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GUAM AGRICULTURAL EXPERIMENT STATION,
ISLAND OF GUAM.

BULLETIN No. 4.

LEGUMINOUS CROPS FOR GUAM.

BY

GLEN BRIGGS, Agronomist.

Issued August, 1922.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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[Under the supervision of the States Relations Service, United States Department of Agriculture.]

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LEGUMINOUS CROPS FOR GUAM.[1]

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INTRODUCTION.

Probably the two most important problems needing immediate solution in Guam are maintaining and increasing the productive capacity of the soils and growing crops which will supply an abundance of excellent forage for live stock. The soils, like those in many other parts of the Tropics, are mostly of a heavy clay type, and as a result of having been poorly managed are lacking in organic matter and nitrogen, which are very essential for plant growth. When nitrogen is lacking, or the content is relatively low, the soil soon becomes depleted in available plant food and is incapable of producing a profitable crop. Improvement and conservation can be brought about either by the application of nitrogen in the form of expensive fertilizers or by the growing of plants that have the ability to replenish the soil with nitrogen which they take from the air. Leguminous crops are well adapted to the climatic and soil conditions of Guam, and have amply demonstrated their value in problems of soil management and their influence upon agricultural development. They restore to the soil an abundant supply of nitrogen in the cheapest way, and when turned under while in a succulent condition, in which stage they rapidly decompose, they increase the moisture-retaining power of the soil. Legumes produce an abundance of vege-

[1] The term "leguminous crop" is used in this bulletin to designate plants usually having one-celled, two-valved, dry pods containing a single row of seed. Legumes include beans, velvet beans, mungo beans, cowpeas, pigeon peas, seguidillas, cerebillas, tañgantañgans, and many other sorts, both wild and cultivated, together with a large number of weeds, bushes, and trees ranging from *Desmodium* spp., locally but incorrectly called "agsom," to the large rain and cassia trees.

tation that can be fed as green forage, pasture, or grain, and they contain the cheapest source of protein (nitrogen) for live stock. The need of nitrogenous feeding stuffs to supplement the grass rations is keenly felt.

Although a large number of introduced and native legumes grow, it was not until recently that their importance was locally recognized. Failure to introduce them into general cultivation is attributed to lack of agricultural knowledge concerning them and to the rather limited distribution of the introduced sorts.

The legumes reported upon in this bulletin have been grown at the Guam Agricultural Experiment Station for some years to determine their relative adaptability to Guam conditions and their value for soil improvement and for forage and grain production, as well as for the purpose of selecting seed of the best varieties for distribution. The results obtained have been so satisfactory that the station unhesitatingly advocates the use of legumes in the dry season to reduce evaporation, and in the wet season, when the ground can not be cultivated to any extent, to prevent erosion; as cover crops to keep down weeds; as soil builders when turned under as green manure; and as forage for animals when the plants are cut in the green stage. The seed can be used for human food or as concentrates for live stock.

USES OF LEGUMES.

Legumes have been grown from the earliest days of agriculture in the Old World, in many places being used almost entirely for human consumption, and in others as forage, cover, catch, and green-manure crops, grain production for stock, soil builders, windbreaks, and in some instances as firewood. In Guam they are not made into hay because of the difficulty of curing.

As a feed.—

The legumes comprise the great group of food-bearing plants characterized by their high content of crude protein, and therefore serve especially for building the muscles and the other protein tissues of the body. Their great value is due not only to this but also to their richness in lime, which is required in large amounts by growing animals.[2]

Many of the legumes produce excellent forage which is nutritious and palatable to and readily digested by all classes of stock. Cows especially respond to the nitrogenous matter contained in legumes by yielding liberal quantities of milk. The seed of many of the legumes is relatively high in fat and protein content and compares favorably in feeding value with concentrates. They may be fed singly or in combination with other grain rations, or used to supplement the roughage of grasses, corn, and sorghum, and other feed that is low in protein.

[2] Henry and Morrison, Feeds and Feeding, 1916, p. 223.

Legumes are frequently used as pasture crops, depending upon conditions, and they meet the requirements of the animals without undue waste of nutritive material when they are fed as soiling crops. When the corral is close to the field, soiling will be a means of (1) conserving the energy of the cattle, which will not have to search for their food; (2) feeding at regular intervals and in regular amounts; and (3) readily and easily collecting and distributing the manure as a fertilizer. By systematic management it is possible to produce enough feed on one acre to carry six or eight head of cattle through the year, and land that is heavily manured will produce enormous quantities of forage and grain.

As soil builders.—That legumes are restoratives in the highest degree is amply demonstrated by the improved physical condition and the increased nitrogen content of soil in which they are grown. The soil particles are considerably loosened by these deep-rooting plants, which are thus enabled to withstand severe drought and excessive rainfall. Leguminous plants assimilate atmospheric nitrogen from the air through the aid of nodule-forming bacteria on the roots.[3] Where these nodules are lacking, the legumes act like other plants in that they take nitrogen from, instead of adding it to, the soil. Since nitrogen is the most expensive fertilizer element that the farmer has to purchase and the one that is most needed by the soils of Guam, it is important that it be obtained in the most economical manner possible, that is, from the air through the growing of legumes. The yield of crop may not be noticeably increased as a result of the organisms found in the nodules, but the value of the crop as a green manure and as a feed is considerably enhanced by the relative and absolute amounts of nitrogen in the plant. Nitrification is hastened by the intense heat of the Tropics and results in the rapid destruction of vegetable matter in the soil. When they decay legumes furnish the soil with large amounts of humus, add enormously to the water-holding capacity of the soil,[4] and set free large amounts of nitrates for the use of the succeeding crop. They supply all the nitrogen that the crop needs when they are grown in a proper rotation.

As a cover crop.—Legumes which make a heavy vine growth or shade the ground to a considerable extent may be advantageously used as cover crops (Pl. I, Figs. 1 and 2). A cover crop is one that is grown to (1) exclude weeds; (2) prevent erosion or surface washing of the soil; (3) improve the mechanical condition of the soil; and (4) afford protection to trees or other plants. Cover crops

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[3] The presence of the bacteria is usually made manifest by the swellings, called tubercles or nodules, on the roots.

[4] Since plants require from 300 to 800 pounds of water for every pound of growth they make in dry matter, it is essentially that the soil be supplied with an abundance of humus.

are very much needed because the seasons vary from extremely dry to extremely wet periods. During the wet season the rainfalls are heavy and the soil runs together and becomes sticky or puddled; and during the dry season the heat from the sun is intense and the surface soil, especially the heavy type, becomes very compact and dries out in hard masses, forming great cracks. Owing to these peculiar climatic conditions it is imperative that some protection be given the exposed soil to keep it in good condition. If grown in the rainy season, cover crops will largely prevent the erosion and loss of nitrates from the soil that would ordinarily take place; and if grown in the dry season, they will prevent evaporation from the soil. Some of the leguminous crops are better adapted to certain soils and for growing with certain field crops than are others, and the Guam farmer will therefore do well to make a thorough study to determine which legumes are best suited for his purpose.

Cover crops can be planted on waste land and on land that is not wanted at the time for planting to other crops. It will be found less expensive to grow cover crops on such lands than to let them grow to weeds which will have to be removed later. The practice is also beneficial in that the crop can be used for forage, green manure, to secure seed for distribution, or to furnish feed for live stock.

As a catch crop.—A catch crop is one that is grown as an intermediate between two crops in ordinary rotation or between the rows of another crop. The purpose of a catch crop is to utilize the land to its fullest extent. Leguminous crops make the best catch crop because they remove very little fertility from the soil, especially if the vines are returned to it. The quick-growing varieties can be used to overcome a shortage in forage supply, or to enable the farmer to maintain a large herd of dairy cows or other stock on land that would otherwise be idle. The employment of legumes as a catch crop enables the man of small means to derive some returns from his land while soil improvement is going on. Some varieties of legumes can be made to grow during almost any period that land would ordinarily be vacant.

As a green-manure crop.—A green-manure crop is one that is turned under to improve the physical qualities and the tilth of the soil. The difference between a green-manure crop and a cover crop is that the former is grown primarily for the purpose of improving the soil, and the latter for the purpose of protecting the soil and the plants and trees growing upon it. A cover crop becomes a green-manure crop when it is turned under after having first fulfilled the purpose for which it was grown.

The decaying organic matter furnished by green-manure crops yields large amounts of nitrogen and loosens the soil to such an extent that cultivation is made easy. It saves the expense of such

FIG. 1.—LEGUMINOUS PLANTS AS COVER CROP IN COCONUT PLANTATION.

FIG. 2.—VELVET BEANS AS COVER CROP FOR BANANAS.

commercial fertilizers as ammonium sulphate, nitrate of soda, and the like, and not only returns to the soil all the nitrogen that the crop took from it, but also enriches it in nitrogenous matter. Vegetable matter, including stalks, leaves, straw, weeds, stubble, roots, and other crop residue, should always be turned under whenever possible.

Green manuring has not been practiced to any extent in Guam, possibly because of the lack of agricultural knowledge and the primitive methods of tilling the soil. The farmers until recently have used wooden plows, or none at all, but now are fast adopting a small, one-handled steel plow. Neither plow, however, is capable of turning under as rank a growth as that of a green manure or cover crop of velvet beans unless the vines are rolled or disked. (Pl. II.) The soil lacks organic matter, and green manure is the only available means of supplying it. The native farmer has no barnyard manure to apply to his land, as the stabling of animals is not practiced.

