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HAWAII AGRICULTURAL EXPERIMENT STATION,
E. V. WILCOX, Special Agent in Charge.

Bulletin No. 23.

LEGUMINOUS CROPS FOR HAWAII.

BY

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Agronomist.

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HAWAII AGRICULTURAL EXPERIMENT STATION, HONOLULU.

[Under the supervision of A. C. TRUE, Director of the Office of Experiment Stations, United States Department of Agriculture.]

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LETTER OF TRANSMITTAL.

HONOLULU, HAWAII, *February 27, 1911.*

SIR: I have the honor to submit herewith and recommend for publication as Bulletin No. 23 of the Hawaii Agricultural Experiment Station a paper on Leguminous Crops for Hawaii, prepared by Mr. F. G. Krauss, agronomist of the station.

Respectfully,

E. V. WILCOX,
Special Agent in Charge.

Dr. A. C. TRUE,
Director Office of Experiment Stations,
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Publication recommended.
A. C. TRUE, *Director.*

Publication authorized.
JAMES WILSON,
Secretary of Agriculture.

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LEGUMINOUS CROPS FOR HAWAII.

INTRODUCTION.

This bulletin is intended to give brief descriptions and practical suggestions that will be helpful in growing leguminous crops under Hawaiian conditions. Recognizing the need and importance of introducing this class of crops into our agriculture to secure the highest development, this station began several years ago to test systematically a large number of leguminous plants to determine their relative adaptability to Hawaiian conditions and to improve by selection such varieties as experience would show best suited to the various uses to which leguminous crops are usually put. Small lots of select seed have been freely distributed among farmers during the past few years, and the reports from these, together with the experimental data accumulated by the station, form the basis of the bulletin.

The legumes to be discussed are alfalfa, cowpeas, jack beans, pigeon peas, soy beans, and velvet beans, each of which has special qualities which fit it better to some conditions than to others. It will be well for growers to give more than one variety of each legume a thorough trial.

The main use of these legumes will be as forage crops. Any one of them may be fed as green fodder, cured as hay or grain, as silage or pasture, depending upon condition. But it is good general practice to feed wherever possible and then distribute on the land the resulting manure rather than to plow under the crop as green manure, although there may be conditions where this latter practice is more expedient. For whatever primary purpose the leguminous crop may be grown, if it enters into rotation with other crops its secondary effect will greatly add to its value.

Since success with any crop depends largely on suitable varieties and a good quality of seed, the station aims to supply select seed in small quantities to applicants who will report on the results of their trials. This is a good opportunity for an enterprising farmer who will undertake to grow the standard varieties of agricultural seeds, among which none is more easily grown or more likely to be in demand than the legumes. Of equal importance to good seed is thorough tillage, and when needed a liberal use of manure or fertilizer will well repay all reasonable outlay.

ALFALFA.

(*Medicago sativa.*)

Alfalfa has not yet received the general recognition as a field crop for Hawaii that its value as a fodder crop would seem to warrant. The total area now planted to alfalfa does not exceed 250 acres, considerable of it in small patches scattered throughout the Territory. The present plantings range from sea level to an altitude of almost 5,000 feet. It is grown under arid conditions, as well as those of heavy rainfall. Both as an irrigated and as an unirrigated crop there is a wide variation in the soils on which the crop is grown. The results thus far obtained by the more progressive planters are such as to encourage its more extensive distribution as a field crop.

Common alfalfa or lucern is a native of the temperate regions of Asia. It found its way to Italy and Spain in ancient times and still maintains a high position among the cultivated forage plants in those and other countries bordering the Mediterranean. From Spain the plant was introduced into South America. It was introduced into California from Chile in 1854, where its great value as a fodder crop was early recognized, and its culture spread rapidly over the irrigated regions of the West.

The first field planting made in Hawaii is accredited to the Hon. D. P. R. Isenberg, who in 1895 planted 5 acres at Waialae ranch to the common California variety originally brought from Chile. This initial planting has been constantly added to until at the present time the total area exceeds 90 acres. The success of this planting has undoubtedly done much to encourage other plantings. Many of the cultural data contained in this paper were obtained from Mr. Bailey, manager of the Waialae ranch.

VARIETIES GROWN IN HAWAII.

There are several varieties and numerous strains of alfalfa grown in the United States. All are perennials and resemble each other closely in general appearance. The seed sold locally is mostly of the common Chilean alfalfa originally brought to California and now extensively grown in that State and the West generally. It is strong and vigorous in growth, but is said to be less resistant to drought and cold than some of the more recently introduced varieties. It succeeds well in Hawaii and is grown exclusively on the Moanalua and Pond dairy farms as well as by most of the smaller growers in the islands. In the station's comparative tests with Arabian and Turkestan alfalfa the common California variety has invariably been the slowest to recover after cutting and to reach both the flowering and seeding stage. It has been second in point of yield of green fodder and second in yield of seed. It is characterized by its broad

leaves and somewhat denser foliage than is usually developed in the other varieties, as well as by its inclination to lodge. Owing to its thick growth and decumbent habit, the basal growth is much more subject to decay in wet weather than are either of the more upright Arabian and Turkestan varieties. Because of its tendency to lodge it is not so easily mowed as are the more upright varieties.

Turkestan alfalfa was introduced into the United States from Russian Turkestan in 1898. It is considered more drought resistant and hardier than common alfalfa. In the station comparative tests this variety stood third in yield of both fodder and seed. It is early maturing, following the Arabian closely in this particular, and resembles that variety in general appearance. It is of upright growth and bears the long narrow leaflets which characterize the Arabian alfalfa, but the leaves are borne more closely to the stem. The stems, on the whole, seem larger and coarser than in the other varieties tested, and the general habit of growth would suggest the greater resistance to drought and cold which is claimed for it.

In 1908 the Parker ranch seeded 10 acres at Waikii to a Texas strain of this variety, and although the average annual rainfall has been less than 5 inches a good stand was secured and has been maintained from the original planting. Mr. Alfred Carter, manager of the Parker ranch, states that during long periods of drought this patch of alfalfa was the only green spot in a tract of some 25,000 acres of grass land. The results of this experiment warrant more extensive planting, and this is contemplated in the near future.

It would be interesting and possibly of much importance to compare the relative value of the several especially hardy and drought-resisting alfalfas now available under these unusual conditions. Of these, Mr. Carter intends giving the sand lucern a trial. This is a hybrid alfalfa extensively grown in Europe. It is more fully described further on. Mr. C. G. White, of Haiku, Maui, considers the Turkestan alfalfa inferior for his conditions.

Arabian alfalfa is of more recent introduction into the United States. It is said to be of special value in regions where mild winters prevail. While it grows better in cooler temperatures than does ordinary alfalfa, it is killed by actual freezing temperatures. It is characterized by its strong upright growth, early maturity, and quick recovery after cutting.

In the station's comparative tests covering three harvests the Arabian alfalfa appears to maintain the qualities claimed for it elsewhere. Planted 15 days later than the Turkestan and the common variety, the Arabian flowered about the same time as the Turkestan and about a week earlier than the common variety. The seed was matured in the same order of precedence. This is equivalent to maturing the first crop from seeding two weeks earlier than

Turkestan and about three weeks earlier than the common variety. In the second and third cuttings the Arabian was ready to harvest about a week earlier than the Turkestan and about two weeks earlier than the common variety. In seed and green fodder the Arabian outyielded both the other varieties to an extent which would indicate that this variety is worthy of trial by all who contemplate growing alfalfa in Hawaii.

It is interesting to note that this variety has failed to seed satisfactorily in California, while in the station trials it appears to have seeded most heavily of the three varieties under test. So far as the station has been able to determine, Arabian alfalfa has not previously been grown in Hawaii. It is recommended for trial in all parts of Hawaii. It should prove hardy even at the higher altitudes where there is arable land. While the seed of this variety is as yet somewhat limited, it can be purchased from San Francisco seedmen at 40 cents per pound in small quantities.

Sand lucern, as has already been stated, is a hybrid alfalfa. It is supposed to be originally a natural cross between the common alfalfa (*Medicago sativa*) and the wild yellow-flowered alfalfa (*M. falcata*), with probable numerous intercrossings so that it closely resembles *M. sativa*. It is one of the hardiest of all alfalfas. Not alone does it resist the cold winters of the Northern States, where other varieties are likely to winterkill, but it likewise succeeds well on drier and poorer soils than do most other sorts. Its chief drawback is said to be its tendency to lodge. The now famous Grimm alfalfa of Minnesota is of this type.

A German strain of the sand lucern is now grown by Mr. Isenberg exclusively in his extensive plantings at Waialae ranch. Here it succeeds much better than the common alfalfa previously grown.

The best seed now available is imported from Europe. The samples of imported seed of this variety examined by the station are the best that have come to our notice. It is free from dodder and other weed seeds, and unusually bright and plump, as well as of strong germinating power.

Peruvian alfalfa is a new type recently introduced into this country by the United States Department of Agriculture. It is similar to the Arabian alfalfa in habit of growth, but the stems are said to be somewhat taller and more woody than the Arabian. Its more important agronomic value lies in its quick recovery after cutting and subsequent rapid growth, which permits of more frequent cuttings.

Seed of this variety was recently received by the station from the Bureau of Plant Industry of the United States Department of Agriculture and has been planted, together with other available varieties,

FIG. 1.—ARABIAN.

