vitamin B complex because of the influence of vitamin B, and especially of riboflavin, on different liver functions (*5*). Three times a week these animals received injections of 0.1 cc. of a product containing 0.2 mg. of riboflavin, 0.1 mg. of thiamine chloride, and 1 mg. of nicotinic acid. Finally, one series was treated with 0.1 mg. of histamine every second day. Our liver extract was not entirely free from histamine, and this substance could, by closing the hepatical veins (*3*) influence the origin of hepatical damages. Table 2 shows the results of these experiments.

From these results the protective influence of concentrated liver extract seems evident, while vitamin B seems to exert very little protective influence. Probably the active principle in the liver is related to the antinecrotic substances described by Forbes and Neale. In future research these relations are to be studied.

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Forty-Five Years of Continuous Cropping With Lima Beans

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The declining yields resulting from continuous cropping, which has generally been regarded as inadvisable, have usually been with nonleguminous crops. The gradual decline in wheat yields under a single cropping system in California eventually made the practice unprofitable. Experimental data on continuous cropping, accumulated from the Morrow plots (*1*) at Urbana, Illinois, have shown that corn grown continuously showed a gradual decline, the yields averaging 39.7 bushels/acre from 1888–1903 and 24.5 bushels from 1904–44—a decrease of 38 per cent. On the Sanborn field (*3*) in Missouri, there was a 39 per cent decrease in yield of timothy in the second half of a 50-year period, a 12 per cent decrease in the yield of corn, and a slight increase in wheat. However, this report indicates that recently the continuous wheat plot has produced satisfactory crops only in alternate years. Experimental work on continuous cropping in California (*2*) was conducted for only 10 years. Various nonlegume crops were used. In the cultivated crops of milo, the second 5-year period showed a decrease of 51 per cent. The yields of barley were reduced 55 per cent; rye, 43 per cent; wheat, 42 per cent; and oats, 54 per cent. In the noncultivated cereal crops, weed growth, which could be controlled in the milo plots, may also have been a factor.

In the dry Lima bean area in California, centered in Ventura County, growers have not experienced such declines. The general practice is often to plant Lima beans on the same land year after year. On one field a continuous record is available from 1901 to 1945, with the exception of 1902, when the records are not complete. This field, which consists of 235 acres, was purchased by the Samuel Edwards Associates[1] in 1882 and since then has been under continuous management of the family. Barley was probably grown prior to 1882 and large Lima beans since that time although no yield records are available prior to 1901. The soil is Yolo loam. In the early days, when the beans were threshed with stationary threshers, the straw piles were burned. Later, when orcharding came in, the straw was sold to orchardists for a winter cover. Since 1938, when the pickup threshers came into use, the straw has been scattered in the field as the beans were threshed. Irrigation after planting was not practiced until 1921. However, previous to 1921, in years of short rainfall, the land was irrigated before planting. Since then, a 4- to 6-inch application of water has been made in June or July to insure adequate moisture. During this period, with the widespread use of power equipment, other changes in farming practices have been made, one of these being to plow the dry land deeply in the fall.

At harvest, the beans were threshed, sacked, and hauled to the warehouse. The yields of the Edwards field were calculated from the receiving weights at the warehouse. The cleanout averaged 3–4 per cent. The 45-year yield record from this field is shown graphically in Fig. 1. From 1900 to

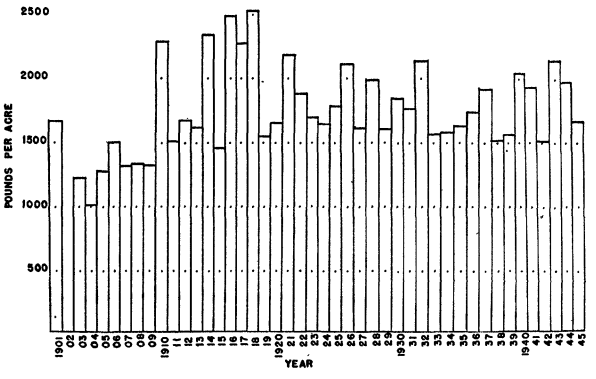

Fig. 1. Yield record of Lima beans grown continuously for 45 years on a 235-acre field in Ventura County, California.

1942 the Lewis variety, or selections from it, was used; since 1943 the Ventura variety has been planted. The lowest yield, 1,018 pounds/acre, was obtained in 1904; the highest, 2,533, was obtained in 1918. The averages of the nine 5-year successive periods were 1,283; 1,553; 1,717; 2,100; 1,856; 1,836; 1,746; 1,751; and 1,827 pounds/acre. An analysis of variance showed that the variance between periods was not significant. The F value was 0.46. There was no correlation between rainfall and yield; therefore, other important factors, such as temperature, pests, diseases, and perhaps humidity, were the causes of yearly yield variations. Both wireworms and nematodes have caused some reduction in yield during some years. Because of losses from wireworms, the rate of planting has been increased from 40 pounds/acre to 80 or more in recent years. The average yield of the 45-year period

[1] These data were made available through the kindness of the Samuel Edwards Associates, Santa Paula, California.

was 1,751. Since 44 crop years are represented, there are two 22-year periods. The average yield of this first period, ending in 1923, was 1,717 pounds/acre; that of the second period, 1924–45, 1,786 pounds/acre. Continuous cropping has therefore not resulted in any loss of yield of Lima beans in this 45-year period.