As a windbreak.—A windbreak is the growth in a belt of trees which will withstand and break the force of the wind. Some varieties of legumes admirably serve as windbreaks, not only modifying the velocity and temperature of the wind, but also greatly reducing evaporation from the field to the leeward. High winds often bring with them a dry, parching air, which robs plants of their turgidity, causes grain to lodge, and the soil to dry out quickly. Such damage can largely be prevented among the low-growing crops by surrounding them on the windward side with such leguminous crops as pigeon peas grown as windbreaks. Some of the legumes have very strong taproots which act as supports in keeping the plants upright when used as a windbreak. Even when planted in single rows these plants are rarely overturned in the windiest weather.

ADAPTATION TO GUAM.

Climatic conditions.—The seasons in Guam are the rainy and the dry. The average annual precipitation is less than 100 inches, over half of which falls during July, August, September, and October. The dry season extends from January to April, and is more pronounced in some years than in others. The mean annual temperature averages about 81° F. and is very uniform throughout the year. The seasons have a very marked effect upon the soil, which dries out, bakes, and cracks to a depth of 3 feet under the intense tropical heat, and becomes watersoaked and easily puddled, neutralizing the effects of working and cultivation, in the wet season. The seasons influence nitrification and the rapid decay of vegetable matter that takes place, as well as the leaching of humus and other plant food from the soil. Nitrates are produced only in the presence of free oxygen, and oxygen can not gain access to soil that is water-logged. To prevent

these changes in the mechanical condition of the soil, or to counteract the injurious effect brought about by the seasons, the farmer should judiciously use the proper legumes, a large number of which are adapted to the climatic conditions of Guam.

Soil requirements.—Any land that will produce good crops of corn, rice, or bananas will produce good crops of legumes. In fact, nearly all types of soil that are well drained will produce a thrifty growth of legumes. The character of the soil will to some extent determine the variety that is best suited to it. Cowpeas, for instance, do not grow as well on sandy soils as they do on heavy clay soils, but they make better growth on thin soils, or on soils that are lacking in lime, than do some of the other legumes. A very rich soil will produce a heavy vine growth and give a small grain yield, while poor soils will produce little vine growth but comparatively large quantities of seed.

Effect on the soil.—The soils of Guam are of two general classes, the light or sandy types and the heavy or clay loams. The surface of both dries out quickly during the dry season and should be protected from the heat of the sun by the use of leguminous cover crops that are quick growing and produce a luxuriant top growth. Soils that are lacking in vegetable matter should be planted to legumes that can be turned under as a green-manure crop. Such crops have a tendency to bind sandy soils, loosen heavy ones, improve water filtration, and enrich both types as a food storehouse for future crops. The following quotation from a previous report[5] bears this out:

> Near the last of July the entire garden area was planted to cowpeas. A good stand was secured during even the extremely wet season immediately following the typhoon. It was intended to plow these under for a green manure shortly after blossoming, but owing to the scarcity of all kinds of seeds upon the island and uncertain transportation to Guam, they were left until they had matured considerable seed, after which the vines were disked and plowed under. Since that time a very noticeable change has occurred in the condition of the soil, which has not packed, run together, baked, nor cracked as has that soil of the same type which was not similarly treated. This same effect has also been observed in other types of soils on the station when green manures have been plowed under. In all cases they produce a more friable and improved physical condition of the soil.

GROWING LEGUMES.

PREPARATION OF THE SOIL.

Some of the legumes give fairly good results when they are grown in a poorly prepared seed bed, but all make much better growth, especially while small, if they are planted upon well-prepared land (Pl. III, Fig. 1), and they give their best results when they are planted on land that has received as careful cultivation as that given corn.

[5] Guam Sta. Rpt. 1919, p. 34.

Land that has not been plowed seldom, if ever, gives the large yields that are obtained from plantings made on plowed fields. On the other hand, most legumes readily grow on some of the newly cleared land where the soil is loose, with no preparation other than that given with machete or fosiño. After being plowed, and before the crop is planted, the land should be harrowed to kill any small weeds that may be starting growth (Pl. III, Fig. 2). Harrowing also smooths the ground, and by breaking large clods of earth into small pieces puts the ground in fine tilth and provides a good home for the tiny rootlets of the developing plant.

PLANTING.

The best time of the year for planting depends largely upon the season and the purpose for which the crop is to be grown. Usually, legumes make small and slow growth when they are planted during extremely wet weather. On the other hand, the seed may fail to germinate if it is planted during the very dry part of the year. When seed is wanted, the crop should be planted at such a time that it will not produce flowers or seed during the season of heavy rainfall. If this precaution is not taken, most of the flowers will fail to pollinate, or the seed will likely rot before it can be picked. When a cover crop is wanted for use during the dry or the rainy season, the legume should be planted long enough before the dry or the wet season begins so that the vine growth can get a good start. Some varieties may last through both seasons, or for two or more years, and are desirable when permanent cover crops are wanted, as, for instance, in a coconut plantation.

The rate of planting depends entirely upon the variety to be planted and the use to which the plant is to be put. Cowpeas are generally planted in hills 2 or 3, and even sometimes 4 feet apart, or they may be sown broadcast. Velvet beans, on account of their long vines, may be planted 3 or more feet apart, depending upon the variety. Ordinarily they are planted about 4 feet apart each way, and under favorable circumstances will cover an area that is much greater than that indicated by this distance of planting. Mungo beans are planted rather close together because they make a bushy, upright growth. When set at distances of 6 or 8 inches in rows 3 feet apart, they make a very satisfactory growth and permit of the use of animal-drawn cultivators. Patani and jack beans are usually planted from 2 to $3\frac{1}{2}$ feet apart each way.

Planting may be done by making holes in the soil with a fosiño or a hoe, or by making a shallow furrow with a plow, and dropping the seeds at the required distance. In the States where a planter is used, the work of making furrows and planting is done in one operation with much less labor than is required when a plow and

carabao are used. Planters may be purchased to plant either one or two rows at a time.

CULTIVATION.

Most of the legumes are such vigorous growers that little cultivation can be given them except while they are very young. This is true especially of those plants that make a viny growth and are planted on fertile soil. Velvet beans planted 6 feet apart, and when the conditions were favorable, have been known to cover practically the whole ground within six weeks. Legumes do not grow so rapidly on the hillsides and on some of the poorer soils, and in such locations more cultivation can be given them than to those growing on the very fertile soils. Stirring the ground well with an animal-drawn cultivator whenever possible has been found to be one of the best means of keeping the land clean and the plants growing rapidly. Where no cultivator is available, a fosiño should be used to keep the soil as loose as possible and free from weeds. Keeping the weeds down and the soil loose will enable the plants to make the best growth and shade the ground quickly so that further cultivation will not be necessary. The same kind of cultivation as is given corn will be found beneficial for nearly all legumes.

HARVESTING.

The time and method of harvesting depend upon the purpose for which the legumes are grown. If they are wanted for cover crops, or for green-manure crops, they need not be removed from the land. In either case, however, the seed may be harvested if it is wanted. Green-manure crops are best handled by running a roller or disk-harrow over them to crush down the vines or to cut them into pieces so that they can be readily turned under by small plows when the field is being prepared for the next crop. The plants are cut with a machete when the crop is wanted for forage. Varieties that make upright growth or that do not make too matted a growth may be cut with a mower.

Ripe pods are picked from the plants by hand, since no modern machinery has been devised to do this satisfactorily. Pods of the mungo bean are picked rather frequently because they ripen seed unevenly and the seed shatters freely after fully ripening. Cowpea pods should be picked at least twice during the season in order that all the seed may be saved. On the other hand, the pods of the jack and velvet beans remain on the vines for some time and it is rather difficult to shell the seeds from them. After the pods are thoroughly dry they should be placed in thin layers in the sun for a few days until they begin to crack, in which state they are easily threshed or shelled.

FIG. 1.—ROLLER USED TO CRUSH VINES BEFORE PLOWING.

FIG. 2.—DISKING LEGUMES FOR GREEN MANURE.

FIG. 3.—PLOWING UNDER GREEN-MANURE CROP.

FIG. 1.—USING DISK IN PREPARING LAND FOR LEGUMES.

FIG. 2.—HARROWING LAND FOR LEGUMES.

The weight of the dry shelled seed is from 50 to 70 per cent of the entire weight in the pod, depending largely upon the kind of legume. A shelling percentage record was kept on a number of cover crops when harvested, with the following results: Cowpeas, 69.2 per cent; mungo bean, 54.7 per cent; velvet beans, 56.25 per cent; soy beans, 60 per cent; jack beans, 54.8 per cent; pigeon peas, 62.5 per cent; and string pole beans (garden variety), 66.2 per cent.

STORING SEED.

The presence of great numbers of weevils makes it almost impossible to keep seed in good condition for any length of time, and the prevailing high temperature and humidity are largely responsible for seed deterioration and imperfect germination. Air-tight containers have been devised by the station to preserve the viability of seed and protect it from insect attack.[6] These containers or storage tanks are sealed with coconut oil, ordinary machine oil, or any slowly volatile oil, and even with grease, which is placed between the collars that surround the opening of the container and the wide flange of the lid which extends down into the oil. Metal containers have been found to give the most satisfaction for general use. Tin cracker boxes having tight-fitting lids are used to good advantage in saving small quantities of seed, and very small lots are kept in glass bottles that can be properly stoppered by pushing the cork part way down the neck and putting a heavy oil on top of the cork to keep out weevils and moisture. In all cases the seed should be thoroughly dried before it is placed in the container.

FEEDING VALUE OF LEGUMES.