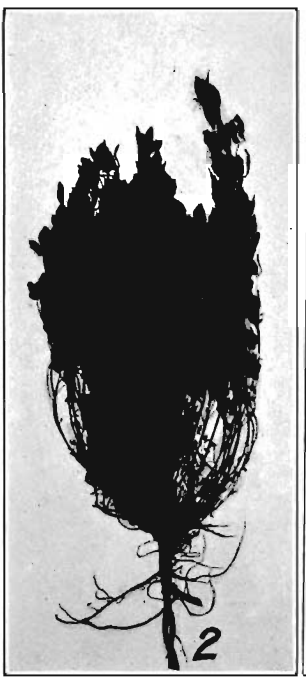


FIG. 2.—COMMON.

FIG. 3.—TURKESTAN.

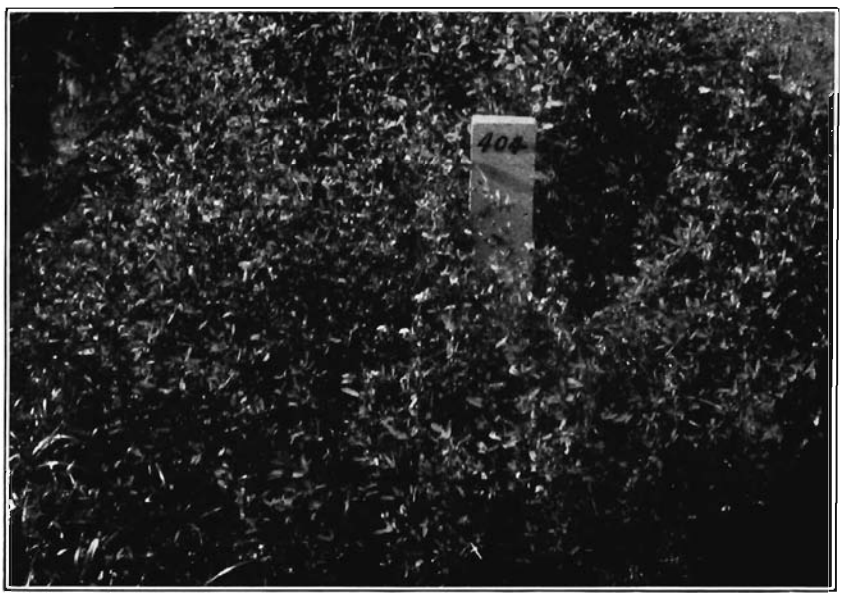


FIG. 4.—TEST ROW OF ARABIAN ALFALFA, FIVE-FOOT SPREAD, SEVEN MONTHS AFTER SEEDING.

with a view to determining their relative value under Hawaiian conditions.

Plate I, figures 1, 2, 3, illustrate the three varieties that have been grown by the station.

REQUIREMENTS AND CULTURAL METHODS.

Alfalfa is perhaps more exacting in its cultural requirements than are most of the forage crops now grown in Hawaii; however, it is not a difficult crop to grow when the more essential conditions are supplied. These are comparatively few and well defined. For those having no previous experience in growing the crop, it is suggested that only a small area be seeded at first.

The first essentials for growing alfalfa successfully are a clean, deep, and well-drained soil. The plant is one of the deepest-rooted plants known, and when conditions are right for its best root development the plant lives for many years and yields abundantly, even when the surface supply of moisture is scant, as is well illustrated in the unirrigated Waikii plantings on the Parker ranch. Alfalfa can be grown on shallow soils, but the crops usually wane in the second or third year wherever the subsoil is of an inert or impervious nature.

Standing water is disastrous to alfalfa, whether the planting be recent or long established. Soils that are not naturally well drained and can not be drained to a good depth artificially should be avoided. On the other hand, soils may be so porous that the large and frequent irrigations necessary to supply adequate moisture would make the crop unprofitable. However, such soils, because of their otherwise unfavorable character, may often be improved in their water-holding capacity by green manuring. This supplies the necessary organic matter in which such soils are usually deficient. Besides improving the texture, the resultant humus adds greatly to the direct fertility of the soil, and at the same time supplies the necessary media for the nitrifying organisms so important to the successful growing of leguminous crops.

While alfalfa succeeds best on light loamy soils, heavy clay soils may sometimes be so modified as to yield profitable crops of alfalfa. Since the main trouble with clay soils is their compact character, inclination to become waterlogged and "sour," the first step for their improvement is that they be well drained. The Waialae ranch has greatly improved the physical condition of some of its heavy soils by heavy applications of beach sand. But unless such material is easily accessible, the cost would be prohibitive. The Moanalua ranch has found that liming greatly improves their heavy soils for alfalfa growing. A half ton of ground burnt lime is the rate they use per acre. Liming is an old practice for correcting the acidity in

soils. It also greatly improves the physical condition of heavy clay soils by its granulating effect on the fine particles, which greatly improves their tilth and ease of cultivation. Mr. C. G. White, of Haiku, also finds liming beneficial.

The plowing under of coarse manure and other rank vegetation will often improve the physical condition of clay soils, but such treatment may bring about an acid condition which would need correction before alfalfa or other legumes could be grown successfully. In contrast to the experience of most growers, the Kamehameha schools report that they have obtained the best results with alfalfa on a moderately heavy adobe soil with thorough preparation. Those who have failed to grow alfalfa successfully on heavy clay soils, not excessively wet, should test the effects of liming. One-half to 1 ton per acre of ground burnt lime, well worked into the surface 12 inches, will tend to sweeten and make more friable the most compact and tenacious soils.

It is said that no other forage crop requires so much lime in the soil as does alfalfa. However, conditions are sometimes such that it is more practicable to grow especially adapted crops for several years preparatory to growing alfalfa. This should preferably be a deep-rooted plant, and if this can be a legume, so much the better. In the station's investigations of crop adaptability, no leguminous plant has shown greater adaptability to adverse soil conditions than has the pigeon pea, described in another part of this bulletin. Its deep-rooting habit and strong root penetration would seem especially to adapt it to the requirements in hand, and it is strongly recommended for trial in this connection.

Next to an unsuited soil condition, perhaps no other cause is more responsible for failure to secure a stand in alfalfa, or the source of greater expense in securing a stand, than is foulness from weeds. Nothing is more certain to destroy a promising stand of young alfalfa than a soil full of weed seeds, nor is any phase of its culture more expensive than the eradication of weeds from the young growing crop. The remedy is simple: Do not sow alfalfa on weedy ground. The young alfalfa plant is a most delicate seedling, and almost any kind of weed is certain to crowd it out during the earlier stages of growth. If for some reason it is not feasible to leave the land uncropped until all the weed seeds have been destroyed by a season or two of clear tillage, it is better to grow some hoed crop, such as corn or potatoes, or even pineapples, in which clean culture is readily maintained; or a dense leguminous crop, such as velvet beans or cowpeas, which have a tendency to smother out even the most tenacious weeds, may be grown.

Of equal importance to the requirements already cited is a thorough preparation of the soil before sowing the seed. The seed of

alfalfa is small (see Pl. VIII, p. 30) and the plantlets tender compared with legumes of the pea and bean type, so that to give the crop a favorable start the soil must be mellow to begin with. Three to five plowings and as many disk harrowings at sufficient intervals to give the weed seeds a start, so that as many as possible may be destroyed in the process of cultivation, followed by a final planking to smooth off and firm the land, will be found none too much working to prepare a suitable seed bed. Mr. Bailey, manager of the Waialae ranch, states that he frequently plows and harrows 10 times preliminary to seeding his alfalfa, and he lays his success, in large part, to this practice of thorough tillage.

With all other conditions supplied, there still remains the important matter of good pure seed. This should be plump and of strong germination. Great care should be taken to secure seed free from dodder and other weed seeds. The former is a parasitic plant which preys upon alfalfa and may be considered one of its worst enemies. Much of the commercial seed sold in bulk contains dodder and other weed seeds which it is difficult to separate from the alfalfa seed. If possible, seed should be secured from a source known to be free from dodder or carefully recleaned seed should be used. It may be well for prospective planters not familiar with dodder and other impurities to submit samples of their seed to the station for examination before planting; or, if this is not convenient, the seed may be hand sifted. While it is somewhat difficult to separate the large-seeded dodder from ordinary alfalfa seed, it can be done by using a screen made of 20 by 20 mesh, No. 34 steel or iron wire on the W. & M. gauge; or, the same mesh of brass or copper wire, No. 32, English gauge. This should be stretched over a light wood frame about 12 inches square. A half pint of seed should be placed in the sieve at a time and thoroughly sifted until all of the dodder seed is removed. This will require a half minute vigorous shaking, and the results will well repay the trouble.

SEEDING.

Owing to the prevalence of cutworms, the fall months have generally been found safest for seeding alfalfa in Hawaii, August, September, and October being the months recommended by the most successful growers. At the station trial grounds seed has been sown in early spring, midsummer, and late fall with equal success. In the absence of cutworms the spring months would appear to be the most favorable season for planting. Cutworms have been combated in several ways by local alfalfa growers. Waialae ranch invariably follows the rule to grow corn or sorghum as the first crop. The stubble is then carefully hoed out by hand and the ground is left clean of insect pests and weeds, and is otherwise well conditioned to receive the

succeeding alfalfa crop. The process is expensive, but pays. Others have found the standard cutworm remedies, baits of sweetened bran or alfalfa clippings combined with arsenic, an effective means of destroying the pest. Frequently the worms may be drowned out, as has been practiced at the station trial grounds, although this latter method is not always feasible.

The usual method of seeding the more extensive areas in Hawaii is to broadcast the seed, as is the common practice elsewhere. Here, planters use from 40 to 60 pounds of seed per acre. This is two to five times more seed than is usually sown on the mainland and would seem an unnecessary waste of seed.

Drilling the seed is a much more economical method of sowing and is believed to have other advantages to warrant its general adoption in Hawaii. Molokai ranch has planted successfully with an ordinary grain drill, seeding at the rate of about 14 quarts per acre. This is equivalent to about 25 pounds seed per acre and should be ample for the most adverse conditions under which the crop should be grown.

