SNAP BEANS IN THE DEVELOPING WORLD

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INTRODUCTION

Observers of the Latin American and Asian food situation are paying increasing attention to food quality issues. Twenty years ago most development specialists were concerned with producing enough food to feed the world's rapidly increasing population. Questions on the quality of the produced food were secondary. The events during the 80's have shown that the world's capacity to produce food is in no way exhausted. Through the combination of sensible agricultural policy, investments in agricultural infrastructure, improved agricultural technology and better training and extension, food availability in these continents, especially rice and wheat, has improved greatly. Today highly populated countries like India and Bangladesh are capable of being net food exporters.

The world's food problem, however, is not solved. The situation in sub-Saharan Africa, where neither rice nor wheat production had great impact, remains critical. The purchasing power of the many poor in Asia and Latin America is insufficient to provide adequate nutrition, and the ongoing vagaries of agricultural production still deeply affect the world's small farmers and low-income consumers in years of bad harvest.

In many countries further improvements of the food situation will depend on producing not only more but also better products. Two main arguments support this thinking. The first one is that better quality products will satisfy more easily the needs for secondary nutrients, such as vitamins and minerals. The other argument is that the extra value added of improved products will allow income increases for the agricultural population, allowing their incomes to keep up with those in other sectors.

Vegetables are a suitable food crop that would comply with both arguments. Most of them do not provide major amounts of calories and proteins per kilogram, but are rich in a variety of vitamins and minerals. While they are mostly grown on very small farms, they still tend to provide more than average incomes to their producers. The increased attention for vegetables is evident in FAO's networking activities (e.g., FAO, 1987), in the discussions within the Consultative Group on International Agricultural Research and in the increased attention for production systems that combine staple food and vegetable production (e.g., Zandstra et al., 1981).

Snap beans hold a special place among vegetables grown and consumed in developing countries. They are eaten in many parts of Asia and Latin America and are of increasing importance in Africa. Because snap beans belong to the same species as common dry beans, Phaseolus vulgaris L., they can be grown in similar conditions and with comparable cultural practices. Snap beans do not provide the proteins and calories dry beans do, but they do provide the vitamins and minerals that most staple foods lack. The similarity in production methods, but the difference in the final product, allows producers to supplement (quantity-oriented) staple food production with (quality-oriented) vegetable production. Snap beans thus provide the ideal crop with which to initiate vegetable production in areas traditionally relegated to staple food production.

This paper aims to introduce the role of snap beans in the food sector of the developing world. A brief description of snap beans and other bean vegetable products will be followed by the major features involved in the production, processing, marketing and consumption of snap beans in the developing world. Chemical control in snap bean farming is particularly high and will be discussed in detail. Observations on seed distribution and on the effect of agricultural development on snap bean production will be made. Finally some suggestions for possible snap bean research will be outlined.

VEGETABLE BEAN PRODUCTS

In both the developed and the developing world P. vulgaris is primarily consumed as dry beans; however, P. vulgaris is also harvested and consumed in its fresh, green state (common in Latin America and Africa), and bean leaves are consumed as a sort of vitamin A-rich spinach in Africa (Bittenbender et al., 1984). Alternatively, in the case of snap beans, the green pods are commonly consumed in their immature, preferably fiberless state, in Europe, the Americas and Asia. As shown in Table 1, production, marketing and consumption characteristics of green shelled beans, snap beans and bean leaves are very different from those of dry beans.

Dry beans mainly supply proteins and calories. The consumption of fresh bean products provides high vitamin and mineral levels, in exchange for decreased protein and carbohydrate contents. In many parts of the world, vitamin availability is deficient, causing serious problems, even blindness (Davidson et al., 1975). Increased consumption of vegetable bean products could contribute to improved health conditions.

The production cycle of dry beans is shorter than that of most cereals but still longer than that of the vegetable bean products. For this reason green shelled beans will be eaten in parts of Africa until dry beans become available. Cooking time of the immature bean products is shorter than that of dry beans, which is an advantage in fuel-deficient regions. The immature nature of bean vegetable products decreases postharvest storability, which in turn leads to higher marketing margins than for dry beans.

Snap beans are the most important of vegetable bean products due to their wide geographical distribution, relatively large production and their imminent potential as an income source to small farmers. In comparison with other vegetables, snap beans are particularly rich in vitamin A, calcium, phosporus and iron. They form an

important source of vitamins and minerals to many people in the developing world.

Table 1. Characteristics of different edible bean products.