The feeding value of the different legumes varies somewhat, but all are high in nutritive material. Analyses show them to contain a fairly high percentage of digestible protein, which is one of the most essential constituents for forming muscle, and a relatively large amount of lime, which is needed for bone formation, or before milk can be secreted in abundance. They are unquestionably higher than any of the nonleguminous forage crops in feeding value. The forage of all the legumes, and especially of the cowpea, mungo bean, and velvet bean, is palatable and wholesome to and greatly relished and easily digested by all classes of stock. In feeding tests conducted at the station, legumes when fed singly were found to make a perfect maintenance ration for horses, cattle, and hogs.

In Guam the legumes have not been considered as natural pastures, although they are sometimes used as such in the dry season. The succulent forage may be used to supplement the pastures during the

[6] Guam Sta. Bul. 2, p. 6.

time when natural pastures are short, and it will be found to carry the stock in good condition until the drought is ended. In most cases, however, the forage is cut green and fed as a soiling crop. Leguminous forage is most valuable while the plants are still succulent and tender and after they have matured some seed.

The dry seeds have a very high feeding value and may be profitably fed if they can be produced at a price low enough to justify feeding. In many tests conducted at the station the best results were had when the seeds were mixed with other feeds that were not so high in protein content. Usually, for use as feed, the seeds are ground. Ground cowpeas make a most efficient feed for chickens. The velvet bean is a valuable addition to the list of local swine feeds, both as a pasture and as a grain, and can be fed in the dry pod, since the hogs have no difficulty in shelling the beans of any of the legumes. Much labor in harvesting can be saved and waste in feeding prevented if hogs are allowed to pasture the fields in small areas at a time and are turned from one to another as each is grazed.

SELECTION OF THE CROP.

The kind of legume to grow depends upon the use to which it is to be put, the demand for forage or grain, the length of time that the crop will occupy the land, and its suitability for the soil. Cowpeas and mungo beans do well in the dry as well as in the rainy season. Velvet beans and pigeon peas do best between the rainy and the dry seasons. Mungo beans mature in a comparatively short time, but jack beans, Patani beans, and pigeon peas remain upon the ground for two or more years and continue producing. Each kind of legume has special qualities which make it better fitted to some particular conditions than to others. Realizing that the success of any crop depends largely upon the selection of varieties that are best suited to local conditions, the Guam station has tested a number of legumes to determine their adaptability to Guam conditions. Those included in the observations were cowpeas, velvet beans, soy beans, pigeon peas, jack beans, mungo beans, alfalfa, Patani beans, and a number of small miscellaneous sorts.

SOME VARIETIES TESTED BY THE STATION.

Cowpea (*Vigna sinensis*).

The cowpea is not yet considered a staple farm crop, but it is ranked as an important forage crop, and has furnished large amounts of green forage when other crops were scarce or suffering from drought. It is grown in nearly all parts of the island, but mostly on small areas, being produced as edible food and largely picked while the pods are in the green stage. Farmers are rapidly begin-

ning to recognize the value of the cowpea as a forage crop and as a soil renovator.

Varieties of the cowpea differ greatly in their manner of growth, some being erect or bushy in habit and others decidedly trailing or even viny (Pl. IV, Fig. 1). Some varieties bear a heavy seed crop and others a heavy forage crop, and some are early maturing, while others are late. All intermediate forms of each group occur. The habit of growth is generally dependent upon the variety, but it varies to a certain extent as the result of soil and climatic conditions, time of planting, and the like.

The pods of the cowpea are usually straw-colored, although purplish or dark sorts are sometimes found. They vary in length from 5 to 10 inches and contain a number of seeds that are roundish or kidney-shaped. In some varieties the seed is rather blunt at the ends, and in the different varieties it varies very much in color and size (Pl. IV, Fig. 2). The threshed seed usually runs about 70 per cent of the weight of the entire dry pod.

In tests at the station Early Buff and Blackeye were found to be early maturing varieties, ripening their first pods about 65 days after planting. The varieties New Era, Groit, and Whippoorwill were only medium early in maturing, requiring 75 or more days to ripen the first pods. The varieties Iron, Red (probably Chinese Red), Victor, and Brabham were rather late in maturing, since they did not ripen their first pods until a week or more after others in the test. A previous report of the station [7] states that—

> The Chamorro farmer is rapidly taking to the cowpea, and its distribution and planting has probably been greater than that of any other new crop ever advocated by the station. Its use, however, has been limited to food purposes, either for human, or, to a less extent, for live-stock consumption; but a good start has been made, and it is expected the plantings will continue to increase and that in the future the crop will be used more or less for green-manure purposes. As cowpea seed on the island has all come from station distribution, it has been limited to the Whippoorwill variety, and seed has been kept pure. * * *

Several tests of the following varieties of cowpeas were conducted during the year: New Era, Whippoorwill, Early Buff, Iron, Large Blackeye, and Brabham, to which was added Groit near the close of the year. During the drought all of these varieties made a good vine growth but produced little seed at the height of the drought. Early Buff and Large Blackeye were found to be the earliest varieties, but were shy yielders of vine and peas. Iron and Brabham were vigorous growers and offer much promise as a cover crop, but the New Era and Whippoorwill, which were intermediate in growth, seemed to be well adapted for all purposes, and produced good crops of seed. * * *

In a forage test started January 8, in which Whippoorwill and New Era seed were planted broadcast and in drills 3 feet apart, the drilled plats gave the larger yields of peas, but the broadcasted areas gave slightly the more forage. The New Era variety blossomed earlier and set on a great many pods, while the

[7] Guam Sta. Rpt. 1919, pp. 27–29.

yield of Whippoorwill peas, which are a later-maturing variety, was affected by the dry weather to a marked extent. The following table shows the results of the test:

Comparative yields of two varieties of cowpeas planted broadcast and in drills 3 feet apart.

Variety.	Broadcast.		In drills.	
	Yield of peas.	Yield of green forage.	Yield of peas.	Yield of green forage.
	Bushels.	*Tons.*	*Bushels.*	*Tons.*
New Era	0.75	6.80	16.99	4.88
Whippoorwill	.50	6.11	3.56	7.33

Four variety tests were conducted at the station during the latter half of 1919 to determine the difference in yield of cowpeas planted on old soil and on newly broken land. The following table gives the results of the tests:

Effect of date of planting on maturity and yield of different varieties of cowpeas.

Date of planting and variety.	Date blossomed.	Date first pods matured.	Date harvested.	Length of vine.	Yield per acre.	
					Seed.	Green forage.
				Feet.	*Bushels.*	*Tons.*
Planted on old soil June 19, 1919:						
Whippoorwill	Aug. 21	Sept. 23	Dec. 16	6.95	(1)	[2] 2.03
New Era	Aug. 13	Aug. 26	...do	8.55	(1)	13.56
Early Buff	Aug. 1	Aug. 18	...do	1.89	(1)	7.28
Iron	Sept. 23	Oct. 20	...do	9.35	(1)	12.08
Large Blackeye	Aug. 8	Aug. 21	...do	8.31	(1)	11.64
Groit	Aug. 18	Sept. 2	...do	6.06	(1)	10.10
Brabham	Aug. 16	...do	...do	9.37	(1)	15.30
Planted on old soil Dec. 20, 1919:						
Whippoorwill	Feb. 4	Feb. 20	Mar. 13	6.03	7.45	6.55
New Era	Feb. 6	Feb. 28	...do	7.15	8.14	9.25
Early Buff	...do	Feb. 18	...do	3.42	1.16	2.33
Iron	Feb. 13	Feb. 16	...do	5.67	2.91	4.11
Large Blackeye	Feb. 2	Feb. 26	...do	7.65	1.45	1.19
Groit	Feb. 6	...do	...do	4.63	6.39	6.77
Brabham	Feb. 8	...do	...do	5.58	9.31	5.20
Red	Feb. 10	...do	...do	4.59	2.33	4.15
Planted on newly broken land July 8, 1919:						
Whippoorwill	Sept. 23	Oct. 7	Nov. 5	7.10	15.49	4.61
New Era	Sept. 8	Sept. 18	Nov. 6	5.31	19.56	4.90
Early Buff	Sept. 2	Sept. 10	Oct. 27	3.39	5.01	1.00
Iron	Sept. 23	Oct. 3	Nov. 6	7.00	15.73	6.20
Large Blackeye	Aug. 26	Sept. 18	...do	8.18	10.64	1.93
Groit	Sept. 3	Sept. 19	Nov. 7	6.21	17.24	5.72
Brabham	Sept. 18	Sept. 24	Nov. 6	6.74	15.02	7.98
Planted on newly broken land Nov. 29, 1919:						
Whippoorwill	Jan. 8	Jan. 30	Feb. 19	7.13	4.15	[3]
New Era	Jan. 3	Jan. 23	Feb. 18	8.33	8.37	[3]
Early Buff	...do	Jan. 18	Feb. 7	3.37	3.44	[3]
Iron	Jan. 11	Jan. 23	Feb. 18	10.02	4.77	[3]
Large Blackeye	Jan. 3	...do	Feb. 19	7.95	2.50	[3]
Groit	Jan. 6	Jan. 26	Feb. 17	8.92	8.92	[3]
Brabham	Jan. 3	Jan. 25	Feb. 18	7.20	3.13	[3]
Red	Jan. 6	Jan. 26	Feb. 17	7.88	6.42	[3]

[1] No seed harvested on account of insects and wet weather.
[2] Yield greatly reduced by stray animals getting into plat.
[3] Plowed under for green manure.

The three best varieties of cowpeas for seed and forage production are New Era, Groit, and Brabham, with Iron and Whippoorwill ranking fourth and fifth, respectively. The lowest yield was made by the Early Buff and Red varieties. The table below shows the average acre yield of cowpeas in the four preceding tests:

Average acre yield of cowpeas from four plantings made by the Guam station in 1919.