In the station's experiments and other trials where the seed was sown in drills 12 to 24 inches apart, 5 pounds of seed has been found ample to sow an acre, and even at this rate, thinning out the plants has been found an advantage to the crop. Besides the saving of seed, sowing in drills usually insures a more uniform stand than does broadcasting, and greatly facilitates weeding. When the rows are sufficiently far apart, say 20 to 30 inches, horse cultivation to suppress weeds and conserve the moisture may be practiced economically. This is especially advised on soils where there is a scarcity of water for irrigation. In many cases it will lessen the cost of production as well as increase the yields. Such treatment would also often increase the life of the planting. In the station trials, test rows of three varieties planted 5 feet apart completely covered the intervening ground at the end of seven months from sowing the seed. One such row is shown in Plate I, figure 4. The yield of green fodder at that stage ranged from 3 to 3½ pounds per running foot for the first cutting; and for subsequent harvests, 30 days apart, the yields were 1 to 1½ pounds of green fodder per running foot. These yields compare favorably with the production obtained from most of the broadcast plantings, but are somewhat less than when the rows are only half as far apart. Observations thus far made indicate that greater acre yields may be obtained from row planting with thorough cultivation and an optimum amount of moisture than by broadcasting and unlimited irrigation. The relative cost of production of the two methods of growing will depend upon adaptability of conditions and the relative cost of water and labor. Mr. C. G. White is decidedly in favor of planting alfalfa in rows. A progressive grower in the South finds that he is able to cultivate 3½ acres per day with a 1-horse cultivator, the rows

24 inches apart. With a modern 2-horse riding cultivator this would be considerably increased where conditions will permit the use of such an implement. Where irrigation is practical and small beds are necessary to facilitate irrigation, a hand wheel hoe may be used to advantage. Seeding may likewise be done with a hand implement.

While many growers find it most practical to irrigate immediately after seeding, a few claim that they get better germination by irrigating before seeding. On soils inclined to puddle and bake the latter method, if followed by a light disking when not too moist, would appear to possess advantages.

IRRIGATION.

Except at Waikii, no extensive planting is being maintained without irrigation during the dry months. The amount of water used varies greatly in different localities and by different growers. On the low sandy and gravelly soils on the lee side of Oahu, weekly floodings, ranging from 50,000 gallons to more than twice that amount per acre, are found necessary during dry weather. On the more retentive mauka lands, as at Moanalua, 50,000 gallons and less applied fortnightly is found ample. The usual plan on Oahu is to lay out long narrow beds ranging from 10 to 50 feet in width and 100 or more feet in length. These are separated by low dikes. Each bed is then flooded independently from a head ditch. The source of water is more often from artesian wells, either flowing or necessitating pumping, than from natural streams. When pumping is necessary the cost of irrigation is considerably increased, and may in some cases be prohibitive. So far as it has been possible to determine, the cost of irrigation may range anywhere from 50 cents to $3 or more per acre per crop during the drier months of the year. One of the advantages of growing alfalfa in rows is that it permits of furrow irrigation. This system of irrigation, while it requires more labor, permits of a more economical use of water, and on heavy soils, to a large extent, avoids puddling.

HARVESTING AND YIELDS.

Probably in no other country where alfalfa is grown as a cultivated crop are more crops harvested per annum than in Hawaii. It is hard for mainland growers to believe that 10 crops are here harvested annually in general practice. As a matter of fact, Waialae ranch regularly harvests 12 crops a year, and frequently 13 cuttings are made within the 12 months. The usual practice is to clip the young plants for the first time when from 6 to 12 weeks old. This is thought to strengthen the plant, but is sometimes done to check weeds. In the station's experiments, no advantages could be noted from clipping

the plants, and the strongest growth was obtained without such practice. The number of days between harvests at Waialae ranges from 16 to 24 days during the summer and from 28 to 35 during the winter, which is the time required to bring the crop to the flowering stage. In less sheltered localities and on colder soils in the same locality, 10 crops are harvested annually. At Moanalua, at an altitude of several hundred feet, and at Kamehameha schools, where the soils are heavier and less well drained, and exposed to cold winds, 8 to 10 crops are harvested annually, while at Waikii on Hawaii, at an altitude of 4,700 feet, 6 crops per annum are usually harvested.

While a large number of cuttings is usually associated with large total annual yields, the total annual yield from a less number of cuttings in an otherwise favorable location may equal or even surpass the greater number of cuttings. Thus, while the total annual acre yields in the warm, sandy lowlands, which produce 10 to 12 cuttings annually, range from 10 to 20 tons green fodder, the colder and heavier uplands, producing 8 to 10 cuttings, yield an approximately equal amount of forage. On the other hand, all growers seem agreed that, while it requires from one to three weeks longer for the crop to mature in winter than in summer, the yields from the winter crops are usually considerably smaller. From this it would appear that, even in our mild climate, the influence of cold during winter may be a factor of considerable importance in growing common alfalfa. It may be well for those located in the colder regions to consider some of the hardier alfalfas described in this paper.

In regard to the yields and quality, the data at hand would indicate that the Hawaiian product compared favorably with that grown on the mainland. The average composition of three samples of the Hawaiian product shows a considerably higher percentage of protein and a slightly lower percentage of fat and nitrogen-free extract than does the average mainland sample. Since protein is the most valuable and expensive constituent in our feeding stuffs, it would appear that the home-grown product is not lacking in the more important constituents, and therefore its feeding value should at least be equal to the imported product. Indeed, such small amounts of alfalfa hay as have been produced locally have found ready sale in competition with the imported product.

Some difficulty has been experienced in curing alfalfa in Hawaii, but Mr. P. M. Pond reports that he has made and sold something over 100 tons from his Mokolee ranch during the past year. The average yield of hay was about 7 tons per acre. The average price realized was $24 per ton. The Moanalua ranch cures all the hay needed for their work horses. Their practice is to cut the alfalfa intended for hay on a bright, warm day. It is permitted to lie where

cut for one day, turned over the next, and stored under cover the third day when the conditions for drying have been favorable.

While most dairymen prefer green alfalfa to any other forage crop that can be grown, most of them agree that greater feeding value is obtained from its admixture with corn or sorghum, while one dairyman stated that he got as large or larger milk flow from prime green corn fodder than from alfalfa.

Aside from being fed to horses and especially to dairy cows, alfalfa has been fed to some extent to hogs. The Molokai ranch finds it especially suited to this class of stock and is continuously extending its acreage for this purpose alone. Probably no other green feed equals alfalfa as a poultry food. For this purpose it should be cut fine, or better still, pastured. However, for larger live stock, it is too valuable a crop to pasture under Hawaiian conditions and should be used as a soiling crop.

COST OF PRODUCTION.

No reliable data are at hand on which to base cost of production. It seems quite certain that the first cost of establishing the crop is considerably greater than that of any of the other forage crops now grown. However, when a good stand is established and can be maintained for five or more years, as is being done at Waialae, the crop becomes a comparatively economical one to produce.

ENEMIES.

While the cutworms and annual weeds are the greatest enemies in establishing the crop, the encroachment of manienie or Bermuda grass is the worst enemy to the crop after it has been established for a number of years. No other serious hindrances have thus far been observed.

ROTATION.

When because of declining yields it becomes necessary to plow up a field of alfalfa, it has been found that corn and other crops are greatly benefited because of the rotation. This has been observed especially at Moanalua. Likewise alfalfa follows well after corn and most other hoed crops. Because of the difficulty in establishing alfalfa it is not well adapted to a short rotation, but should be cropped at least two years.

INOCULATION.

In regard to inoculation for alfalfa, no case has as yet come under the station's notice where the root tubercles were wanting, so that it would appear that the bacteria necessary for their production are

naturally present in most of our soils. An experiment conducted with artificial cultures by the station some years ago gave negative results. Several independent growers have had similar results.

However, when it is found that the nitrogen-fixing bacteria are absent, the simplest and most effective means of inoculation appears to be by the introduction of several hundred pounds per acre of a good alfalfa soil. This should be scattered over the surface and lightly harrowed in at a time when the soil is warm and mellow.

FERTILIZATION.

The only fertilization thus far practiced in Hawaii is the application of well-rotted barn manure, to which the crop usually responds well. As alfalfa is usually grown in connection with stock raising, manure is a cheap and practical fertilizer, and should be used extensively. Alfalfa is a greedy feeder. Especially is it valuable on our sandy soils which may be lacking in humus.

COWPEA.

(*Vigna catjang.*)

The cowpea is an annual plant, but under favorable Hawaiian conditions may produce one or even two ratoon crops. In appearance the plant resembles the bean more than the pea, and like the bean it appears to be more sensitive to wet and cold. The commonly grown varieties are characterized by their vigorous growth and rambling or trailing habit. Compared with other viney legumes of like vigor, the cowpea would be classed as early maturing. When planted in rows and well cultivated the vines may attain a length of ten or more feet and produce a great amount of foliage. Where the seed is thickly broadcasted, they show less inclination to throw out strong tendrils and produce less seed and foliage. Most of the standard varieties are heavy seeding, but for the maximum production of seed, especially if uniform maturity is desired, the crop should be planted thinly, preferably in rows, and at such a time as to ripen the seed during the warmer and drier seasons of the year. In comparison with the growth above ground the root system of the cowpea does not appear to be as extensive as in most other legumes, nevertheless the plant is quite drought resistant, due to its shading the ground so thoroughly. The roots are nearly always supplied with the nodules which harbor the nitrifying bacteria so important to enriching both the plant and the soil.