To substantiate the data from the Edwards field, interviews with officials, cooperative associations, and others familiar with local farming practices were made. These interviews indicate that continuous cropping of Lima beans for 15–25 years is rather common. The yield records of four growers who had practiced continuous cropping for a period of 16 years were obtained and are presented in Fig. 2. The 16-year period was divided into two 8-year periods. The average of the first period was 2,173 pounds/acre; that of the second, 2,224.

Prof. W. W. Mackie, emeritus agronomist of the California Experiment Station, who has been a close observer of the Lima bean industry for many years, wrote in a recent letter: "Continuous yields of large Lima beans have been observed by me many times in the Ventura area on irrigated land. On the dry mesa or hilly soils in Ventura and San Diego Counties this condition does not always follow, due to lower soil fertility of the hilly residual soils and often to an absence of nodule forming bacteria."

Some fertilizer experiments have been conducted on small

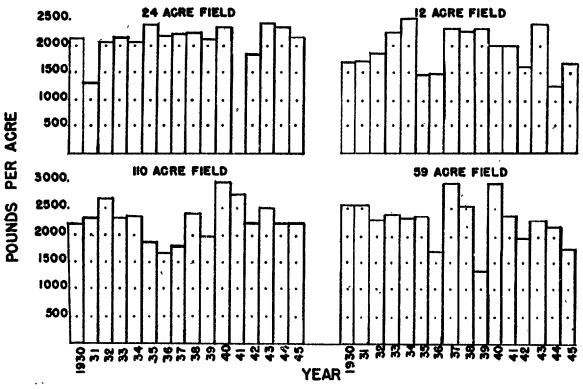

FIG. 2. Yield record of 16 years of continuous cropping with Lima beans on four independent fields in Ventura County.

plots in the Edwards field. In 1937 liquid ammonia was applied on three plots at the rate of 62 pounds of nitrogen/acre and on three at the rate of 82 pounds of nitrogen/acre. There was no difference in yield between the unfertilized check plots and those receiving the lighter application of ammonia. With the heavier application there was a barely significant increase of 117 pounds/acre (P = .05).

In 1942, 1943, and 1944 fertilizer experiments were conducted on replicated plots, 20 x 100 feet. The fertilizers were applied as side dressings 6 inches from the planted bean rows. The three treatments used were: (1) 84 pounds and (2) 168 pounds of phosphoric acid (P_2O_5), as well as (3) both 168 pounds of phosphoric acid and 100 pounds of nitrogen/acre. The phosphoric acid was supplied by treble superphosphate, and the nitrogen by ammonium sulfate. There was significant increase in yield only when both nitrogen and phosphoric acid were added. This fertilizer application gave an increase in yield of 239 pounds of beans/acre in 1942, 415 pounds in 1943, and 560 pounds in 1944. The least significant differences in pounds/acre were 198 in 1942, 287 in 1943, and 409 in 1944.

This evidence indicates that on rather fertile soil, Lima beans do not decrease in yield when continuous cropping is practiced. This may be partially explained as the replenishment of the available nitrogen supply by the Lima bean nodules. The other essential elements must be in abundance.

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Role of the Axis Cylinder in Transport of Tetanus Toxin[1]

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The purpose of this article is to show that the neurofibrillae in the axis cylinder are the agents responsible for the transport of tetanus toxin to the cell bodies of motor nerves. In this transport the rate of progression has been measured and will be stated below. The chief interest in this problem is primarily to add one more fact to our knowledge of the physical and chemical nature of the neurofibrillae. Howe and Bodian (*2*) have stated that the axis cylinder is the route taken by the virus in experimental poliomyelitis in monkeys. Their method of freezing the sciatic nerves was used in the experiments outlined below. Friedemann (*1*), in discussing the blood-brain barrier, states that the capillaries of the central nervous system are impermeable to tetanus toxin. In this article he also lists the literature dealing with the controversial subject of blood stream versus neuron routes taken by the tetanus toxin. The experiments here listed substantiate the nerve-fiber route.

After carefully exposing and severing the sciatic nerve very close to the knee joint, 8 guinea pigs were inoculated with a tetanus toxin which had 75,000 m.l.d./cc. The inoculation was made in the following manner: The central cut end of the sciatic nerve was held firmly against the end of an applicator stick which had been dipped in the tetanus toxin of the above-mentioned strength. The time of exposure in each case was 5 minutes. The end of the applicator stick did not hold a drop of the toxin but was merely moist. All of the guinea pigs were dead within 72 hours. Their death was due to tetanus, the symptoms of which were those of the local type. First to show signs of stiffness was the opposite limb, then the lower back, thoracic level, and finally the cervical and head region. The wound was closed surgically under strict aseptic conditions.

On 8 other guinea pigs the sciatic nerve was exposed and frozen with CO_2 snow as far centrally as was conveniently possible. This technique produces the degeneration of the axis cylinder but does not alter the blood supply or the neurilemma sheath. The frozen area is about 2 mm. in length. Sixteen days

[1] Present address of author: University of Louisville. Tetanus toxin supplied by courtesy of Eli Lilly and Company, Indianapolis.