Relative rank.	Yield of grain per acre.		Yield of forage per acre.	
	Variety.	Yield of grain.	Variety.	Yield of forage.
		Bushels		*Tons.*
1	New Era	12.02	Brabham	9.49
2	Groit	10.85	New Era	9.24
3	Brabham	9.15	Groit	7.53
4	Whippoorwill	9.03	Iron	7.46
5	Iron	7.80	Blackeye	4.92
6	Blackeye	4.86	Whippoorwill[1]	4.39
7	Red	4.37	Red	4.15
8	Early Buff	3.20	Early Buff	3.54

[1] Yield greatly reduced by stray animals getting into plat.

In a test begun on May 21, 1920, on old soil, the Early Buff matured very quickly, escaping many heavy rains and giving one of the largest yields of the varieties tested. The Red produced a fair yield of seed and a good yield of forage. This variety at first makes upright growth and later shows a tendency to spread, being more twining in habit and producing finer stems than any of the other varieties. The Victor was late in maturing and produced a small yield of seed. The vines make a good heavy growth and cover the ground well. Groit was one of the best producers, both of grain and of forage. The Iron matured seed medium early and continued to bear for some time. This variety is more upright in habit than the others, and forms a dense, heavy growth. The following table gives the results of the test:

Comparative yields of nine varieties of cowpeas planted on old soil on May 21, 1920.

Plat No.	Variety.	Date blossomed.	Date harvested.	Length of vine.	Yield per acre.	
					Seed.	Green forage.
				Inches.	*Pounds.*	*Tons.*
19	Brabham	July 2	Aug. 3	60.8	237.6	.....
20	Blackeye	(1)	.....	.....	.....	.....
21	Early Buff	June 25	July 23	.....	1,100.0	4.45
22	Red	July 7	July 27	.....	600.0	5.10
23	New Era	June 30	July 23	80.4	837.0	.....
24	Victor	Aug. 4	Oct. 20	62.0	62.6	.....
25	Groit	July 1	Aug. 3	62.0	1,162.6	.....
26	Whippoorwill	July 7	Aug. 3	65.2	350.2	2.90
27	Iron	July 2	July 23	72.8	800.2	2.60

[1] No germination.

Cowpeas planted August, 1919, made the highest yield in tests carried on by the station, producing 30 bushels of threshed seed per acre. Yields varied greatly in the different tests, but in general the highest yields were obtained from plants which blossomed and produced pods during the season of light rainfall; and the lowest yields were obtained from plants that flowered or produced fruit during the time of heaviest rainfall.

To determine their ability to improve the physical condition of the soil, cowpeas were planted on June 23, 1915, in a soil that had been inoculated two days previously with material obtained from the Bureau of Plant Industry, United States Department of Agriculture. A similar field that had not been inoculated was also planted. The cowpea pods were hand-picked twice, the last picking being made on October 5 just before the vines were mowed. From the inoculated and uninoculated fields the yields of grain per acre were 885 and 808 pounds, respectively, and the yields of green forage were 15,125 and 9,790 pounds, respectively. These results would seem to indicate that the yield, especially of forage, was greatly increased by artificial soil inoculation. Later results, however, were not in accord with the data obtained in this test, and in some instances they did not justify the trouble of obtaining the inoculation material. A large number of roots that were well supplied with nodule-forming bacteria were obtained when cowpeas were planted in any part of the island.

Velvet Bean (*Stizolobium* spp.).

The velvet bean is probably the most vigorous of the legumes growing in Guam (Pl. V, Fig. 1), and has been found by the station to be a most valuable crop for furnishing concentrates in the feeding rations. The plant does well at all seasons of the year, but makes its greatest yield of seed at this station when it is planted so that the beans will mature in the dry season. The velvet bean adapts itself to a wide range of soils, but does best on soil that is sufficiently moist and fairly well drained.

All the varieties of velvet beans tested by the station differ in time of maturity, amount and manner of growth, shape and size of pods and seeds, color of flowers and seed, and the like. They produce two distinct types of pods. one of which is covered with short, thick, black, velvety hairs, and the other with short, white or grayish hairs. Examples of the first type are found in the Georgia, Mauritius, and Osceola varieties; and of the second type in the Lyon, Chinese, and Yokohama varieties.

The pods of some varieties are only 2 to 3 inches long, while in others they vary from 4 to 6 inches. The seeds may be white, mottled brown, or black, depending upon the variety. The vines of all the

velvet-bean varieties are long and trailing, with the exception of the Bush variety, which makes a stalky and upright growth. The foliage is heavy and in some varieties makes a very dense growth.

Velvet beans have a large number of uses, but they are used principally for stock feed, or as green manure and as a cover crop. The vines remain green, even when large quantities of grain have been taken from them, and they can be plowed under while in a succulent condition, in which stage they rapidly decompose in the soil. When used as a forage the vines make a fairly well-balanced ration. The meal from either the beans or the beans and the pods is rich in protein, and being classed with the concentrated feeds should be fed with other more bulky substances. The pods are fed whole to hogs, which have no trouble in shelling them, and the vines are readily eaten by both hogs and cattle. The vines remain on the ground for an indefinite period and will easily pasture a number of animals for some time if the latter are handled judiciously.

Owing to the tropical climate, it is possible to grow cover crops the year round. In all comparative tests made by the station, velvet beans have been most effective in preventing erosion, keeping down weed growth, and lasting for long periods of time. The vine growth is so heavy that it soon smothers weed growth (Pl. V, Fig. 2). The velvet bean makes an excellent cover crop for protecting the soil from the intense heat of the sun and from beating rains. It has few equals for producing large amounts of humus.[8] The crop is invaluable not only for its effectiveness in holding weeds in check, especially when the ground is too wet to be cultivated, but also for its ability to add to the soil nitrogen and organic matter, both of which are lacking.

Yields of velvet beans have varied from nothing to more than 100 bushels of seed per acre, and from 1 to almost 10 tons of green forage per acre. The length of time from planting to maturity of the first pods has varied from less than 100 to more than 250 days, depending upon the variety and the soil and climatic conditions. The early-maturing varieties gave the smallest yields at the station. Among these were the Florida, Alabama, Bush, Georgia, and One-Hundred-Day Speckled. Medium-early maturing varieties were the Chinese, Lyon, Osceola, and Yokohama, and the latest-maturing variety was the Black Mauritius. In a test conducted by the station, the Yokohama variety made an average of 47.61 bushels per acre of shelled beans, the first pods of which ripened 150 days after planting. The Black Mauritius bean ranked second in grain yield, producing an average of 43.43 bushels of seed, the first pods of which ripened in 192 days. Of the early-maturing varieties, the Georgia gave the

[8] The amount of humus formed can be approximately measured by the tonnage of the crop.

highest yield, averaging 24.59 bushels of seed per acre, and ripened its first pods in 129 days after planting. The following table gives the results of the test:

Average results obtained in four variety tests with velvet beans.

Variety.	Time plant required to blossom.	Time plant required to ripen first pods.	Length of vine.	Yield of seed per acre.
	Days.	*Days.*	*Feet.*	*Bushels.*
Georgia	57	129	8.69	24.59
Florida	67	149	7.36	2.71
Alabama	59	132	8.72	16.35
One-Hundred-Day Speckled	58	132	7.79	14.78
Bush	89	115	2.20	2.50
Chinese	94	157	7.00	8.19
Lyon	77	143	7.71	11.22
Yokohama	86	150	7.84	47.61
Osceola	78	141	9.02	14.84
Black Mauritius	112	192	9.68	43.43

The pods of the Georgia velvet bean when immature are green and covered with black fuzzy hair. The mature pods are black, very hairy, about 2 to 2½ inches long, and contain four seeds. The seeds are oval or roundish, and light in color with brownish-black mottling, or speckled to solid markings with a tendency toward lines.

The One-Hundred-Day Speckled velvet bean pod (Pl. VI, Fig. 1) is covered with thin fuzzy black hair on a green ground which shows through the hairs very plainly on the immature pods. When mature, the pods are black and wrinkled, and have a series of broken ridges on the sides. The seeds are very similar in appearance to those of the Georgia.

The pod of the Black Mauritius or Bengal bean (Pl. VI, Fig. 2) is fleshy and green, and when immature is covered with many white hairs. The ripe, black pod is covered with gray hair and has on each side an unbroken ridge which extends nearly the length of the pod. The pod is about 4 inches long and generally contains five seeds. The seeds are shining black, rather flat, and have a prominent white hilum.

Immature pods of the Osceola velvet bean (Pl. VII, Fig. 1) are green, very fleshy, and covered with black hair. The mature pods are black and covered with a medium number of black hairs. These pods are about 4½ inches long and contain four or five seeds. On the sides of the pod there are several short wrinkled ridges and one main ridge which extends the length of the pod. The seeds are oblong, fairly large, and mottled on a dirty white ground.

When immature, theYokohama velvet bean pods (Pl. VII, Fig. 2) are light green, fleshy, and covered with light silky hair. The ripe

FIG. 1.—TEST PLATS OF COWPEAS.