In the Southern States the cowpea easily takes first place as a forage and manurial crop. The plant adapts itself readily to a wide range of soils, and is especially prized for its ability to make a satisfactory growth on soils too poor for other crops. Because of its dense

FIG. 1.—WHIPPOORWILL.

FIG. 2.—GIANT.

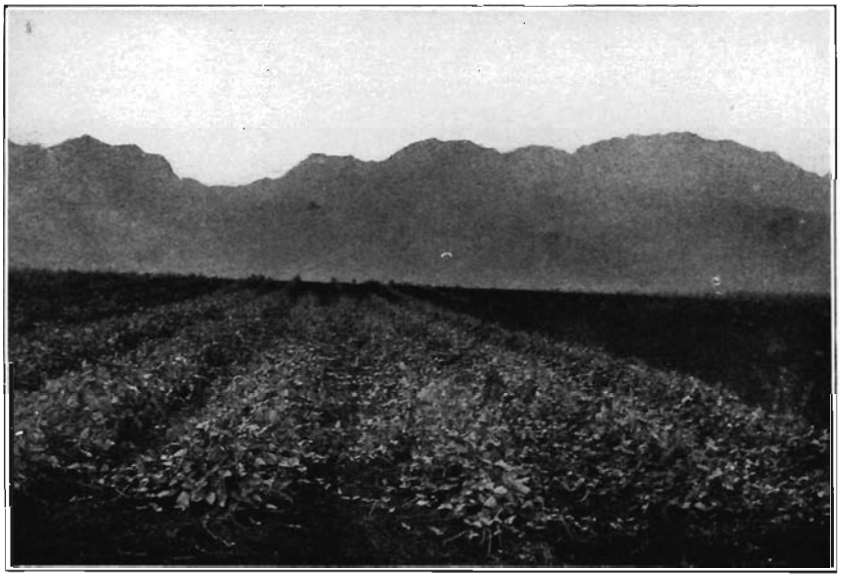


FIG. 3.—FIELD OF CLAY COWPEAS GROWN AT KUNIA, OAHU, WITHOUT IRRIGATION. RAINFALL 22 INCHES FOR THE YEAR.

growth, it makes an excellent cover to choke out weeds. Except on well-drained soils, it is less well adapted as a winter cover to prevent wash and later to be turned under as green manure.

When conditions for curing are favorable the cowpea vines make excellent hay, even after the seed is removed. The yields of hay (including seed) range from 1 to 3 tons per acre, and the shelled seed alone from 10 to 30 bushels (600 to 1,800 pounds) and over per acre.

VARIETIES.

Ten standard varieties and several hybrids have been grown at the station trial grounds for from one to four years, a spring and fall crop being usually grown each year. All varieties were planted in rows 5 feet apart. No irrigation or fertilization was applied, and so far as possible successive planting on the same ground was avoided.

The following varieties have succeeded the best and are arranged in the order of their merit. They appear to possess all the qualities that could be looked for in this legume and are recommended for trial.

Whippoorwill (No. 215). This variety has uniformly given the highest yields of both seed and fodder. It is a very vigorous grower, producing a dense foliage (Pl. II, fig. 1). It is of fairly upright growth, standing 30 to 36 inches high without support. The vines often measure 10 or more feet in length. The seed is medium large and somewhat angular in form. The color is a dark chocolate brown mottling on a lighter colored ground. The seed matures in about 125 days, and shows little inclination to shatter. The crop may be cut for fodder or turned under as green manure in about 100 days from sowing the seed.

Iron (No. 274). This is a heavy seeding variety of moderately vigorous growth. The foliage is dark green and inclined to be leathery. It is somewhat more erect than Whippoorwill and of an even clay or brownish color. It matures with Whippoorwill, but the foliage remains green longer.

It is claimed for this variety that it is resistant to wilt and to root knot caused by eelworms, but neither of these diseases has as yet attacked any of the varieties in Hawaii. The seed appears to be less liable to the attack of the weevil.

Clay (No. 213). This is a vigorous, half erect variety, which appears to seed somewhat less heavily than either of the above varieties. The seed is similar to the Iron variety, but less uniform in size. A number of attempts have been made to establish a small and a medium large seeded strain, but the selections have invariably reverted to mixed sizes, showing that the type is not well established. Because of the originally large supply of seed available, this variety is the most extensively grown by the station. The horticultural department is using

it extensively as an orchard cover crop, for which purpose it has given good satisfaction.

Giant (No. 217). This is the most vigorous and rankest growing cowpea thus far tested by the station (Pl. II, fig. 2). It is of low trailing habit and continues to grow for a long period. At six months stems have been measured exceeding 20 feet in length. It bears large dark crimson pods, 8 to 10 inches long, $\frac{5}{8}$ of an inch broad, and $\frac{1}{2}$ of an inch thick. The seed is exceptionally large, measuring 12 by 10 by 6 millimeters (see Pl. VIII, p. 30). Their color is buff, similar to that of the Iron and Clay varieties; unfortunately it is light seeding. It should prove especially useful to plant on idle land to keep down weeds and as a soil improver, and should also prove valuable as pasture.

No. 257 (*Dolichos sesquipedalis*). This species is so much like a cowpea and was for a long time mistaken for the large "Black Eye" cowpea that it is included here for the time being. It is of rank, trailing habit, yielding an abundance of both seed and forage, somewhat later than the preceding varieties. The seed is medium large, kidney shape, white or cream colored, with a prominent black eye surrounding the scar. The seed is used extensively by the Chinese as a sprouted grain, under the name "Mit tan." It thrives wherever the cowpea succeeds.

CULTURE, HARVEST, AND FEEDING.

The cowpea has been grown successfully on a field scale at the station grounds at Kunia (Pl. II, fig. 3), the uplands near Waipahu, and on the dark soils at Wahiawa, on Oahu; at Haiku, Maui; and at Kaunakakai and Kualapuu, Molokai.

The greatest drawback to growing the crop profitably is the attacks from aphis, to which the plant is especially subject. The plants may become infested in their early growth or well after the flowering stage. Frequently the crop is totally destroyed, but more often the pest confines itself to a restricted area, when the crop may recover with the advent of more favorable weather conditions.

Experience has shown that the drier and warmer regions and seasons are best adapted to this crop and that it should preferably be grown without irrigation.

Except when intended as a cover and green manuring crop, the crop is best drilled. It gives the largest yields of seed and fodder when planted in rows and well cultivated. It can be grown to advantage as a mixed crop with corn or sorghum, as it usually increases the yield and greatly improves the feeding value of the fodder, as well as being beneficial to the land. The usual practice is to sow the two varieties of seed together with a grain drill, but better results have here been obtained by planting in rows $3\frac{1}{2}$ to 5 feet apart and culti-

FIG. 1.—PLANTS IN PRIME GROWTH.

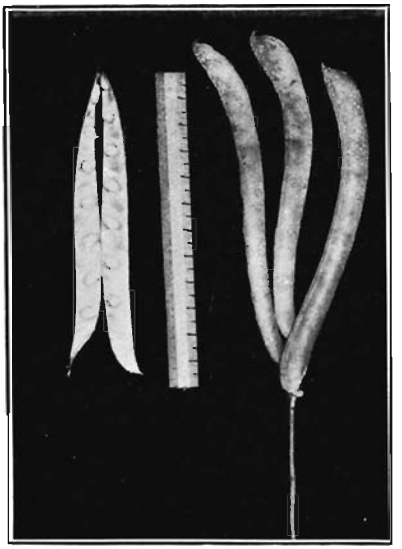


FIG. 2.—MATURE PODS.

FIG. 3.—FIELD OF JACK BEANS GROWN AT KUNIA, OAHU.

JACK BEANS.

vating as long as the growth will permit. In close drilling, about 50 or 60 pounds cowpea seed to 25 to 30 pounds of sorghum seed are used, or if corn is used instead of sorghum, use as much corn as cowpeas. If planted in rows less than a fourth of this amount will be needed. Any of the varieties of cowpeas recommended in this bulletin, excepting Giant (No. 217) and the sorghum and corns commonly grown in Hawaii, are suitable for this purpose. When planted with corn with a view to harvesting the grain of both corn and cowpeas, the cowpeas should be sown between the rows at the last cultivation of the corn crop.

The harvesting is best done with a 2-horse mower, and if intended for green fodder the crop should be cut before the seed becomes too ripe.

The seed crop from cowpeas is a valuable one, especially if there is a demand for it for seed purposes, as there is on the mainland. But to pick the seed by hand is a tedious process. However, satisfactory bean thrashers are now to be had at a reasonable price. A small power machine having a capacity of 200 to 500 pounds of seed per hour direct from the vines can now be purchased for about $100. Such a machine would handle the crop from about 10 acres. Besides thrashing cowpeas such a machine will handle soy beans, pigeon peas, and other legumes not having excessively heavy vines. To a certain extent the vines are shredded in passing through the thrasher, which adds considerably to their value as stock food.

Cowpeas are fed to and relished by all classes of stock. In the Southern States work horses are fed on well-cured hay containing some ripe seed as an exclusive ration. Milch cows respond well to both the green and cured fodder. The seed is usually too expensive to feed, but is said to make a very nutritious feed for hogs and poultry. Some varieties are used extensively as human food.

JACK BEAN.

(*Canavalia ensiformis.*)

The jack bean (Pl. III), also known as the Chickasaw Lima bean, is a strong, vigorous-growing bushy plant. Under favorable cultural conditions the plant attains a height of 30 to 36 inches, with an equal spread of dense bushy foliage. The leaves are large, nearly as broad as long, and deep green in color. The green, fleshy pods, when they have attained full size, are very large, measuring 12 to 15 inches in length, $1\frac{3}{4}$ inches in width, and almost an inch in thickness. As they mature they become hard and woody, and contract considerably in size. The seed is a large, smooth, pure white bean.

