LIMA BEAN

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INTRODUCTION

The lima bean (Phaseolus lunatus), like other legumes used for their seed, is highly diverse in seed size, shape and color, plant form and principle uses. Although sprouts and young pods may be eaten, the lima is commercially grown for the seeds (Nabhan, 1985). The green-mature seeds are used as a vegetable for freezing, canning or fresh market use. Limas at the hard, dry-mature stage have also long been used as a grain legume. The reader is referred also to articles by Duke (1981), Kay (1979), and Aykroyd et al. (1982) for a more complete review.

ORIGIN AND HISTORY

Limas originated in tropical Central and South America (Mackie, 1943). The "Potato" group developed from limas carried eastward into the Caribbean, and south into northern, eastern and central South America to Brazil. The "Big Lima" group developed from limas carried south along the Andean chain toward temperate South America. The "Sieva" group of limas, from limas carried north into Mexico and Southwestern United States, was an important grain legume of the Hopi. With the discovery of the Americas, the lima quickly was carried to Asia, Europe and Africa and many new types evolved or were selected. Not surprisingly, many common names now exist for limas in one form or another, among them Sieva bean, Butter bean, Civet bean, Sewee bean, Carolina bean, Madagascar bean, Sugar bean, Rangoon bean, Java bean, Hibbert bean, Burma bean, Haba, Paiga and Paigya (Seelig, 1980). The tendency in some countries to place limas under a general name, such as "dry beans" results in a serious underestimate of world production.

There is interest among some taxonomists in classifying lima beans into more than one species. The small-seeded annual climbing forms would be classified as Phaseolus lunatus, while the large-seeded types would be classified as P. limensis. Small seeded bush forms would be classified as P. lunatus var. lunonnus. Since the various types can be hybridized with one another, the legitimacy of separate species classification is questionable.

CULTIVARS

Lima beans tend to be classified according to plant type, seed size and thickness, and seed color (Table 1). Wild limas probably were climbing types and today some well known improved cultivars of climbing limas, such as 'King of the Garden,' 'Carolina' and 'Florida Speckled', continue to be used for home and market gardens (Cook et al., 1978 and pers. comm.). Commercial vegetable limas for canning or freezing are short bush types. Commerical dry (grain) limas are primarily vining types which grow flat on the ground. Whether bush or vining, dry or vegetable, lima seed size and thickness may vary greatly from cultivar to cultivar. Historically, the three major categories of limas have been 1) the large seeded (Fordhook), 2) the small seeded (baby lima), and 3) the pole (sieva) lima. These groupings now overlap as new cultivars have been developed which combine characteristic traits of two or more categories. In addition, popular cultivar names in one category have been used in naming new cultivars in other categories. For example, both large and small seeded cultivars carry the term "Fordhook" in their name (Table 1). California, the major United States lima producer, recognizes a different grouping of cultivars. Their major categories are 1) fresh frozen limas, 2) baby frozen limas, and 3) dry (grain) limas. The fresh frozen category consists of Fordhook bush cultivars. Bush type baby limas with green seeds are included in the second category. Both large and small seeded cultivars of the grain limas are produced and all are white seeded. Nearly all of the large seeded cultivars are vining types. All of the small seeded dry cultivars are vining types, and also are referred to in the trade as "baby limas." This can result in some confusion with the small green seeded baby bush limas used for canning and freezing in the vegetable industry.

In the Upper Midwest, bush cultivars of the baby lima group such as 'Early Thorogreen' have long been used for processing, although thicker seeded types, such as 'Kingston' are becoming more popular (Binning et al., 1985). In the Southeast, baby bush cultivars such as 'Cangreen', 'Nemagreen', 'Fordhook 242', and 'Henderson Bush' are grown for processing and fresh market use. Other fresh market cultivars include the high yielding 'Jackson Wonder' and the delicately flavored 'Dixie Butterpea', two bush cultivars (W. Cook, pers. comm.). Pole cultivars, such as 'Carolina' and 'Florida Speckled' are still used but primarily on a home garden basis.