	Dry beans	Green shelled beans	Bean leaves	Snap beans
Protein content (%)	20.4	7.0-10.5	3.6	2.1
Calories/kg	3,020	1,040-1,510	360	290
Vitamin A (I.U./g)	0	0.4	10.0-20.0	2.0
Water (%)	12.3	58.2-70.0	86.8	90.0
Cooking time (minutes)	120	40	10	25
Days from planting to first harvest	90	55	25	40
Yield (kg/ha)	700	1,575	10,000	8,000
Postharvest storability	medium-long	short	short	short

Sources: Bittenbender, 1984; Platt, 1977; Instituto Nacional de Nutrición, 1967; author's estimations.

THE IMPORTANCE OF SNAP BEANS

Statistics on snap beans in the developing world are very deficient. The areas of snap bean production per farm are so small that harvest data are often omitted from agricultural production statistics. Where statistics are available, production is underestimated because of the short cultivation cycle -- if a certain area is planted continuously with snap beans, it may have produced more than four crops rather than one by the end of the year. Instead of estimating the importance of snap beans by studying production statistics, it is often more useful to examine food budget or wholesale market inflow data. Production and consumption data for some countries of particular importance, or for which reliable data are available, are given in Table 2.

Snap bean consumption per country is highly variable, even within continents. In Latin America, Colombia and Chile have high consumption levels but Peru has rather low ones. In Asia, China appears to have high consumption levels but Indonesia and the Philippines low ones. In the latter countries, snap beans are secondary to yardlong beans (*Vigna sinensis*), which are more heat tolerant and better adapted to growing conditions in these countries as shown by consumption levels of 1.5 and 2.7 kg per capita, respectively.

Data on snap bean production in Africa are very deficient. Reliable data is only available for a few countries in the Mediterranean basin. For other parts of Africa, consumption of immature green pods has been reported (Due et al., 1984), but estimates of national production have not been made. In many parts of Africa specific snap bean varieties appear to be absent and immature dry bean varieties (with more pod fiber) are consumed as green beans.

In Asia reliable data are available for Indonesia, the Philippines and some minor countries. The importance of the crop, however, depends on its role in China and

India, where almost 40% of the world population is living. In China, several sources (e.g. Plucknett and Beemer, 1981) suggest consumption levels between 1.5 and 2.5 kg, resulting in a production of almost 2,000,000 t; however, these sources do not clearly distinguish between P. vulgaris and other species. For India the FAO Production Yearbook (1986) reports a production of only 45,000 t, less than 100 g per person annually. This seems to underestimate its importance, but better production estimates for India have not yet been identified.

Among the countries listed in Table 2, snap bean production already adds up to almost 2,500,000 t. Considering the low figure for India and the number of countries not included in Table 2, a 3,000,000-t estimate of snap bean production in the developing world is probable. This implies an average per capita consumption in the developing world of 0.9 kg.

Snap beans are grown for the domestic market as well as being produced for export. In 1985 and 1986 the USA imported around 10,000 t of snap beans, mainly from Mexico (USDA, 1986). Somewhat older data for Europe (1978/1979) show imports during the winter season of around 30,000 t (ITC, 1981). Imports in Europe are higher than those in the USA because of the absence of suitable winter climates in Europe for snap bean production, such as those present in southern USA. Although the import volumes in these markets are not outstandingly high, they represent considerable amounts of money because of the high prices paid.

In both the U.S. and European markets, prices fluctuated between US$750 and US$1350 per t. The chances for increasing export-oriented snap bean production should be considered rather low. The European market has become more difficult to access with the entrance of Spain and Portugal in the European Economic Community; the American market is increasingly satisfied with domestic produce. As will be shown in the consumption

section of this paper, domestic consumption growth for snap beans looks more promising.

Table 2. Estimated annual snap bean production and consumption in selected developing countries, 1980-1985.

	Yields (kg/ha)	Production (t)	Consumption (kg/capita/yr)	Main source*
Latin America				
Argentina	9,300	41,900	1.3	A
Brazil	7,000	92,000	0.7	B
Chile	7,900	39,500	3.2	A
Colombia	7,000	75,900	2.7	C
Peru	4,300	6,400	0.4	A
Africa				
Egypt	8,720	117,750	2.5	A
Morocco	10,200	17,880	0.9	A
Asia				
China**	10,200	1,465,500	1.5-2.5	D
India**	2,100	44,100	0.1	D
Indonesia	6,200	43,498	0.3	C
Philippines	3,250	19,500	0.4	C
Turkey**	8,250	404,250	6.0-7.0	D

* A, National Production Statistics; B, Market inflow data; C, Food Budget Survey; D, FAO Production Yearbooks 1982-1986. (In case of China, it is not clear whether the reported figures only concern P. vulgaris.)