While grown to some extent in the Southern States, the plant does not appear to thrive as well there as here, and no extensive feeding

experiments are reported. The bean meal is said not to be very palatable or digestible for cattle, but this may be due to a too limited experience in its use. The early feeding experiments with the green fodder in Hawaii gave similar results to those reported above, but as feeders gained in experience the fodder was found to be both palatable and nutritious for dairy cows as well as swine. As with most new feeds, it is important to use in the beginning only a small proportion of the new feed in the accustomed ration and then increase the proportion gradually. The Dowsett and Pond dairies have fed green jack beans and sorghum in equal proportions to dairy cows with excellent results.

The crop requires about a month longer to mature than do cowpeas, but the yield is proportionately greater. Yields of 16 to over 20 tons of green fodder per acre have been reported from various sources. The best yield of seed reported is 1,200 pounds per acre. While a single crop is usually grown from each sowing, the station has occasionally grown a good ratoon crop. Such crops, however, are subject to a leaf blight common to the bean family. Otherwise, the crop is exceptionally free from diseases and insect pests, a point greatly in its favor over the cowpea. Another possible advantage possessed by the jack bean over the rambling legumes is the absence of trailing stems which might interfere in some forms of intercropping.

The crop would appear to be well adapted for interculture between coffee, rubber, sisal, and other perennial crops, sufficiently spaced to permit of cultivation during the earlier stages of their development. It is suitable as a cover crop to keep down weeds and prevent wash, and would doubtlessly prove valuable as a green-manuring crop.

Several experiments have already been conducted by the station and private parties along these lines which indicate that the jack bean possesses value for these purposes. Extensive plantings have also been made by the Kunia Development Co. on this island and by the Molokai Ranch Co. at Kualapuu, which indicate that the crop is adapted to widely different conditions of soil and climate.

While the crop is quite drought resisting, as was shown in the excellent yield produced at Kunia during the dry season of 1909 (Pl. III, fig. 3), it responds well to irrigation, and makes a good growth during the wet season if the weather is not too cold. The jack bean develops a strong root system. The roots are nearly always well supplied with the nodules produced by the nitrogen-fixing bacteria, so that the stubble remaining after the crop is harvested should prove beneficial to the soil. The best method for the culture of the crop, whether it is to be used for green fodder or seed, is to plant in rows and cultivate freely throughout the growing season. For the largest amount of green matter, plant the seed 3 to 6 inches apart in rows 2 to 3 feet apart. If seed is the object, especially if wanted for planting, the rows should be at least a foot farther apart,

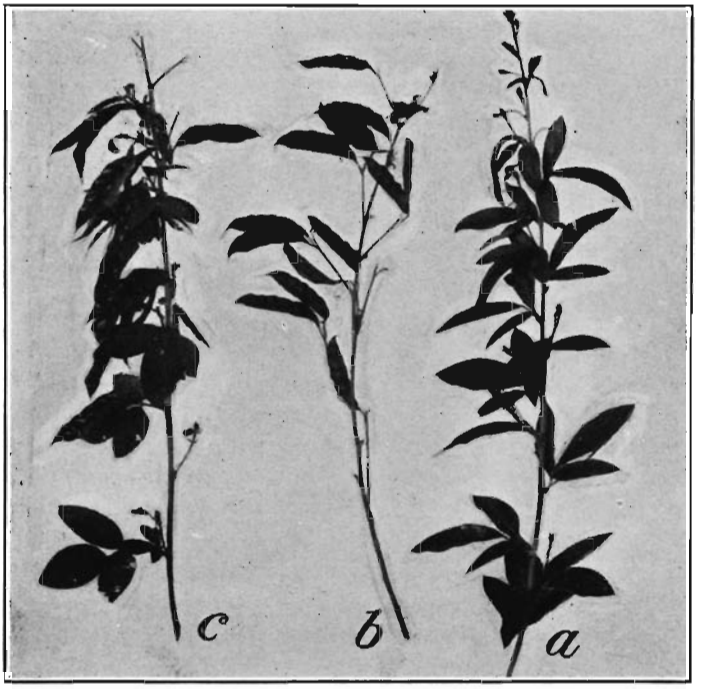


FIG. 1.—*a*, FLOWERING BRANCH; *b*, FULLY FORMED PODS; *c*, MATURE PODS.

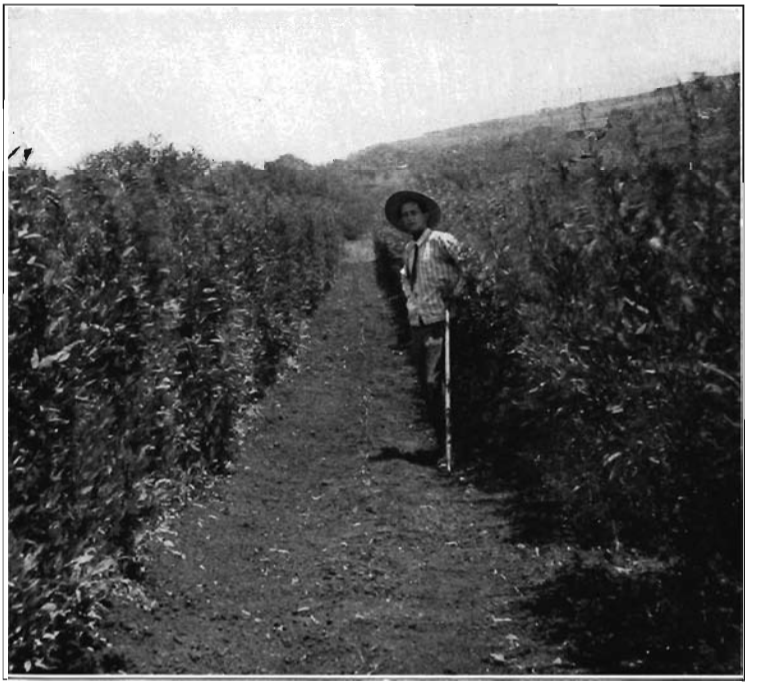


FIG. 2.—PIGEON PEAS GROWN AS WINDBREAK FOR YOUNG TREES.

PIGEON PEAS.

and the seed planted 6 to 10 inches apart in the row. Forty to 60 pounds of seed will be required to plant an acre. The optimum amount of moisture for seed growing is about two-thirds that required for maximum fodder production.

PIGEON PEA.

(*Cajanus indicus.*)

The pigeon pea (Pl. IV), commonly called the Porto Rican pea, after the source from which it was first introduced, has been grown locally, in a small way, for 10 or more years. More recently it has come into prominence as a valuable crop for both feeding and green-manuring purposes, and especially as a temporary windbreak. In Hawaii the plant grows into a stout shrub, attaining its maximum growth the second or third year, when it may reach a height of 10 or more feet. If given ample room for its fullest development it branches freely. It yields a heavy crop of seed the first year, and if left undisturbed continues to flower and fruit without intermission throughout the greater part of the year.

The plant makes a slow spindling growth at first, but at seven or eight months from planting it matures its first crop of seed and has usually attained a height of 5 or more feet with numerous branches. The peculiarly segmented pods, which are 2 to 3 inches long and half an inch wide, contain four to six seeds, which in one variety resemble the Iron cowpea in both size and color; in another variety the seed is somewhat larger, more spherical, and speckled with small brown spots on a light gray ground (see Pl. VIII, p. 30). These latter markings, which may hardly be noticeable at time of harvest, become pronounced as the seed ages. A number of growers have fed the plant tops, which bear almost the entire crop of seeds, to horses and cows with good results. Likewise the seeds have been found excellent feed for poultry. On account of the pods being borne along the upper ends of the stems they are readily harvested by cutting with a scythe or sickle, and may be thrashed after curing. Such harvesting serves at the same time to prune the plants, which quickly send out new flowering shoots.

Two varieties have been grown by the station for a number of years. The old type, No. 218 (probably *C. indicus flavus*), bearing small seed like the Iron cowpea, is a heavy bearer. The first crop at the trial grounds gave a yield of 102 pounds of shelled seed from 100 running feet of row at eight months from planting.

The plants were then pruned to varying heights. Those which were cut back one-half made the most satisfactory subsequent growth. Those which were cut back to within a foot of the ground never fully recovered and a large percentage died outright. The general practice

now is to cut back just enough to obtain the seed, which is about a third of the first year's growth and about a fourth of the growth of the plants entering the second season. After such pruning the plants become more bushy and usually produce a heavier yield of seed. At the trial grounds the two subsequent crops were harvested in the succeeding twelve months, the yield from both harvests approximating the first yield of a pound of seed per running foot. This is equivalent to over 2 tons of seed per acre for the first year, and almost twice that amount the second year, with calculations based on rows planted 10 feet apart.

The newer variety, No. 219 (probably *C. indicus bicolor*), bearing speckled seed, has not been tested as fully as the other and does not as yet show any advantages over the old sort. The two varieties resemble each other closely in all particulars excepting that the yellow flowers of the *C. indicus bicolor* are streaked with maroon on the outer surface of the standard, while the pods also show distinct maroon markings, such markings being entirely absent in No. 218. It is also claimed that No. 219 is earlier in fruiting, and this is partly borne out in our tests. On the other hand, it has been found to bear less continuously than the former variety. In general the Porto Ricans prefer No. 218 and state that this variety is preferred by the natives in Porto Rico.

The horticultural department of the station is planting the pigeon pea extensively as shelter for young seedling citrus stock. It is also being widely planted as a temporary windbreak for cotton and other crops (Pl. IV, fig. 2).