MAJOR PRODUCTION AREAS

Principal states in lima production for processing are California, Delaware, Wisconsin, Washington, Georgia, Alabama, South and North Carolina, and New Jersey, with lesser amounts found also in New York, Pennsylvania, Ohio, Illinois, Michigan, Minnesota, Missouri, Virginia, Tennessee, Arkansas, Oklahoma, Idaho, Utah, and Oregon. Total acreage of vegetable limas approximates 56,000 acres. Limas for processing as a vegetable in the United States typically are grown under a forward contract basis for a processor, who then assumes responsibility and risk for marketing, similar to that for other processed vegetables. The dry limas of California, however, are marketed by individual growers under a marketing order assuring certain specifications. With input from the Lima Bean Council, the California Dry Bean Advisory Board assists in quality control, market development, and legislative counseling, and in raising funds for promotion and production research. California produces approximately 85% of the United States acreage of Fordhooks and 70% of the baby bush limas for processing. California is also the chief producer of seed limas, producing some 200,000 hundred weight (cwt) annually. Western grown seed is preferred as it is more likely to be free of seed-borne diseases.

CROP PRICE AND VALUE

Over the 10-year period from 1976-'77 to 1985-'86, the value of the California dry lima crop ranged from 28 to 48 million dollars with large seeded limas accounting for 60 to 70% of that value (Table 2). Grower prices averaged $36/cwt for large limas, and $23 for baby limas during that time. Yields varied from 22 to 38 cwt/A for the dry baby limas, depending primarily on year and location, averaging 28 cwt/A. The yield of large dry limas averaged 25 cwt/A. The production area during 1981 to 1985 ranged from 27 to 44,000 acres for large limas and from 24 to 30,000 acres for baby dry limas.

Table 1. Categories of selected lima bean cultivars.

Plant Type	Seed Size	Seed Thickness[z]	Cultivar	Seed Color[y]	Principle Use
Bush (determinate)	Large	Thick	Fordhook 242	---	Processing
			Concentrated Fordhook	---	Processing
			Maffei 57	Green	Processing
		Flat	Burpee's Improved	---	Processing & Garden
			Early Market	White	Dry
			Maria	White	Dry
			Dompe 95	White	Dry
			Ventura Bush	White	Dry
	Small	Thick	Triumph	---	Multiple use
			Baby Potato	---	Multiple use
			Dixie Butterpea	---	Multiple use
			Wasatch Baby Lima	---	Multiple use
			Baby Fordhook	---	Multiple use
			Buttergreen	---	Multiple use
			Emerald	---	Multiple use
		Flat	Clark's Bush	White	Dry
			Henderson Bush	White	Dry & processing
			Early Thorogreen	Green	---
			Jackson Wonder	Purple buff	Garden & market
			Woods Prolific	White	Dry
			C-Elite	Green	Processing
			Thaxter	Green	Processing
			Mendoza	Green	Processing
			Kingston	Green	Processing
			Improved Kingston	Green	Processing
			Bridgeton	Green	Processing
			Maffei 76	Green	Processing
			Maffei 15	Green	Processing
			Maffei 8	Green	Processing
Pole or Vining (indeterminate)	Large	Thick	Challenger	---	Garden
			Burpee's Big 6	---	---
		Flat	King of the Garden	---	Garden
			Large Speckled	Cream & red	Garden
			Burpee's Giant Podded	---	---
			Ventura	White	Garden
			White Ventura N	White	Dry
			Dompe 190	White	Dry
			Lee	White	Dry
			UC8	White	Dry
			Westley	White	Dry

Table 1 (continued)

Small	Flat	Carolina	White	Garden & market
		Florida Speckled Butter	Buff w/ brown spots	Garden & market
		Willow Leaf	White	Garden & market
		Mezcla	White	Dry baby bush
		Westan	White	Dry baby bush
		Wilbur	White	Dry baby bush
		Pat	White	Dry baby bush

[z]"Thick" seeded cultivars also are known as "potato" limas.
[y]Color refers to dry mature seed.

USES AND MARKETS FOR DRY LIMAS

A recent market research study for the California Dry Bean Advisory Board indicated that in the domestic market the largest share of the dry lima crop is marketed as a dry, packaged item. The remainder is canned. Dry, packaged limas are used in the United States in the institutional and home markets as a product for rehydration, similar to that for dry common beans. Dry limas are not as frequently used in processed foods, such as soups and chili, as are dry common beans. The large limas are more exacting as to proper production environment but are preferred by growers over the dry baby limas because of better flavor and, therefore, higher prices. They are grown wherever the environment will permit and remaining market needs are met with the dry baby limas.

Dry limas and dry common beans are similar in essential dietary nutrients, with protein averages near 20% and carbohydrate (subtraction basis) averages near 65%. Baby lima flour contains 5% sugar as compared to 11.7% for soybean and 8% for lupine, cowpea, chickpea and lentil (Sosulski et al., 1982). For a review of the nutritional composition and quality of limas and other legumes, the reader is referred to Aykroyd et al. (1982).