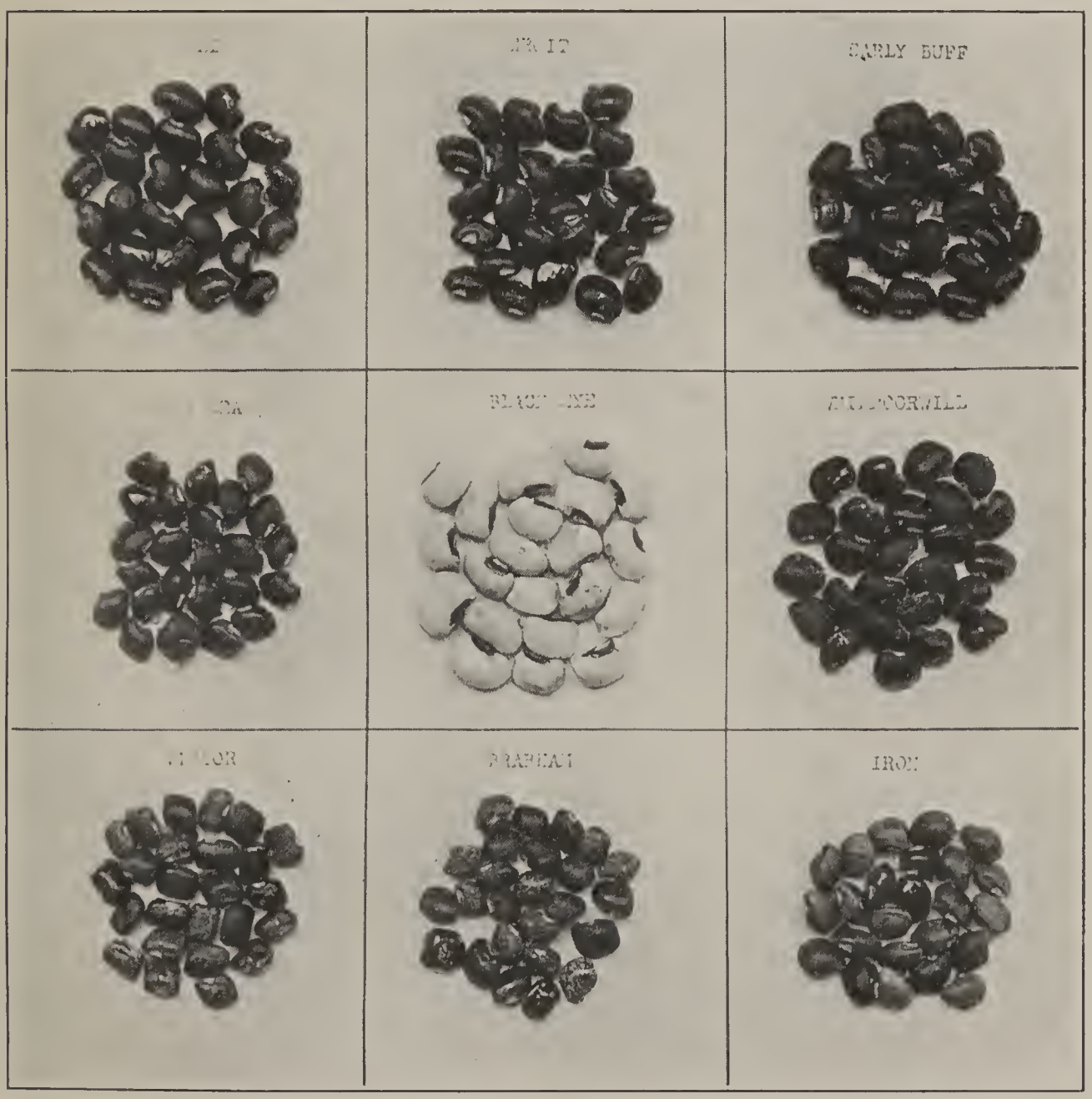


FIG. 2.—SEED OF NINE VARIETIES OF COWPEAS, RED, GROIT, EARLY BUFF, NEW ERA, BLACKEYE, WHIPPOORWILL, VICTOR, BRABHAM, AND IRON.

FIG. 1.—VELVET BEANS AS COVER CROP. NOTE CLIMBING HABIT OF THIS VARIETY.

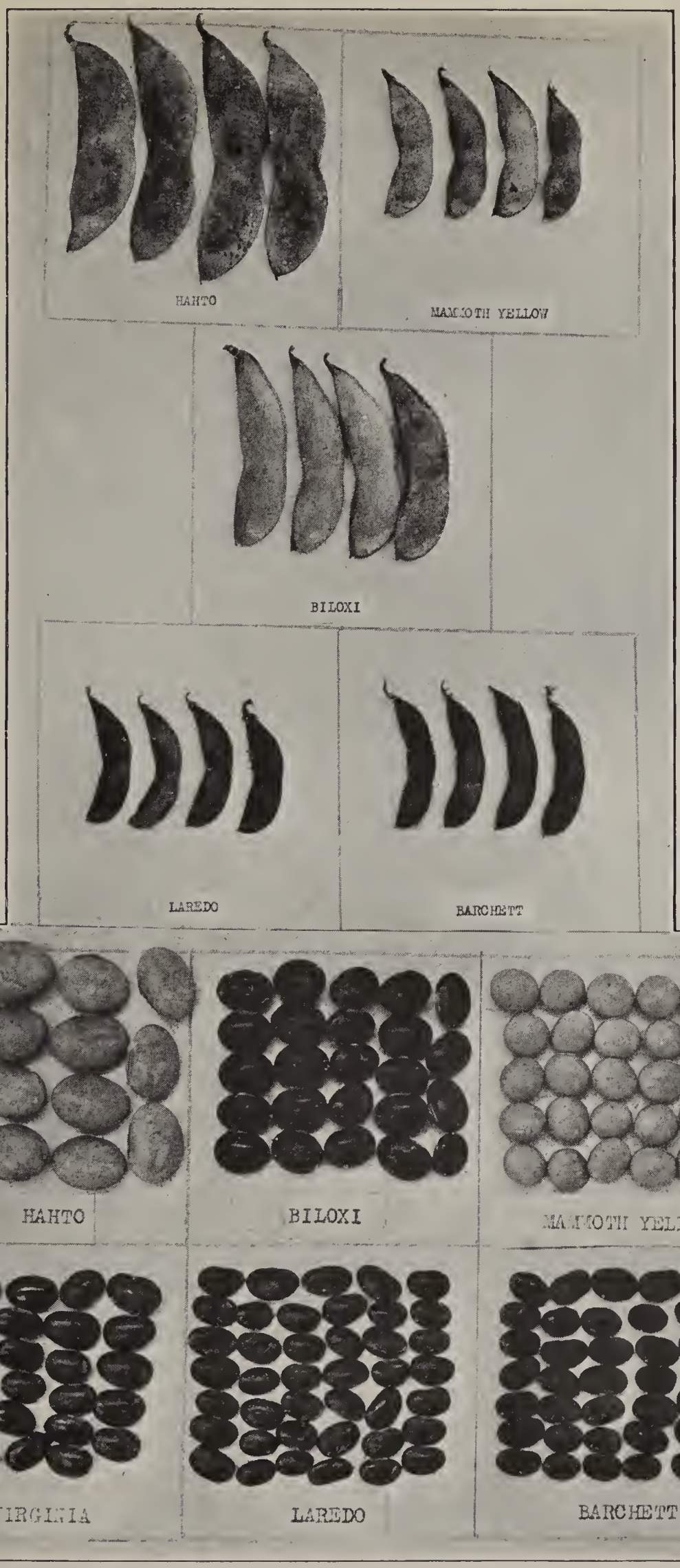
FIG. 2.—VELVET BEANS SIX WEEKS AFTER PLANTING.

FIG. 1.—VELVET BEAN, 100-DAY SPECKLED, SEEDS AND PODS.

FIG. 2.—VELVET BEAN, BLACK MAURITIUS, SEEDS AND PODS.

FIG. 1.—VELVET BEAN, OSCEOLA, SEEDS AND PODS.

FIG. 2.—VELVET BEAN, YOKOHAMA, SEEDS AND PODS.



SOY BEANS, PODS AND SEEDS.

FIG. 1.—BILOXI SOY BEAN, GROWN AT BILOXI, MISS. PHOTOGRAPH FROM BUREAU OF PLANT INDUSTRY.

FIG. 2.—MUNGO BEANS GROWN AS A COVER CROP.

pods are thickly covered with fine, short hair, and are lighter in color than those of most of the other varieties. The pods are from 4 to 5 inches long, bear five seeds, and have on each side a single ridge extending from the stem to the strongly hooked outer end. The seeds are grayish white, large, flat, oblong, and sometimes slightly sunken on the sides.

The selection of a variety for growing depends somewhat on the use to which the crop is to be put. The late-maturing varieties are best where there is need for a cover crop to remain on the ground for an indefinite period. When seed is wanted, selection should be made from the early or late maturing varieties, depending upon the immediate need for the seed. The late-maturing varieties give a large yield of both forage and seed, but the seed is more easily gathered from some of the earlier varieties because the vine growth dies down and the pods are left exposed.

At the station it was found that staking the ground or providing the vines with supports markedly influenced seed production, which was as high again as that made by the vines that were allowed to trail. When grown among corn or grain sorghums, velvet beans find support by climbing the stalks. The beans can then be harvested by hand, or if they are wanted for feed the crop can be hogged off.

In a comparative test made by the station with cowpeas, jack beans, and Patani beans that were planted in a coconut plantation to keep down weed and second growth, the velvet and Patani beans were the most effective. They gave so much satisfaction, in fact, that at the close of the year following the test the farm manager cleared and prepared for planting an additional 35-acre tract, and it is planned to use them as cover crops on 400 acres of coconut plantation. Growing velvet beans with Para grass produced larger yields and a better grade of forage than is ordinarily obtained (Pl. X, Fig. 2). Legumes when mixed with Para grass make the feed of better quality by adding to the ration protein, which is especially valuable for growing animals. The seeds were planted in hills about 4 feet apart each way in fields having no preparation other than making a hole in the sod with a sharp-pointed stick.