The principal advantage of the pigeon pea over other leguminous crops as a soil improver is due to its long, strong taproots. These penetrate deeply into subsoils impervious to most crops, with the result that such soils are greatly improved physically as well as in fertility. Its long taproot also acts as a powerful support in holding the plant upright when used as a windbreak. It rarely happens that plants are overturned in the windiest weather even when planted in single rows, and as the plant is of upright growth and readily trimmed, it serves admirably as a windbreak.

As a cover crop and as a green manure plant it possesses no less value. In writing of his experience with this crop at Haiku, Mr. White states:

> It is the only plant that honohono (*Commelina nudiflora*) has not downed. It is the hardiest legume of all I have tried at Haiku. It maintains itself for years, and no insects have seriously bothered it so far. It does not start well when planted in winter, but November plantings loiter along and grow vigorously at the coming of warm weather. Its chief drawback is its size. With special care and arrangements, plowing one-half acre a day, I have turned it under fairly well when 4 years old, using a disk plow and four large mules. This disk plow has a subsoiler to hold it

in the ground. In three months time the plants had rotted so that it gave no trouble in replowing and fitting the land in good shape.

In warm weather it grows rapidly and will plow under comparatively easy when 2 or 3 feet high. I would recommend planting 2 bushels (about 120 pounds) of seed per acre to make a crowded and spindling growth. The best corn I ever grew followed these peas, and there is to-day, five months after laying by, a crop of volunteer peas on the corn land 6 feet high.

The leaves and twigs have a menthol taste. Cattle browse it. It is not a heavy bearer of seed here.

Mr. White's planting referred to above covered several acres, and would certainly seem to be a practical demonstration of the value of this crop for green manuring purposes.

On the dry lands at Kunia the plant has made an excellent growth and yielded heavily of seed. On the Waipahu uplands the plants have made a less vigorous growth but yielded fairly well of seed. It is said to grow well at Pupukea even exposed to the salt spray, and Mr. F. S. Lyman, of that district, reports that he finds the plant an excellent feed for work horses, cows, and poultry.

Few insect pests have been found to attack the pigeon pea, although the cottony cushion scale has been found attached to the twigs in large masses. Such attacks appear to be most prevalent in dry localities, where the plant grows less vigorously. Under these conditions the roots are frequently found infested with mealy bugs, which appear less prevalent when the ground is well cultivated. The plant is rarely attacked by aphis unless when very young, and usually when the growth is at a standstill from cold weather.

SOY BEAN.

(*Glycine hispida.*)

While possessing most of the good qualities common to other leguminous forage plants, the great diversity of type to be found in the soy bean adapts it to many uses and conditions unsuited to other legumes. Its chief characteristics are its heavy seeding and early maturity. Nearly all varieties are of compact and upright growth, with strong tap roots, and stiff stems which rarely show any tendency to trail, although some of the ranker growing varieties sometimes lodge. In nutritive value the forage compares favorably with any legume that can be grown, and the ground or crushed bean is said to be equal to the best and most costly concentrates that can be purchased for feeding purposes. Among its most important uses is that for culinary purposes, especially in the manufacture of the Japanese products (soy and miso). These products are imported into Hawaii from Japan in large quantities, but their manufacture is being rapidly extended in Hawaii. This has created quite a demand for the bean locally. At present two and one-half million pounds of the bean are being imported into Hawaii annually. The average

cost is about $3 per hundred pounds landed in Honolulu and the beans sell for from $3.25 to $3.40 per hundred pounds. The Japanese coffee growers in the Kona district in Hawaii have been growing the beans as an intercrop for a number of years. The total production is said to be about 200,000 pounds per annum. It will thus be seen that the immediate local demand is very far from being supplied at present.

Because of the great diversity of types available, the crop may be adapted to many forms of culture. Any crop that will permit of intercultures may have some variety of soy bean adapted to its need. Thus if it should be found advisable to intercrop the pineapple, sisal, coffee, rubber, or other crops during the unproductive periods, to help pay for the expense of maintenance, or as a direct aid in fertilization, the soy bean would be found to fill this need better than almost any other legume that could be grown. As a catch crop to fill in a short interval between two staple crops, its early maturity may give it advantages not possessed by other legumes.

While in a regular rotation it fills all the needs that can be supplied by any legume, its value as a green manuring crop would seem to be of equal value. It is more easily turned under than any other legume treated in this bulletin and rots more quickly than the coarser stemmed sorts. In Japan and other oriental countries this crop, to a greater extent than almost any other, is responsible for the remarkable maintenance of their soil fertility.

At least one American grower in Hawaii has profited by these practices. His method is to sow the soy beans between various perennial fodder crops. The beans are grown between the rows, where they are permitted to ripen and rot on the ground and are cultivated in. In this case they have helped suppress the weeds as well as to make mellow the soil and gather nitrogen as a fertilizer.

The greatest direct value to Hawaiian growers and feeders of this crop should come from its culture as a fodder and grain crop to supplement the roughage they are already producing in the form of grasses, sorghum, and corn, and to supplant in part or whole the expensive imported mill stuffs. For the former purpose it may be grown as a mixed crop with almost any of the nonleguminous crops now grown, or it may be combined with some of the trailing legumes. The object of such combination cropping is to balance more perfectly the nutrients, to increase the acre yield, and to lessen somewhat the drain upon the land; in other words, to utilize the land to the best possible advantage. On the other hand the soy bean may be grown alone, to be mixed with other feeds later. If grown primarily for grain it will of course be necessary to plant the crop separately, and this may be the better practice under some conditions, even when fodder is the principal object.

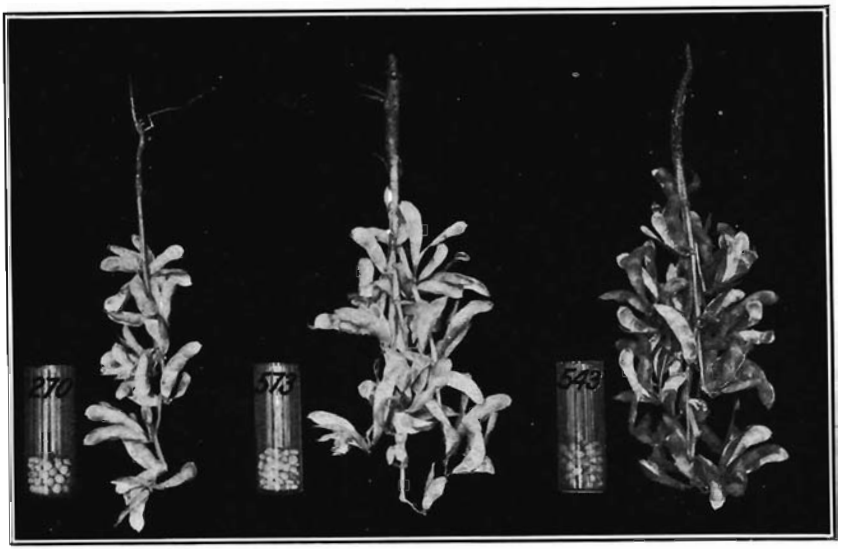


FIG. 1.—DWARF TYPES (CULINARY VARIETIES).

FIG. 2.—INTERMEDIATE TYPES (GENERAL PURPOSE VARIETIES).

SOY BEANS.

For the low, compact varieties seed may be drilled in rows 18 to 24 inches apart, but the tall, branching sorts should be planted at least 30 inches apart; 40 to 60 pounds of seed will be required to plant an acre, depending upon the size of the seed and the distance apart. As the soy bean shades the ground less than do most of the other legumes, it requires more cultivation to keep down weeds and conserve the moisture, and it will repay all reasonable tillage. If intended for green or cured fodder or silage, the crop should be harvested when the pods are half formed. If intended for seed, care should be taken not to delay the harvest too long, since most varieties shatter the seed very readily, with the result that much of the seed may be lost.

As the seed of the soy bean is more easily separated than most of the other legumes, they may be thrashed either by flail or by a power thrasher made especially for the purpose, or an ordinary rice separator may be altered to do satisfactory work in skilled hands. No very accurate data are available on yields. The Japanese in Kona claim to produce ten to twenty 100-pound bags of seed per acre. A spring and fall crop is usually grown, and the product is said to go a long way toward paying expenses until the coffee comes into bearing.

The yield of seed obtained by the station from small experimental plantings ranges from 600 to 1,000 pounds per acre from the dwarf early maturing varieties, and about twice that amount from the medium late and medium tall sorts. It seems very doubtful that more than a ton of seed per acre can be obtained under any except unusually favorable conditions. The yield of fodder from the heavy seeding varieties about equals or slightly exceeds the yield of seed. The ranker growing varieties have yielded at the rate of 4 to 8 tons of green fodder per acre, which, while hardly equal in weight to that obtained from some of the other legumes, even during a corresponding period of growth, may, because of its greater nutritive value and palatability, more than balance the outcome.

The following list has been selected from about 100 varieties tested by the station. It is believed to include the best sorts for each of the several purposes for which the soy bean is especially recommended. In the case of the culinary varieties, both quality and yield of seed have been considered. The soy and miso manufacturers demand a large, hard, light colored seed, with a thin skin, and the writer is indebted to Mr. N. Yamakami, manager of the Hawaiian Soy Co., for his assistance in selecting varieties according to these qualities.

Under Group I has been collected the best culinary varieties (Pl. V, fig. 1). These are usually to be found among the dwarf early maturing sorts, qualities which also make them well suited for intercultures, short rotations, and catch crops. Group II contains the heaviest seeding sorts irrespective of their culinary qualities (Pl. V, fig. 2). These varieties are especially suited for growing as grain for cattle

feeding. Group III contains the rankest growing sorts. These supply the maximum yields of both forage and grain, which makes them especially valuable for fodder and green manuring. The arrangement is in all cases according to yield of seed and size of plant, since these qualities, other things being equal, appeal most to the grower. The number of seeds and their weight as given with each variety is the product of the select mother plant from which subsequent seed is grown.