** Preliminary estimates

The monetary value of snap bean production in the developing world is significant. Farm-gate prices tend to fluctuate between US$0.20 and US$0.40 per kg, roughly 50 to 100% of dry bean prices. At the consumer level, prices fluctuate between US$0.35 and US$0.55 per kg, equal to or above dry bean prices. Assuming a snap bean

price of 75% of dry beans at the farm level, the total farm value of the crop in the developing world is some US$900,000,000. At the consumer level, the value would be US$1,500,000,000. This equals about 32% at the producer level or 43% at the consumer level of the dry bean crop in the developing world. These figures should be interpreted with care, because the estimations of Asian production and consumption are rather rough.

As in the case of dry beans, snap beans can have different growth habits, varying from the determinate bush growth habit to the indeterminate climbing habit. In the developing world the majority of snap beans are of the indeterminate climbing type. Although the cultivation of this type is difficult to mechanize, it offers the advantage to the farmer of higher yields per hectare with a harvest spread of some six weeks or more. This staggered harvesting of snap beans allows the to adapt his supply to changing daily fresh market conditions thereby spreading his marketing risk over a longer time period.

Snap beans in the tropics are mainly produced by small farmers, due to two factors. Firstly, snap beans are often supplied to rather thin and unstable markets, subdued by severe quality exigencies. Large farmers cannot supply such a market without destabilizing it even further, and they also have severe difficulties in sufficient attention to quality. Only where snap bean production is integrated with a processing or export industry (e.g., Turkey), can large-scale farmers start to grow snap beans.

Secondly, snap bean production is very labor intensive and, because of the dominating indeterminate climbing growth habit, difficult to mechanize. Preliminary production studies in Colombia, Taiwan and the Philippines show labor needs per hectare of 241, 680 and 580 man-days per crop, which is more than double what is needed in a maize/beans or potato crop (Table 3). These labor needs are far higher for climbing beans than for bush beans, which can be mechanized almost

completely. Market access and production technology limitations interact to maintain snap beans as a small farm crop.

Table 3. Production parameters of snap beans and other crops, Colombia 1980-1985.

	Labor days (/ha)	Input costs (US$/ha)	Returns (US$/ha)	Returns (US$/ha/month)
Snap beans	241	1,218	982	327
Maize/beans	108	156	155	16
Potato	119	625	1,667	278
Wheat	30	221	32	5
Barley	35	192	209	42

Source: CIAT, Bean Economics, internal data

Consequently, snap bean plots are small, often less than a hectare. Fertility levels of the plots tend to be high, due to choice of site or very high inputs of organic and inorganic fertilizers. These plots are intensively managed and may include five different crops in a single year. Snap beans are often rotated with other climbing crops, like tomato and cucumber, because this improves the use of the trellising structure.

The snap bean grower may cultivate a small but costly piece of land, because production is often concentrated in highly valued areas close to the urban markets. Also, the snap bean grower needs large amounts of capital to finance his inputs (seed, fertilizer, chemical control means). In the previously mentioned production studies, fertilizer costs were more than US$500 in Colombia and almost US$400 in the Philippines. Chemical control costs were close to US$200 in both cases, while seed costs US$125 in the Philippines and

US$280 in Colombia. A final important input, though not always paid for, is irrigation water. Snap beans are not very drought resistant and the high costs of other inputs are only justified if irrigation water is available to assure reasonable yields. In case production circumstances allow a stable yield, snap beans offer a considerable income to the farmer in exchange for the use of a small piece of land during a short period of time (Table 3).

CHEMICAL CONTROL

Many vegetable species presently grown in the tropics, including snap beans, were not specifically developed for those areas but rather were transferred directly from the temperate zones. This is also the case with snap beans. Although P. vulgaris originated in the tropics, almost all snap bean varieties were developed in the USA and Europe. Consequent poor adaptation to the tropical medium coupled with intensive cultivation has often resulted in high insect and disease pressure. Rust, anthracnose and angular leaf spot are major snap bean diseases; white fly, leafhoppers, stemborers and leafminers are very damaging insects. Insect and disease pressure not only decreases the yields of the plot but also the quality and value of the produce.

Snap beans are a highly commercial crop, predominantly grown for the market. Since a successful snap bean crop, even on a small area, represents a considerable cash income, farmers are willing to invest in chemical control. In order to prevent insect and disease losses, extremely high and frequent doses of insecticides and fungicides are commonly used. Biweekly applications have been reported in Indonesia and Colombia (e.g., Davis, 1987).