Soy Beans (*Glycine soja* or *Soja max*).

Soy beans have not been grown on the island for a length of time sufficient to warrant the drawing of definite conclusions regarding their adaptability. Judging from present indications, however, it is thought that they might become a valuable crop. Eight varieties of soy beans were planted in a variety test on May 22 (Pl. VIII), and with the exception of the Biloxi variety (Pl. IX, Fig. 1), which gave

a good germination at the start, had to be replanted on June 5, 1920. The results of the test are shown in the following table:

Results obtained with eight varieties of soy beans grown at the Guam station.[1]

Variety.	Date of blossoming.	Height of plants at harvest time.	Date of first harvest.	Yield of seed per acre.	Remarks.
		Inches.		*Pounds.*	
Mammoth Yellow	.....	22.2	Sept. 7	500.0	Medium growth; medium amount of foliage.
Laredo	July 7...	31.8	Sept. 15.	2,150.0	Slender plants; seeds well set up the plant.
Hahto	...do....	19.0	...do....	1,037.5	Low, bushy plants; pods large and clustered; medium amount of foliage.
Tokio	...do....	16.2	Sept. 28.	175.0	Medium size and foliage; seed pods grown in clusters.
Haberlandt	July 6...	17.2	Sept. 15.	162.6	Small plants; seed scattered along main stem.
Virginia	...do....	42.4	...do....	400.0	Fairly heavy foliage; pods small and scattered along the branches on the taller plants.
Biloxi	June 29.	55.2	Sept. 7..	3,600.0	From 3 to 4½ feet tall; upright growth; heavy, dark green foliage; medium-sized pods well scattered along main stem.
Barchett	July 12..	40.0	Sept. 28.	1,625.0	Slender vines; medium height; small leaves; thick foliage; very small seed pods.

[1] Since these results were obtained during extremely wet and unfavorable weather, it is thought that very much better results would be had in a favorable season.

Pigeon Pea (*Cajanus indicus*).

The pigeon pea, or gandul, is strictly a tropical plant and one that is well adapted to Guam conditions (Pl. X, Fig. 1). It is especially valuable as a temporary windbreak for orchards, gardens, and even field crops, particularly corn, during the rainy season, and is grown for forage and grain production. The plant makes a slow, spindling growth at first and does not attain its maximum growth until the second year, when it develops into a stout shrub, reaching a height of from 10 to 15 feet, and if given sufficient room, branching freely. Seed is produced in about eight months from time of planting, and the plant continues to flower and fruit for several months. The seed is borne in pods along the upper ends of the stems on the new growth. They may be harvested by removing the ends of the limbs with a machete or a sickle, or they may be picked by hand. When pruned in this manner the plants put out new growth upon which more seed is produced. The tops with the seed can be fed to cattle or hogs, or the seeds alone can be fed to poultry.

The peculiar segmented pods, which contain from 4 to 6 seeds, are from 2 to 3 inches long and vary from a straw to a dark red or purplish color. The spherical seeds also vary in color and size, some being speckled with small brown spots on a light gray ground, and others being light or dark red, according to the variety. The yield of seed is high and must be promptly harvested when ripe to prevent its becoming infested with weevils. While still green, the

pigeon pea furnishes a fairly good substitute for garden peas, which do not succeed well.

If the plant is grown primarily for seed, it should be pruned back from one-quarter to one-half at the beginning of the rainy season. This will cause it to make new growth during favorable growing conditions and to send out new flowering shoots in time to produce a crop during the dry season. To produce the greatest quantity of seed, the crop should be planted 3 feet apart in rows 3 to 10 feet apart. The plantings should be made closer than this when the crop is wanted for forage, else it will be coarse and shrublike.

The pigeon pea is especially valuable as a windbreak around young citrus orchards and gardens, and usually lasts about three years. Owing to its strong, penetrating roots, the pigeon pea is seldom, if ever, uprooted by heavy winds. The best temporary windbreaks are secured when the crop is planted in double rows 3 feet apart in the row.

Peanut (*Arachis hypogea*).

The peanut, locally known as "cacaguate," is an annual plant of decumbent and spreading habits, and rarely attains a height of more than 1 foot. The plants produce pods with edible nuts or seed which are largely used in confections, for making peanut butter and peanut oil, and as stock feed. The nuts are usually eaten raw and the vines are fed to the work animals. The leaves and vines make excellent forage, and when turned under as a green-manure crop build up the soil by supplying it with atmospheric nitrogen.

Peanuts will grow on almost any soil that is reasonably fertile and well drained. A sandy soil seems best adapted to the needs of the plant, and in addition to producing a highly marketable nut makes the work of cultivating and harvesting easy. A heavy soil produces a larger yield of nuts than does sandy soil, but it stains the pods and by discoloring them lowers their marketable value. The general preparation of the soil for growing peanuts is the same as that given other cultivated crops. The ground should be plowed moderately deep and cleaned of all weed growth. If the peanut is used to follow a cultivated crop, the ground is likely to be free from weeds and grasses at planting time. If it is used to follow weedy or foul land, the vegetative growth on the ground should be turned under some time before planting. Probably the best time to plant peanuts is immediately after the rainy season is over. A good growth will then be insured before the soil dries out and the nuts will develop and mature without danger of rotting.

Seed for planting should be selected from vigorous productive plants and be shelled and thoroughly dried after harvesting to insure an even stand. The Spanish peanuts are planted in the whole pod, but the larger varieties are best hulled or at least broken in two.

Many people plant the cuttings and never use the nuts for seed. In a test conducted by the station, germination was found to increase about 20 per cent when the nuts were placed in the shade for about 36 hours after being soaked in water for 12 hours. The following table gives the results of a test made with three varieties of peanuts that were planted on May 22, and replanted June 5, 1920 (Pl. XI, Figs 1, 2, 3):

Results of test made with three varieties of peanuts.

Variety.	Date of blossoming.	Date harvested.	Yield per acre.	
			Seed.	Green forage.
			Pounds.	*Tons.*
Large Chinese	June 22	Nov. 21	4,600	3.50
Guam-grown	...do.....	Nov. 22	7,000	4.10
Small Chinese	...do.....	...do.....	1,500	2.35

The Large Chinese and the Guam-grown varieties are low-growing spreading plants, and the Small Chinese makes an upright, bushy growth. The yields were large for plantings made in May, but the operation of removing the plants with all the nuts adhering was most tedious and the pods were very much stained. The vines made a good forage which was readily eaten by the cattle at the station. In feeding value, the forage equals that of cowpeas.

Peanuts are harvested by running a plow along each side of the row and by forking out the plants and shaking the dirt from the vines and the nuts. The crop is best harvested as a hog feed by turning the animals on the field and allowing them to eat the vines and root out the nuts.

Jack Bean (*Canavalia ensiformis*).

The jack bean, also called the Chickasaw Lima bean, is a strong, vigorous-growing plant, which makes a bushy growth and reaches a height of from 36 to 40 inches under favorable conditions (Pl. XII, Fig. 1). It produces an equal spread of dense foliage and green pods which are long, slender, and fleshy until they mature, when they shrink to about a foot in length and an inch in thickness. The seeds are large, smooth, and pure white, and are covered with a very tough membrane. They are not used as stock feed unless ground into meal. The immature pods and the young shelled beans are edible if harvested while they are tender.

The jack bean is best adapted for use as a cover crop where the twining and climbing varieties of other legumes are objectionable. It will prevent the growth of all weeds with the exception of the morning glory, which is held in check only by a heavy growth of

FIG. 1.—PIGEON PEAS IN ROWS 3 TO 6 FEET APART.

FIG. 2.—VELVET BEANS AND PARA GRASS FOR HOG PASTURE.

VARIETIES OF PEANUTS. (1) SMALL CHINESE; (2) LARGE CHINESE; AND (3) JUMBO, GUAM-GROWN SEED.

FIG. 1.—JACK BEANS, SHOWING PODS.

FIG. 2.—JACK BEANS AS COVER CROP IN CITRUS ORCHARD.

velvet bean, and has been successfully used in citrus orchards and coconut plantations. The root system is strong and generally well supplied with nodules produced by the nitrogen-fixing bacteria. The jack bean was the only crop at the station to live through the typhoon of 1918, although it was stripped of nearly all its leaves.

The jack bean is best cultivated by planting in rows 3 feet apart and from 15 to 30 inches apart in the row. The plant grows rapidly and soon covers the space between the rows if it is cultivated in the same way as corn. The crop has never been grown primarily for bean yield, but single pickings of mature beans have given yields of 12 and 15 bushels per acre even when all the pods were not picked from the plants. The plant fruits nearly the year round and in some instances has remained on the ground for more than two years. In comparative pasture tests with cowpeas and velvet beans, the jack bean was least preferred by hogs and cattle. Probably the principal objection to the jack bean is its woody growth, which makes difficult the work of turning it under as a green manure when its use as a cover crop is ended (Pl. XII, Fig. 2).

Mungo Bean (*Phaseolus aureus* or *P. mungo*).

The mungo bean, locally called the mungo or moñggo, and in some places the green gram bean, is the best known legume, being originally the principal leguminous crop cultivated on the island. It is a quick-growing plant of bushy habit and has rather slender branches which produce pods on the ends. The stems and leaves are pubescent or hairy, but not to such an extent as to be distasteful to live stock. The plant grows to a height of from 24 to 40 inches, depending upon the fertility of the soil and the cultivation given the crop (Pl. IX, Fig. 2). It is the earliest maturing legume cultivated, sometimes ripening seed in less than two months after being planted, and under favorable conditions being ready for harvesting in less than three months.