GROUP I. CULINARY VARIETIES.

(Dwarf type maturing in from 60 to 100 days. Yellow seeded.)

No. 345. Very dwarf and compact, 6 to 9 inches tall, seed medium size, oval, 54 seeds, 9 grams.

No. 270 (S. P. I. No. 17278) (Hollybrook). Medium dwarf. Single slender stem, 10 to 12 inches tall, seed slightly larger than No. 345. Can be planted very closely, 53 seeds, 10 grams.

No. 573 (S. P. I. No. 17277) (Manhattan). Strong, branching dwarf type, 12 inches tall. Seeds smaller than No. 345, somewhat flattened, 74 seeds, 10 grams.

No. 543 (S. P. I. No. 22379) (Swan). Same height as No. 573 but more compact, seed larger and less flattened, 85 seeds, 13 grams.

No. 554 (S. P. I. No. 20406) (Elton). Single stemmed, thickly podded, 12 to 14 inches tall, seed medium, slightly flattened, 89 seeds, 14 grams.

No. 549 (S. P. I. No. 14954) (Acme). Slightly taller than No. 554, less compact, branching. Seed very small, 212 seeds, 14 grams.

GROUP II. CULINARY AND GRAIN VARIETIES.

(Medium to large type, best suited for fodder. Yellow seeded.)

No. 484 (S. P. I. No. 14954) (Acme). Medium tall, 20 to 24 inches, strong, branching, spreading, seed of good size, oval, 197 seeds, 31 grams.

No. 483 (S. P. I. No. 14953) (Edward). Slightly taller than No. 484, more compact, considerably later. Seeds oval, very large. (Mr. Yamakami, of the Hawaiian Soy Co., pronounces this the largest seeded yellow soy bean he has ever seen and considers it a very desirable variety for the production of miso and other Japanese food products.)

No. 468 (S. P. I. No. 17268) (Ito San). Taller and more branching than No. 483, very prolific, seed medium size, slightly flattened, 240 seeds, 50 grams (see Pl. VIII, p. 30). Very desirable for growing as grain for stock feed.

No. 574 (Ruralnook). Tallest of the yellow seeded varieties, 30 or more inches high, freely branching, compact. Very prolific seeding. Considered the best general purpose variety grown.

GROUP III. FORAGE VARIETIES.

(Tall, rank-growing varieties, best suited for green manuring.)

No. 210 (S. P. I. No. 20797) (Riceland). One of the two tallest varieties tested; 3 to 4 feet high, freely branching, medium dense foliage, prolific seeding, inclined to shatter its seed. Seed black, medium small, oblong, flattened, very late maturing. Said to be used extensively in China for green manuring rice fields, and as a fodder for live stock.

No. 211 (S. P. I. No. 20789) (Barchet). Similar to the preceding in habit and appearance, excepting that seed is a reddish brown. The variety was not well established when first received, but more constant in third generation of selection. Mother plant for 1910 yielded 301 seeds weighing 34 grams.

VELVET BEAN.

(*Stizolobium* spp.)

The velvet bean is usually classed as an annual plant, but under favorable conditions it may be carried over for more than one season in Hawaii. In general appearance the plant resembles the strong trailing type of cowpeas, but the growth is more rank and considerably later in maturing. When harvested at the same time as cowpeas it yields considerably less forage than the cowpea, and no seed, but when permitted to mature, which in some varieties requires twice as long as in the cowpea, it may outyield the latter both in forage and seed. The main advantage of velvet beans over cowpeas is that they are not often attacked by the aphis, which makes the cowpea so uncertain a crop in Hawaii. The velvet bean also appears to be more tolerant of wet and thrives better in heavier soils than does the cowpea, but the young twining stems are easily injured in windy weather.

While it is a more difficult crop to harvest than are the cowpeas, and less palatable as a cattle food, it would seem to be better adapted for a cover and green-manuring crop. For the latter purpose it has already found favor in some of our sugar plantations, notably in the Kohala district, on the island of Hawaii.

VARIETIES.

The following three varieties of the velvet bean have been grown by the station for several years past. While commonly classed under the genus Mucuna, they are here entered as Stizolobium to conform with the classification adopted by the Bureau of Plant Industry of the United States Department of Agriculture.

No. 226. Florida velvet bean (*S. deeringianum*). This variety was received in 1908 from Tampa, Fla., under the name *Mucuna utilis*,

and from the United States Department of Agriculture under the number 22339. It is very rank in its growth and yields abundantly; the short thick pod contains 3 to 5 large seed blotched with a dark brown or black on a gray ground.

Another type (24766) bears a seed without markings, the color being an even gray. No advantages were noted in this variety and it has been discarded.

No. 227. Mauritius or Bengal bean (*S. aterrimum*). This variety was received from the Hawaiian Sugar Planters' Experiment Station in 1908 as *Mucuna aterrimum*, also from the United States Department of Agriculture, under number 21300, but the former bears a larger and somewhat more flattened seed. This variety is even stronger growing than the preceding and matures later, but does not yield so heavily of seed. The pods are about as large as in the Florida bean, but the seeds are shiny coal black, larger, and more flattened. This is the variety generally referred to as the velvet or Mauritius bean in Hawaii, and is the only variety that was grown up to a few years ago when the station began distributing seed of the Florida bean. This latter variety is now considered superior to the old type, both for green manuring and for forage, because of its heavier seeding quality.

No. 225, Lyon velvet bean (*S. niveum*). This variety was received in 1908 from the introducer, Prof. Lyon, of Manila, P. I., under the name *Mucuna lyoni*, and later under No. 24834 from the United States Department of Agriculture.

This variety is considered superior to the other varieties and yields an abundance of forage. It bears larger pods and seeds than any of the other varieties. The young green beans are said to be used extensively as a vegetable. They resemble the large garden limas, both in appearance and flavor. Now that considerable seed of this variety is available for distribution, it is recommended for trial as both a forage and cover crop.

Regarding the merits of the velvet beans, Mr. C. G. White, of Haiku, Maui, reports that the Lyon bean did very well in the warm season, seeding heavily; makes a good cover crop; early plantings not successful; dies out in winter. The Mauritius bean he considers slightly inferior to the Lyon bean. The Florida velvet bean did not succeed well, the vines grew only 3 feet long, and the tips seemed to blast from being whipped about in the wind.

In an extensive field experiment conducted by the Molokai Ranch Co. at Kualapuu and Hoolehua, the latter district being one of the driest on Molokai, the velvet beans appeared to be the most promising, the jack beans next, and the cowpeas last, but up to the flowering stage the velvet beans had not sent out trailing stems as they do normally. Owing to the extreme dryness the experiment was not considered a success, but it showed possibilities for the velvet bean

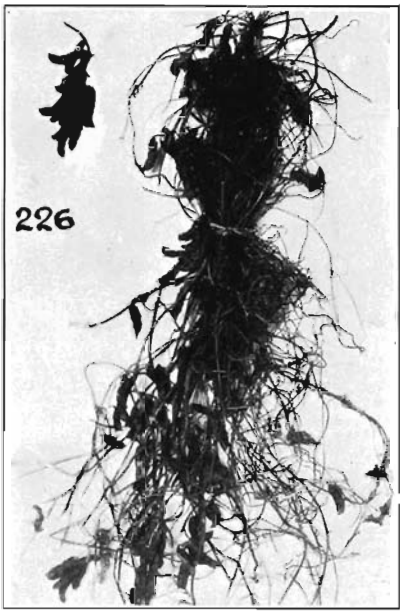


FIG. 1.—FLORIDA VELVET BEAN.

FIG. 2.—LYON BEAN.

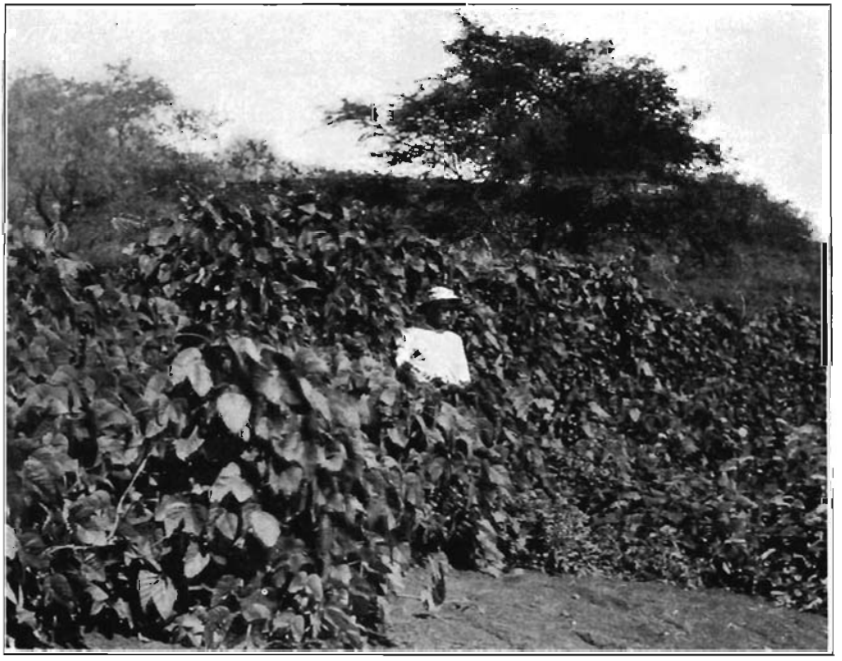


FIG. 3.—VELVET BEANS GROWING AT STATION GROUNDS.

