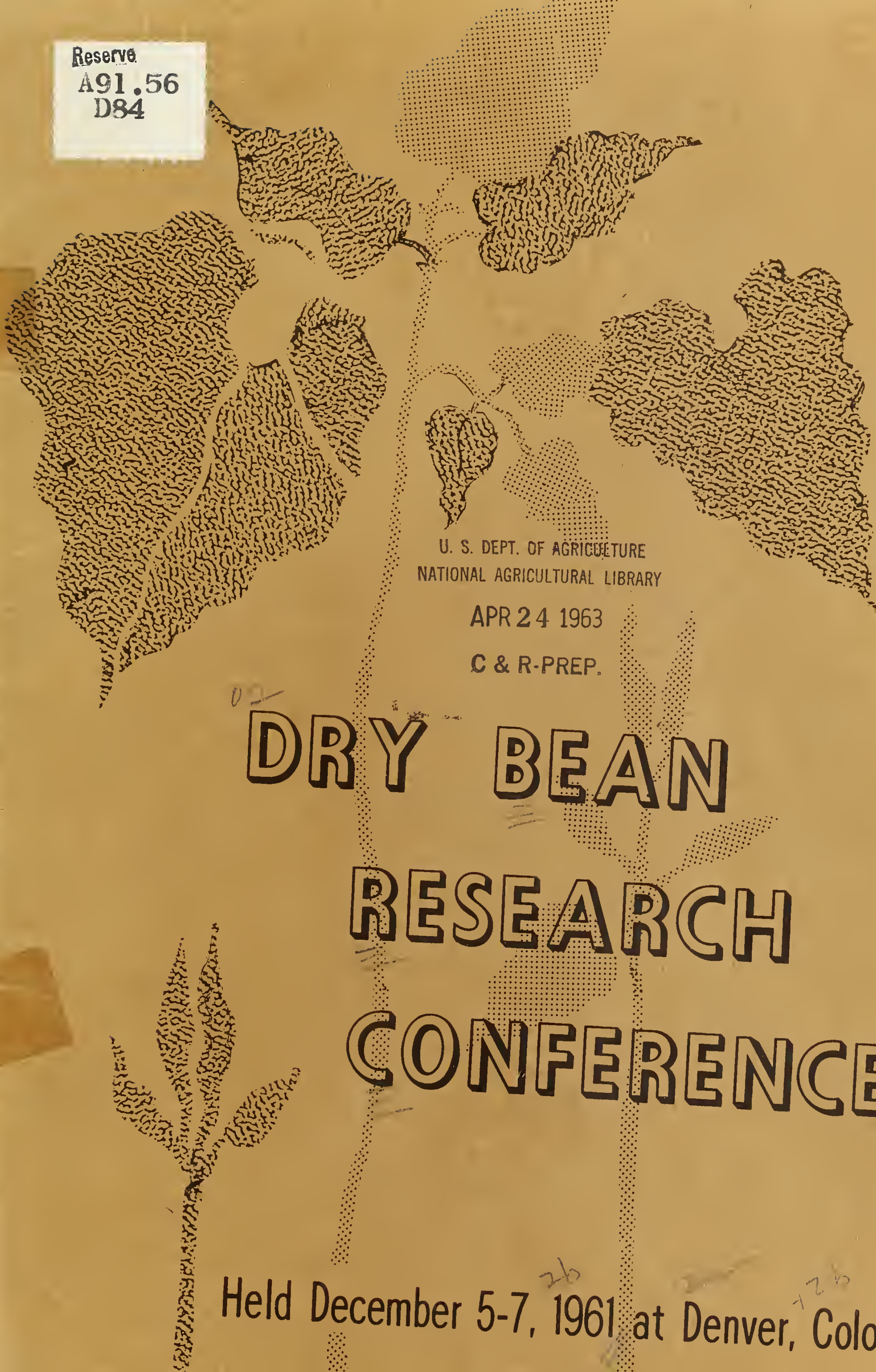

DRY BEAN RESEARCH CONFERENCE

Held December 5-7, 1961 at Denver, Colorado

THE FIFTH ANNUAL DRY BEAN RESEARCH CONFERENCE was held December 5-7, 1961, in Denver, Colorado. It was attended by bean growers, shippers, and processors from various growing areas in the United States and by research and extension workers from State and Federal agencies. Its purpose was to present the results of current research and development pertaining to the production, marketing, and utilization of dry beans and to afford an opportunity for an exchange of information and discussion of problems. Principal topics on the program were new easy-to-prepare food products from dry beans, production developments in the major areas, foreign markets, canning, packaging, and composition.

Sponsors of the conference were the National Dry Bean Council, the U.S. Department of Agriculture, and State Agricultural Experiment Stations. Ralph W. Farr, The Farr Company, Greeley, Colorado, was General Chairman. M. J. Copley, Director, Western Utilization Research and Development Division, Agricultural Research Service, USDA, Albany, Calif., and Maurice A. Doan, Executive Secretary, Michigan Bean Shippers Association, Saginaw, were program co-chairmen.

This report was prepared in the Western Utilization Research and Development Division, Agricultural Research Service, USDA. Copies are available on request from Western Regional Research Laboratory, Albany 10, Calif., headquarters of the Division.

PROGRAM and CONTENTS

PANEL DISCUSSION ON NEW BEAN PRODUCTS
Introductory Remarks

M. J. Copley
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One of the most striking developments in the marketing of food crops has been the recent proliferation of food products available to the consumer. Whereas the average large supermarket carried about 3000 products in 1940, the number is at least double that today. An official of a large grocery chain has said that his firm's buyers are offered an average of 24 new products a day, or 6000 a year. The president of another food chain has estimated that within a very few years his stores will stock 15,000 grocery items. The great majority of these new food products feature convenience for the housewife--they are the "instant" foods, concentrates, dehydrated products, frozen prepared dinners, cake mixes, "boil-in-the-bag" foods.

It appears that if the public is offered a new food product which is more convenient to use and is of good quality, it will meet with rapid and widespread acceptance. In these relatively prosperous times, the housewife seems willing to pay substantially higher prices for many items if they offer a commensurate saving in preparation time and effort. Certainly the fact that 3 out of 10 homemakers now work outside the home is a major factor in the demand for easy-to-prepare foods.

Canned dry beans can certainly be classed as a "convenience" food, but only about one-fourth of the crop is thus processed. Roughly three-fourths of our beans are sold to the consumer in unprocessed form and require a long time to prepare for the table. How then, have dry beans fared recently in competition with other foods on the grocers' shelves?

In the 1940's average per capita consumption of dry beans in this country was 8.2 pounds; in the first half of the 1950's we consumed nearly as much, 8.1 pounds; but in the last five years of the decade the figure fell to 7.6 pounds; and the estimated figure for the year 1960 was only 7.3 pounds.

To halt and reverse the recent downward trend in domestic consumption of beans the industry needs new bean products--modern products which can be prepared for serving in minutes instead of hours. This afternoon we are to hear reports from four organizations that are developing such products. I believe that you will find their papers interesting and significant for the future of the dry bean industry.

INSTANT BEAN POWDERS

H. J. Morris
Western Regional Research Laboratory
USDA, Albany, California

For a number of years, we have devoted part of our research efforts to the preparation of beans in a "convenience" form. Recently, we have prepared cooked bean powders that have some interesting properties.

Method of Preparation. The preparation of the powder is quite simple. The beans are steam-blanched to insure uniform swelling, then soaked overnight. The soaked beans are cooked with meat stock, celery, onions, etc., if added flavors are desired. After cooking, the beans are pureed in the cooking liquor by being forced through a perforated metal screen. The puree is drum-dried.

The best conditions for drum drying any product can be selected only after careful evaluation of the consistency of the feed material, the film thickness applied to the drum surfaces, the drum temperature, and the drum's rotation rate.

The feed material should be thin enough to allow application of a uniform coating on the drum, but the material should contain enough water for good working consistency, since cost of the drying largely depends on the amount of water that must be evaporated. The film thickness applied to the drum should permit rapid and uniform drying.

The drum temperature determines the drying rate, but the nature of the product limits the maximum usable temperature, since the products should be dried without heat damage. The drum rotation rate determines the time allowed to dry the product, since complete drying must take place in about eight-tenths of one revolution.

Conditions used to dry the bean puree were selected after all these factors were studied. The puree had a thick paste consistency and would just flow when poured. The film thickness applied to the double-drum equipment used was 0.006 inch, since the clearance between the drums was 0.012 inch. Temperature of the drums was 260° F. The drum rotation rate was 1.5 r.p.m., which means a drying time on the equipment used of about 35 seconds. Using these conditions, the product comes off the drum in small flakes to thin sheets that are easily broken to a coarse powder by gentle stirring. The yield is excellent, since there is practically no loss in total solids.

Properties. Bean powders prepared in this manner are of course thoroughly cooked. They disperse readily when stirred in water and rehydrate very quickly. They have flavors characteristic of the varieties used as modified by seasoning agents added in cooking.

Varieties. Powders have been prepared from five varieties: large limas, California small whites, blackeyes, pintos, and Red Mexicans. Since the powders from these varieties were very similar with respect to dispersibility and rehydration it is quite likely that many other varieties would be suitable for use in powder production. Good-quality powders have been prepared from green and yellow dry peas.

Uses. The powders can be used in several ways. Soups can be prepared almost instantly by stirring the powder in hot water. Bean puree of mashed potato consistency can be readily prepared by limiting the amount of hot water added. Beans in this form are attractive. Excellent refried beans can be prepared from the bean puree. In fact, a powdered bean product is prepared and marketed in Mexico for this purpose at present. Other possible uses are as meat extenders in meat patties or meat loaves, or as the bean component in chili.

Stability. Stability of bean powders during storage is being studied in a fairly extensive experiment. Powders of two moisture levels are being stored in air and nitrogen at three temperatures. Use of antioxidant is also being studied. The experiment is designed to run for at least as long as the shelf life of some products being marketed in volume, for example, potato flakes and granules. This does not mean that the bean powders are not subject to deterioration. The higher moisture powder stored in air became quite unpalatable in two months at 100° F. Lower moisture samples packed in nitrogen and stored at 72° F. have remained excellent in quality.

Discussion. There are several reasons to believe the bean powders just described could be marketed successfully. They are simple to prepare. They may be prepared from many bean varieties, thus affording a whole family of powders, each one with its own distinctive flavor. Multiple end uses are possible, for example soups, mashed beans or puddings, meat extender, refried beans, chili, and perhaps dishes such as molded gelatin salads. If flavor variation is desirable, the powder can be used in special formulations.

Thus far, their stability is encouraging. It's possible that they may have both a military and a civilian use. When we learn how beans can be modified to reduce or control their flatulent property, it is likely that bean powder can be more effectively modified than whole beans.

DRIED PRECOOKED BEANS

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Several years ago the U. S. Quartermaster Food and Container Institute initiated a series of Industrial Preparedness studies on precooked dehydrated legume vegetables (lima, navy and small red beans). Vacu-dry Company was awarded the contracts for these studies.

The studies had their origin at the Institute in a research program aimed at developing "instant" precooked beans for use in operational rations. The objective was a bean which could be reconstituted ready for consumption merely by the addition of hot water at 180° to 190° F. The results of these preliminary investigations have been reported by Feldberg, Fritzsche, and Wagner, in Food Technology, November, 1956, under the title, "Preparation and Evaluation of Precooked, Dehydrated Bean Products."

During their investigations these workers found that precooked beans split wide open immediately upon introduction into an air dehydrator. This splitting is known as "butterflying." To circumvent this undesirable effect, a freezing step was inserted between precooking and dehydration. This freezing procedure proved effective in reducing "butterflying." Recognizing that the freezing step involved extra handling and processing costs, another approach was tried: the use of high-humidity dehydration conditions during the initial stages of drying.

"Butterflying" is caused by the differential rate of drying between the skin and the cotyledon. The skin dries rapidly and contracts. The slower-drying interior develops vapor pressures that rupture the skin and produce the "butterflying" effect. It was hoped that high-humidity conditions would retard the rapid drying of the skin and that after sufficient internal moisture had evaporated, the internal forces would be reduced to that level where subsequent "butterflying" would not occur.

The commercial feasibility of preparing precooked, dehydrated lima and precooked, dehydrated navy beans by both prefrozen and high-humidity techniques was explored in the first two Industrial Preparedness studies. These studies were completed by Vacu-dry Company and reported to the government in 1959. The results for navy beans were later projected to and tested for small red beans through limited procurement contracts. Each report discussed manufacturing processes, equipment requirements, operational considerations, personnel requirements, and costs. They also provided data for use in establishing specifications for each legume.

Some of the more important conclusions were as follows:

1. Navy and small red beans should be blanched prior to soaking. Vacu-dry Company introduced the blanching step in the commercial feasibility studies primarily to insure complete rehydration of navy and red beans in the subsequent soaking operation. Prior to the use of this technique, the degree of rehydration was variable. It was subsequently noticed that this blanching produced a product which possessed improved storage stability over nonblanched beans.

This provided a clue to the solution of a problem which had been of great concern to the Institute. The principal difficulty encountered with precooked dehydrated navy and small red beans was the rapid development within 2 to 3 weeks of storage at 100° F. of an unacceptable flavor and odor. This deterioration was presumed to be oxidative in nature and was attributed to the absorbed oxygen tightly held by the beans even when subjected to vacuum or nitrogen packing conditions.

The blanching operation revealed the possibility of lipoxidase activity in the rapid deterioration process. A project undertaken by the Chemistry and Microbiological Branch, Food Division, at the Quartermaster Food & Container Institute proved that this was actually the case. The results and findings were reported just recently by Robert B. Koch and Bruno Gini in a paper titled "Enzyme-Catalyzed Oxidation in Legumes--The Implications of Lipoxidase Activity" in the December 1960 Activities Report of the Institute. As a result of these findings, navy beans and small red beans are now routinely blanched for 15 minutes in atmospheric steam prior to soaking.

2. The second conclusion stated that the high-humidity process cannot be considered to be acceptable. (a) First, "butterflying" was not sufficiently reduced by this method over plain air dehydration to warrant adoption of this procedure. (b) Second, the drying time was prolonged, and (c) the use of live steam raised havoc with the structural components of the first compartment of the dryer.

High-humidity conditions were obtained by injecting live steam into the air stream of the first compartment of the Proctor and Schwartz dehydrator. The degree of humidity was achieved by recirculating part of the air within the compartment and by metering the amount of steam injected into the air stream. A hygrometer controller which activated the live steam line was used to achieve the desired relative humidity of 70% RH at 163° F.

The time within the compartment under high humidity was 15 minutes. This time was set by controlling the rate of belt movement. This rate was identical for the second compartment, since it was serviced by the same belt. The rate of speed of the second belt could be reduced, but by doing this the belt loading was increased from an initial 1-1/2 inches to about 6 inches deep. This depth retarded the rate of drying. The drying time was of the order of 6-3/4 hours and the rate of production of finished product was about 500 pounds per hour.

3. The third conclusion stated that the production of precooked dehydrated beans by the prefrozen technique was commercially feasible. The beans were received at the plant in a precooked IQF condition and were simply metered into the dehydrator at the rate of 2,000 pounds per hour. Finished product rate was about 1,000 pounds per hour. The beans dried to about 4 percent moisture in approximately 4 hours at 163° F. Most important of all, the degree of "butterflying" was greatly reduced. Upon subsequent rehydration of the end product, the beans resumed their normal cooked shape and the splitting was barely discernible.

4. The fourth conclusion was that the cost of production of precooked dehydrated beans can be substantially reduced if the complete operation, including the freezing phase, can be conducted at the dehydration plant. In the commercial feasibility studies of 1959, the individually quick frozen IQF beans had to be prepared at an outside freezing plant simply because the dehydration plant was not equipped with freezing facilities.

The freezing plant had to perform all the preliminary operations prior to freezing. This created a serious production scheduling problem. The freezing plant had blanching, soaking, and freezing facilities but not in the correct physical relation to each other. It did not have pressure cooking equipment. This had to be supplied by the dehydration plant. A special line had to be installed to include all of the processing equipment in the correct sequence and modifications had to be made to insure uniform product flow at realistic rates.

It was virtually impossible to superimpose this task upon the full production load at the height of the harvest season. This meant that the beans had to be processed through the freezing stage during lulls or during the off-season and stored in frozen storage against the needs of the dehydration plant. However, by conducting the total operation from dry bean to finished product under one roof, it would be possible to achieve better control, greater flexibility of operation and, most important, reduced charges for transportation, frozen storage, and overhead.

Lima beans created a special problem. In this case, the fresh bean was required instead of a dry bean as with small red and navy beans. This requirement tied the lima beans right into the harvest season. Moreover, specifications stated that only small beans 30/64 to and including 34/64 inch in width, or medium beans 34/64 inch to and including 38/64 inch in width could be used.

This requirement precluded the dehydration plant from direct acquisition of lima beans from the grower, since the dehydration plant had no outlet for the over- or under-sized beans. They would have become an economic loss whose cost would have had to be borne by the properly sized beans. The dehydration plant, therefore, must turn to the frozen lima bean packer for its source of fresh lima beans to meet these specifications.

The frozen lima bean packer quality grades but does not normally size grade his lima beans. However, the packer can size grade the lima beans if prior arrangements are made. Moreover, they already possess channels whereby they can sell the lima beans falling outside specification size limits. Since the frozen lima bean packer blanches his product, it is fairly easy to extend the blanching operation to a full cook operation. This can be done without any changes in the processing line whatsoever and usually without sacrificing rate of through-put.

Lima beans, unlike small red and navy beans, must be sulfited prior to dehydration. The best time to do this is right after the cooking operation and before freezing. The frozen lima bean packer will probably require, at least initially, some assistance from the dehydration plant to insure that the right concentration of sulfur dioxide is added to the beans. The sulfur dioxide can be administered in the form of a sulfite spray as the beans pass over a belt. In this way the dehydration plant received properly sized and properly prepared IQF lima beans ready for dehydration. It is then only necessary to meter the frozen beans into the dehydrator without any additional preparation at the dehydration plant.

At the conclusion of the 1959 commercial feasibility studies, the following statements and recommendations were made: "The military might of our government is interwoven with the industrial potential of the nation. The best insurance to the government of substantial supplies of military rations is a large and varied food industry.

"In a state of national emergency the government can draw immediately for its food requirements from established processing plants. Construction of new food processing facilities to provide essential rations previously developed by research and development groups but not yet in commercial production can conceivably seriously impede any war effort.

"In a nuclear conflict there is a grave possibility that there will not be sufficient time to provide specialized military rations in quantity to our nuclear forces unless these rations are already in production.

"Perhaps the best way to insure production facilities for potential military food procurement use is to develop a food product with equal military and civilian potential. In this case, the civilian market will finance processing operations and the plant's full capacity will be available to the military in time of war. But in those cases where this happy solution cannot be achieved, it will be desirable for the government to sponsor the construction of plant facilities and to support these facilities by agreeing to purchase specialized military rations, serving them to our current global forces, even though these military rations might be initially more expensive than equivalent civilian rations."