The United States market for dry limas seems stable with a quite resilient base but does not appear to be a growth market at present. The most important market for large limas as a packaged product for retail sale is the southeastern United States. In the market for canned rehydrated dry limas, the northeastern sector of the United States receives 67% and 90% of the large limas for retail and food service outlets, respectively, while 80% of the small limas are sold to retail outlets in the south central region. Approximately 50% of the California dry lima production is exported to Japan. Exportation was initiated when Japan encountered a shortage of the white baby limas from traditional sources. The California dry limas make a better quality, lower cost paste ("Anko") for specialty bean cake manufacture than

Table 2. California production, crop price and value of dry lima beans from 1972-73 to 1985-86.[z]

Large Limas

Crop Year	Annual Production 000 cwt[y]	5-Year Average Production 000 cwt	Annual Crop Value 000 $	5-Year Average Sack Price To Grower $/cwt
1972-73	499		$14,044	
1973-74	621		24,325	
1974-75	685		16,820	
1975-76	432		14,109	
1976-77	528	553	21,492	31.84
1977-78	565	566	17,782	32.39
1978-79	458	534	16,966	31.67
1979-80	529	502	23,048	36.18
1980-81	757	567	30,794	37.80
1981-82	642	590	23,693	37.05
1982-83	573	592	18,697	37.27
1983-84	458	592	23,358	39.43
1984-85	646	615	28,043	39.52
1985-86	929	649	22,210	34.73

Baby Limas

Crop Year	Annual Production 000 cwt	5-Year Average Production 000 cwt	Annual Crop Value 000 $	5-Year Average Sack Price To Grower $/cwt
1972-73	369		6,222	
1973-74	447		14,533	
1974-75	604		9,670	
1975-76	451		7,991	
1976-77	414	457	8,634	19.58
1977-78	492	482	10,042	20.11
1978-79	512	495	11,407	18.29
1979-80	656	505	13,869	19.56
1980-81	447	504	17,530	23.38
1981-82	661	554	17,696	24.49
1982-83	525	560	15,031	25.96
1983-84	468	551	12,439	26.77
1984-85	543	529	13,292	27.74
1985-86	674	574	14,023	24.25

[z] Courtesy of California Dry Bean Advisory Board.
[y] Hundred weight.

limas from their previous sources. California white baby lima production is also more reliable and the export market has remained fairly stable over the past several years.

ENVIRONMENTAL ASPECTS OF PRODUCTION

Moisture

The lima originated in damp, hot, tropical America. Limas will grow under variable moisture levels (Duke, 1981; pers. comm. with H. Erickson, Purdue Univ. and G. Nabhan, Univ. of Arizona). The lima crop ET (water use) is 20 to 24 inches (Osterli, 1986). California growers apply about 3-acre feet of water during the growing season. Moisture requirements coincide with crop needs and vary with soil type and condition, temperature and humidity. Dry limas are even more sensitive than the common bean to rain as harvest time approaches. Excess moisture will discolor the seed, wrinkle the seed coat, and distort seed shape.

Temperature

Limas are frost susceptible and are sensitive to cold, wet soils. Soil temperatures ideally should be 65°F or above for best germination. Throughout their development limas are sensitive to temperatures below 50-55°F and are easily checked in growth.

In the wild, some limas are highly tolerant of heat. However, most of the cultivars grown in the U.S. are sensitive to high temperatures, especially at low humidities. Some lima cultivars drop flowers at temperatures above 90°F. With either a short season or a once-over harvest, maximum pod set at a particular time is essential. If high temperatures occur during the short "effective bloom" period, blossom drop can be severe. Therefore, fluctuation in temperature, characteristic of a continental environment such as ours, may be as important as the temperature *per se*. The vulnerability of the lima crop to high temperatures is further aggravated by the use of early maturing, concentrated-bloom, bush cultivars, as for the vegetable processing market.

Soil

Light textured, well drained loam soils having moderate to high organic matter and a pH in the range of 6.0 to 6.5 are preferable for lima production. The higher mean temperatures of these soils improves seed germination in early plantings. Because the large cotyledons are raised above the soil during germination, the lima is especially vulnerable to soil crusting. Soil crusting following heavy rains or irrigation will be less of a problem on the light textured soils.

CULTURAL PRACTICES

Field Preparation

In the Upper Midwest most of the heavier soils used for limas, i.e. the vegetable processing limas, are fall plowed to improve spring tilth. In the spring, one should avoid overworking the soil before and during seedbed preparation to reduce crusting (Binning et al., 1985). In the spring a pre-emergence herbicide is broadcast and then incorporated by discing (Osterli, 1986). For California production, the field is furrowed out every 30 to 36 inches. A nematocide may be shanked in about 6 inches to the side of the seed row.