The pods are round and slender, being about the size of a slate pencil, and from 2 to 4 inches long. They contain 8 to 10 small green or dark seeds. The pods of the native or Filipino bean are not so hairy as those of the introduced varieties. The beans are highly prized as food by the Chamorro people, being used in soup and often sprouted for use as a salad. The beans or seed are also used as chicken feed. Much of the seed is harvested during the rainy season and consequently is not always of good quality. It matures very unevenly and must be harvested promptly and frequently on account of its tendency to shatter. Only good, sound seed should be planted. Rows are planted from 20 to 40 inches apart, and at the latter distance when the crop is grown in the field, so that an animal-drawn implement can be used to cultivate the ground. The beans are planted from 4 to 8 inches apart in the row. The plants grow rapidly and soon cover the space between the rows.

The plants make a fairly good cover crop when they are planted close together, or when the seed is sown broadcast, but they lose their effectiveness after the seed matures, which is from 60 to 90 days after planting. Mungo beans should be used as a catch crop or to smother weeds on any plat that is not needed for several weeks. After they have produced enough seed for future plantings, the plants should be turned under as green manure. They are easy to plow under and make an excellent soil renovator.

Yields of seed have varied from 5 to more than 25 bushels per acre. The first crop in a planting made on January 21, 1918, was ready for harvesting on April 2, and the last of the crop on May 8. The seed harvested from this planting was 600 pounds per acre. A large portion of the seed shattered freely, however, and was lost. The first crop from a planting made on May 22, 1920, was ready for harvesting on July 26, and yielded at the rate of 1,200 pounds of seed per acre. An average seed yield probably would be not less than 900 pounds per acre.

Alfalfa (*Medicago sativa*).

Data gathered from a large number of tests covering several years' work under widely varying soil conditions and at different seasons conclusively show that alfalfa can not be successfully grown at this station, nor probably in Guam, because of the unsuitable soil and climatic conditions, the low altitude, and the exceptionally humid atmosphere. In some cases as many as two good cuttings have been obtained, but in all tests the plants died sooner or later. The following is quoted [9] as being typical of all tests:

> As negative results were secured last year in tests of alfalfa on the lowlands of the station, three tests of the crop were started this year on hillsides with different slopes and different soil textures. One test plat planted in January grew very little during the dry season, but after a clipping with a mower it made a good growth with the beginning of the rains. After the heavy rains had continued for some time, the alfalfa on this plat began to die, although in apparently one of the best-drained locations at the station. * * * All uninoculated plats were much slower in growth than the inoculated plats.

Experimental work with cultural methods, inoculation, and varieties was carried on during five or more years, but the best results were obtained in the test reported by Hartenbower.[10]

> From the information obtained during the fiscal year 1915 it appears that two or three unsuccessful attempts had been made to grow alfalfa on this island. Since the cause of the failures was undetermined, it was deemed advisable to find whether they were due to inferior cultural methods or to natural forces.
>
> Four varieties or strains of alfalfa seed—namely, Peruvian, Grimm, Black Hills, and Kansas-grown—together with a supply of cultures of alfalfa bacteria, were obtained from the Bureau of Plant Industry of this department. Low,

[9] Guam Sta. Rept. 1917, p. 28.

[10] Guam Sta. Rept. 1916, pp. 13, 14

heavy clay soil, fairly well drained, was chosen for the test. The land had produced cowpeas in the first season of 1915 and was in excellent physical condition. It was plowed about 5 inches deep, harrowed, and then pulverized. The seed bed obtained was well pulverized, weed free, and compact. Four plats, numbered from 1 to 4, inclusive, each 66 feet by 28 feet in size, were laid out. Each plat was divided into four parts and each part given the following treatment: Section a, inoculated; b, inoculated and fertilized; c, fertilized; and d, untreated or check. The fertilizer was applied at the rate of 100 pounds of nitrate of soda, 200 pounds of acid phosphate, and 50 pounds of muriate of potash per acre.

The seed was planted on January 7. Timely showers sprouted the seed promptly, and an excellent stand was obtained on all plats. The Peruvian and Kansas-grown plats, in particular, made a quick start, and by March 15, when the plants were approximately 1 foot high, they showed blossoms. The weather at that time was very dry and the soil cracked open, cracks 2 inches wide occurring generally in all plats. The plats were clipped high on March 27 and the cut-off stems left on the ground.

The first heavy rain of the season came on April 15, and from then on the alfalfa grew rapidly. Between April 15 and June 30 two cuttings from plat 1 and one cutting from each of the other plats were obtained, and the yields from areas 14 by 33 feet are given in the following table:

Effect of inoculation on the growth of alfalfa.

Plat section.	Variety.	Treatment.	Date of harvesting.		Yield of green alfalfa.	
			First crop.	Second crop.	First crop.	Second crop.
					Pounds.	*Pounds.*
1a	Peruvian	Inoculated	May 24	June 26	65.5	62.0
1b	do	Inoculated and fertilized	do	do	75.5	61.0
1c	do	Fertilized	do	do	56.5	31.5
1d	do	No treatment	do	do	33.0	21.5
2a	Grimm	Inoculated	June 12		15.0	
2b	do	Inoculated and fertilized	do		39.0	
2c	do	Fertilized	do		26.5	
2d	do	No treatment	do		11.0	
3a	Black Hills	Inoculated	do		22.5	
3b	do	Inoculated and fertilized	do		35.5	
3c	do	Fertilized	do		21.0	
3d	do	No treatment	do		15.5	
4a	Kansas grown	Inoculated	do		42.5	
4b	do	Inoculated and fertilized	do		51.5	
4c	do	Fertilized	do		35.5	
4d	do	No treatment	do		24.5	

While the field selected for this test is well drained when compared with most of the lowlands of Guam, yet there are times after heavy rains when the water does not drain from the plats promptly. During the month of May the total rainfall was approximately 23 inches, probably as much as would occur in any month of a normal year. The alfalfa has so far apparently escaped injury, and this promises well for the future. It will be only from the results of the entire coming rainy season that any real estimate may be made of the adaptability of alfalfa to Guam conditions. To date, the Peruvian alfalfa appears to be better adapted to the conditions than any of the other varieties or strains. Neither Grimm nor the Black Hills strain has grown well.

Chochomeco (*Phaseolus lunatus* sp.).

The chochomeco, or Patani bean, is a variety of Lima bean. The beans vary in color, being white, black, or speckled. The black bean

has been reported as poisonous and should not be used as a food. The principal value of the Patani bean lies in its effectiveness as a cover crop which produces edible green beans during the dry season. The plants make a low, viny, matted growth, which remains on the ground from several months to two years, and are very effective in keeping down weed and second growth in new clearings. They are especially valuable in young coconut plantations, where there is need of a leguminous crop that will live for an indefinite period. The Patani bean is planted and cultivated in the same manner as is the cowpea. It produces seed during the dry season. The pods are hard to pick, being scattered on the vines instead of being borne in clusters at the end of the branches.

Miscellaneous Small Bean Varieties.

Nearly all kinds of beans do well, although some do better than others. On May 22, 1920, a number of small-seeded beans were planted to determine the best varieties to grow for cover crops and grain production (Pl. XIII). A good stand was obtained in all plats, and all varieties made a dense, heavy growth and kept down weeds. When planted close together, they made a most effective cover crop. The most noticeable difference in the efficiency of the plants as cover crops was in the time they required to reach maturity. The work of harvesting was tedious on account of the small pods, which require several pickings. The following table summarizes the results obtained in the test:

Results of variety test with 10 varieties of small beans planted May 22, 1920.

Variety.	Date of blossoming.	Height of plants at harvest time.	Date of first harvest.	Yield of seed per acre.	Remarks.
		Inches.		*Pounds.*	
Native mungo[1]	July 5	51.4	July 26	1,200.0	Upright, bushy, tall plant.
Hawaiian mungo[1]	...do	54.0	...do	900.0	Do.
Green mungo[1]	June 23	.....	July 19	1,400.0	Prostrate growth of viny nature.
Black mungo[1]	July 7	63.8	Aug. 23	2,150.0	Taller than the green mungo, very hairy pods and vines. The hairs stick out straight from the pod.
Urd mungo (*Phaseolus mungo*).	July 16	75.4	Sept. 10	1,825.0	Similar to green mungo in growth and hairiness; otherwise resembles the black mungo.
Rice bean[2]	Aug. 4	39.2	Sept. 15	1,762.5	Slender, viny, and rather tall. Late maturing.
Do[2]	June 22	52.8	July 23	1,937.5	Low growth; viny and slender. Blossom and seed similar to first-mentioned rice bean, but growth not so heavy. Matures early.
Adzuki (buff)[3]	...do	.....	July 19	1,975.0	Low, rather upright growth, and slightly bushy. Loses leaves early.
Adzuki (red)[3]	...do	.....	Aug. 3	937.6	Very much like buff variety, but retains its leaves.
Adzuki (buff and mixed).[3]	...do	.....	July 19	2,600.0	

[1] All varieties of *Phaseolus aureus*. [2] Varieties of *P. calcaratus*. [3] Varieties of *P. angularis*.

PODS OF SMALL BEAN VARIETIES.

Left to right, top row, *Phaseolus calcaratus* var., Rice bean, Black Mungo, Urd: lower row, Red Adzuki, Buff Adzuki, Hawaiian Mungo, and Guam Mungo.

PLATE XIV.

TAÑGANTAÑGAN (*Leucæna glauca*).

LEGUMES FOUND ON THE ISLAND.