The last Industrial Preparedness study on precooked legume vegetables was in accord with the above recommendations. The primary purpose is "to develop and provide a practical system for mass production of precooked dehydrated legume vegetables (lima beans, red beans, and navy beans) using commercially acceptable processing methods and equipment. A production facility will be assembled which will demonstrate the feasibility of the production system developed, and which will provide data for the construction of similar or larger scale production facilities."

The production system had to be geared to a rate of 2,000 pounds of IQF beans per hour and capable of operating continuously for 8 hours. To assemble this system, Vacu-dry Company installed a special preparation line just for legume vegetables and integrated this line with its existing dehydration line. This line can operate continuously around the clock. This system has already been put into operation at the Vacu-dry Plant at Selah, Washington. It is available for large scale commercial production, both to meet government requisition requirements for "instant" type beans and to service civilian commercial needs. It can also produce simmer-type beans for soup, casserole and similar uses. The time of simmer of the finished product can be simply controlled by the degree of cook in the preparation stages. The line is currently being tested for fresh green peas and whole kernel corn. Other vegetables will also be evaluated.

And so the current Industrial Preparedness study completes a full circle from laboratory, pilot plant, feasibility evaluation to full-blown production capabilities.

PRECOOKED, DEHYDRATED WHOLE BEANS AND GROUND BEAN SOUP STOCK

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When rehydrated large lima beans are heated and subsequently dried, a large proportion of the beans are split or broken; the proportion depends primarily upon the method of drying. In an attempt to lessen the damage, several drying methods were used: initial high humidity, freezing followed by conventional low-humidity drying, and lyophilization. The procedure used to prepare the beans for drying was modified from the method developed previously and consisted of soaking for 2 hours and then blanching in flowing steam for 20 minutes, followed by hydration for 6 hours at 80° to 90°F. The beans were then removed from the soak water, placed in fresh 2.5 percent salt brine, cooked for 45 minutes in steam at atmospheric pressure, and drained.

The high humidity method, described previously, reduced the number of defects from 82 percent obtained by conventional drying to an average of 40 percent. The freeze-step method consisted of freezing the drained beans at -20°C. in shallow trays which were then dried in low humidity air at a dry bulb reading of 165°F. The number of damaged beans was lessened to an average of 19 percent by this method.

When the drained beans were lyophilized, under a vacuum of at least 150 microns mercury, defects were reduced to 2 to 5 percent.

Precooked, dried beans prepared by the freeze-step and lyophilization methods were packaged under 10 to 14 inches of vacuum in 2-1/2 size cans and under nitrogen in vapor-tight plastic bags. The beans contained approximately 4 percent moisture. Storage stability studies are in progress at 20°, 30°, and 37°C.

Hydration of the finished product to firm cotyledons was faster with the lyophilized beans (30 sec. to 90 sec. in water at 90°C.) than with the freeze-step beans (2 to 5 min. in water at 90°C.)

Dried soup products were prepared by mixing ground precooked lyophilized beans with various dehydrated vegetables (onion, garlic, celery, bell pepper, and leaks), and the addition of such condiments as salt, pepper, and oregano. Several formulations were judged to be acceptable by a taste panel.

DRY BEANS FOR MILITARY USE

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The logistics of military feeding have always been an operation of unbelievable complexity and of staggering proportions. Each branch of the Armed Forces, as well as the subdivisions of these branches, have special food requirements. The impact of radical new weapons, in this atomic age, on the concepts of tactical employment of troops has added to the complexities of feeding logistics. In previous conflicts company or larger group feeding situations were predominant in all but the initial phases of a campaign and limited warfare under stable and static conditions prevailed. World War II type operational rations could meet the requirements of this type of situation. A highly mobile, fluid, and dispersed operation envisioned in concepts of future all-out warfare imposes a requirement for a feeding system having substantial capability for supporting troops in small detachments and individual feeding situations. Logistically our current rations fall short in one or more of the following attributes:

1. Preparation time and required preparation equipment excessive.
2. Trained personnel required for its preparation.
3. Storage life short without refrigeration.
4. Excessive weight and/or space per unit of food served.

Recognizing the potential of precooked dehydrated foods toward overcoming many of the envisioned shortcomings of our current ration, a research and development program was initiated in 1955. Much has been accomplished. Prototypes of many dehydrated foods have evolved which are easy to prepare and require no complicated equipment or skilled cookery. In fact, preparation is largely a matter of "add hot water and stir" and can be done by the members of a combat team in a matter of a few minutes. Typical of the items developed are precooked dehydrated navy beans and precooked dehydrated red beans.

Being aware that the successful development of prototypes in the laboratory was a long way from insuring the availability of the items for troop feeding, the Quartermaster Corps negotiated with industry for an Industrial Preparedness study. This study was designed to ascertain the commercial production feasibility of dehydrated navy beans. The contract for the study was awarded to the Vacu-dry Company. Results of the study completed in 1959 indicated:

1. Production of precooked, dehydrated navy beans was commercially feasible.
2. That freezing of the cooked beans prior to dehydration as opposed to drying in high humidity air resulted in a more even textured rehydrated product and better controlled "butterflying" of the dehydrated product.
3. That the beans could be prepared in commercial volume using currently available plant facilities.

Although the study adequately demonstrated the production feasibility of precooked dehydrated navy beans, subsequent investigations revealed additional problem areas:

1. During storage, the dehydrated product developed a "fishy" odor and flavor. Since the processing of beans included a H_2O soak at ambient temperature for several hours prior to heating, it was postulated (a) that lipoxidase was activited by H_2O

uptake, and (b) that these enzymes, through their normal action, added molecular oxygen to unsaturated fatty acids in the oil of the seed. Adding oxygen to unsaturated fats, especially linoleic acid by lipoxidase, results in the production of a hydroperoxide. This latter compound is highly unstable. It produces odoriferous breakdown of products similar to those produced by autoxidation of fat but, unlike fat autoxidation, does not need the presence of molecular oxygen for the production of "rancid odors and flavors." Research conducted at the Quartermaster Food and Container Institute for the Armed Forces indicated that lipoxidase could be inactivated by steaming the dry beans for 15 minutes at 212° F. when employing bed depths not exceeding one inch.

2. The product, while exhibiting good rehydration properties in hot water, did not reconstitute satisfactorily when a dehydrated tomato sauce was mixed with the beans prior to rehydration. Rehydration in the presence of the dehydrated sauce was considered essential for maximum operational efficiency. Research at the QMF&CIAF led to a modification in the process, namely, conditioning of the bean prior to cooking, which resulted in a better texture in the end product.

3. Under the terms of the contract details of the study could not be revealed to industry, in general; thus the potential for establishing an adequate production base was lacking.

4. The commercial production of precooked, dehydrated red beans had not been demonstrated although research at the QMF&CIAF had indicated processing conditions similar to those employed for navy beans would produce a satisfactory product.

Therefore, in 1959, the Quartermaster Corps sponsored another Industrial Preparedness study which has as its objective the commercial production of precooked dehydrated navy and red beans, having the desired quality characteristics and making available the results of the study to industry.

The study has been completed. The products produced have the desired dehydration and rehydration characteristics. The final report, when completed, will be made available to industry. The report will contain detailed information relative to processing conditions, equipment, plant design, personnel, production cost etc.

Both of the previously mentioned Industrial Preparedness studies were conducted employing a procurement document which we call a purchase description. This document, as such, cannot be used for continuous procurements as it contains no quality assurance provisions. Experience gained from the two Industrial Preparedness studies indicated changes be made in the procurement document in order to better insure its workability. These changes have been made, the Inspection Division of the Military Subsistence Supply Agency has incorporated quality assurance provisions, and a new procurement document called a limited production purchase description, which is the forerunner of a proposed military specification, has been published. This document must be production tested in order to ascertain its workability.

Now let me tell you how the military has geared itself to using these dehydrated foods as well as other new foods. A new joint Army-Navy-Air Force regulation dated 1 May 1961 entitled, "Subsistence Supply Single Manager Subsistence System, Integration of New or Improved Subsistence Items into the Military Supply System," has been issued and put into effect. I shall read the purpose of the regulation exactly as it appears in paragraph one, of the regulation --

"1. Purpose -- These regulations establish policies and procedures for orderly integration of both newly developed and technically improved subsistence items into the military supply system and planning for phase out of those items which are to be replaced." Supporting this regulation is a QM Corps implementing regulation which requires close coordination between Headquarters, MSSA, The Army Subsistence Center, and the QMR&E Command in development and execution of the new and improved food items plan for introduction into the military supply system. Execution of the plan works somewhat as follows:

(1) As a new or improved item approaches completion of R&D, it is listed in a publication entitled, "Procurement Instrument Release Forecast." Items are programmed in this document at least two years prior to availability to the supply system. All pertinent information is listed on an individual sheet of the forecast and published copies are distributed to the appropriate offices within the Army, Navy, Air Force, and Marine Corps. Twice each year this forecast is brought up to date.

(2) Planning by all potential users, procurement and distribution personnel as well as budgeting officials, is based on this document.

(3) This instrument forecasts when a purchase description will be available for production testing, when such testing will be completed, and when a suitable purchase instrument will be available for regular procurement purposes.

Production testing is the limited quantity procurement on the proposed specification, in purchase description form, to prove workability of the document: As soon as production testing is completed, the results of such testing are reflected in a revision of the proposed specification and formal coordination with industry and other government agencies is commenced. In the meantime, product resulting from production testing is used by all of the military services in order to become acquainted with the specific item. In the event there is immediate need for an item, the revised proposed specification is published as a purchase description to be used until a formal specification is published. Production testing for precooked, dehydrated navy and red beans has been scheduled for completion by 1st Quarter of Fiscal Year 1963. Large scale procurement of precooked, dehydrated navy and red beans should commence after completion of the production testing.

While the wheels of progress do not always move as rapidly as many of us would like, we feel that we have made good progress in the direction of insuring the availability of these products to our service men. I am sure that all in attendance recognize the military interest in these products as indicated by the dollars spent in research and development. I am also sure that you appreciate the current position of the Armed Forces in that there are far in excess of 2-1/2 million men in uniform, and the number increases daily, each of whom consumes about the same quantity of food each day as each of you. We do constitute a large potential market, but it is not unlimited. I am sure that the military would selfishly like to see an industrial production capability commensurate with operation requirements in times of peace or total mobilization. The military is currently considering substitution of precooked dehydrated navy and red beans for dry beans in both the A and B rations and canned beans in the A ration. The final decision, to a great extent, will depend on the results of the production test. With this in mind, I would welcome the opportunity to talk with those of you representing companies which may have an interest in producing these items.

Let me say that you must have confidence in our desire for dehydrated food of high quality. The military cannot alone support the industrial production potential required for an all-out fight to sustain our way of life. We shall car as much of this load as taxpayers permit. In past research and development, we h... shouldered a fair-sized load of investment. We hope the military can continue to invest in activities designed to improve rations. We are looking toward enjoying the results of many years of developmental effort.

RELATIONSHIP BETWEEN CONSUMPTION OF DRY BEANS AND FLATULENCE IN HUMAN SUBJECTS

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University of Illinois, Urbana

The twofold object of this report is to briefly describe the results of our research on the relationship between dry bean consumption and flatulence production in five male subjects and to make recommendations for further study of the problem.

The usual experimental procedure was to put the subjects (age range 25-55 yrs.) on a prescribed diet for two weeks that was nutritionally adequate but free of beans. During this period the subjects consumed the same amount and kind of food each day. By means of chemical analysis of samples and feces excreted, balance studies on such items as nitrogen and certain minerals could be determined. Each subject was also scheduled to collect two hour samples of flatus on two days of each week. On the days assigned, he would collect for a two hour period after lunch and dinner, starting within one hour after the meal was consumed. In all cases, the volume of flatus passed and its chemical composition were determined.

After the two weeks on this basal non-flatulence producing diet the subject would begin another two weeks' diet in which different forms of dry bean preparations were consumed. This diet was adjusted so that it was isocaloric with the basal diet. In some cases the amount of beans consumed was as much as 50 percent of the diet. During this period the same observations were made on the subjects as previously described.

In the course of experimenting, the preparation as well as the level of beans consumed was varied. Specifically we have studied the effects of a name brand of (1) pork and beans, (2) Boston baked beans, (3) dry lima beans, and (4) a preparation of pork and beans passed through a mill to rupture the cellular-like masses of starch found in beans. It should also be mentioned that an experimental run was made in which the subject consumed methyl-cellulose wafers with a fibrin content equivalent to that found in beans. This was done to establish the fact that the cellulose content of beans was not related to the mechanism of flatulence production.

In general, the results would indicate that we now have enough objective evidence to state that when beans are consumed under the conditions of our experiments, there is something in the bean that can alter the normal physiology of the gastro-intestinal tract so that flatulence production is markedly stimulated. One of the most striking observations is that the average flatus production, while on the basal diet, is 16/cc./hr. with a CO_2 composition of 10 to 12 percent; but on a pork and bean diet (50 percent of total caloric consumption) the average volume changes to 190/cc./hr. with a CO_2 composition of the flatus increasing to above 50 percent.

Furthermore, as a result of our present experiments on both man and animals, we would like to submit the following hypothesis as to how beans influence the physiology of the gastro-intestinal tract and in turn, cause excessive flatulence. Under normal conditions there is secreted into the mouth and intestines rather large quantities of CO_2 in the form of sodium bicarbonate. This fact is well established and supported by examination of the chemical composition of saliva, pancreatic, bile and intestinal secretions. The CO_2 can be liberated from the sodium bicarbonate by either dissociation of the action of the gastric acid in the stomach and small intestine. As the CO_2 passes along the gastro-intestinal tract, it is very effectively absorbed into the bloodstream so that by the time it passes through the colon along with the other gases that make up flatus, its concentration is usually around 10 to 12 percent. The O_2 of normal flatus is approximately 3 to 4 percent; H_2 and CH_4 often vary widely from individual to individual. The N_2 percentage concentration determined by difference is also variable.

When beans are consumed, the only thing markedly changed is the volume and percentage concentration of CO_2 in the flatus; this suggests that the CO_2 which is normally produced in the gastro-intestinal tract is not being absorbed as effectively as is normal, because of the presence of some inhibiting agent. Another possibility is that the motility of the gastro-intestinal tract has been stimulated so that the CO_2 present is moved along at such a rate that it cannot be effectively absorbed.

From the data so far collected, it would appear that the hypothesis above is tenable and that there is some sort of alkaloid or drug present in the beans that can serve both as a carbonic anhydrase inhibitor and a stimulator to the motility of the gastro-intestinal tract. It is our present desire to find out more about the chemical composition of beans and test some of the chemical fractions first on animals and then on human subjects to find whether the active compound can be isolated and identified.

Along with further research on this problem, an effort will be made to establish a satisfactory semi-quantitative technique for testing different food samples as flatulence stimulators which can be used in the hands of laboratory technicians.

It is believed that the use of Borgström's technique for the final study of the ultimate fate and effects of beans in the small intestine would be most desirable. Although this particular type of work involves considerable technical detail and chemical analysis, and can be done on only two or three subjects, it should afford information on the location of gas production, motility, and digestion in the human that would be very modern and up-to-date.

WORLD BEAN SITUATION, 1961-62

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World bean production in 1961 seems to have been above a year earlier. How much is not known because of lack of official estimates from countries which produce one-third of the world's beans. In the rest of the producing area (28 countries reporting) the 1961 crop totaled 101 million bags, or 1.7 million above 1960, 4 million above 1959, and 10 million above the 1950-54 average.

These increases are less significant than their magnitude suggests because most of the increase was in Brazil whose large production is largely isolated from international markets. Brazil neither imports nor exports much beans. Of greater significance is the fact that 1961 bean production was down 2.3 million bags from 1960 in Western Europe, the world's largest importing market; and up 1.3 million bags in the United States, the largest exporting market.

These opposing situations apparently should stimulate trade in 1962. But the imbalance is offset to some extent by other factors. The kinds of beans preferred and normally eaten in the major shortage areas differ considerably from the kinds in major surplus in the U. S. Also, there are artificial barriers to the free flow of international trade in several shortage areas. The major surpluses in 1961-62 are U. S. pea beans, used principally by canners, and pintos, used almost exclusively in the U. S. and Mexican grocery trade. The major 1961-62 shortages are in Yugoslavia and France, where canning is negligible. Pintos are practically unknown and major consumption is the larger white beans. The problems created by taste or use preferences and by trade barriers vary from country to country; therefore, the principal countries are treated separately below:

IMPORTING MARKETS

Yugoslavia: The sharpest decrease reported in 1961 production was in Yugoslavia where the crop was 3.1 million bags, or 35 percent below 1960 and almost 2 million bags below 1959. Yugoslavia has imported U.S. beans in several previous years, nearly all under U.S. Government export programs. Since World War II, Yugoslavia has exported beans in some years and imported in others. Before the war, Yugoslavia was a sizeable exporter of beans to Western European countries. Yugoslavs prefer white beans of the larger grocery types. It has requested no beans from the U.S. under Government programs so far in 1962.

France: The second sharpest decrease was in France, where the 1961 crop was 600,000 bags or 22 percent below 1960. It was almost as low as in 1959 when France opened its market to U.S. beans for the first time after the war. In the 1959-60 season, France purchased 232,000 bags of U.S. beans. Of these, 127,000 bags were pea beans and 97,000 bags were Northerns. France purchased some U.S. beans late in 1961.

France normally imports 300,000 bags annually, but is expected to import 800,000 bags in 1961-62. France uses beans for two purposes: a moderate quantity for canning, for which pea beans are well adapted, and a larger quantity for the grocery trade. For the latter, the French prefer the larger white beans, such as the French flagelet, which is similar to the U.S. Great Northern or the larger white beans of Eastern Europe. France usually buys in Eastern Europe and Africa.

Spain: The Spanish 1961 bean crop is estimated at 100,000 bags less than in 1960, but double the level of 10 years ago. Spanish per capita consumption has increased in recent years, now averaging about 9.5 pounds. This is up one pound from the 1950-54 average, but only two-thirds of the pre-Spanish War average of 14.6 pounds.

The consumption rise has resulted largely from increased domestic production, as there have been few imports until the last two years. This recent move toward greater imports has been accompanied by a slight two-year downward trend of Spanish production. There should be even less production in 1962 because of the Government's program to increase wheat acreage and the likelihood that cotton acreage will expand due to favorable returns from cotton in 1961.

Bean imports were expected to pick up in 1962 due to the shorter crop. Also, imports of beans were put on the liberalized list on September 1, 1961. From now on, the General Supply Commission will lose control of purchases abroad. The United States has been the most important source of Spanish bean imports in recent years, although principally under U.S. Government programs. Spain has no large bean canning industry and uses principally grocery-type beans.