Fertilizer

Typically, the necessary fertilizer is added on a 2/3 blend broadcast prior to working the soil and 1/3 banded below the seed depth and 3 to 4 inches to one side at planting. During growth, additional N and K may be added as a sidedressing or via the irrigation system. The lima is not known for particular sensitivity to micro and secondary nutrient deficiencies in our region, but is acutely susceptible to boron toxicity.

Planting

In Minnesota, limas are grown on flat culture in 30 inch rows at 75 pounds of seed per acre, resulting in 3 to 4 plants per foot of row. This plant spacing for baby bush limas is similar in many regions in the U.S., although a row spacing of 33 to 36 inches is also common. Over the past several years in Minnesota there has been a change to high density planting in order to increase yields. A 12 to 14-inch row spacing with 3 to 4 plants per foot of row has been used, requiring 150 lbs of seed. Depending upon the grower's equipment, 4, 6 or 8 rows are planted on a pass through the field.

Trellised types as grown in the south for fresh market usually are grown at low density. For example, in Georgia, limas grown under continuous overhead wire trellis will be planted 2 to 3 per foot in 36 to 48 inch rows (Granberry et al., 1980). If poles are used, hills of 2 to 4 plants, 12 to 14 inches apart in the rows are planted.

Planting depth may vary from 1 to 2 inches, depending on soil texture, temperature and moisture availability, with the greater depth appropriate for light soils which dry quickly. Increasing seed moisture before planting will hasten germination and improve stand establishment (Bennett and Waters, 1984). Limas have also been planted in irrigated loamy sand to improve stand establishment.

Weed Control

Inadequate stands of limas may result in weed problems, particularly since the lima is a full season crop. This allows for ample time for weakening of pre-emergence herbicides and weed growth. In California, several effective herbicides, Sonalan^{R}, Lasso^{R}, and Dual^{R} are applied to control weeds such as nutsedge, nightshade and ground cherry. Shallow cultivation also helps limit weed problems. California limas are planted on beds which are worked with a small spike harrow, a lilliston rolling cultivator, a power tiller or a knife (Osterli, 1986). By leaving the beds intact, the moisture remains closer to the soil surface, aiding herbicide activity and facilitating shallower planting. In the Upper Midwest, one of the more serious weed problems in limas is quackgrass. Field selection or pre-plant use of Roundup^{R} may be most effective.

Harvesting

Various types of mechanical harvesters are used in large scale production of dry limas in the U.S. These harvesters cut off the roots 2 to 3 inches below the soil surface, and windrow the cut vines to dry. Harvesting must be done when the pods are still moist to reduce shattering. The cut vines are left to dry from 7 to 21 days, after which they are threshed, cleaned and sorted. Care must be taken during harvesting and threshing as the seeds are easily damaged. In the U.S. about 5% of the total weight of field-run lima beans is removed during the cleaning and sorting operations. The clean-sorted beans should have a moisture content of less than 15% before they are packed in sacks, polythene bags, or bins, for warehouse storage. More information on harvesting is available in Kay's 1979 paper.

White limas harvested soon upon drying may tend to have a green seed tint but will bleach if left longer on the plant. The green-seeded limas, such as the baby bush cultivars for canning or freezing as a vegetable, will have green cotyledons at dry maturity. Although some bleaching may occur, the green color remains strongly evident.

CONSTRAINTS TO PRODUCTION

Diseases

Seed, Root and Stem Rots. There is a special need for seed treatment to control seed rot and pre-emergence damping-off of seedlings, especially in cold, wet soils. These treatments are not effective, however, against the root and lower stem rots caused by *Pythium*, *Fusarium*, and *Rhizoctonia*. For these, long (4 to 6 year) rotations may be the best control strategy. Rotation should not include both lima and common dry or snap beans, since limas are subject to many of the diseases which affect the common bean. Good soil structure and drainage will also help to reduce these diseases. These diseases have not been as serious on limas as on green peas and common beans in the Upper Midwest.

Brown Spot and Halo Blight. Brown spot, caused by *Pseudomonas syringae* and halo blight, caused by *Pseudomonas phaseolicola* can be serious in the climate of the Upper Midwest. As a preventative, one should start with disease-free seed. These bacterial diseases are quickly spread by driving rains. Streptomycin seed treatment and copper sprays may reduce the yield loss but will not stop a serious infection under conditions favorable to bacterial spread. Brown spot is the more serious of the two on limas (D. Hagedorn, Univ. of Wisconsin, pers. comm.)

