermost 4 inches of the stalk, 32 per cent in the second 4 inches, and only 5 per cent below the 8 inch zone, as determined by detailed observations made on two flower stalks in 1926.

TABLE II. *Weekly growth of two Yucca elata flower stalks, 1926*

Date of Observation	Plant No. 1 Total Height Inches	Plant No. 2 Total Height Inches
May 25	Start	0
June 1	18	Start
June 8	38	19
June 15	58	33
June 22	68	48
June 29	72	54
July 6	76	60

The flower stalk is surmounted by a great panicle of white or cream colored flowers arranged in much branched compound clusters, as shown in figure 1. Very rarely, as reported by the senior author ('29), a case of phyllody occurs. The number of flowers produced on a single stalk varies from 75 to sometimes over 200. The flowers attract many insects, so that cross pollination should be accomplished, but the percentage of flowers which produce seed pods is low. In fact, many panicles of flowers produce no seeds at all, while the maximum observed production of seed pods from flowers is approximately 30 per cent. However, each seed pod contains 150 or more seeds, so that ample seeds are produced in years when high rainfall favors flower stalk production.

The seeds are light and are well disseminated by the wind when the pods open during the late summer and autumn. They usually have a high viability percentage, as shown by germination tests made from 1925 to 1931. Of nine random samples tested during those seven years, 5 had over 90 per cent germination, 3 were 50 per cent or over, and only one had no viable seeds. In one sample of one hundred seeds, 99 germinated.

Reproduction by seed is very limited because few seedlings become established, and their growth is extremely slow. In 1915, 75 one meter quadrats were established in *Bouteloua eriopoda* associations on the Jornada and adjacent ranges for range management studies. The soils were suitable, and *Yucca elata* constituted at least 2 per cent of the stand in the types surrounding the quadrats, but on only 4 of the 75 were Yucca seedlings present, with only one on each quadrat. Only ten seedlings have been observed during 17 annual chartings of these study plots, and in 1931, only six living seedlings were recorded on a total of 170 quadrats. Occasional seedlings not on the quadrats have been noted.

The unusual feature is that none of the seedlings recorded grew enough to have a measurable stem height, even in 1931. Quadrat B–3 supported one seedling when it was established in June 1915. The seedling was charted on the quadrat every year, but in October 1931, sixteen and one-half years later, it had just 16 leaves with an average length of 7.5 inches, and its stem still was too short to measure above ground. A more striking case was found on quadrat B–2, which supported one Yucca seedling when it was established in June 1915. The seedling was charted every year until October 1922, when it could not be found on the quadrat, and was not mapped in the next two annual chartings. In October 1925, however, the seedling was found in the same location on the quadrat, and was charted each following year, including 1931, when it had 22 leaves with an average length of 8 inches.

The extremely slow growth of *Yucca elata* seedlings may be attributed partly to their comparatively limited root systems, as shown by the bisect in figure 3, the full significance of which is brought out by a comparison with figure 2, which shows the ample root system by which sprouts are supported.

Rodent damage is responsible in part for the slow development of Yucca seedlings and sprouts, and often of retarded growth in more mature plants. Wood rats (*Neotoma albigula albigula*) cut leaves from mature plants, and rabbits habitually cut off a few of the leaves of seedlings or sprouts within their reach. At times they cut all the leaves, and even the growing point so that the plant dies back and is forced to send up a new sprout to continue its life. This undoubtedly is what happened to the seedling on quadrat B–2, which was charted from 1915 to 1921, disappeared for three years, was charted again in 1925 and then continued to grow. The same situation is evident on the seedling shown in figure 3, which died back at least twice before the existing leaf cluster was produced. Rodent damage undoubtedly

causes the death of many sprouts. This conclusion is supported by the fact that late in the summer of 1930, there was a noticeable decrease in the rabbit population on the Jornada range, with the result that in 1931, little damage was recorded and practically every seedling and sprout observed made unusually good growth.

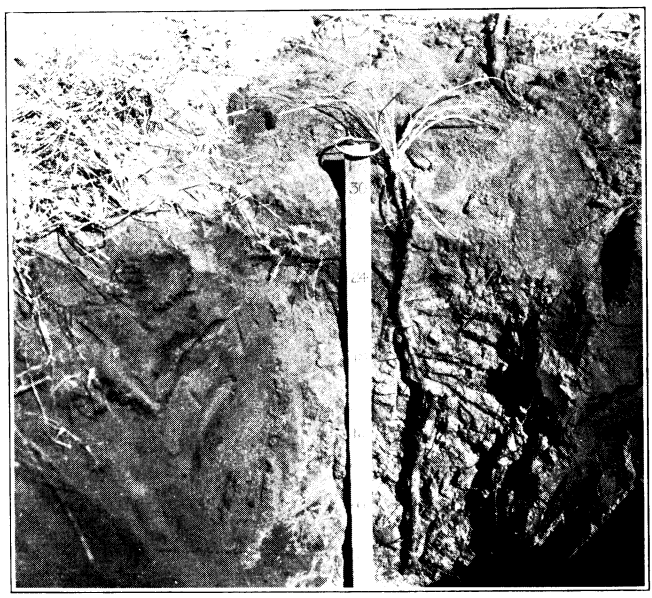

FIG. 3. Bisect of a *Yucca elata* seedling, showing the caudex ending at the hardpan, and sparse development of lateral roots.