Italy: Historically, Italy has imported considerably more beans than it has exported, but this situation has reversed in two out of the three last years. Thus, notwithstanding a 6 percent shorter crop in 1961, the production was still one million bags or 30 percent above the 1950-54 average. Italy is now exporting a few beans to France and West Germany and expects to export about 100,000 bags in 1962. Italy usually exports beans even when importing. Each year, 5,000 to 10,000 bags of Italian Cannellini beans come to the United States for use by people of Italian descent.

Greece: Greece does not expect to import in 1962 due to carryover from its record 1960 crop. The 1961 crop, although down from the preceding year, was the second largest on record. Because of its large crops in 1960 and 1961, Greece recently sold 350 tons of beans to Israel, and the Greek Government purchased 450 tons additional to strengthen the sagging domestic bean prices. These beans will be used by the Greek armed forces, which previously have been supplied with imported beans purchased under the now familiar Greek tenders.

United Kingdom and Germany: The two largest bean importing markets in Europe produce few, if any, edible beans; thus, the decline of 1961 production has little effect upon the 1962 demand for imports in these countries. Bean imports into the United Kingdom average almost 1.5 million bags a year and are used for British canning and the grocery trade. The substantial and growing canning industry uses about 1.0 million bags a year. Canners prefer smaller white beans, such as Michigan pea beans, Chilean Arroz, and the smaller white beans of the Danubean Basin. Some larger beans, including limas from the Malagasy Republic, also are canned. The grocery trade uses larger white and colored beans. The colored beans are used primarily by immigrants who prefer beans from their native lands. Reportedly, British canners now have stocks sufficient for several months' operation, which is normal for the canning industry. Stocks in the hands of traders who supply canners or grocers are reportedly below normal.

Bean imports into West Germany are used for feed, grocery, and canning in that order of importance. Of the 1.2 million bags imported in 1961, almost half were low-cost beans from Communist China, probably intended for livestock feed. The other half, mostly good quality, was used in the grocery trade, with 130,000 bags for canning. There is a shift in German consumption patterns from household cooking toward factory preparations of packaged and canned beans. Whereas 5 canning factories were canning dry beans in 1958, today there are 20 factories. Imports of food beans for 1962 are expected to be 350,000 bags. Most of these will be for the grocery trade where the larger white beans are preferred.

Cuba: Outside Europe, the largest importer has been, and possibly still is, Cuba. No information is available directly from Cuba, but it is known that Cubans have been purchasing beans in Eastern Europe, Chile, Africa, Canada, and Japan, thus absorbing supplies that otherwise would compete elsewhere with U.S. beans.

Mexico: Mexico reports 1961 production at a record 13.7 million bags, up 400,000 from last year and almost 8 million bags above the 1950-54 average. During the U.S. marketing year ending August 31, 1961, the United States sold 460,000 bags of pinto beans to Mexico. Probably due to the larger crop, Mexican bean prices have declined. Black bean prices dropped from $9.15 per cwt in January, 1961, to $8.65 the following November; red beans from $9.35 to $7.45; and Bayo gordo from $8.70 to $5.25. It would appear that the Mexican demand for U.S. pinto beans will be less in 1962.

EXPORTING MARKETS

Western Europe bean imports came principally from the United States, Eastern Europe, Chile, Africa, and Japan in that order.

United States: The United States has a sizeable exportable supply this year consisting principally of pea beans, the bulk of which normally goes to Britain for canning; and Pintos which go principally to Mexico. The supply of pea beans is at a record high.

Balkans: Production data are not available from the Eastern European Communist areas, but 1961 is known to have been droughty. The Danube River was at its lowest in 100 years, so low that ships were tied up. The drought broke in November. Fall plowing was difficult because of the dryness. Corn production was reduced 20 percent on the average, and as much as 35 percent in Yugoslavia and Hungary. Since 40 to 80 percent of the beans in these countries are interplanted with corn, the 1961 bean harvest undoubtedly was low.

In addition, exports from these countries have declined 70 percent in the last three years, notwithstanding some good crop years. In 1959 these countries produced good crops. Nevertheless, Western Europe imported only 360,000 bags of Eastern European beans that year, and only 340,000 bags in 1960. Western European importers report that few beans will be exported from Rumania or Hungary this year and less than usual from Bulgaria.

Chile: Chile's 1961 crop was harvested in March and April and probably is now sold. The 1962 crop will soon be harvested. In the last two years, outbreaks of weevil have been serious enough to cause Germany to cease buying Cristales. The Germans report weevils in Arroz beans also; however, control measures are reported to be improving the weevil situation with respect to Arroz for export. The quality of Arroz beans in Chile has deteriorated in recent years, probably due to inbreeding.

Africa: There is little information concerning bean production in Africa in any year. Western European importers have been importing about 500,000 bags annually from all of Africa, about half of which have been butter beans from the Malagasy Republic. Quantities of smaller white beans have been imported at a cost low enough to suggest that they are used in feeds; probably a few go to the grocery or canning trade.

Japan: Japan's bean crop, exclusive of Adzukis (cow peas) and other pulses, declined in 1961 to 2.8 million bags or 11 percent below 1960 and 15 percent below 1959. Bean consumption in Japan is rising because of improving economic conditions. Japanese exports in 1960 totaled 400,000 bags of kidney-type beans and in January-June, 1961, 150,000 bags. In 1960, 175,000 bags went to Cuba; 190,000 bags went to Western Europe; and 43,000 bags to Australia. With bean production down in 1961 and domestic use up, it is doubtful if Japan will export as many beans in 1962 as in 1961 or 1960.

MARKET QUALITY RESEARCH

C. H. Kingsolver and J. A. Thompson
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We have just heard two discussions on marketing of dry beans. Both have dealt with commonly considered aspects of marketing. Our work in the U.S. Department of Agriculture deals with the market quality of commodities from farm gate to consumer. We work in two general categories: research to maintain quality of commodities throughout the marketing channels and research to develop techniques, methods, and devices for measurement of quality.

In past meetings of the National Dry Bean Council, we have reported work relative to storage of Michigan pea beans in that area and information on the fungal deterioration which occurs under various storage and handling conditions. We have reported handling studies, storage of seed beans, and work on problems concerned in the export of dry beans to the European market.

Work done cooperatively with the Michigan Bean Company and Heinz & Company has resulted in the development of improved equipment and procedures for moving bulk beans to canners. We wish to extend this bulk handling work to movements on the west coast and from that area to eastern canning areas but such tests have not yet been made. However, tests have shown that with the use of the RBNX rail car, beans can be moved from shipper to canner with greater efficiency and with less damage to the product. As a result of these tests, equipment necessary for bulk handling has been installed by some of the larger shippers and canners.

Our study demonstrated that bulk beans, in the special fruit growers express RBNX cars, maintained a near-constant temperature both in hot and cold weather during transit periods up to 10 days. Outloadings were made at temperatures ranging from near zero to 70° to 80°F. Maintenance of constant temperature in the beans reduces "tempering" time for the canner. Bulk handling also eliminates bags and the labor of bagging, sewing, trucking, and conveying bags into cars at both origin and destination. Shipments in covered hopper cars of noninsulated steel were unsatisfactory. Some work was done with beans in 1-ton-unit steel (tote) boxes. Beans in bulk cars were found to settle in transit, causing difficulty in probing with the standard grain probe. A pneumatic sampler was developed and used satisfactorily to obtain samples from bulk cars.

Most of you have heard reports, formal or otherwise, of the export studies conducted on three shipments of Michigan dry beans from Detroit via the St. Lawrence Seaway to European markets. A publication is in press reporting these results, but it will be a few weeks before copies are available. I think it will be permissible to restate briefly some of the findings of this study.

Temperature and humidity recording devices and samples of known quality were placed in a 1,600-ton shipment of pea beans as they were loaded at Detroit, Michigan. Daily records of temperature and humidity were made throughout the voyage.

The following tabulation illustrates a typical crossing via the St. Lawrence Seaway. Note that cargo was added at Montreal. This means that hatches were opened, possibly exposing the beans to abrupt changes in temperature and humidity. Another significant point is the movement of the vessel from the cold Labrador current into the warm Gulf Stream, causing condensation of water on the cold cargo. Aeration was found to be helpful in offsetting this "water drop-out."

M/S SUDERHÖLM LOG
Detroit - London   June 12 - July 6

June		June	
12-14	Installed equipment.	22-24	Labrador current.
14	Debarked at 6:30 p.m.	25	Enter gulf stream
14-17	Detroit - Montreal	25-29	Humidity near 100 percent
18	Added cargo, Montreal	29-July 3	Aeration
19	Debarked at 3:30 p.m.	3	Hatch opened, Belgium
20-21	Montreal to Atlantic	4-6	Unloading

Our records show that relative humidity in bean hatches can be controlled by aeration. There is ample reason to believe that quality can deteriorate as a result of abrupt changes in temperature and humidity during transit. In addition, there is always the physical damage problem. This too, is important in these shipments. At unloading in the west European ports, rope slings and cargo hooks are used. In the shipment aboard the Suderholm, one bag in 10 was damaged. We recommended that bagging material no lighter than 10.4-ounce be used.

The use of defoliation has been considered in the eastern bean-growing areas. Studies of its effect on quality of pea beans indicate that defoliated beans require less soaking time and produce a more tender canned product. Taste panels also rated defoliated beans as more tender.

A new procedure for determining cracked seed coats in Michigan pea beans and other seeds has been developed and will be reported in detail in a technical paper tomorrow. In this procedure, samples of beans are stained with indoxyl acetate. Only beans with cracked seed coats take up the stain and even minute cracks are visible. The method is simple and rapid. Cracked beans in the sample can be readily sorted from intact beans, either by hand or with any of the electronic sorting machines available. We think this procedure will be valuable in inspection tests. Inclusion in the inspection standards, however, would be the decision of the Grain Division, AMS. Our job is to develop procedures. We feel that availability of a means of detecting cracked seed coats will be important in the evaluation of handling equipment and procedures and may be helpful in our studies of storage deterioration. It seems logical that a bean which has a damaged seed coat will not store as well as one with an intact seed coat.

I would like to mention work on commodities other than beans, which may have applications to the dry bean industry. One of the primary advantages in our present type of organization may be the cross-commodity application of techniques, procedures, and equipment. We are working on methods for moisture measurement in both grain and oil seeds. Equipment developed may be applicable to beans. We are starting some work on grain sampling; here again information developed may be useful to your industry. Many of you may have seen the simple pneumatic sampling device which we used in our bulk handling studies. Refinements of this device are already in use. Work under way on storage deterioration of rice and corn may yield information applicable to beans.

A photometric device has been developed for measuring maturity in apples, degree of milling in rice, and smut contamination in wheat. Adaptation of this device may find use in some aspect of your industry. We have a basic research program underway on the biochemistry of seed germination. We are investigating seed blending methods and procedures and are starting work in seed pathology. We are working on the physiological changes in corn resulting from high temperature drying. Any one of these research projects may find application in the dry bean industry.

OPPORTUNITIES FOR DRY BEAN UTILIZATION

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In spite of their relatively high cost per pound of protein in the United States, meat, eggs and dairy products as a group are consumed in amounts about ten times larger than peas and beans, which contain greater proportions of proteins. The legumes are obtainable at about one-fifth to one-tenth the cost. The marked preference for these animal proteins may be related to their unique, delicate balance of component amino acids and their resultant higher nutritive value. Compared with the animal proteins, bean proteins have a lower proportion of the amino acid methionine. Laboratory animals have performed as well with methionine-supplemented, cooked lima beans as with casein, a protein of high nutritive value obtained from milk. Unsupplemented lima beans had a much lower nutritive value. Dry beans might find greater general acceptance if food formulations and recipes were designed in a more scientific manner. This would require supplementation of dry beans with small, specific amounts of animal proteins or other methionine-rich ingredients. In this manner, dry beans could be the major component in a product having a high nutritional value and a balanced array of amino acids comparable and competitive with the higher priced animal proteins.

It is recognized that the broadest expansion in utilization of dry beans in the United States may also require the availability to the consumer of bean products that can be prepared quickly and conveniently and that would not tend to produce flatus or gastrointestinal distress. Commercially available canned beans of many kinds are prepared quickly and conveniently for table use and at a relatively low cost. Several types of quick-cooking or precooked dry beans are now available. However, the latter products command a relatively high price. Work in progress at a number of laboratories should result in the development of improved, low-cost, quick-cooking or precooked bean products. However, the flatus-inducing properties of dry beans may be the most important factor limiting their more general acceptance. The empirical approach to the problem of preparing nonflatulent beans has been unrewarding. The basic cause or causes of flatus remain unknown and must be determined before any rational approach can be made to the problem of producing nonflatulent dry-bean products.

A number of suggestions have been made in respect to the possible causes of the flatus-inducing properties of foods. However, none of these premises have been confirmed and it would appear that some new concepts and working hypotheses might be in order. It was of interest to the writer to attempt to relate available chemical data on the composition of foods which tend to produce flatus with the degree to which they produce gastrointestinal disturbances. In 1935, Alvarez and Hinshaw published a table of data indicating the incidence among hospital patients of complaints of gas, belching, distension, and flatulence lodged against numerous common foods. The foods blamed most frequently were those that contained relatively low levels of methionine and a considerable amount of non-methionine sulfur. Conversely, the proteinaceous foods that elicited fewest complaints were among those known to have high nutritive values, adequate levels of methionine and a well balanced array of amino acids. Although the data are fragmentary, there would appear to be a relationship between the complaint frequency (CF) for a food and an empirical index MxN/S relating total nitrogen (N), methionine content (M), and the total sulfur (S) in that food. This correlation implies that the sulfur compounds are related intimately to the flatulence characteristics of certain foods including beans and that flatus may be due to the organism's physiological response to a shortage of methionine and/or other antagonistic sulfur compounds. The presence of methionine analogues, such as S-methylcysteine, as well as their oxidation products, including sulfoxides and sulfones, in many of the so-called "flatulent foods" is well known. In addition, it has been shown that methionine sulfoxide inhibits the metabolism of glutamic acid and that S-methylcysteine sulfoxide inhibits the metabolism of aspartic acid by certain microorganisms. If it can be shown that these premises are correct, the solution to the problem of bean-initiated flatulence may be less difficult than anticipated. A process can be visualized in which hydration-extraction would be employed to remove superfluous sulfur compounds and the beans would be cooked with or after supplementation with methionine or methionine-rich protein fractions. In this way, the nutritive value of dry beans could be improved at the same time that the flatus-inducing properties are obviated. The availability of quick-cooking or precooked, nutritious, dry bean products should facilitate the development of a broad expansion in the utilization of dry beans.

DRY BEANS FOR CANNING

Charles E. Tinkle
Stokely-Van Camp, Inc., Indianapolis, Indiana

Quality requirements of beans for canning include soundness of raw material, freedom from checked seed coats and absence of foreign material such as small rocks, bits of scrap metal, adobe, burs, etc. Improper handling of beans not only harms quality but also reduces yield of canned product. A good job is being done in Michigan in educating farmers and elevator operators toward improvement of handling practices. Efforts of plant breeders to increase yields of beans should not sacrifice processing quality.

Per capita consumption of rice, macaroni and potato products is increasing each year despite their higher cost relative to beans. Consumers could afford to pay 50 percent more for beans on the basis of food value received. Uniformity in quality and freedom from foreign materials tend to favor the competitive products.

Millions of dollars are being spent in advertising and promoting bean products. Much effort is also being expended in developing new and improved products for the convenience of the housewife. Consumers are entitled to receive the same quality in beans that they receive in other foods. This can be achieved only by exercising more care on the farm, in the elevators, and in the canning plant.

DRY BEANS FOR PACKAGING

Dean A. Broadhead
Vice President,
N. K. Hurst Company, Indianapolis, Indiana

We in the packaging and cannery fields certainly have our work cut out for us and this in turn reflects directly to you as research men, processors, and producers, because it will require the cooperation of all to make more effective the marketing of dried beans.

In 1947 super markets carried 2,000 items. Today they carry 5,000 to 6,000 and floor space has not increased in proportion. You can see that everyone has had to fight and justify the space allotted for their products in the store. More than ever, quality products are playing an increasingly greater part in this justification. You processors have felt it and you producers have not felt it to any great extent as yet, but you will, and in the not too distant future. Self-service stores and super markets will continue to make it more important that we do a better job of harvesting, processing, and re-processing before the beans are packaged and offered to Mrs. Housewife. We have heard from representatives that visited Europe last year how quality conscious the people there are. I was interested in an article in the October, 1961, issue of Modern Packaging, which I would like to quote:

"Sweden now has a higher portion of self-service outlets than any other country in Europe. By 1965 it will have overtaken the United States in this respect. Swedish housewives will then be buying 70 percent of all consumer goods through self-service stores and super markets. As a result, packaging has become an important instrument of distribution and high standards of presentation and protection are customary. This country has a strong consumer movement and close attention is paid to quality and nutritional value of a product." Over 76 percent of the packaged dried beans in super markets and self-service stores today are purchased after Mrs. Housewife has entered the store. Manufacturers and packagers realize the importance of point-of-sale purchases such as this, and are spending an estimated 11 billion dollars on packaging of their products to woo the consumer. In 1965 projections call for a packaging outlay in the neighborhood of 15 billion dollars or approximately a 40 percent increase. You have heard of some of the things that research is doing to improve quality and develop new uses for dried beans. What are you doing to improve the product you produce and process for selling? Here are some of the things that we as packagers of dried beans would like to see improved.

Improved colors, particularly in white beans, navy or pea beans and California limas, are particularly noticeable to packagers, but veining in some of the other white varieties is sometimes quite prevalent. In navy beans the first loads after harvest are beautiful and exceptionally white, but after that they have a grayish cast. This has been explained as due to climatic and growing conditions, types of elevators in which they are stored, types of equipment over which they were processed. We feel more work should be done to maintain white color and to eliminate grayish cast. In limas, as we understand it, work is being done on a more uniform white color. This is good and I am sure canners will agree as many of the green-colored limas turn dark on cooking. We have had this complaint from many housewives and I am sure that the cannery people have too.

The elimination of adobe, rocks, silt and even small pieces of manure. Let me read what a packager had to say about this: "One of our problems is the large amount of adobe, silt and rocks, as well as some small pieces of manure present in dried beans that we receive for packaging. This is evidently picked up by combines and gets through operations without removal. Can't the grower do something about this and leave it on his farm?" Another processor quotes: "Can't the growers keep the wire, nails and worn-out farm machinery at home, or can't it be taken out elsewhere?"