The intensive chemical control in snap bean production is causing a number of problems. Firstly, the ecological balance of production areas is disturbed and the sustainability of cropping systems compromised. As a

result of the intensive control methods, pest resistance, resurgence and substitution occur. In this way the existing plant protection problems are often exchanged for a new set of often more complicated problems.

Secondly, the high chemical control intensity risks poisoning the labor force, affecting not only the persons that apply the chemicals, but also those active in other cultural practices. Often women of reproductive age and children are involved in these activities.

Thirdly, residual pesticides might put the snap bean consumer at risk. The nervous system and other parts of the human body might be affected by the intake of residuals, even though residuals are reduced by cooking the snap beans before consumption.

Finally, chemical control becomes a routine activity. Farmers do not assess potential damage before spraying but use chemical control preventively. Pesticides might be applied when there is actually no need for them. This affects the profitability of snap bean production.

The costs of intensive chemical control does not only include the monetary costs of the inputs, but also the environmental costs, the medical costs of treating poisoned people and the human costs from suffering irreversible or reversible toxification. Strategies to overcome the problems of intensive chemical control are urgently needed. Presently integrated control strategies appear most appropriate. These strategies could lead to decreased chemical control frequencies by monitoring snap bean production and applying chemicals only when certain thresholds have been passed.

Since excessive chemical control is due to the susceptibility of present germplasm, a program of breeding for insect and disease resistance, as well as for general adaptation to the tropical circumstances, is the other necessary component in the development of

integrated control strategies. It should be clear that the justification for resistance breeding is very different for snap beans than for dry beans. In dry beans it is important because farmers cannot pay the inputs; in snap beans it is important because farmers presently rely too heavily on chemical control.

PROCESSING

In the developed countries most snap beans are processed before being sold to the final consumer. Processing most commonly takes the form of canning or freezing. In the developing world processing is less important for a number of reasons.

In many countries snap beans can be grown year round because seasonal variability is low. Consequently there is no specific harvest period when snap beans become available in large quantities at a low price. Neither is there a period in the year when fresh snap beans are in low supply and command a high price. The feasibility of processing as a storage mechanism is highly reduced.

Processed snap beans have shorter preparation time and offer increased consumer convenience. In developing countries reduced preparation time is not as overriding a consideration as it is in developed countries.

The cost of processing adds considerably to the final price of the product. Processed snap beans happen to be more expensive than fresh snap beans. Most consumers in the developing world are poor and will not be attracted by a more expensive substitute, just because it is processed.

A final reason is the difficulty of getting an adequate supply of snap beans to be processed. The large number of farms that are needed to obtain sufficient volume will increase the cost of logistic planning and will make quality control more complicated.

MARKETING

The high perishability of snap beans has strongly influenced the evolution of its marketing channels. Since there is no stock to draw on to complement or to reduce existing daily supplies, the market suffers from strong price fluctuations. The short growing cycle of the crop causes these fluctuations to occur within weeks or even days.

The perishable nature of the product increases the risk of postharvest losses to the snap bean trader. These losses take two forms. Because of sales delays, the quality of the product might be reduced. Although the trader is still able to sell, he will have to do so at a discount. At the same time the product will gradually lose some humidity, which in turn lowers its weight, so the trader loses money as the product loses water. Also quality deterioration can be so great that the crop becomes inappropriate for human consumption. This deterioration might be through the occurrence of pathogens or through advanced dehydration and decolorization of the crop.

Snap beans are mostly traded in the developing world by intermediaries with limited sales volumes. These intermediaries are better able to control the quality of the product than large traders and make a more effective effort in speeding up sales. Besides snap beans, many of these traders will handle other vegetable products to spread their energies as well as their risks over a number of activities.

Traditional sales outlets such as market places, neighborhood shops or street vendors play an important role in snap bean distribution. The importance of nontraditional outlets, such as supermarkets, is increasing, especially in Latin America. Snap bean distribution patterns are developing in much the same way as for other vegetable crops. For each country, the importance of specific market outlets depends very much on the overall developments in food retailing.

The perishability of the crop and the small volumes handled per trader have a marked impact on margins. In most countries the price that the urban consumer pays will be double or more the price that the farmer receives.

CONSUMPTION: PRESENT AND POTENTIAL

Snap beans are consumed in many different ways. They are often served alone as a cooked vegetable, but might also be found in salads, soups or stews. Because they are relatively expensive in many countries, snap beans are often considered a luxury to be served on special occasions.