VELVET BEANS.

under adverse conditions. At Kualapuu, where there was ample moisture and much wind during the early part of the season, the cowpeas and the jack beans thrived better than the velvet beans. Here the tender runners suffered severely from being whipped about by the wind, which resulted in stunting the growth somewhat. Later on as the weather moderated they came on finely and made a satisfactory growth, comparing favorably with the jack beans and the cowpeas.

The crop matured in about 165 days, when many of the leaves had dropped, and was then turned under as green manure.

At the station and trial grounds experimental plantings have given uniformly good yields. During the past season, planted May 26 and harvested December 10, representing a growing season of 200 days, the Lyon bean (No. 225) yielded 323 pounds of green matter and 67 pound of seed from 83 running feet of row. This is equivalent to $3\frac{1}{2}$ tons of seed and 17 tons of green forage per acre.

The Florida bean (No. 226) yielded 209 pounds of green matter and 111 pounds of seed from 78 running feet of row. This is equivalent to over 6 tons of seed and almost 12 tons of green matter per acre. Some idea of the growth made in these plantings is shown in Plate VI. Figures 1 and 2 show the production of pods from single plants and figure 3 shows the plant during the height of the season. The variety in the background is supported on cornstalks, a practice that may be followed to advantage in general culture.

It is recommended that the seed be planted 5 to 8 inches apart in rows 4 to 5 feet apart, when 20 to 35 pounds will be required to plant an acre; or the beans may be planted 7 to 10 feet apart with a row of corn between. Broadcasting is not recommended for this crop unless it is intended as a cover crop for waste places to be pastured later. In any event it will pay to cultivate the ground thoroughly before planting. The crop may be planted any time when the ground is not too cold and wet. If intended for hay or seed, it should be planted so as to mature during a dry season. One hundred and seventy to two hundred days are required to mature the seed. If intended for fodder or to be turned under, the crop will be ready a month or six weeks earlier.

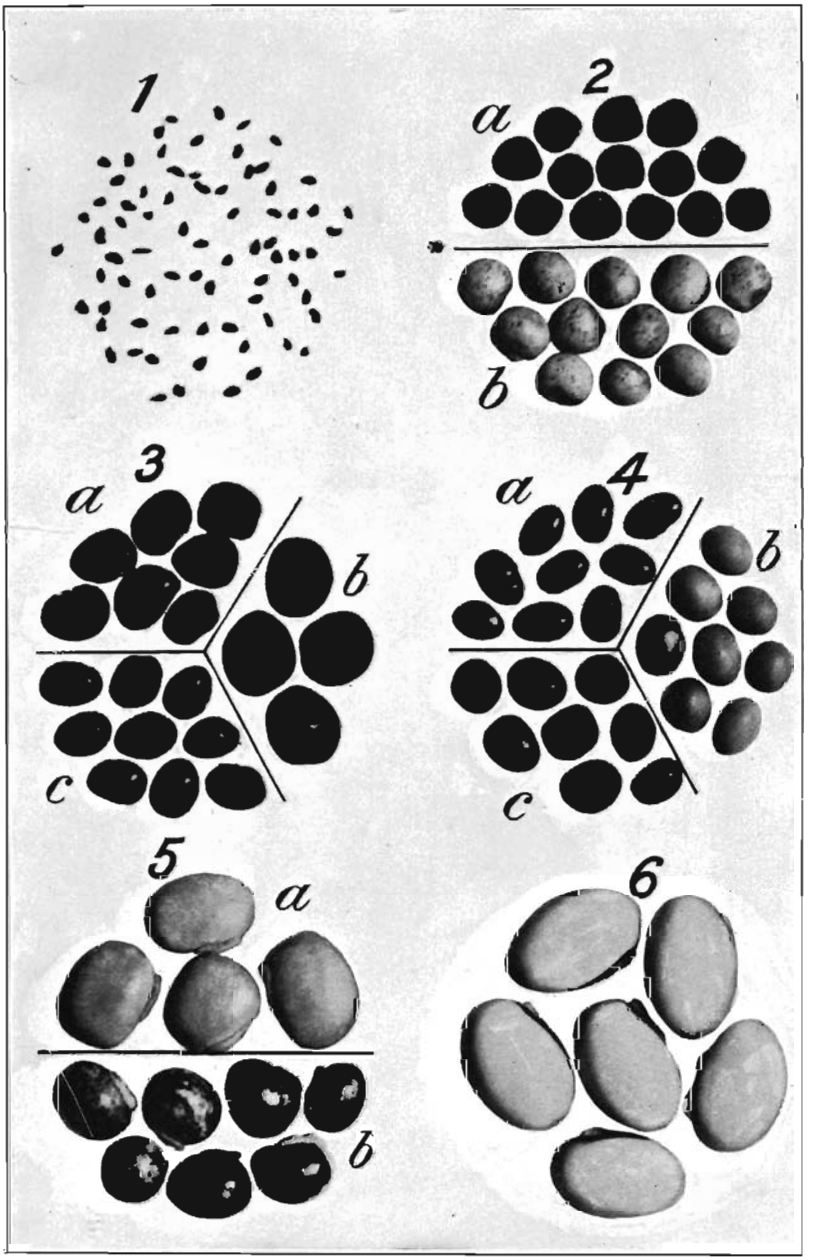
While the velvet bean appears to be the least palatable of the several legumes treated in this bulletin, most cattle will learn to eat it if at first the ration is formed by mixing the forage with sorghum or corn in small quantities, and then gradually increasing the proportions until about one-half of the forage ration may be of velvet beans. At the station the forage has not been cured as hay, but this is sometimes done in the Southern States and it is said to make a satisfactory feed in that form. The principal use for the velvet bean in Hawaii would seem to be as a cover crop to smother out weeds and later to

be pastured and turned under as green manure. For this purpose this crop seems to be especially well adapted. However, because of their very long twining vines, which often measure 25 or more feet in length, they are not suited to orchard planting. The velvet bean as grown by this station has always been abundantly supplied with root nodules. Great clusters as large as a hen's egg are not uncommon on a well-tilled open soil, and this would suggest that the crop would be especially valuable for inoculating soils deficient in the nitrogen-gathering organisms.

Plates VII and VIII show the relative growth of the plants and the size of the seeds of the various crops discussed in this bulletin.

RELATIVE GROWTH OF LEGUMINOUS PLANTS FIFTY DAYS AFTER SOWING.

[1, Pigeon pea; 2, alfalfa; 3, soy bean; 4, velvet bean; 5, jack bean; 6, cowpea.]



SEEDS OF LEGUMINOUS PLANTS DESCRIBED IN THIS BULLETIN. NATURAL SIZE.

[1, Alfalfa; 2, pigeon pea, (*a*) *C. flavus*, (*b*) *C. bicolor;* 3, cowpeas, (*a*) Whippoorwill, (*b*) Giant, (*c*) Iron; 4, soy beans, (*a*) No. 478, (*b*), No. 468, (*c*) No. 477; 5, velvet beans, (*a*) *M. lyoni*, (*b*) *M. utilis;* 6, jack bean.]

APPENDIX.

Composition of Hawaiian-grown leguminous forage crops and fertilizing constituents contained in 1,000 pounds of fresh material.

Kind of feeding stuff.	Proximate constituents.					
	Water.	Protein.	Fat.	Nitrogen-free extract.	Crude fiber.	Ash.
Alfalfa:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Sample No. 1	84.75	5.23	0.35	3.30	4.19	2.18
Sample No. 2	68.13	7.31	.44	10.20	10.32	3.60
Sample No. 3	70.46	5.59	.48	12.74	7.89	2.84
Average	74.45	6.04	.42	8.75	7.47	2.87
Cowpea (*Vigna catjang*):						
Sample No. 1	86.16	2.63	.12	5.40	4.19	1.50
Sample No. 2	83.15	3.71	.22	5.26	5.75	1.91
Average	84.65	3.17	.17	5.33	4.97	1.71
Pigeon pea (*Cajanus indicus*)	70.00	7.11	1.65	7.88	10.72	2.64
Jack bean (*Canavalia ensiformis*)	76.81	5.21	.48	8.44	6.36	2.70
Soy bean (*Glycine hispida*)	75.10	4.00	1.00	10.60	6.70	2.60
Florida velvet bean (*Mucuna utilis*)	82.20	3.50	.70	6.60	5.10	1.90

Kind of feeding stuff.	Ash constituents.			Fertilizing constituents in 1,000 lbs.			
	Potash.	Lime.	Phosphoric acid.	Nitrogen.	Sulphuric acid.	Potash.	Lime.
Alfalfa:	*Per ct.*	*Per ct.*	*Per ct.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Sample No. 1	0.41	0.17	0.19	.....	.....	.....	.....
Sample No. 2	.84	.45	.30	.....	.....	.....	.....
Sample No. 3	.64	.41	.21	.....	.....	.....	.....
Average	.63	.34	.23	9.7	2.3	6.3	3.4
Cowpea (*Vigna catjang*):							
Sample No. 1	.35	.21	.09	.....	.....	.....	.....
Sample No. 2	.68	.29	.18	.....	.....	.....	.....
Average	.51	.25	.13	5.0	1.3	5.1	2.5
Pigeon pea (*Cajanus indicus*)	.90	.42	.25	11.3	2.5	9.0	4.2
Jack bean (*Canavalia ensiformis*)	.65	.78	.16	8.3	1.6	6.5	7.8
Soy bean (*Glycine hispida*)	.56	.....	.14	6.3	1.4	5.6	.....
Florida velvet bean (*Mucuna utilis*)	.57	.....	.14	5.5	1.4	5.7	.....