A large number of the legumes which grow wild over the island would probably make valuable cover and green-manure crops were they tested in cultivation. Most of them are classed as weeds and as such are excluded from the cultivated fields. A number of other tropical beans, which also grow readily, have never been thoroughly tested to determine their yields or effectiveness as cover crops. These beans are not native to the island, but are well acclimated, having been grown on small areas for a long time. Several of these varieties, locally known as red cerebilla, white cerebilla, seguidilla, and fijoles, were collected by the station and planted in a series of plats on June 5, 1920.

Cerebilla (*Dolichos lablab*).

Two kinds of lablab, hyacinth, or bonavist bean, locally known as red cerebilla and white cerebilla, are grown in Guam. The red cerebilla has distinctive reddish-purple vines, the color of which extends around the margin of the seed pod; while the white cerebilla has light-colored foilage. Both cerebillas make vigorous and viny growth and produce the most seed when they are allowed to climb upon supports. Both withstand dry weather remarkably well. The pods are eaten in the green stage as snap beans.

Seguidilla (*Psophocarpus tetragonoloba*).

The seguidilla produces a large amount of dense foilage and a peculiar four-sided pod that is winged with four longitudinal frills, one of which is on each corner. Some of the large pods are an inch square. The plants make effective cover crops for long periods. The station recommends the more extensive use of the seguidilla as a cover crop. The beans are edible and of high quality.

Fijole (*Vigna sinensis*).

The fijole is a tropical variety of the cowpea, and is known as Chinese asparagus bean, twining cowpea, sítao (in the Philippines), yard bean, and in Guam as fijole. It produces pods which are from 18 to 40 inches long and the beans are set about 1½ inches apart in the pod. The beans are only medium in size and of kidney shape and a brownish color. The plant produces few leaves and would be of little account for forage purposes, but it makes an exceptionally high yield of good string beans and is worthy of a place in the garden.

Tañgantañgan (*Leucæna glauca*).

The tañgantañgan is a shrub-like plant which grows wild in many places (Pl. XIV). The leaves and tender parts of the branches are

fed in considerable quantities as green forage to cattle, especially during the dry season. As a forage they seem to have a high feeding value. Tañgantañgan has been reported as causing the hair of horses to fall out, but no experimental data can be found to verify this statement. The coarse part of the plant is commonly used for firewood. The plant has even been recommended for extensive planting to furnish firewood for the inhabitants of the island.

Tañgantañgan reaches a height of from 12 to 15 feet and grows from 1 to 2 inches in diameter in a single season. It has a very deep taproot and is propagated by placing the branches or the green stalks upright in the ground or by sowing the seed. The former method of planting gives quick results, as the cuttings take root easily. The cuttings should be planted at the beginning of the rainy season. The plant makes a good hedge or windbreak and is often planted along road embankments to prevent the soil from washing. No doubt the tañgantañgan could be made a valuable crop on some of the poorer soils on the hills.

Camachile (*Pithecolobium dulce*).

The camachile is a hardy, deep-rooted, spine-bearing tree, which when cut back has a tendency to spread. It will stand severe pruning, however, and is largely used for fences and windbreaks, being both serviceable and ornamental. The bark is used in tanning hides. The tree bears pods containing black, shiny seeds embedded in a sweet, white, spongy substance which is eaten by the Chamorro people.

Aromo (*Acacia farnesiana*).

Aromo is one of the noxious legumes. It grows in abundance if it is not painstakingly eradicated and is one of the worst pasture pests on the island. Aromo seldom reaches a height of more than 10 feet and produces a light-colored button-like flower. The pods containing the seed are rather flat and from 2 to 4 inches long. The plant is covered with many thorns which cause swellings and disagreeable sores to develop on the nose and legs of horses.

The plant develops a long, deep taproot which is very hard to remove. Aromo can be killed only by a removal of the entire plant with root, or by keeping it cut down before it makes any growth. Aromo is not troublesome in cultivated fields where crops are grown that completely shade the ground.

Yam Bean (*Pachyrhizus tuberosus*).

The yam bean, locally known as "hikamas," is a vigorous climbing herbaceous plant that is grown for its large, edible, tuberous root. The root resembles the turnip in shape, and is crisp, sweet, and very

tender before reaching maturity. It is eaten cooked or raw. The seeds are planted about 2 inches deep, 8 to 10 inches apart in the row, and 3 feet between the rows. When the vines are provided with trellises the yields are very large. The roots should be harvested before they become coarse and woody.

Creeping Tick-Trefoil (*Desmodium triflorum* and *D. heterophyllum*).

The creeping tick-trefoil is a small trailing plant that somewhat resembles clover and produces small flowers. It thrives well when planted with Bermuda (grama) grass or with other mixed grasses and grows very thickly in some areas. When supported by other crops the creeping tick-trefoil makes a more upright growth than when it is grown alone. It is largely found on the better-drained areas of the lowlands, and is welcomed in all pastures though never planted.

Algaroba (*Prosopis juliflora*).

The algaroba or mesquite tree is an introduced variety which is growing at the station. It is well suited to dry areas, where it will make good growth after once becoming well established. The foliage and the pods are eaten by cattle and the wood is very valuable for use as fuel. In Hawaii the algaroba is recognized as a source of valuable feed and it is extensively planted on waste land. Doubtless it would make a valuable feed for Guam.

Bur Clover (*Medicago hispida*).

Notwithstanding the fact that plantings of bur clover have failed a number of times at the station owing to heavy rains, the crop is deemed worthy of further trial. Seed received from California was unhulled and although it germinated slowly it resulted in a good stand in most cases. The plants were very decumbent in habit and have died in many of the tests. Seed received from the Bureau of Plant Industry, United States Department of Agriculture, was hulled and gave a good germination. The plants were more upright than those of the California clover and survived better, although a number died soon after coming up or about the time the fourth leaves appeared. The two plats that were planted in August made good growth and matured seed during November. Some of this seed was saved for future plantings and some was left to reseed the plats. More trials will be made to determine if the plant can be established in Guam.

Kudzu (*Pueraria thunbergiana*).

Seed of the kudzu plant was received from the Bureau of Plant Industry, United States Department of Agriculture, and planted on

August 6, 1920. On October 12 the vines were already beginning to spread, and at the end of five months they measured 13½ feet in length. At this time a number of cuttings were made and planted but none of them struck root, probably on account of the immature condition of the young plants. If the kudzu plant is found adapted to Guam, and there is every indication that it will be, it doubtless will be one of the most practical legumes for planting on the hillsides and poorer soils of the island.

SUMMARY.

The data reported in this bulletin have been obtained from tests carried on by the Guam Agricultural Experiment Station.

Legumes are grown for forage and seed production, to improve the soil, and as cover and green-manure crops.

Guam is in need of leguminous crops that will improve the soil and supply forage for the live stock.

Legumes will grow on nearly any soil that is well drained.

Where the soil is lacking in organic matter, improvement can be brought about by growing leguminous crops and turning them under while green.

Good cultivation helps to increase the production and the quality of the forage and seed.

Particular attention should be given to the proper storing of the seed, else it will become weevil-infested or lose its vitality. Special containers that have been devised by the station are recommended for use in storing thoroughly dry seed.

On account of the large amount of protein that they contain, the legumes have a high feeding value. Nearly all classes of stock relish the forage, and the grain is excellent as a concentrated feed.

The selection of the kind of legume to grow depends upon the use to which it is to be put, the soil and climatic conditions, and the length of time that the crop is to occupy the ground.

Cowpeas are rapidly coming to be recognized as an important forage crop and they are used for a number of purposes, including food for human consumption. In tests conducted by the station the Brabham variety gave the highest average forage yield and the New Era cowpea the highest seed yield. The late-maturing varieties are the most effective of all the cowpeas for use as cover crops. The highest yields were obtained from cowpea varieties that produced pods during the season of light rainfall.

Velvet beans are among the best leguminous forage crops because they are well adapted to the soil and climatic conditions and are vigorous growers. They have a high feeding value. In tests conducted at the station the varieties Yokohama and Black Mauritius made the highest yields of seed per acre, producing an

average of 47.61 and 43.63 bushels, respectively. The Georgia made the best yield of the early maturing varieties, producing an average of 24.59 bushels of seed per acre. The average number of days from planting until ripening of the first pods was 150, 192, and 120, respectively, for the three varieties. Velvet beans and Patani beans grown in comparative tests were found to be the best cover crops for coconut plantations.

Soy beans and peanuts give promise of becoming valuable leguminous crops.

The pigeon pea is used as a windbreak and for forage and seed production.

Jack beans are vigorous growers and quickly cover the ground. They are especially well adapted to use as cover crops in citrus orchards, where climbing vines are objectionable, and as such are effective for more than a year. When their usefulness as cover crops is ended, however, the coarse stalks are difficult to turn under for green manure.

The mungo bean is commonly grown for its edible seed. It makes a good cover crop for short periods and matures in from 60 to 80 days. At the station it has produced as much as 25 bushels of seed to the acre and as low as 5 bushels.

Miscellaneous small beans, including several mungo varieties, rice beans, urd, and adzuki beans, made good cover crops when grown in comparative tests, although they varied in yield of seed.

Alfalfa failed at the station when grown on a number of different soil types and in tests covering several years. It has been conclusively demonstrated that alfalfa can not be successfully grown in Guam because of the unsuitable soil and climatic conditions, the low altitude, and the very humid atmosphere.

The Patani bean makes a good cover crop and is recommended for planting among coconut trees to keep down brush and weeds.

There are a number of native and miscellaneous legumes that are worthy of trial as field crops. Of these the cerebilla, seguidilla, bur clover, and kudzu are very promising.

Tañgantañgan, a shrub, and algaroba, a tree, are two of the largest legumes that might become valuable for forage purposes and for use as firewood in the drier sections of the island, but their value can be determined only by experiment.

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