Sclerotinia White Mold. As lima producers in the Upper Midwest increase planting density, Sclerotinia white mold, caused by *Sclerotinia sclerotiorum* will become more serious. The fungus is soil-borne and infection takes place through open flowers. The disease is favored by warm, humid weather, a damp soil surface, and a heavy, slow-to-dry plant canopy. Fungicides currently registered for use on lima beans are only partially effective on severe outbreaks and cannot be applied near harvest.

Anthracnose. Anthracnose, a fungus (*Colletotrichum lindemuthianum*) disease attacking pods and foliage, may on occasion be serious. The organism is spread by equipment and driving rains. The use of disease-free seed and seed treated with fungicides will help to reduce the likelihood of a serious anthracnose problem. This disease has not been a significant factor in lima production in the Upper Midwest.

Downy Mildew. Downy mildew, caused by *Phytophthora phaseoli* can be a serious problem on lima beans, especially in warm humid weather. The disease can be controlled through the use of fungicides and removal of bean plant debris from one season to another. Resistant cultivars have been developed but several races of the organism exist and a cultivar resistant to one of the races may not be resistant to another. Although downy mildew is one of the most devastating diseases of limas, it has not been significant in the Upper Midwest.

Insects

Potato leafhoppers, plant bugs, black bean aphids, green clover worms, various loopers, European corn borer, and seed corn maggot and occasionally white grubs, cutworms and wireworms are the most important insect pests of limas in Minnesota and Wisconsin (Binning et al., 1985). The leafhoppers and plant bugs cause blossom failure. European corn borer larvae and loopers may bore into pods and stems, reducing yield and quality of the seed. Wireworms, cutworms, white grubs and seedcorn maggot reduce stands at germination by damaging the seeds or seedlings. Frequent scouting is necessary to monitor the damage caused by such a diversity of pests, particularly since the effects of many of the above insects are not quickly seen upon infestation of the field.

OTHER CONSTRAINTS

Lima beans possess some anti-nutritional materials. Like other legumes, a substantial portion of the phosphorus is in the form of phytic acid, which cannot be digested by humans. Some limas are inedible due to the high content of cyanogenic glucoside, which produces hydrogen cyanide when tissues are eaten or ground. While United States lima cultivars contain as little as 10 to 17 mg/100 g and are safe to eat, certain cultivars may exceed 200 to 300 mg/100g (Montgomery, 1969). Pre-soaking of seeds and long cooking times reduce phytate and hydrogen cyanide content in limas. (Akpapunam, 1985; Ologhobo and Fetuga, 1984).

Legumes are well known for producing intestinal gas (flatulence). The degree of flatulence is dependent on crop species and cultivar. The lima bean ranks below common bean and chickpea in gas forming potential (Calloway et al., 1971).

BREEDING

Relative to many other food legume species the lima has not received much attention on a world basis for improvement through breeding. More than 900 cultivars and wild introductions from around the world are kept in the U.S.D.A. lima bean germplasm collection, constituting an important but largely unused resource. In recent decades new cultivar development in the United States has focused on the bush, small green seeded, processing types and on the large white seeded dry types, which are either bush or vining (Table 1).

The behavior of some germplasm in the tropics and subtropics indicates that the high temperature sensitivity of United States lima cultivars might be further reduced by breeding. Some Mexican limas have been identified which will set pods regularly at 112°F day temperatures (pers. comm. with G. Nabhan, Univ. of Arizona). Neither the very high yield performance nor the high temperature tolerance found in a few of the tropical limas have been completely transferred into adapted types in the United States. Selections having greater tolerance to cold have been developed by Dr. Mike Dickson, New York State Agricultural Experiment Station. At the University of Minnesota, derivatives of experimental hybrids between the lima bean and the wild thicket bean, *Phaseolus polystachus*, appear promising for earlier maturity, small and erect plant size, tolerance to temperature extremes, and small seed sizes. These may offer promise in high density plantings.

PROSPECTS

On a world basis the lima is an important legume food crop. The potential for the lima bean as a grain legume depends on the market for products from the raw beans around the world. In addition, the cost and returns of producing limas in comparison to competing products must be considered. The development of products such as quick cooking lima beans, lima bean powder and lima bean protein isolate may increase dry lima usage in the U.S. and other markets (Kay, 1979). Even with expanded product diversity and markets, the short season of the Upper Midwest presents problems in lima production. Earlier maturing cultivars with a high product to vine ratio and shortened, concentrated bloom, pod set and ripening periods, offer potential for increased production of lima beans in this region.

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