MANAGEMENT OF YUCCA ELATA

On conservatively grazed range, supporting the *Bouteloua eriopoda* climax stage, *Yucca elata* has little importance as feed in most years, because it furnishes so small a proportion of the actual forage. However, because of its value as emergency feed during drought, both on the range and as ensilage, and its possible commercial use for fiber, a policy should be developed for the management of *Yucca*, in case further cutting should be undertaken in the future. Since the plant reproduces so prolifically by sprouts and so poorly by seed, it should not be necessary to leave any large plants for seed production, although it would be desirable to leave a few mature plants to furnish shade and protection from winds to live stock. According to Forsling ('19), it is not profitable to cut plants under 36 inches in height for feed, and since ordinarily more than 50 per cent of the plants are less than 36 inches, the cutting of stems above that height leaves enough plants to furnish reasonably effective protection from wind erosion. Further, if cutting is done only for emergency feed, the amount of feed furnished by flower stalks, blossoms, and

green leaves is not reduced materially. Selective cutting for emergency feed, then, would require a minimum cutting cycle of 15 years on a given area, and at least 20 years after the first two cuts, based on a growth rate of approximately one inch per year for both mature stems and sprouts.

Just what would be the most profitable minimum size for cutting to produce fiber can be determined only by study. The cutting cycle would depend upon the minimum size, the area of plants available for cutting, and annual requirement of the fiber factory. In any event, the probable cutting cycle would be similar to that necessary for emergency feed production.

Summary

Yucca elata, a perennial shrub of the Liliaceae, occurs on the dry plains and mesas of southern New Mexico and adjacent parts of western Texas, southern Arizona and northern Mexico. Even in scattered stands, it is of value in reducing wind erosion, its flower stalks and flowers are eaten readily by cattle in late spring, and its green leaves furnish feed for cattle in dry springs when grass is scarce. Yucca plants were chopped for ensilage and were used extensively in southern New Mexico for supplemental feeding during drought from 1916 to 1919. The stems have abundant fibers which are of potential economic value, and the roots often are used for soap. In addition, the plant is a desirable ornamental, although its deep root system makes transplanting difficult. There is an abundance of fauna associated with the plant. Insects especially are numerous when it is in flower.

Measurements of mature *Yucca elata* plants show an average annual height growth of approximately one inch, and indicate that the amount of growth depends largely upon the rainfall, especially the summer seasonal. As much as two inches growth was observed in a favorable year, while the minimum growth observed was 0.50 inch in a dry year. The leaves grow rapidly from the center of the leaf cluster during the summer, but gradually droop during the second and third years of growth, and usually die at the end of the third or fourth season. The dead leaves persist close to the stem for many years.

Yucca elata reproduces both by seed and from sprouts. Although seed viability generally is good, few seedlings have been observed, and the data show that in 16 years, the seedlings on record grew very slowly, with no measurable stem development above ground. Any injury to the growing point of a Yucca usually kills it, the stem dies back, and sprouts come up from the base. The growth of sprouts is very similar to that of mature plants. Rodents cut the leaves of all plants to some extent, but rabbits especially are responsible for leaf cutting and resultant retarded growth of seedlings and sprouts.

On a basis of cutting no plants under 36 inches in height, the cutting of *Yucca elata* for ensilage should be on a minimum cycle of 15 years, while at least a 20 year cycle probably would be required after the first two cuttings.

Literature Cited

Campbell, R. S. 1929. A case of phyllody in *Yucca elata*. *Bot. Gaz.*, **88**: 109–110.

Cottle, H. J. 1931. Studies in the vegetation of southwestern Texas. *Ecology*, **12**: 105–155.

Dayton, William A. 1931. Important western browse plants. *U. S. Dept. Agric. Misc. Publ.* 101, p. 14.

Forsling, C. L. 1919. Chopped soapweed as emergency feed for cattle on southwestern ranges. *U. S. Dept. Agric. Bul.* 745.

Wooton, E. O. 1913. Trees and shrubs of New Mexico. *New Mexico Agric. Exp. Sta. Bul.*, **87**: 33–34.

Wooton, E. O., and Paul C. Standley. 1915. Flora of New Mexico. *Contr. U. S. Nat. Herb.*, **19**: p. 135.