Processors are doing a much better job than they were doing up to two or three years ago; however we still find some processors that are trying to mill their beans too fast, not using proper-size screens and are not properly putting them over stoning equipment and gravities, which we definitely feel are a necessity as far as processing is concerned. About five years ago Mr. Hurst was telling me how much metal they used to take out of coffee beans when they were processing them. We decided to put a magnet on our processing lines to see just how much metal we would take out of dried beans. I have here a sample of metal which has been taken out over a two-week production period. I also have samples of rocks and adobe that have been removed with our stoning equipment and I also have samples of silt that has been taken out of clean beans that were sent to us. This is not all the processor's fault. They have tried to do a good job. Some of them, I will admit, could do a much better job, but producers should also try to improve the quality of beans they deliver to elevators.

When in Colorado this summer, one of the elevator people was telling me about a new bean windrower. In investigating to find out how this equipment works, I was advised as follows, and I quote: "We have been furnishing 2- and 4-row machines for a number of years but only the past season has the 6-row been available. Also, a wide pick-up attachment that reaches across the platform of a conventional swather has been developed and offered during the past season. Where 22-inch rows are planted, which occurs in 90 or 95 percent of the cases, a 12-foot swather with a wide pick-up on it makes a perfect 6-row windrower. Six rows are becoming quite desirable, since the farmer usually plants 6 rows and cultivates 6 rows as well as cutting 6 rows for threshing.

"We made some very thorough checks on tare during the past year and are happy to announce that where the bean windrower or the wide pick-up attachment was used in conjunction with a swather, the tare was reduced to below 1 percent in some cases. The same condition where a side-delivery rake is used for windrowing the tare runs as high as 10 percent and even above.

"This is all beyond the saving on the combine when threshing. Nearly all of the dirt and rocks are eliminated before depositing in the windrow, and consequently the threshing operation is reasonably clean and without fear of a rock going through the combine and tearing something to pieces. We like to think, and we believe we are close to the figure, that the saving on tare, machinery and disposition on 75 acres of 18 to 20 sacks of beans will pay for a machine the first time over. In addition to this the windrower has been especially designed for use in dry edible beans and users report less than 3 percent dirt and windrows are fluffier and dry faster than raked beans."

I understand several of these are in use in Michigan. I have never seen one of these windrowers in use, but those who have speak very highly of it. Some of you producers with heavy soil or rocky land should certainly look into something like this. In fact I believe that similar equipment will be offered by other companies in the not too distant future. I have some literature with me if any of you would like to look at it or obtain the address for additional information.

Worm cut and insect damaged beans. Let me quote two packagers on this point: "One of my pet peeves in dried beans is the worm cuts which crop up from time to time and seem to be more prevalent this year in the Nebraska area than previously, but at times it is quite bad from some of the other producing areas. This particular problem almost has to be controlled at the grower level, although processors can help a great deal. Processors report that they have found it physically impossible to remove all worm-cut beans from a lot that contains a substantial amount when delivered. Certainly additional work should be done on this problem."

Another packager reports: "Weevil damage and stings on beans, and I refer particularly to Blackeyes, give us a lot of trouble. Why can't growers be more careful so that processors can deliver a better product. Pure Food and Drug will some day force them into it and we feel in the not too distant future. The same goes for worm-cut beans."

Along this line let me tell you what a packager of dried beans recently reported to us. I am quoting from a lot of packagers and processors, but I am representing them and want you to know their feelings as well as ours. He said: "We had Pure Food and Drug move in on us this week and they came in with white coats and long probing instruments and we honestly thought they were going to 'operate.' They went over every inch of our warehouse; they went into high piles and low piles, and they spent hours checking weights and labels. We were surprised to have them put a hold order on some beans which originated in California and Texas, as these bags came to us without what they considered proper identification. This will reflect to the original shipper, and it is just one more instance of where the slackness must be taken out of the bean business. We have heard of previous instances of what they called mislabeling and no doubt it could become very serious, especially if taken to court and involving fine, etc. So, if the bean industry is to live with Food and Drug, and we believe they do, we think that is more reason why quality and all labeling and weight rules should be observed to the letter of the law. We just received a shipment of California Blackeyes which we had graded and they did not get a number one. They were short weight and they were processed in bags as our truck was waiting to load. We complained to the shipper and we were told that they were just trying to take care of us and get us some good Blackeyes off quickly. The bags were not properly identified and this is just what the government boys are looking for."

We have many shipments from California and a few from other areas where bags are not properly identified. This makes it bad in a packaging plant where you are handling 20 or more varieties. We feel that shippers should be more careful and should have their bags properly identified. You notice this packager said something about short-weight bags. A few years ago this was an extremely bad situation, particularly in the late winter and early spring months when beans that had been processed early in the fall were shipped. We started an aggressive campaign on short-weight bags. We weighed everything that came into our plant and billed the processors for the short-weight and paid them for any over-weight, after tolerances were considered. This situation has nearly been eliminated. Very seldom do we bill for short weight or make payment for overweight at this time and I certainly hope that continues. Many shippers could be more careful with the type of bags used. Processors pay for good, new bags and are sometimes shipped used bags that show a large amount of usage. Pure Food really checks these, as most of you know.

Grading dried beans. We of the packaging field certainly believe USDA and cooperating agencies should review the method of sampling and grading of dried beans. This is less prevalent in the Michigan, New York, California, and southern Idaho areas, but in most other areas a definite review should be made. From these areas a grade certificate means nothing as far as we are concerned. I value the integrity of the shipper much more. Competent shippers and processors know where beans are going and should be able to supply quality and color desired. Canners, for example, are not too concerned over a more grayish white bean. Packagers definitely are.

In talking to one of the packagers the other day he made this statement to me: "The rice industry has long been cleaned up and we do believe that a good many of the others have been cleaned up but we are of the opinion that it probably now is the turn for the dried bean industry. Judging from the activity of the Food and Drug Administration in bean processing plants in the last two months, we believe that Food and Drug also thinks it is now the dried bean industry's turn for a clean-up. For an effective clean-up we will have to have the cooperation of growers, processors, packagers and canners."

One other thing I would like to point out before closing. At times we receive beans that have not been properly screened. By this I mean they are run over No. 8 or smaller screens and many small hard seed coated beans are left in. We have had several complaints from housewives about these hard seed coated beans and the difference in cooking time. Research has done a good job in eliminating hard seed coats in beans during the last several years, but I still think that we have extra work to do. Of course growers and processors can be of much help in eliminating this before it gets to the packaging and canner trade. We also find some processors still shipping an excessive amount of splits. This is objectionable not only to canners but also to the packaging trade, because splits are unsightly when they become excessive in packaged beans. Both of these could be helped with a proper screening and job of cleaning. Growers can be a big help here in seeing that their machinery is operating properly by checking frequently during harvest and making necessary adjustments, by checking samples with the elevator to see if damage is apparent, and by careful handling.

CROPS RESEARCH ON DRY BEANS IN THE U. S. DEPARTMENT OF AGRICULTURE

Victor R. Boswell, Crops Research Division
U. S. Dept. of Agriculture, Beltsville, Md.

We are prone to become so absorbed in our respective immediate problems that we overlook or forget the interdependence of the farmer, the dealer, the processor, and the consumer. It is easy to under-rate or even ignore the degree to which the success or satisfaction of any one of these depends on the success or satisfaction of the other. Each must keep the problems and requirements of the others in mind and do all he reasonably can about them.

The dealer, processor, and consumer all want beans at the lowest price obtainable, and they want beans of the highest quality they can get. Beans of superior quality at harvest can have their quality impaired in many ways after they leave the farm. They can be improperly handled in storage, in shipment, in the food factory, and in the home. Most of such loss can be prevented, either by known methods or by methods that research can and will develop. But I don't believe there is now or likely to be any way to make first-class beans out of beans that are inferior when harvested. The farmer must be able to produce the high quality desired before any of the rest of you can preserve that quality and profit from it.

Inherent properties of appearance, composition, texture, and flavor depend largely on the variety, on the hereditary characters that make up a bean. But effects of environment, diseases, insects, weather, and the farmer's methods of growing and harvesting the crop must not be under-rated. The properties of the beans available to dealers, processors, and consumers are determined mainly by variety, and where and how they are grown and harvested. The farmer does <u>not</u> have an easy time producing the quality and quantity of beans the rest of us want. The cost of production of beans, per bag, as well as the quality, is vitally important to every segment of the industry--not just to the farmer. If the farmer can't get profitable yields of beans for any reason, he will turn to other crops or enterprises. When you need beans a lack of supplies is not profitable to you.

High yields and high quality generally go together. The causes of poor yields generally tend to impair quality too. High yields are necessary for low costs of production per bag. If processors and consumers are to continue to get beans at reasonable prices, the beans must be produced at low cost, which usually means at relatively high yields per acre.

These are the reasons why crops research on beans is essential during a time of plenty. We want to keep America a land of plenty and push our standards of excellence still higher. The relationship of research to modern crop production is much like that of purposeful human relationship to a successful marriage. Both enterprises are full of problems. Both require frequently changing but continuing thoughtful attention if they are to prosper. We need to remember that research can't be turned on and off like a spigot for quick delivery of results. This is especially true of research dealing with living things, and we need to remember that a surplus can turn into a shortage pretty fast.

USDA OBJECTIVES IN DRY BEAN RESEARCH

Very briefly stated, our objectives in crops research on dry beans are to help develop knowledge, principles, and methods that will enable farmers to produce ample supplies of dry beans of progressively better quality, for all desired purposes or uses, with the greatest efficiency, and at the lowest possible cost per bag.

Our program specifically on dry beans is admittedly small, but it is productive. With our resources alone we could not accomplish nearly as much as we are able to do with the generous and effective cooperation of the State agricultural experiment stations and private industry. When I say "we," in talking about this program, I usually mean USDA and its cooperators, not merely USDA alone. Much of our work deals with the bean as a species of crop plant without reference to variety or manner of use. Some of the major diseases we are working on, for example, affect all kinds of common beans, both snap and dry. What we learn in these studies will have value for enterprises concerned with dry beans as well as those concerned with so-called garden or snap beans.

The USDA is responsible for working on big nationwide and regional problems, not local problems. Most of our research men are located at State experiment stations rather than at headquarters at Beltsville, Maryland, but their areas of responsibility extend far beyond the boundaries of their respective host States.

Introduction of beans from abroad. In efforts to improve varieties breeders, geneticists, pathologists, and others often need characteristics to incorporate into new varieties that they can't find in commercial or other available sources in this country. It is the responsibility of the New Crops Research Branch of Crops Research Division in Agricultural Research Service to scour the world for any and all kinds of beans (and other crop plants), wild or cultivated, that might be useful as parents for new varieties. Collections of seed made by our explorers or obtained through exchange with other lands are first studied at our four regional introduction stations, where certain observations and evaluations are made. The materials, together with whatever information is known about them, are then available to any bona fide breeder in the country. Maintenance and evaluation work on bean introductions is done on a modest scale at Experiment, Georgia; Geneva, New York; Ames, Iowa; and Pullman, Washington.

There are many kinds of beans in Mexico, Central America, and South America that we know little or nothing about. There may be some very valuable characters among them that we could use: resistance to certain diseases, nematodes, or insects; habits of growth and maturity that would be adaptable to direct combining; or interesting eating qualities or market properties. There may be superior characters among the few American Indian varieties of beans still left in this country. The odds against finding what we want in any one lot of seed are very high, but if enough collections are made there are good chances of finding many of the characters that we need and can use.

A Hopi Indian lima bean is in the pedigree of the nematode-resistant Nemagreen lima. A root-rot-resistant bean found in Mexico by a California botanist is now being used as a parent by several bean breeders here. Resistance to lima bean mildew races A and B came from India and Guatemala, respectively.

Breeding and disease investigations. In our Division it is hard to separate much of the bean disease work from the breeding work because breeding for disease resistance (and other desirable features) is the biggest single effort, for both dry and green beans. We have one man on breeding and diseases of pea beans full time at East Lansing, Michigan, in cooperation with the Michigan Agricultural Experiment Station and through the station with the pea bean industry. He also devotes some attention to the Cranberry, Yellow Eye, and Red Kidney bean problems of the Northeast in cooperation with Cornell University. Resistance to anthracnose and viruses is a primary objective in addition to high yield and quality.

One man at Twin Falls, Idaho, devotes most of his time to dry bean breeding and disease work and one man at Prosser, Washington, gives part time to dry beans for the West. Red Kidney, Red Mexican, Pinto, and Great Northern types have received most attention in the West. Resistances to curly top, to other viruses, and to rusts are major objectives. Disease investigations are being started on edible cowpeas by a new man at Tifton, Georgia, with a view to breeding disease-resistant varieties and developing other kinds of disease control. Progress in these basic studies will be valuable wherever the species is grown. Research on the nature and methods of control of virus and fungus diseases of beans is conducted at Beltsville, Maryland.

A major objective of the work at Prosser, Washington, is learning how to control root rot by microbiological means--by favoring the beneficial micro-organisms of the soil and suppressing the disease organisms through proper use of crop residues, fertilizers, cropping systems, and soil management. The details of these studies will be discussed in the production research session on Thursday. Although it is not directed to dry beans as such, we have a two-man project at Beltsville on microbiological control of soil-borne plant diseases. Rhizoctonia of beans has been studied extensively in this work. We are providing new greenhouse facilities and our host States at Tifton, Georgia, and Prosser, Washington, have plans for new laboratory facilities for our men that will be of great help to these cooperative programs.

From the cooperative work in Michigan, four improved varieties of pea bean were released from 1956 to 1961. Sanilac, released in 1956, accounted for about two-thirds of the pea bean acreage in Michigan in 1961 and produced about 5 million bags. Seaway, Saginaw, and Michelite 62 are the other very promising new pea beans. Charlevoix, released in 1961, is a promising Dark Red Kidney type. These give a range of short-, medium-, and long-season varieties resistant to anthracnose, mosaic, or both diseases.

Great Northern 1140, released in 1960 in cooperation with the Idaho Agricultural Experiment Station, is already in second place among the Great Northern beans grown for certification in Idaho, and first in commercial acreage--about 2-1/2 million bags in 1961. It requires good rich soil, is not well adapted to the sandier lands. Columbia Pinto, released in cooperation with the Washington Agricultural Experiment Station, is extensively grown in the Columbia basin because of its resistance to curly top and two mosaic diseases. About 30 percent of all bush lima bean seed now produced is Thaxter, a new mildew-resistant variety suitable for canning or freezing immature, and for dry baby lima beans.

We are able gradually to add new knowledge about control of diseases, and to produce new varieties having resistance to certain diseases. Merely having this knowledge and these varieties, however, does not solve all the disease problems in practice. The resistant varieties are resistant only to certain diseases, not all diseases.

No research group in the world can produce varieties that can withstand all the mismanagement and poor farming practices to which beans are too often subjected. Research can help, but the producer has a responsibility to inform himself and carefully follow the best practices known. Dealers and processors who are not growers themselves can nevertheless exercise helpful influence in these matters with the growers from whom they obtain their supplies. It is good business for dealers and processors to work actively and harmoniously with growers, and try to help insure that proved good practices be followed. Each segment of the industry needs to understand the problems of the others, and all need to help one another for their mutual advantage.

We welcome the assistance of all segments of the bean industry in evaluating potential new varieties for specific uses and conditions of production. The true commercial value of a new bean can be determined only under commercial conditions. We need dealers' evaluations on suitability of a bean for their markets, on the weak and strong points that may show up in handling, storing, and merchandizing. We need processors' reactions to a variety's suitability for baked beans, canning, and soup and other preparations. And we need consumers' reactions too.

Seed bean investigations. Cost of seed for growing beans is a considerable item. Uniform, dependable performance of seed is essential for good yields and product quality. It is essential for effective handling of the crop by modern mechanized methods. Our breeders pay special attention to the propagating qualities of new lines. We have recently studied the effects of irrigation practice and certain harvesting practices on propagating value of beans, in cooperation with the Utah and Idaho Agricultural Experiment Stations.

Weed investigations. The Crops Protection Branch of the Crops Research Division conducts research on weed control. Much of its work deals with principles, across the board, rather than with control of weeds in a specific crop. Men of that Branch, however, cooperate with individual crop specialists. At Prosser, Washington, and Laramie, Wyoming, each of two men devotes a share of his time to control of weeds in the dry bean crop.

Insect investigations. In Agricultural Research Service, "Crops Research" refers to a Division and "Entomology Research" refers to another. Since, however, growers and others generally consider the control of crop insects to be part of the whole "crop problem," I include here very brief reference to the work of our colleagues in the Entomology Research Division that applies to the production of dry beans. USDA entomologists in California are working on control of insects and mites on dry lima beans by use of systemic chemicals and by conventional spray and dust applications with ground equipment or aircraft. USDA entomologists have done much of the background research and serve as consultants in the new effort to reduce curly top losses to beans and other crops in southern Idaho by reseeding certain desert breeding grounds of the beet leafhopper to non-host grasses.

CONCLUSION

In conclusion I wish to say that agriculture is a highly unnatural system in which man pushes the performance and qualities of animals and plants up to much higher but less stable levels than occur in nature. The objectives of the dry bean "crops" researcher are: to push the levels of plant performance and product quality still higher, to prevent opposing natural forces from bringing those levels down, and to find ways of accomplishing these objectives that will be mutually profitable and advantageous to all phases of the dry bean industry: processors, merchandisers, and consumers.

VARIETAL IMPROVEMENT IN CALIFORNIA

Carl L. Tucker
University of California, Santa Ana

At the University of California, Dr. Francis Smith, Dr. Robert Allard, Mr. Roland Sanchez, and I are charged with varietal improvement work on dry beans. Breeding schemes used in varietal improvement of beans are designed to make two general types of change. One is a single character change made in an adapted variety, the other, several character changes used in cases where none of the adapted varieties are acceptable.

The areas of improvement in common beans are in cortical root-rot, common bean mosaic, cowpea wilt, and a seed coat color change in Pintos. Dr. Smith has recently completed a date-of-planting experiment, consisting of eight plantings, at two-week intervals, started April 20th, and done in four different years. Percent flower set and beans per pod were estimated. The correlations of age of plant to flower set and age of plant to temperature were noted.

The lima bean breeding project is directed toward the following areas of improvement: nematode resistance, root-rot tolerance, earliness, white seed coat, increased vigor, and yielding ability. The large-seeded lima bean breeding program has been limited by the lack of variability. In 1959, a collection of lima beans was made in thirteen Latin American countries. Most of the collection, which numbers over three hundred, consisted of short-day plants. These short-day plants are now being crossed with day-length neutral plants, so that this source of variability can be incorporated into the breeding program.

Several plant population studies of lima beans are being conducted in California. These are studies of the effects of male steriles, certain mutants, natural hybridization, natural selection, artificial selection, and certain unique combinations of genes in plants grown essentially under the same conditions of a commercial operation.

The purpose of these experiments is to gain insight into characteristics of populations which have large effects upon economically important characters such as yield, competitive ability, vigor and also arrive at some ideas in modifying existing breeding schemes, and possibly help in devising new ones.

DRY BEAN DEVELOPMENT IN IDAHO

Leslie L. Dean
University of Idaho, Twin Falls

I would like to express appreciation for the fine cooperation that we at the University of Idaho have with the U. S. Department of Agriculture personnel stationed at Twin Falls. This work is carried on in cooperation with V. E. Wilson and Kenneth E. Gibson, both of the Agricultural Research Service.

The objectives of our bean improvement program first are development of dry bean varieties with multiple resistance to diseases. In this project we are concerned primarily with resistance to the seed-borne mosaics and to curly top. At the same time, we are placing some emphasis on development of varieties resistant to root rot and other diseases. Our primary interest in disease resistance obviously cannot overlook the important agronomic characters necessary to a successful dry bean variety. We necessarily are concerned with yield, early germination and rapid emergence, a particular attention to plant type, and plants with an upright growth character. More recently we have introduced into our breeding work crosses and selections in which we are seeking tall determinate or bush-type plants. Necessarily, also, we are concerned with the various seed characteristics, such as color, size, and characteristic shape.

Under our southern Idaho conditions, the length of growing season required by any particular variety becomes highly important to the farmer. We place considerable emphasis on maturity date in our selections. Also receiving important consideration are such harvest characteristics as ease of threshing without undue shattering. It may be well to elaborate briefly on some of our objectives.

At present in southern Idaho we recognize three strains of seed-borne mosaic (Bean Virus 1) as being sufficiently widespread to warrant attention. Two of these strains, the Type strain and the A strain which is also called New York 15 strain, or just the 15 strain, have been present for a number of years and are well known. Resistance to these two strains are present in all of our dry bean breeding stock. However, more recently a strain of seed-borne mosaic which we tentatively have called strain B has been found in Great Northern UI-123. This strain has not been widely spread and has not been found in fields off from Twin Falls Branch Station. We are confident that the B strain of seed-borne mosaic is not widespread in southern Idaho because it has not been found by the inspection teams of the Idaho Crop Improvement Association. This strain of the virus, however, is of particular concern to the dry bean industry because at present all commercially grown varieties of dry beans are susceptible to this B strain, even though they may be resistant to either the Type strain or to the A strain.

Resistance to the B strain is available to us, however, through the dominately inherited factors present in garden bean types. I have previously mentioned the fact that we are looking toward development of dry bean types borne on a determinate or bush-type plant. Inasmuch as it has appeared that it would be necessary to introduce into dry beans the dominate type of resistance to common bean mosaic as is usually found in garden bean types, this has presented an opportunity not only to introduce the dominately inherited factors from the garden beans, but at the same time it has presented an opportunity for evaluating the possibility of introducing bush type field beans. The open type of plant growth that is attained on bush beans would have considerable value in increasing the ease of handling the crop in the field and will undoubtedly benefit growers in reducing the amount of sclertinia that may develop in the field. In addition, there may be some benefit toward reduction of other foliar diseases.

With regard to root rot, I am certain that most of you are aware of the work done by Dr. A. M. Finley of the Idaho Plant Pathology Department, wherein he has directed considerable effort toward finding effective chemical controls as well as rotational controls for root rot. This work will be expanded. Beginning in February of this year there will be a man stationed at the Twin Falls Research Laboratory who will devote full time to seeking new sources of resistance to bean root rot and to the problem of introducing such resistance into present bean lines.

In our program on dry bean types, major emphasis is placed on Great Northern, Pinto, Small White, and Red Mexican. To a lesser extent the breeding program includes Red Kidney and Pink types. At the present we have in yield test a number of typical Great Northern lines which are resistant to curly top and two strains of seed-borne mosaic. In addition to this, as previously mentioned, we have in early generation hybrids, crosses between Great Northern and garden bean types, in which we are selecting for bush plants with Great Northern seed and which, in addition to the resistance to curly top and two strains of seed-borne mosaic, will carry resistance to the B strain mosaic.

The situation with regard to Pinto lines is very similar to that of the Great Northern. We have a considerable number of standard Pinto types in yield test and these lines also carry the same type of resistance as the Great Northerns; i.e., they are resistant to curly top and to two strains of seed-borne mosaic. Here again we are actively incorporating resistance to the B strain of seed-borne mosaic and, at the same time, are selecting for Pinto seed type on a tall bush plant.

The Small White types are receiving a great deal of attention because at the present time we do not have curly top resistance in suitable Small White beans. We have a large number of lines ready for yield test, as well as a considerable number of lines still undergoing selection. This material is very promising. It is of early maturity, seed type is good, and the plant type appears to be one that is very desirable.

We have had considerable interest in Idaho in a Red Mexican bean which will mature earlier than the standard Red Mexican UI-35. Through a series of crosses we have now developed, and have in yield test, Red Mexicans which will mature in as few as 85 to 100 days, as compared to a maturity of 110 to 120 days on UI-34. In three years' yield data we have found no significant difference in yield among some of the early Red Mexican types and UI-34 or UI-35. In addition, it appears that probably our early hybrids have a slightly brighter seed coat color than the presently used Red Mexican varieties. These lines are resistant to curly top and two strains of seed-borne mosaic as are the other field types. We feel that the most important characteristic of our new Red Mexican lines is the extreme early maturity. We now have a modest increase on this seed and probably within another year will release it to the growers.

By way of summary, I might restate that in our research in southern Idaho, we recognize three strains of seed-borne mosaic (Bean Virus 1). We have now established resistance to two of these strains (Type and A strains) in all dry bean types presently important in Idaho, and in connection with resistance to a third strain (B) are making consierable progress in the introduction of resistance into the dry bean types presently grown in Idaho.

DRY BEAN PRODUCTION DEVELOPMENTS IN THE ROCKY MOUNTAIN STATES

D. R. Wood
Agronomy Department
Colorado State University, Fort Collins, Colorado

The fact that this panel is made up of plant breeders and chaired by Director Wheeler of the Colorado Agricultural Experiment Station indicates that the purpose of this discussion is to present the thinking of people engaged in production research.

At Colorado State University our production research is directed toward varieties of pinto beans of improved agronomic type with a high degree of disease resistance.

Varieties in an advanced stage of testing show a high degree of resistance to rust and curly top. Testing for curly top has been conducted with the fine cooperation of Dr. Douglas Burke of the U.S.D.A. at Prosser, Washington, and Dr. L. L. Dean of the Idaho Agricultural Experiment Station, Twin Falls, Idaho. Final selection of varieties from this breeding material will not be made for several years, pending yield trials and final testing for disease resistance.

We are trying very hard to develop a pinto with determinate growth habit, similar to that of red kidney and Sanilac. As yet, we have not found how much sacrifice in yield will result from the change in growth habit. Some of our populations are in the third backcross to good type, disease resistant pintos. The objective of course is to have varieties available should direct combining become a reality. We have also hoped that the bush habit will reduce the incidence of white mold in our irrigated bean areas. In Northeastern Colorado this disease has become a persistent problem. Comments by Dr. Wayne Adams indicate that bush habit does not entirely eliminate this problem.

We would like to know more about any possibilities of white mold control and in particular we are anxious to hear of any evidences of resistance in beans to this disease.

We are planning a varietal improvement program for the dryland bean acreage in Southwest Colorado. This program would have its major emphasis on the production of varieties that will resist mosaic and curly top and produce as well as the San Juan Select pinto.

We are also planning an extension of our work on cultural practices for production of beans on dryland and irrigated acreages. We find that there needs to be more work done on row width, rate of planting, date of planting and fertility management practices.

DRY BEAN PRODUCTION DEVELOPMENTS IN THE GREAT LAKES BASIN

M. W. Adams
Michigan State University, East Lansing

Rather arbitrarily I define the Great Lakes Basin as New York State, Ontario, Canada, Michigan, and Wisconsin. I should like to deal with research developments in Michigan before considering the other regions. The work in Michigan will be subdivided under several headings.

Plant Breeding. Our over-all goals in plant breeding include resistance to several diseases. Among those most important are common bean mosaic, anthracnose, bacterial blight, and root rot. We are concerned also with the canning quality of new strains and varieties. We customarily send sample lots on which we wish canning quality information to commercial processors and receive evaluations of our lines. We also can many different lots of beans at Michigan State University, in cooperation with Drs. Bedford and Robertson of the Food Science Department. Of foremost importance in plant breeding is our research directed towards an understanding of the genetic and environmental forces which affect yield. We have partitioned yield into three basic components and are attempting to study the genetics of each component separately and the interrelations from both a genetic and an environmental standpoint.

We are seeking to bring about new kinds of variability in the navy bean for selection purposes by maintaining a series of hybrid populations in a high state of heterozygosity. We do this by re-current intercrossing. In addition to the intercrossing series we are submitting these several populations to neutron irradiation for the purpose of causing mutations and genetic recombinations.

Item No. 3 of our work in plant breeding is directed toward a study of relative growth rates, net assimilation rates, and leaf area indexes in relation to yield and yield components in ten strains of navy beans grown at two locations for two years. In this study we hope to get some understanding of the gross physiological basis for yield differences among lines and locations.

We have recently concluded a genetic study of reaction in several crosses to three races of the organism causing anthracnose in beans. The genetic situation in these crosses varies from simple to fairly complex and essentially runs the gamut of classical Mendelian situations, including some indication of linkage of genes responsible for reaction to the beta and gamma forms of the organism.

Presently we have under way a genetic study of reaction to three different viruses causing common bean mosaic. The emphasis here is to understand the genetic system responsible for resistance to each of the races and then we also want to learn something about possible linkages between genes involved and, of course, the kinds of gene action that seem to be involved.

We are selecting for root rot resistance in populations derived from the Mexican bean known as N-203 and in population derived from the scarlet runner bean. We appear to have satisfactory levels of resistance to the Fusarium root rot, but this genetic source of resistance has not yet been obtained in a satisfactory navy bean type.

Plant Pathology. The pathological work in beans at Michigan State University is under the direction of Dr. Axel Andersen of the U.S. Department of Agriculture and the Botany and Plant Pathology Department at Michigan State University.

1. A study of types and severity of pod infection by common and fuscous blight bacterial pathogens as related to seed transmission.

A. Suture infection not visible externally.

B. Suture infection does not mean that systemic infection must necessarily follow.

C. Pod lesions may occur without seed infection.

D. It will be necessary to determine the correlation between pod and suture infections with seed infections.

2. Using long established rotation plots, a study is being conducted on the effect of crop sequence on root diseases of beans. The rotations involve beans after each one of the following crops: sugar beets, corn, barley, wheat, and beans.

3. The ecological aspects of soil microflora as related to environment and disease. This study involves both fungus and bacterial antagonisms and parasitisms along with symbiotic relationships.

4. Physiologic studies of natural and induced resistance to Fusarium root rot employing several growth hormones.

5. A survey of legume viruses on beans in Michigan. So far the important viruses are common bean mosaic, yellow bean mosaic, alfalfa mosaic virus, and tobacco ring spot viruses.

6. A new virus disease known as red blotch which occurs on dark red kidney beans has been described. This disease is caused by a strain of the tobacco ring spot virus.

Production of New Varieties. The plant breeder and the plant pathologist in their joint relationship are engaged in the production of new varieties possessing agronomic desirability, canning quality, and disease resistance. To date two new varieties have resulted from this program. The first was released in 1957; it is known as Sanilac. The second was released in 1960 and it is known as Seaway. At present several other strains are being increased for release. In certain cases names have been attached to these strains. For example, we are preparing for release a strain of dark red kidney beans which is resistant to the prevailing races of anthracnose in Michigan. The strain has been named Charlevoix. We have also repurified and reselected the old Michelite variety, improving it for uniformity, maturity, and disease resistance. The new strain will be known as Michelite 62. Approval has also been granted for the release of two other strains of navy beans, one a midseason vine possessing resistance to both forms of mosaic and to all three races of anthracnose and the other midseason bush which has resistance also to both forms of mosaic and all three forms of anthracnose.

Canning Results. It was mentioned earlier that we customarily observe our advanced strains for canning quality. In 1959 in cooperation with several states we were able to grow 25 strains at seven different locations ranging from New York to Idaho. The results are as follows:

1. At one location the beans produced a very dry pack.
2. At another location there was excess fluid in the can.
3. Certain strains in general were drier over all locations than other strains.
4. Certain strains likewise resulted in excess fluid in the can as compared with other strains of beans.
5. There were no marked differences in consistency or in wholeness.
6. There were differences in strains and locations in texture or firmness.
7. One strain was very nonuniform in size of seed.
8. All strains at all locations possessed a satisfactory flavor.

Effects of Supplemental Nitrogen. This work on sidedressing with ammonium nitrate following emergence of the bean was done in cooperation with the Soils Department at Michigan State University. In 1960 four levels of supplemental nitrogen were applied to two varieties at one location. The rates of application were 0, 30, 60, and 90 pounds of nitrogen as ammonium nitrate applied July 1. The varieties were Sanilac, a midseason bush, and Seaway, an early bush variety of the navy bean type. Over the range of nitrogen from 0 to 90 the yields of Sanilac ranged from 32 bushels to 33.4 bushels per acre. With Seaway over the same range the yield results were 30.6 to 32.6 bushels per acre. In 1961 when plots of both bush and vine varieties were treated with 50 pounds of nitrogen as ammonium nitrate on July 6 and 7, the general averaged results were as follows: no additional nitrogen, 31.05 bushels per acre; with additional nitrogen, 31.38 bushels per acre.

Relationship of Oxygen Availability and Root Rot. This work was done in the Soils Department at Michigan State University and tends to show that the lower the oxygen availability in soils the more severe is the root rot. This effect was studied and noted both in the clay and the sandy loam soils, but the effect was more pronounced in the clay than in the sand.

Effect of Sugar Beets as a Preceding Crop Upon Production of Beans. In one test in Saginaw County, Michigan, in which five different strains were involved, beans after sugar beets yielded from 42 to 80 percent as much as the same varieties after wheat except for one strain, numbered 0165, which yielded on the average 92 percent. In the one strain noted, 0165, vegetative growth was completely normal on the sugar beet soil so far as could be determined by repeated examinations throughout the season and it yielded within one bushel per acre as much as the same strain on land which had been in wheat the previous year. (It should be noted that root rot did not appear to be involved in accounting for differences between the beans after wheat and after sugar beets.) The most obvious factor was one related to oxygen availability, since the beet land was not plowed and was, in fact, very firm as compared to the wheat land which was plowed prior to planting. This observation needs to be confirmed by subsequent tests but the information available constitutes a promising lead as to experimentation related to discovering the nature of the sugar beet effect.

Weed Control Research in Field Beans in Michigan. Dr. Bill Meggitt of the Farm Crops Department of Michigan State University has submitted to me the following report concerning his work on weed control in beans. He has two general studies under way. The first is effect of cultivation on bean yields when weeds are controlled by herbicides, which involves two varieties, four different levels of cultivation, in association with three different herbicides. The second study involves an evaluation of pre-emergence and preplanting herbicides on field beans. There are 5 different varieties involved and 6 different herbicides. In terms of results it would appear on the ordinary bean soil in the Saginaw Valley that there is no increase to be expected from cultivation when weeds are controlled by herbicides. Dr. Meggitt remarks that even though no increase in yield was shown for cultivation in the presence of herbicide, he feels that one cultivation is good insurance in affording maximum weed control because the herbicide used, when used at the maximum rates for weed control, may sometimes be dangerously close to the tolerances of the beans to the chemicals and that an effective system might be to use the herbicides at something less than their optimum rate along with one cultivation to avoid any possible hazard to the beans from the chemicals. Dr. Meggitt next points out that Eptam at three pounds per acre and Tillam at four pounds per acre appear to be promising as preplanting herbicides. Eptam is presently recommended though it is expensive. Tillam provides less chance of injury but is not quite so effective in weed control. Both chemicals are more effective on annual grasses than on the broadleaved weeds. A substance known as DNBP recommended at 4-1/2 pounds per acre appears promising but is sometimes erratic in effect due to variable environmental conditions. DNVP is better on broadleaved weeds and grasses and is not nearly so apt to have a deleterious effect upon the beans themselves as some of the other chemicals when the environmental conditions do not favor their use. Finally, Dr. Meggitt points out several problems: (1) the control of perennial weeds, (2) the need for information on environmental factors and effects of these on herbicidal responses, and (3) rotational studies with applicable herbicides to prepare for beans in the rotation, this being a way to approach the problem of perennial weed control.

Progress Report of Work in States Outside Michigan in the Great Lakes Basin Area. New York State: Dr. Don Wallace of Cornell University indicates that they are stressing two areas in their breeding program. The first is the development of a Halo blight resistant red kidney bean. A satisfactory level of halo blight resistance has been transferred to acceptable red kidney types and the final lines are in the process of testing before final selections. He says it is probable that halo blight resistant line ultimately released will have mosaic resistance. In the second area, Dr. Wallace indicates that they are breeding for root rot resistance. They have very good resistant material but as yet nothing with commercial type. Additional work has been done with respect to finding extracts of root rot resistant and root rot susceptible varieties which have differential inhibition properties when applied to cultures of the root rot organism, Fusarium. This study is preliminary but very suggestive.

Ontario, Canada: Mr. Wendell Snow at the Western Ontario Agricultural School of Richtown, Ontario, has for the past several years tested many of the navy bean varieties available to him including several produced at Michigan State University. They have evaluated varieties and strains at differential dates of planting and are presently doing work on irrigation in relation to fertility. They are interested in using the early navy bean variety Seaway as a follow-up crop to be planted immediately after winter barley harvest. This program commenced in 1960 and conclusive results have not yet been obtained.

Wisconsin: Mr. Myron Groskopp, superintendent of the Hancock Branch Station of the University of Wisconsin, has been growing navy beans made available to him by Michigan State University for the past three seasons. He is following a production technique based upon a plow-plant proposition with row widths varying from 20 inches under conditions of irrigation to 36 to 40 inches when nonirrigated. He believes that they should plant about May 20 with seeds about two inches at the rate of 4 to 6 seeds per foot. On the sand plains of central Wisconsin where Mr. Groskopp is located, based upon soil tests, adequate fertilization is given to the beans often supplemented with heavy applications of manure when this is available. He notes that satisfactory control of weeds has been obtained with two pounds of Dinitro per acre at the emergence stage, followed by the rotary hoe about ten days later. Eptam applied preplant and worked in seven days prior to planting has also worked very well. Under his conditions the beans will require about one-half inch of water per acre every week up to the time of flowering. After flowering they will require 1 to 1-1/4 inches of water per acre per week until the pods are filled. If natural rainfall does not provide this amount, irrigation water should be applied. It is noted that yields can be expected to vary from 40 to 60 bushels per acre with the better adapted varieties and good cultural practices. t present diseases are not a problem but freedom from disease is not expected to last once the acreage is built up beyond the initial experimental acreage.

COMPOSITIONAL STUDIES ON DRY LIMA BEANS

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It has been shown that at least one immature legume (soybean) seed has greater nutritional value than the mature, dry seed. It is also accepted generally that immature green seeds, such as lima beans and peas, are tenderized by cooking in boiling water more quickly than the hydrated dry beans. Subjective opinions by individuals are reasonably consistent in supporting the proposal that cooked, immature peas and beans produce less flatus and less general gastrointestinal distress than their mature dry, cooked hydrated counterparts. Detailed chemical studies have been in progress to determine the character of any significant chemical differences between immature-fresh and mature-dry lima beans.

Previous reports on lima beans have included studies on: the lipids in immature and mature dry beans, variations among free amino acids and peptides during maturation, and on losses by leaching of free amino acids during hydration. Studies are in progress or have now been completed on: identification of free sugars in lima beans and their variations during seed maturation, characterization of the proteins in lima beans, and changes in the total water-extractable nitrogen, the soluble nonprotein nitrogen, the extractable protein nitrogen, and the soluble amino nitrogen during maturation and final seed desiccation.

Lima beans contain six major free sugars including: the monosaccharides glucose, fructose, and galactose; the disaccharide sucrose; the trisaccharide raffinose; and the apparent tetrasaccharide believed to be stachyose. The variations in the proportions of these sugars at various stages of maturity is consistent with current theories concerning the biogenesis of the complex sugars in plants.

A crystalline protein, representing about 25% of the total protein nitrogen, has been obtained from lima bean extracts. Three additional proteinaceous materials have been demonstrated in lima bean extracts by means of curtain electrophoresis. Studies on the nitrogen distribution in lima beans during maturation and desiccation indicate that during the final stages of maturation, no further changes occur in the total nitrogen or apparent protein. However, significant redistributions of the nitrogen-containing components appear to occur both during the final stages of maturation and during the desiccation process. Analogous changes in relative amounts of ether extractable (lipid) material and total sulfur occur during similar stages of bean development. These chemical studies are consistent with previous work and support the premise that the immature, green beans are chemically distinguishable from the mature, dry lima beans.

If the observed chemical changes in composition can be related directly to either the flatus-inducing properties or cooking characteristics, a reasonable basis will be provided for the development of a process for the production of quick-cooking, non-distressing dry lima beans.

COOKING-TIME AND COMPOSITIONAL STUDIES ON VARIETIES OF DRY BEANS

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The studies reported here were conducted under a contract between the University of Idaho Agricultural Experiment Station and the Western Utilization Research and Development Division of USDA's Agricultural Research Service at Albany, California. The objective was to determine whether there is any simple correlation between cooking time and chemical composition. Fourteen classes of compounds were analyzed. The CT_{50} or time when 50 percent of the taste panel judges considered the beans cooked was determined. In two instances 3- to 4-fold differences in cooking times of same variety from different locations were found. This is important for the processor because much more heat must be used to cook the longer-cooking beans. A report on cooking times is included in the report of last year's bean conference.

A significant correlation coefficient (5 percent level) of 0.51 between cooking time and nitrogen (soluble in 80 percent ethanol) was obtained. This value is probably too small for practical importance. A highly significant correlation coefficient (1 percent level) of 0.81 was obtained between moisture content and cooking time. The higher the moisture content, the longer the cooking time. Although the correlation coefficient was high, it is not expected that water, as such, causes longer cooking times. Other factors associated with high moisture content are probably important. The beans used in this investigation were about 20 months old. Other studies with beans stored for shorter periods should be performed.

The ratio of water-soluble to total nitrogen was found to range from 0.30 to 0.58. Some of these values are lower than the literature values. The difference could probably be due to the higher drying temperatures used in this study. The protein was probably denatured and rendered more insoluble at the higher temperature. Because there are a number of definitions of nonprotein nitrogen, a comparison of two methods of separation was studied. The nonprotein nitrogen extracted by the two methods was compared as the ratio of nitrogen soluble in 80 percent ethanol to nitrogen soluble in 10 percent trichloracetic acid. The ratios ranged from 1.3 to 2.5. With such values it is apparent that the term nonprotein nitrogen should be specifically defined by the method used in the determination.

THERMOBACTERIOLOGY OF LIMA BEAN PUREE

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The characteristics of heat death of bacterial endospores when heated in lima bean purees were studied to develop sterilization values for aseptic canning. When Clostridium parabotulinum, 69A, was heated in puree with 16 percent solids at pH 6.8, an F = 5.3 minutes and a Z = 17°F was obtained. Although this was higher than in phosphate buffer, pH 7.0, it was lower than in either green pea puree, green lima bean puree, 1 percent peptone, and in brine with whole lima beans. When preheated in puree at 212°F. for 30 minutes, a further decrease in resistance was observed. Thermal death rate studies in heated water extracts of puree revealed a decrease in resistance as the concentration of extract was increased. It is probable that there is a compound or compounds present in dried lima beans which affect the heat resistance of endospores of C. parabotulinum, 69A. Preliminary experiments indicated that the extract had little or no effect on germination of spores, per se. Further studies are in progress to purify the substance and determine the mechanism of action.

EXTRACTION AND SEPARATION OF PROTEINS OF DRY BEANS

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As part of an investigation of the proteins of dry navy beans, methods of extraction and separation of the proteins were studied. The procedure of Lund and Sandstrom separates proteins into water-soluble, saline-soluble, alkali-soluble, and insoluble proteins. Finely ground beans (bean flour) were extracted by this procedure. The largest portion, 71 percent of the total, of the nitrogen was extracted by water. Because beans contain some salts and nonprotein nitrogen, the water-extracted material would have had to be dialyzed to remove salts and nonprotein nitrogen and precipitate any extracted globulins, in order to have only albumins in this solution, which contained albumins, part of the globulins, and nonprotein nitrogen.

Solutions of different salts (0.5N) extracted between 61 and 86 percent of the total nitrogen from bean flour. The amount of nitrogen extracted appeared to be related to the pH of the extract; $CuCl_2$ solution with a pH of 2.9 extracted 61 percent, and $NaHCO_3$ solution with a pH of 8.3 percent extracted 86 percent. Normality of the salt solution had little effect on nitrogen extraction. Bean flour was extracted with 2 percent NaCl solutions with added amounts of HCl or NaOH to make the solutions acidic or basic. The least nitrogen was extracted at pH 4 (60 percent), and about 70 percent was extracted at pH 2 and 85 percent at pH 10.5.

Solutions of weak acids and alkalis were also used to extract the nitrogen from bean flour. The least nitrogen was extracted at pH 3.8 (18 percent) with 74 percent extracted at pH 1.8 or pH 7.0, and 85 percent at pH 12. When nitrogen was extracted at pH 7.0 and the extract then adjusted to different pH values, the least nitrogen was left in solution, or the most was precipitated, at pH 3.8. Studies with nitrogen extracted at pH 2 were erratic and inconclusive.

Two methods of extracting and fractionating proteins were used. One was to extract at pH 7.0 and precipitate part of the protein by adjusting the pH to 3.8. The other was to extract with 2 percent NaCl solution and to precipitate the globulins by dialysis, leaving the albumins in solution. The proteins soluble at pH 3.8 and the albumins gave similar paper electropherograms and peaks on chromatography through DEAE-cellulose columns. However, 2 percent NaCl solution extracted less nonnitrogenous material than pH 7.0 solution, because the dried dialyzed material contained 10.1 percent nitrogen compared to 6.0 percent in the pH 7.0 extract soluble at pH 3.8.

The protein precipitated from the pH 7.0 extract by adjusting the pH to 3.8 had electrophoretic and chromatographic properties similar to those of the globulin fraction prepared by precipitation from the 2 percent NaCl extract by dialysis. The globulins contained 14.6 percent nitrogen compared to 11.9 percent in the protein precipitated at pH 3.8. Classical globulins were prepared by the procedure of Waterman, Johns, and Jones utilizing fractional precipitation of the proteins, extracted with 2 percent NaCl, by different percentage saturation with ammonium sulfate. Bean globulins were separated by this procedure into 20 percent conphaseolin, 25 percent of a mixture of conphaseolin and phaseolin, 54% phaseolin and 1% phaselin Paper electrophoresis and chromatography on DEAE-cellulose showed conphaseolin and phaseolin to be mixtures of proteins. Four peaks were obtained when bean proteins were chromatographed on DEAE-cellulose columns using sodium chloride gradient elution. Each preparation contained all peaks but some peaks were larger than others. Peak No. 1 was largest in the protein soluble at pH 7.0 and 3.8 and the one extracted with 2 percent NaCl and soluble after dialysis. Peak No. 3 was largest in the protein precipitated at pH 3.8, in the one precipitated by dialysis, and in the phaseolin preparation.

CONSTITUENTS AND TREATMENTS AFFECTING COOKING OF DRY BEANS

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Beans have been one of man's important foodstuffs for many centuries, but even today we do not know why it is necessary to cook them so long. Most foods in piece size comparable to beans cook in a fraction of the time required to cook beans. What determines the cooking time? If we had the answer, we could approach the development of quick-cooking beans more scientifically.

Mattson of Sweden has proposed an explanation of differences in the cookability of dry peas. His hypothesis is based primarily on the interrelationship of calcium, phytic acid, and pectin. Phytic acid is inositol hexaphosphate. Soft-cooking peas were found to be rich in phytic acid; hard-cooking peas contained less phytic acid. According to the hypothesis, phytic acid influences the cookability by reacting with the calcium, thus serving as a calcium binder. In the bound state, the calcium is not free or available to react with the pectin in the peas, and if the formation of calcium pectate is prevented, the peas remain soft-cooking. Conversely, calcium pectate toughens or firms the peas, making them difficult to cook. Factors that remove or modify phytic acid make the peas more difficult to cook. Mattson found that excessive leaching, or conditions favoring phytase action, such as holding several days in the hydrated state, made peas very difficult to cook. Soaking peas for an extended period, namely 8 days, made them uncookable.

It is reasonable to suspect that the history of peas or beans during growing, harvesting, and subsequent storage could influence the phytic acid content and hence their cookability. Cultural practices, soil types, climatic conditions during growing and harvesting, temperature and humidity, or moisture content during storage, all conceivably could influence compositional factors affecting cookability. Theophrastus, in the third century B. C., referred to differences in beans as "cookable" or "uncookable" and he also recognized that certain conditions of climate may cause this variation. He stated that "In the district of Philippi, if the beans while winnowed are caught by the prevailing wind of the country, they become uncookable, having previously been cookable."

When we started to work on this problem, we were interested in learning if Mattson's findings and hypothesis for dry peas would explain the differences in the cookability of dry beans. Our first effort was to analyze individual beans for their calcium and phosphorus contents in order to learn how much variation to expect within a given sample or population. The results are summarized in Table 1. These data were arranged in order of decreasing calcium content. The calcium values varied almost four-fold, from 0.38 to 0.10 percent. The phosphorus values varied a little over two-fold. The ratio of calcium to phosphorus also showed a large variation. At this point, it was felt that enough variation in composition might exist to explain differences in cookability. We needed, however, some objective method of determining cooking characteristics. For this purpose, an experimental bean cooker was made in our shops, based on the principle of a cooker described by Mattson. This cooker was described in detail at the bean conference in Twin Falls. During a cooking run, a plunger rests on each bean in the cooking sample. When a bean acquires a cooked texture, the plunger penetrates it. The cooker consists of 100 units and cooks 100 beans at a time. The results of an experimental cooking run presented with cooking time plotted against percent cooked gives an S-shaped curve that furnishes a permanent record. Duplicate runs from the same lot of beans are surprisingly similar. A careful study of many cooking runs raised the question as to how the beans that cook first differ from those that cook last.

Table 1. Pintos: analyses of individual beans

Dry weight, Grams	Ash %	Calcium %	Phosphorus %
0.21	-	0.38	0.40
0.31	5.2	0.33	0.60
0.29	5.9	0.31	0.66
0.35	5.6	0.30	0.63
0.26	5.8	0.28	0.79
0.33	5.7	0.29	0.46
0.24	-	0.28	0.51
0.36	6.5	0.26	0.60
0.33	6.0	0.26	0.48
0.38	5.1	0.25	0.51
0.36	5.2	0.25	-
0.30	6.2	0.24	0.62
0.37	4.9	0.23	0.48
0.32	4.8	0.23	0.48
0.25	-	0.21	0.45
0.29	5.5	0.20	0.47
0.42	5.7	0.18	0.48
0.38	4.6	0.17	0.31
0.29	5.8	0.17	0.58
0.37	5.5	0.16	0.51
0.37	4.6	0.14	0.49
0.24	-	0.12	0.58
0.37	4.9	0.11	0.52
0.35	5.6	0.10	0.61
0.36	5.5	0.10	0.47
Average		0.22	0.53

Since the calcium and phosphorus contents of individual beans had been found to vary about 4- and 2-fold, respectively, we were interested in learning if the differences in composition are correlated with differences in cookability. What we needed was analyses of beans represented on the lower and upper parts of the cooking curve.

At this point, however, our technique did not permit an analysis of the beans after cooking, since they had been subjected to much leaching and mechanical loss as a result of the cooking. We thought it might be possible to use one cotyledon for analysis and the other cotyledon for cooking studies. In order to learn if this approach was feasible, we needed to know how uniform the two halves of beans are with respect to composition and cookability. Both of these factors were studied using pintos and large limas by carefully splitting them with a razor blade and analyzing both halves of some beans and cooking both halves of other beans.

The compositional symmetry data were sufficiently encouraging for this purpose, but the cooking times of the respective bean halves showed large variations. Whether these variations reflect real differences in cooking characteristics or a lack of precision in measuring cookability cannot be answered at this time. However, the results between halves were not uniform enough to use one half for analysis and the other half for cooking on an individual bean basis. Nevertheless, we still thought it worth while to compare composites of the 20 percent of beans that cook first with the last 20 percent to cook, but still using one half of each for cooking and the other half for analysis. The data for the first and last 20 percent of beans to cook were found to be so similar that the hypothesis proposed by Mattson for peas does not appear to offer a rational explanation for the differences in cookability of beans.

We have been reluctant to abandon the hypothesis of Mattson, without exploring other possibilities. We next tried some experiments that almost paralleled Mattson's on peas. Beans were cooked individually in test tubes for the same length of time, then segregated into soft, medium, and hard texture categories. The soft texture category included all beans that were penetrated by a light weight (70 grams) plunger. The medium texture category included those beans that resisted the light weight plunger but were penetrated by a heavier plunger (90 grams). The hard-texture category included the beans that were not penetrated by the heavy plunger. The cooking time and plunger weights were chosen to permit approximately equal quantities of beans in each category. The entire beans and their cooking water for each category were pooled for analyses of phytic acid, calcium, phosphorus and magnesium. The results for pinto beans are shown in Table 2.

Table 2: Pintos. compositional comparison showing different cooked textures

	Texture category		
	Soft %	Medium %	Hard %
Phytic acid	1.07	1.13	1.07
Calcium	.12	.12	.11
Phosphorus	.53	.55	.52
Magnesium	.12	.12	.11

These data for the soft, medium, and hard categories are very similar, and certainly do not appear to afford an explanation for differences in cookability. Table 3 shows the results for large lima beans.

Table 3. Large limas: compositional comparison showing different cooked textures

	Texture category		
	Soft %	Medium %	Hard %
Phytic acid	.64	.58	.59
Calcium	.059	.062	.063
Phosphorus	.26	.24	.24
Magnesium	.16	.17	.17

Again, the data for each category are very similar.

Thus far, we have not found an explanation for differences in cookability. We have reason to believe, however, that the cookability of high-moisture beans changes significantly with age. The observations in our Laboratory that support this belief have been subjective, in experiments that were not designed to establish this fact. At the conference last year in Saginaw, Paul Muneta reported on a sample of beans requiring an excessively long cooking time. The only difference between this sample and other beans used in his work was the higher moisture content. These observations, while interesting, are not adequate to establish the role moisture plays in bean cookability. Since more work on this point is justified, we have recently started a fairly elaborate experiment to study changes in cookability at several moisture levels. The varieties being studied are large limas, pintos, and sanilacs. The experiment has not been in progress long enough to have data to report at this time. However, we hope to find other changes that occur in the beans, in addition to the expected changes in cookability.

One aspect of the results obtained with the experimental bean cooker was very puzzling for a long time. Beans cook quicker in the experimental cooker than when cooked by conventional means. When this fact was first observed, we thought perhaps an error was made in selecting the plunger weight. Since a re-check confirmed the correctness of the plunger weight, it was obvious that some other factor must be responsible.

The heat treatment a bean experiences in the experimental cooker differs from conditions prevailing in conventional cooking. In the cooker, a few beans are placed in about two gallons of water previously heated to 93°C--that is, near the boiling point. Under these conditions, the bean enzymes are destroyed quickly after normal cellular metabolism is disrupted. In conventional cooking, beans experience a more gradual rise in temperature, and under these conditions, the enzymes have more opportunity to catalyze changes after the cell contents are mixed by heating. The difference between the two methods of cooking is believed to afford an explanation for at least part of the discrepancy between the observed cooking times. If changes that affect cooking time do occur in beans after their normal metabolism has been disrupted, but before the enzymes have been destroyed, then it should be possible to show this experimentally. Accordingly, experiments were run in which pinto, large lima, and Red Mexican beans soaked overnight were positioned in the experimental cooker, then held in water at 60°C. for an hour. Immediately after this heat conditioning, the beans were removed from the water and allowed to cool to room temperature for about 10 minutes, followed by a regular cooking run. In all instances, the heat-conditioned beans required a much longer cooking time than the control beans.

It is interesting to speculate that at least two enzymatic changes are occurring during the heat conditioning, which result in longer cooking. First, phytase is reducing the effective phytic acid content, thus freeing more calcium to react with pectin; second, pectin esterase is de-methoxylating pectin, thereby increasing its sensitivity to calcium.

The effect of enzyme treatment on cooking time of beans has been studied. Several commercial enzymes and many fungi culture extracts have been tested. Admittedly, this approach has been empirical since we do not know what type of structure or linkage it is desirable to change. Most of the enzymes used have been marketed for cellulase or pectic enzyme activities; however, such enzyme preparations nearly always contain other enzymes. Hence a positive effect cannot be attributed to a specific enzyme. The fungi cultures also furnish a spectrum of enzymes, but most of the fungi used have been those recognized as cellulase and pectic enzyme producers.

Our screening technique for commercial enzyme preparations is to soak the beans overnight in solutions of the enzymes, followed by an experimental cooking run. For screening the fungi, cultures are grown on sterile ground bean medium, and those that show good growth are harvested and tested. For harvesting, the entire culture medium is blended with enough water to furnish an extract for soaking the beans. After blending, the entire preparation is shaken for 30 minutes and centrifuged. The supernatant is decanted and used for soaking the beans overnight before an experimental cooking run.

The results obtained with some of the commercial enzymes and fungi cultures are shown in Table 4.

Table 4. Pinto beans: relative cookability after soaking in enzyme solutions and fungi culture extracts

Soaking medium	Percent cooked at different times		
	Minutes		
	22-1/2	25	27-1/2
Cellulase, No. 8190	54	80	93
Cellulase XT 541	50	77	92
A. ochraceus	65	89	97
Pen notatum	59	82	97
A. oryzae	60	80	86
Control, water	8	25	50
Control, bean medium	23	58	84

These are selected examples from several commercial enzymes tested and many fungi that have been screened. You can see from the first column of data that these enzymes and cultures were quite effective in reducing the cooking time. More than 50 percent of the beans cooked in 22-1/2 minutes after these treatments, while only 8 percent of beans soaked in water cooked in this time. A similar difference was found in the percentage of beans that cooked in 25 and 27-1/2 minutes. The result with sterile bean medium control was unexpected. This control was run since it appeared as the absolute control for the culture experiments. The difference between it and the water control is significant and consistent. We do not know the reason for this effect, but hope to study it more in the future.

Summary and Conclusions. Beans require much more cooking than most other foods. Furthermore, within a given sample or population, some beans cook in about one-half the time required to cook the toughest beans in the sample. Phytic acid, calcium, magnesium, and total phosphorus contents of beans have been studied, but variations in these substances do not appear to offer an explanation for differences in cookability. Heat conditioning of soaked beans increases their cooking time; enzyme-catalyzed changes may occur during this heat conditioning. Reduction in cooking time of beans can be obtained by treatment with enzymes; however, these treatments are less effective than desired. More research is needed to produce really quick-cooking beans.

TEMPERATURE EFFECT ON RECONSTITUTION OF SMALL WHITE BEANS

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In a previous report (Elbert and Campbell, 1961) on effects of temperature and selected buffer systems on water uptake by dried beans, the results indicated that an initial or preheat temperature of 70°C. was effective in reducing the amount of water imbibed during the subsequent heating at 100°C. The present investigation was undertaken to obtain more information on the nature of this diminished capacity to absorb water and to determine what other effects might accompany it.

Small white beans were immersed in distilled water or a chelate solution (0.5 percent disodium salt of ethylenediaminetetraacetic acid, EDTA) and held at 50 or 70°C. for 2, 3, or 5 hours. Immediately following, the beans were subjected to a higher temperature of 100°C. for 1-1/3 hours (simulated cook). Either a portion of the remaining initial immersion liquid or fresh distilled water was used for this final heating period.

Effect of treatments on weights of beans. Generally, the water absorbed resulted in a "weight ratio" (wt. treated sample/initial wt. dry sample) of 3 or slightly greater. The exceptions to this were samples that had been preheated at 70°C. for 5 hours in chelate solution or water and further heated in the same or initial liquid. However, when the time was reduced to 2 hours, the final weight ratio was approximately 3. The final weight was usually increased by replacing the initial liquid with water prior to heating at 100°C. and after preheating at 70 or 50°C. This increase was substantial for beans pretreated at 70°C. (2 or 5 hours) in water or in chelate solution (5 hours).

Appearance. Beans that had been preheated for 5 hours at 70°C. were much firmer in appearance and to the touch than samples preheated at 50°C. The firming effect was greatest if the beans were immersed in water and heated at 100°C. in this initial liquid. However, samples preheated at 70°C. in water and heated in fresh water and those preheated and heated in Na_2EDTA solution were all firmer than any samples that had been soaked at 50°C. After 2 or 5 hours at 70°C. the beans exhibited a striped pattern which might have been caused by incomplete distending of the seed coat by the cotyledon. From appearance and weight data, all samples appeared rehydrated after the initial or preheat treatment. They were swollen and wet-gray in appearance rather than chalky and the seed coats more translucent than opaque.

Beans treated with chelate solution had unusually translucent seed coats which slipped off the cotyledons very easily. This would seem to indicate that the beans were soft but the cotyledons were actually relatively firm. This effect was not observed when the chelate solution was replaced with distilled water prior to treatment at 100°C.

Amount of residue. Using a procedure based on the FDA method for green beans (1954), pureed samples were filtered through a 30-mesh basket and the residue washed, dried, and weighed. At either 50 or 70°C. beans that had been treated with chelate solution had a very small amount of residue as compared with other combinations of treatments. The amount of residue was increased by replacing the initial water or Na_2EDTA solution with water before the final heating period. This effect was more pronounced with the chelate solution. Also, the increase was greater at either 50° or 70°C. when a 5-hour (rather than 2 or 3) preheated period was used.

If one assumes that the residue represents largely, if not all, seed coat material, then the data indicated that soaking beans for 5 hours at 70° or 50°C. followed by 1-1/3 hours at 100°C. resulted in seed coats of approximately the same firmness (as measured by residue) even though the cotyledons differed considerably in this respect.

Interrupted preheating at 70°C. The difference in weight, appearance, and firmness of beans preheated at 70°C. for 5 hours as compared with other samples gave some indication of enzyme activity. If an enzyme was involved, inactivation should occur in a rehydrated or "wet" bean. Consequently, test tubes, each containing a single bean, were placed in boiling water for a few minutes after the beans appeared sufficiently distended (1-1/4 hours at 70°C.). The samples were then replaced in the 70°C. bath until a total of 5 hours had elapsed; then they were heated for the usual 1-1/3 hours at 100°C. Beans so treated had a swollen, broken appearance and were very soft to the touch. Interruption with brief boiling after 3-1/2 hours at 70°C. resulted in beans that were firm and much less broken and swollen in appearance. Firmness was comparable to that of the control samples--that is, those preheated continuously for 5 hours at 70°C. and then heated at 100°C. for 1-1/3 hours.

These results indicated that enzyme action was probably involved in the formation of firm, less broken appearing beans, and partly or wholly responsible for the decreased water uptake at 70°C. Limited work has shown that this effect is also obtained at 60°C. but not at 80°C. Apparently the enzyme has had insufficient opportunity to act after 1-1/2 hours but the conditions and time after 3-1/2 hours were adequate for the firming effect. The final or cooked weights of samples preheated only 2 hours at 70°C. gave some indication that activity might have occurred to a limited extent at this time. The residues appeared to be unaffected. The firming action would probably be inhibited by a buffer solution of pH 8 since water absorption was scarcely affected when beans were preheated in this medium at 70°C. (Elbert and Campbell, 1961). The firmness was not necessarily undesirable; limited experience with a panel of judges indicated some preferences for the firmer beans.

One and/or two enzymes might conceivably be involved in the firming of the cotyledons: pectinmethylesterase and/or phytase. Numerous tests failed to give a positive test for the former; tests for phytase have not yet been conducted. The role of the latter enzyme in "hard-cooking" peas and the relation of its activity to the calcium and magnesium binding by phytin and pectic substances has been discussed by Mattson (1946).

The replacement of initial immersion liquid with fresh water is of interest because this resulted in a softer cotyledon but more residue, indicating tougher seed coats. The reason(s) for these effects are not clear. Possibly, some substance such as calcium that helps firm the cotyledon is leached out in the initial liquid. However, this does not offer an explanation for the effect on the seed coats.

An EDTA chelating agent does not complex calcium ions at pH values less than 5.5 (Dow Chemical Co., 1959). The pH of the EDTA media was initially 4.5 and finally about 5.0. Consequently, the softening effect of the EDTA on seed coats cannot be explained by the complexing of calcium from the liquid. Other ions such as iron, copper, zinc which can be chelated in the pH range indicated might be involved. The question still remains, however, as to why the cotyledons are softened and more residue is obtained by replacing the initial liquid with water. Investigations on texture of beans, including histological studies, are being continued in this laboratory with the hope of learning how certain factors affect texture of both cotyledons and seed coats.

TRACE GASEOUS CONSTITUENTS IN BREATH AS RELATED TO FLATULENCE

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Previous studies on intestinal gas formation have involved complicated systems of gas collection on nonambulatory subjects and do not differentiate between gas produced in the colon and that produced in the small bowel. The present studies were undertaken to develop better techniques for measuring and investigating the mechanism of intestinal gas production. The research included analyses of the composition of respiratory and intestinal gases studies of gas produced by in vitro incubation of fecal material from normal subjects and from subjects having an ileostomy or colostomy, and studies of the influence of bean meals on these.

Anaerobic incubation of feces from normal subjects produced carbon dioxide and usually methane; of ileal dejecta, carbon dioxide consistently and usually hydrogen, but no methane; of colostomy residues, carbon dioxide and methane, but no hydrogen. Chemical analyses and microscopic observations of dejecta from ileostomies indicate that considerable amounts of starch storage cells and other bean tissue pass through the small intestine without being digested.

Intestinal gas obtained by rectal tube contained carbon dioxide, methane, hydrogen, and nitrogen. It appeared that the more rapidly the gas was produced and expelled, the higher the proportion of hydrogen and the lower the methane. It was theorized that hydrogen and methane produced in the bowel would readily diffuse into the blood stream and into the respired air through lungs. Since hydrogen appeared to be produced before methane in the lower part of the ileum or upper colon and during the most active period of gas production, its content in expired breath was expected to correlate much better than that of methane with flatus production.

Breath methane was readily determined by long-path infrared spectrometry. It was found that breath methane content was much higher in individuals with slow intestinal motility than in those with normal to rapid peristaltic rates. Expiratory concentration rose after bean feeding, but not during the period of distress from flatus.

At the time this work was initiated, there was no method available to determine hydrogen in the part-per-million range in breath samples. An instrument was developed by means of which hydrogen was separated from oxygen in a gas chromatographic column using nitrogen as a carrier gas and measured by thermal conductivity.

Consumption of cooked dried beans caused flatulence and elevations in breath hydrogen (from near zero to 20 - 50 ppm). Flatulence and increased breath hydrogen occurred 3 to 5 hours after the beans were eaten. When the dried beans were chemically treated in a manner that eliminated the factor(s) responsible for flatus production, their ingestion was no longer associated with high levels of breath hydrogen.

Bean feeding did not appear to change intestinal motility (as measured by ingestion of carmine dye with the meal).

CHARACTERISTICS AND PERFORMANCE OF THE NEBRASKA 1 DRY BEAN

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Nebraska 1 originated from an interspecific cross by Homma between *Phaseolus vulgaris*, var. Great Northern Montana 5, and *Phaseolus acutifolius*, var. Tepary No. 4. *Phaseolus vulgaris* is susceptible to common bean blight, *Xanthomonas phaseoli*, (E. F. Sm.), Dows., while *Phaseolus acutifolius* is resistant. Four F_1 plants from the cross were obtained through *in vitro* culture of excised embryos. Flowers produced by the F_1 plants were self-fertile and the seed was viable. Common blight resistance and characteristics of the plants were studied in the F_3 generation. Foliar characteristics in young plants resembled the Tepary parent but later stages of vegetative growth appeared more like *P. vulgaris*. Seed size was comparable to that of the *Phaseolus vulgaris* parent. Common blight resistance was found to be quantitatively inherited. Plants exhibiting good horticultural characteristics and high blight resistance were selected and bulked in the F_4 and subsequent generations from pedigree F_3 plants. Yields of Nebraska 1 were comparable to those of Great Northern strains in Nebraska outstate trials in 1959, 1960, and 1961. Nebraska 1 exhibited resistance to common blight under field conditions in 1960 and in greenhouse innoculation tests in 1961. Limited cooking test reports indicated that Nebraska 1 beans required a longer cooking time than UI No. 59 but were comparable in taste and flavor.

IRRIGATION OF GREAT NORTHERN FIELD BEANS IN WESTERN NEBRASKA

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In irrigation experiments with field beans on Tripp very fine sandy loam, particular attention was given to timing of irrigations with relation to stage of plant development. These experiments indicated that: Three well timed irrigations will produce near maximum bean yield. The first irrigation should be applied promptly after foliage begins to turn dark in color. If the root zone is at or near field capacity at planting time, beans usually will not require a second irrigation until pods begin to set. Available moisture in the top foot of the soil should be kept above about 50 percent of that at field capacity during the pod filling period. An irrigation at the beginning of maturity of the first set may increase bean yield by several bushels per acre if the weather continues warm. If weather turns cold, beans probably will not gain by an irrigation at this stage, and may lose through deterioration in quality. Highest evapotranspiration rate occurred immediately following the first irrigation of the season when crop foliage was inadequate to protect the soil surface from evaporation. Evapotranspiration was about 12 inches in the cooler and about 16 inches in the warmer growing seasons.

PROGRESS REPORT ON DIRECT COMBINING DRY BEANS

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Initial tests conducted in 1958 at Cornell University indicated that direct combining of dry beans is possible. However, to be commercially feasible the total loss would have to be less than 1 1/2 - 2 bushels per acre. Consequently during 1959, 1960, and 1961 main emphasis was placed on developing a direct harvesting combine. Additional efforts were made to improve the existing methods of bean harvesting.

Several different harvester components were field tested. If these units would work satisfactorily, they were to be incorporated into the design of a direct combine harvester. In 1960, I reported on various devices and experimental units that we designed, constructed, and field tested. These included:

1. A two-row hydraulically powered rotary cutter. This unit consisted of two large notched disks that rotated in a horizontal plane just below the ground surface and cut or lacerated the bean roots as two rows were lifted and placed in a single windrow. The resulting windrow was relatively free of dirt, stones and long roots. This cutter worked fine in sandy loam but was not satisfactory in stony soil. (Hopkins Mfg., Saginaw, Mich.--similar to F. Sefkovic, Grand Valley, Colorado.)

2. An experimental belt puller was also tested on dry beans. This unit consisted of two long "V" belts that rotated in a plane 30° above horizontal. These belts were powered through a gear box attached to the power take-off. As the machine moved down the bean row the pair of rotating belts, one on each side of the bean row, grabbed the bean vines a few inches above the ground surface and forcibly pulled them. Preliminary results on very late and poor-condition beans indicated that the belts did a clean pulling job but the rough handling of the bean vine caused considerable shatter losses.

3. Best results were obtained with a completely self-propelled direct bean combine. This unit consisted of a regular Bidwell (Mfg. by Climax Corp., Batavia, N.Y.) bean combine mounted on a Minneapolis-Moline Uni-Trac power frame. The regular pickup and elevating attachment was removed and replaced with a special elevator, cutting mechanism, and a bean lifting head. This head is a modified Hesston Row Crop Saver Head (Mfg. by Hesston Mfg. Co., Hesston, Kansas) with rubber fingers attached to V-belts. These rubber fingered belts were driven from traction wheels at a designed speed ratio to give zero relative forward velocity to the bean plants. The belts were inclined 20° above horizontal and this permitted the fingers to strip up through the vines, lift the beans over the cutter bar, and place the cut vines and beans on the elevating canvas.

In 1959, the results with this machine direct combining red kidney beans were very satisfactory. In one field the total losses with this machine were 1.57 bushels per acre. Using the conventional pulling, raking and pickup combining methods losses on the same field were 2.04 bushels per acre. Other tests resulted in somewhat higher losses but in no one case did the direct combine loss greatly exceed the losses associated with the conventional method.

4. Work was also done with a Chisholm-Ryder green bean harvester (Mfg. by Chisholm-Ryder Co., Niagara Falls, N.Y.). Modifications made by the company improved the performance of the machine.

<u>1960 Results</u>. During the 1960 season two devices were used and compared with the conventional method of harvesting. These devices included:

1. The Bidwell bean combine and modified row crop saver head. Engineeringwise the traction drive unit was altered to eliminate belt slippage. In addition hydraulic control cylinders were added to the cutter bar and head assembly. This control facilitated making cutting height adjustments in the field. When operating under field conditions the cutter bar height had to be adjusted quite frequently, depending upon the crop and terrain conditions. Probably the next step will be to install an automatic hydraulic height adjuster.

The Row Crop Saver Head was field tested on red kidneys and white marrows. Losses for the red kidneys ran higher this year and averaged 2.61 bushels per acre. White marrows ran 2.8 bushels per acre. This higher loss was due to the generally lower growing plants encountered. Numerous pods were actually embedded into the soil and the rubber fingers did not appear to be able to lift them over the cutter bar.

Mr. Hoffman, Muncy, Pa., was interested in our fingered attachment and constructed his own two row direct harvester patterned after our machine. In addition to the fingered belt, Mr. Hoffman's machine had a set of rotating brushes placed below the fingered belts. He was generally satisfied with the machine although he did report trouble with vines winding around the brushes.

2. The second machine that was constructed and field tested was a belt puller attachment for the Bidwell bean combine. This unit consisted of four V-belts--two running on each side of the row, somewhat similarly to the belt puller used in 1959. Preliminary results were very poor. Losses at the higher belt speeds of approximately 780 fpm were very high--between 2.25 and 8.7 bushels per acre. At the lower speed of approximately 580 fpm losses were slightly less. The machine was modified with a sponge rubber layer 5/16 inch thick placed on the belts. This greatly improved the performance and reduced the losses to an average of 2.87 bushels per acre.

<u>1961 Results</u>. During the 1961 season emphasis was placed on comparing two methods of direct harvesting: (1) lifting device and cutting bar, and (2) complete pulling device. Consequently, the rubber fingered device previously described was compared with two new and improved devices:

1. Rubber fingered device with rubber tire and nylon brushes. This attachment consisted of four "V" belts with 2-inch rubber fingers. Two 10-inch pneumatic tired wheels were placed below the front "V" pulleys. In addition two cone-shaped nylon brushes were used to lift or sweep the beans up over the cutter bar. A hydraulic motor was used to power the unit. Best results were obtained with a tire speed ground speed ratio of 1.6:1. Losses averaged approximately 2.4 bushels per acre.

2. Best results were obtained with a complete rubber belt pulling device. This unit used two belts--Goodyear Rough Top--Diamond Cut--18 inches high. The two halves of the pulling device were spring loaded to permit spreading when striking an obstruction. Hydraulic motors were used to vary the speed of the belt. Best results were obtained with a belt speed of 250 to 300 fpm and a ground speed of either 1 or 2 mph. For some reason, losses at 1.5 mph were slightly higher. Losses at optimum speeds averaged somewhat less than 1 bushel per acre.

3. Losses with the regular rubber fingered device previously tested ran about 2.8 bushels per acre at 2 mph.

4. Losses with conventional harvesting in the same field averaged approximately 3 bushels per acre.

<u>A look at the future</u>. Based on three years of testing, I am convinced that direct combining of beans is not only commercially possible but will be a reality in just a few years. Several different companies have indicated an interest in the belt puller device and at least one is working on a commercial adaptation. The first unit will be a two-row attachment probably driven by a traction wheel. Another must for direct combining will be the necessity of using defoliating chemical to promote uniform ripening of the crop. Good weed control will also be a necessity. If possible, bean plants will have to be developed through breeding that will have longer base stems or higher growing pods.

INDOXYL ACETATE AS AN INDICATOR FOR CRACKED SEEDCOATS OF THE PEA BEAN AND OTHER LIGHT COLORED LEGUME SEEDS

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Legume seeds are particularly subject to mechanical damage during harvesting and handling procedures. Cracking of seedcoats is an important type of mechanical damage, yet one which has been hard to evaluate. Currently, microscopic examination of seed for cracks is difficult as well as time consuming. Cracked seedcoats provide an entrance to fungi and bacteria which may accelerate seed deterioration. Cracked seed may fail to germinate or those which germinate may be abnormal.

Cracks in many light-colored legume seeds may be easily detected by soaking the seed in 0.1 percent indoxyl acetate and then exposing the damp seeds to ammonia fumes. Esterase enzymes are present in the cotyledonary and inner seedcoat tissues. These enzymes hydrolyze indoxyl acetate to indoxyl and acetic acid. Indoxyl autoxidizes to indigo, an insoluble blue dye. The reaction is accelerated by the alkaline conditions provided by the ammonia fumes. Intact seeds do not stain. Seeds develop the blue color in areas where damage to the seedcoat permits entrance of the reagent. The following seeds have been successfully stained by this technique: pea, lima, snap, and kidney beans (Phaseolus); soybean (Glycine) (Soja); crimson and white clover (Trifolium); sweet clover (Melilotus); alfalfa (Medicago); and wrinkled and smooth field peas (Pisum).

IMPROVEMENT OF DRY BEANS AND PROGRESS IN ROOT ROT AND VIRUS RESEARCH IN WASHINGTON

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The Irrigation Experiment Station at Prosser, Washington, is one of two locations in the West where work is conducted by personnel of the Vegetables and Ornamentals Research Branch on regional problems of bean production. The other is at Twin Falls, Idaho. Prosser is located at the eastern end of the Yakima valley and just south of the vast, new irrigation project in the Columbia Basin.

This locality is a hot spot for virus and soil-borne diseases of beans. The beet leafhopper, vector of the sugar beet curly top virus, is endemic and prolific here, making the growing of curly top-susceptible crops impractical. Mosaic diseases in beans are very prevalent because of tremendous aphid populations. Soil-borne diseases, especially fusarium root rot and sclerotinia wilt have become serious problems rapidly in the newly irrigated lands. Bacterial diseases, however, seldom appear, because of the hot, dry summers. Weeds, especially barnyardgrass, possibly equal diseases as a problem in many bean fields.

My work is done in cooperation with the Investigations Leader, Dr. W. J. Zaumeyer of Beltsville, Dr. V. E. Wilson of Twin Falls, Idaho, and beginning last fall, with two new members of our Branch, Dr. R. O. Hampton, a pathologist working on the legume virus complex and curly top in beans, and Dr. M. J. Silbernagel, a pathologist-geneticist, who will concentrate on breeding of curly top-resistant snap beans and other breeding and genetics aspects of our program. The latter two men are at Prosser also.

Breeding work. The breeding program at Prosser has been concerned principally with the development of curly top-resistant snap beans. Some excellent products are expected to be ready for release in the near future. In regard to the breeding of dry beans, we already have good curly top resistance in University of Idaho releases of Red Mexican, Pinto, and Great Northern, and in California Pink beans. Recently, Columbia Pinto, developed jointly by USDA and Washington State University, and Red Mexican (University of Idaho No. 35) have been tested and promoted for use in the Columbia Basin. These new varieties are immune to the common mosaic virus and its New York No. 15 strain. In 1961 these beans largely replaced susceptible varieties which suffered over a million dollars of damage by the New York No. 15 virus in the Columbia Basin in both 1959 and 1960.

However, these varieties now in use lack qualities to be desired. Furthermore, curly top resistance is needed in other classes of beans. We are progressing in the development of early-maturing, short-vined Red Mexican types of which we have several very promising lines in advanced generations. Promising curly top and mosaic resistant Red Kidney types are also being developed.

Recently we have employed Great Northern University of Idaho No. 31, a variety which is seldom damaged by our complex of legume viruses, in crosses with other dry bean types. A New Mexico Pinto (56-775) with good color-retaining characteristics is being used to improve our pintos. Many crosses have been made using the above-mentioned dry bean types in combinations with root rot-resistant PI No. 203. We plan an intensive effort to establish resistance to root rot in varieties of both dry beans and snap beans. Other breeding work for which there is a demand in the

Northwest includes the development of curly top and mosaic resistant small white varieties and mosaic resistant Pinks.

Virus research. We find that planting time has a decided influence on the incidence of aphid-borne mosaics in the Columbia Basin. Beans planted before the middle of May are seldom badly damaged, while later plantings of varieties susceptible to common mosaics frequently suffer severe damage. Disease incidence is related to the stage of development of the plants when aphid populations reach their peak, usually in July. In studies of our virus complex and its source, we find that practically every alfalfa plant of 13 varieties, nearly every clover plant of several species, and trefoil from experimental plots and fields near prosser carry one or more viruses infectious to beans.

The practical significance of these observations is yet to be determined fully. Beans do well when planted near alfalfa fields. However, as in other areas, plantings near clover often are damaged by yellow bean mosaic virus and possibly by other legume viruses which we are in the process of identifying. We reported recently a new seed-borne western bean mosaic virus with properties and host range very different from those of the common mosaic viruses. Presently, two or three other seed-borne viruses are being investigated, which appear to be strains of the western bean mosaic virus. These new viruses are frightening because none of our commercial dry bean varieties are resistant to all of them. However, these viruses appear to be less extensively seed-borne than the common mosaic viruses and, so far, they have not been observed to cause serious crop damage.

Control of fusarium root rot. Our approach to root rot control is based largely upon some of the principles explained by Dr. Snyder. In the first place, the nature of the pathogen, its distribution and means of survival in the soil suggest that fusarium root rot might be controlled by locally applied treatments protective to the lower part of the stem and tap root, the more vulnerable parts of the plant. Secondly, we are greatly impressed by the fact that some rotation practices and the incorporation in the soil of certain crop residues largely control root rot through alteration of the microbiological environment of the soil.

Frequently it is not feasible for bean farmers to follow prescribed rotations or to provide large volumes of specific organic materials. Therefore, we have investigated the use of small quantities of organic meals and composts strategically placed in bands in or near the seed furrow. Some of our results show that as little as 50 to 100 pounds of some materials will control root rot. However, such treatments are sometimes unstable. For instance, cool weather, flooding, and nitrogen fertilizer may nullify them. Some materials are detrimental to seed germination or plant emergence. Others increase root rot. Furthermore, it has been difficult to find suitable means for applying such treatments on a practical scale. However, progress has been made in determining (1) what happens to the pathogen in the presence of some types of organic materials, (2) the better materials to apply, (3) timing of applications, (4) rates, (5) placement, and (6) practical methods of application to obtain stability in the treatments.

Crop residues which rot in the field over winter have usually had little value in our type of treatments. On the other hand, a number, when stored dry before application, have been effective. Alfalfa meal and bean straw meal have given good results more consistently than barley straw, wheat straw, or corn stalks. Sterilization (by autoclaving) of organic meals prior to use has increased their value. Pelleting of organic matter makes it easier to apply with available equipment, and treatments so applied show promise.

Detrimental effects on plant emergence have been overcome and effectiveness for root rot control improved in some materials after inoculation with specific fungi or by composting them in mixtures with soils. Some composts actually stimulate plant emergency and elongation of the stems, somewhat as if the seeds had been treated with gibberellin. Suppression of root rot is enhanced in some instances by application of organic matter to the soil 10 days to 3 weeks previous to planting, rather than at planting time.

Among cultural practices studied, plant spacing has been found to have an influence on root rot incidence in Red Mexican beans. Plants spaced 4 to 6 inches apart within the row consistently show less root rot than plants closer together. In 1961 Red Mexican U of I Nos. 3, 4, and 35, Columbia Pinto, Pinto U of I No. 112, and Sutter Pink showed increased yields with wide (6-inch) spacing as compared with the same varieties planted in narrow spacing (1 to 4 inches). Other varieties, Pinto U of I No. 11, Great Northerns No. 1140 and U of I No. 31, and Small Flat Whites yielded best with narrow spacing.

Weed control. Recent work by Dr. J. H. Dawson, USDA Agronomist at Prosser, has opened the way for use of EPTC (Stauffer's Eptam, a well known source) for the control of annual weeds in beans. This material is recommended for use in Washington and has been used successfully on a large acreage. It is sprayed on the soil surface (3 lbs. per acre) and incorporated in the top 3 inches immediately before planting in pre-irrigated land. We have found that EPTC used in this manner on sandy loam soils has no serious detrimental effects on most bean varieties. In fact, the only varieties showing injury have been of the Red Mexican type, in which a tip burn of the unifoliate leaves occurs when soils remain wet and cold after planting. Plants so affected have usually recovered and produced normal yields.

An interesting observation of Dr. Dawson's is that the nature of the bean plants themselves makes this crop particularly adaptable to the use of EPTC. The chemical remains active and effective in the soil for only about 6 weeks. After this time, weed control is dependent upon ground cover and shading characteristically provided by normal rapid growth of bean plants. Without good ground coverage by the vines, weed control is not satisfactory.

PROGRESS REPORT ON ROOT ROT RESEARCH

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Greater losses in yield and quality of beans are sustained from diseases than from any other causes. Neither the bean plant nor the seed can be considered rugged or able to withstand rough treatment in any phases of production or harvest. Vulnerability of the bean in field culture is well ilustrated by the number of diseases to which it is subjected, especially the below-ground stem and root diseases.

Control is being approached nationally by the breeding of resistant varieties, application of soil fumigants, and cultural practices. It was demonstrated in California that rotation of beans with barley markedly reduced stem and root rots caused by *Fusarium solani* f. *phaseoli*, *Rhizoctonia solani*, and *Thielaviopsis basicola*. These findings have since been confirmed by workers in other areas. Present research in the Department of Plant Pathology, University of California at Berkeley, seeks to determine why a rotation crop of barley is beneficial, and to learn how the grower may use the phenomenon more effectively in producing higher yields of higher quality beans.

Special emphasis in current studies has been placed on the *Fusarium* root rot. It now appears that this fungus exists in the soil primarily as *chlamydospores*--these are microscopic thick-walled resting spores or "seeds" of the organism. In a field repeatedly cultured to beans the count of these chlamydospores has exceeded 2,000 per gram of soil. Thus their numbers and distribution may be such as to insure infection of every plant in such a field. The chlamydospore in the soil requires for its activation special stimuli, such as sugars and amino acids or other nutrients that are normally exuded from germinating bean and other seeds, and from the roots of various plants with which the chlamydospore is in contact. Although the spore may be stimulated to germinate by exudates from different plants, it is unable to attack living tissues of any plant except the bean. If the bean is not present in the vicinity of the germinated spore, the fungus growth ceases as available nutrients are exhausted, and it is converted into new chlamydospores which again wait for a germination stimulus.

The bean plant, then, in its growth through the soil contacts the fungus and induces it to germinate by its exudation of nutrients. Infection of the underground parts of the bean plant depends upon an adequate external supply of moisture and nutrients, each spore producing a lesion, and the lesions coalescing eventually to involve the entire underground portion of the plant. Conidia produced on the stem at the surface of the ground convert into chlamydospores as they contact moist soil. As the lesioned tissues die the fungus produces in them great numbers of new chlamydospores which are released into the soil with disintegration of the plant following harvest of the crop.

It is suggested that the beneficial role of the mature barley straw which remains in the soil following a barley-bean rotation is related to its slow decay, a process which ties up nutrients essential to the processes of germination and infection of the *Fusarium*. These and other possible, beneficial factors associated with the depressant effect of barley upon the bean root rot *Fusarium* are under continuing study.

ESTIMATES OF THE AVERAGE LEVEL OF DOMINANCE OF GENES CONCERNED IN THE MEAN EXPRESSION OF A COMPLEX TRAIT IN A FIELD BEAN CROSS

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Two complex traits in field beans, total leaf area and total grain yield, were studied by partitioning them into simpler components. Number of leaflets per plant (N) and mean leaflet size (S) are the components of total leaf area (T), thus, N x S = T. Components of total grain yield per plant (W) are: number of pods per plant (X), number of seeds per pod (Y), and weight of seed (Z). Thus, X x Y x Z = W.

The occurrence of nonsignificant correlations for N vs. S in the case of total leaf area, and between X vs. Y, X vs. Z, and Y vs. Z, in the case of yield, indicated that separate genetic systems are governing each of the components.

Complete dominance for high number of leaflets and lack of dominance for size of leaflets was found when the F_1 was tested against the parents and the mid-parent. These findings were supported completely by the estimates of the degree of dominance $\bar{a}$, calculated from the partition of the variances of the F_2 and means of F_3 into genetic variance and its components. Complete dominance for high number of leaflets and absence of dominance for leaflet size indicate that these traits are influenced by a dominant and an additive genetic system respectively.

The F_1 was compared with the parents and the mid-parent in regard to the components of yield, X, Y, and Z. Complete dominance for the higher number of pods was found, suggesting a dominant genetic system for this component. Lack of dominance was observed with respect to Y and Z, indicating that these components are controlled by additive genetic systems.

In the complex traits, total leaf area and grain yield, heterosis was observed. This heterosis was a clear consequence of multiplicative relationships among the components. Estimates of the average level of dominance in the case of the complex trait, total leaf area, were well into the overdominance range. On the basis of the existence of independent genetic systems for components, it seems obvious that this overdominance is spurious and does not reflect the behavior of real genes at all.

In contrast to a condition of heterosis being due to genetic heterozygosity, heterosis due to interaction between components could be potentially fixed in a true breeding form, by fixing separately the genetic systems of each of the components. The suggestion is made that it might be more realistic, and more fruitful, to select for high component values, and to attempt to recombine high or optimal values of the components in a single line, than to select in a large uncontrolled segregating population for the very infrequent, randomly occurring optimal combination.

Parenthetically, one possible serious drawback to this suggestion should be stated. If, under a selection scheme based upon components, there should develop large and significant negative correlations among the components, such relationships would tend to mitigate any progress that one made by selection for component superiority. That is to say, as one made progress in terms of component X, one would be faced with declining values of Y and/or Z. Similarly with selection for high values of component Y and component Z, any progress in one or the other of these components would probably

*This paper is taken from Mr. Duarte's Master of Science thesis at Michigan State University, 1961.

be offset by declining values in the other components. Negative correlations have, indeed, been found between components, but it cannot be stated with assurance at this time whether these negative correlations are genetic or developmental, and I cannot say just how serious such correlations are going to be in a selection program at this time.

RELATIVE FERTILITY OF PHASEOLUS VULGARIS AND PHASEOLUS COCCINEUS

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Colorado State University, Hesperus

Phaseolus coccineus, commonly called "scarlet runner", is used as a green bean in parts of Europe and Asia, and as an ornamental in the U. S. It behaves as a perennial in the warmer climates and it is of interest to plant breeders because it is thought to be resistant to most root rot organisms that attack *Phaseolus vulgaris*. *P. coccineus* has been reported as varying from almost completely self-sterile to fully self-fertile. In a greenhouse study conducted during 1959 and 1960 at Colorado State University, an attempt was made to ascertain if there is a genetically controlled incompatibility system present in *P. coccineus*, a cross pollinating species, which would act as a barrier to self-fertility.

A previous study by H. B. Cooper disclosed the presence of several mechanical barriers to self-fertility: (1) the pollen is dehisced below the stigmatic surface and (2) there is also a layer of papillar cells on the stigma surface which must be ruptured before pollen tubes can penetrate the stigma. Both are effective barriers to self-pollination. Removal of these barriers to pollination by artificially placing the pollen on the stigma with a toothpick covered by an abrasive material resulted in a pod set of only 17 percent while the untreated flowers set 4 percent pods. In the present study four plants of *P. coccineus* from different sources were crossed and selfed in all combinations, using the toothpick method described by Cooper. Approximately 25 crosses per combination were made. The average percent success for crosses was 48.0% and 52.0% success for selfs.

Thirty F_1 plants from three of the original parent crosses were grouped into six families of five plants each, based on the parents involved, i.e., families A-B, B-C, and A-C and their reciprocals. The F_1's within each family were selfed and crossed in all possible combinations. Selfing the F_1's disclosed six plants with less than 10 percent fertility and seven plants with more than 50 percent success, all significantly different from the expected. Results obtained from crossing the F_1's within each family were rather inconclusive. The data did not support the hypothesis of a genetic incompatibility system such as has been described in tobacco by East and Manglesdorf or in clovers by Brewbaker, Atwood and Williams. In nearly all crosses the fertility was much too high for incompatibility to be present, although the presence of a weak incompatibility system cannot be ruled out.

It was rather evident that there are factors for pod setting (fertility) in *P. coccineus*. The average success of the F_1 crosses for all families was 52 percent with a variation from 40 to 68 percent, while the average success for all F_1 selfs was 31 percent with extremes of 19 and 54 percent for the family averages. Differences in fertility of the F_1 families were shown to be due to the parent plants involved. Parent plant C, Oregon 2014, resulted in higher percent success among the F_1 crosses and selfs whenever it occurred in the parentage. Parent plant B (P.I. 175829) was nearly as fertile as C in all crosses and the most successful families were those with B-C parentage. Parent plant A (P.I. 176675) was the least fertile of the three parent plants.

After making most of the P. coccineus crosses and observing the relatively high success (approximately 50 percent), a second study was initiated with P. vulgaris to ascertain what "normal" fertility was in a naturally self-fertile species of Phaseolus. In this study four varieties were grown in the greenhouse under the same conditions as the P. coccineus. Three varieties, U.I.-111, U.I.-31, and U.I.-34, are or have been commercially acceptable varieties released by the University of Idaho. The fourth variety used was N-203, a black Mexican bean from Mexico collected by Oliver Norvell of the Carnegie Institute of Washington at Stanford University, Palo Alto, California. "Normal" fertility of the P. vulgaris varieties was ascertained by tagging, daily, the blossoms on each plant as they opened and at maturity counting the number of pods formed. Each variety was replicated four times in a randomized block design with two four-inch pots with one plant each per replication. The average percent success was 56.7 for U.I.-111, 44.4 for U.I.-31, 63.1 for U.I.-34, and 43.2 for N-203. There were no significant differences between the varieties in their ability to set pods, which was not too surprising, but the 49 percent average pod set was indeed quite surprising. These results are in agreement with the results A. M. Binkley obtained in a study of 45 plants of each of six varieties of garden beans. In the study made in 1932, he found the percent of pod set varied from 24-56 percent.

With the high percent success of selfs and crosses, 31 and 52 respectively, it is difficult to advance a theory of incompatibility in P. coccineus, especially when four varieties of P. vulgaris, a naturally self-fertile species, averaged only 49 percent success under the same conditions.

The results of this study indicate the need for additional work on the factor(s) affecting pod set in our commercial beans. Perhaps varieties can be improved through selection and breeding for pod retention or perhaps work with growth hormones such as is used in fruit production would increase the pod set of the commercial bean varieties.

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