Snap beans is one of a large number of vegetable crops. The importance of vegetable products in the diet increases strongly with rising income, which in turn is associated with the desire for a more balanced and diversified nutrition. In a similar way, the importance of vegetables rises when absolute caloric needs decrease and when availability improves (e.g., in the case of rural vs. urban environments). Most vegetable crops can easily be substituted for each other, in production as well as consumption, with their consumption levels being determined by price, quality and compatibility with other food sources. To fully understand snap bean consumption, the influence of income, urbanization, price and quality will be analyzed here in more detail.

Income and snap bean consumption

Snap bean consumption is strongly income dependent. In Indonesia as well as in Brazil, a ten-fold increase in income leads to a six- or seven- old increase in snap bean consumption. In Colombia consumption per capita is more than seven times higher in the richest than in the poorest income quintile (DRI-PAN, 1981). Among a group of major vegetables eaten in Colombia (cabbage, tomato, carrot, onion, green peas), snap bean consumption responded most to income growth.

The income-dependent nature of snap bean consumption suggests that as the developing world advances, strong consumption increases will occur. For every 10% income growth it might be reasonable to assume a 5% per head consumption growth. The validity of this reasoning can be found in the US consumption level, which is around 3 kg per head annually.

Urbanization and snap bean consumption

Snap bean consumption tends to be higher in urban than in rural areas, mainly due to the higher availability of snap beans but also to the lower energy needs in the urban environment. For example, in Manila consumption is about 2.5 times higher than in the rest of the Philippines. In Colombia, urban consumption is four times higher than rural consumption among the poorest consumers and two to three times higher among the richest. Brazilian data show similar patterns.

Desirable or not, urban migration is an ubiquitous phenomenon in the developing world. In Latin America the great majority of the population is already urban and in Africa and Asia the move from country to city is increasing rapidly. In 1983, 35% of the developing world population lived in towns, with urbanization proceeding at a rate of 1.5% per year. If this tendency continues, it will cause a per capita demand growth for snap beans (at stable prices) of 0.5% per year.

Relative prices and snap bean consumption

Consumption of snap beans is strongly determined by its price relative to other vegetables. On a per kg basis, snap beans are expensive (as shown in Table 4 for some selected countries). Only in Indonesia snap beans were cheaper than tomatoes or carrots, probably because their price was kept down by competition with the yardlong bean. In Colombia snap beans were cheaper than tomatoes because of tomato production problems (diseases).

The high snap bean price stems partly from the marketing margin, which often makes up more than 50% of the consumer price. Postharvest research to reduce marketing costs would be highly appropriate. Another part of the high snap bean prices can be explained by its deficient adaptation and subsequently high production costs. This suggests there is considerable room for cost reducing technology, which through price reductions might further stimulate consumption. Data from Brazil and Colombia, where price elasticities of 0.4 (short-term elasticity) and 0.8 (long-term elasticity), respectively, were estimated do confirm the potential impact of price reductions on consumption.

Table 4. Relative prices of snap beans and some other vegetables in selected countries in selected years.

	Snap beans	Carrot	Tomato	Lettuce	Cabbage	Cauliflower
Brazil (1987)	100	85	57	124	28	63
Colombia (1986)	100	-	114	161	36	84
El Salvador (1982)	100	48	95	128	26	66
Indonesia (1984)	100	113	121	-	49	70
Peru (1985)	100	55	87	-	-	-
Venezuela (1983)	100	59	54	101	54	66

Sources: Wholesale and retail price statistics from different countries.

Snap bean quality

Many different types of snap beans are grown and sold: flat, semiflat or cylindrical pods; curved or straight ones; short or large ones; light green, dark green or yellow ones; small-, intermediate- or large-seeded ones. Pods can be hairy or smooth, completely fiberless or not so. Most markets have specific requests regarding these characteristics. Additionally most markets appreciate a uniform, fresh, clean, insect- and disease-free appearance.

At first glance one might expect similar quality requests for snap beans in the developing world and for snap beans in developed countries. In North America and Western Europe snap beans should be fiberless, without seed development or air holes and as tender as possible. In the developing world, however, quality requests are not necessarily the same. Consumer surveys in Bogota, Colombia, showed that consumers in the low-income strata prefer snap beans with well developed seeds and are willing to compromise on the amount of fiber (CIAT, Bean Economics, internal data). For these consumers snap beans with well developed seeds still supply vitamins and minerals but provide more energy and a greater sense of repletion than fiberless, seedless snap beans.

Supplying snap beans with quality characteristics conforming to the local market is a major key to increasing consumption. Varietal improvement is an important means to this end but needs to be combined with good agronomic and postharvest management. Varietal improvement efforts should take into consideration that for the first 20 years most snap beans in the tropics will be supplied to the fresh market.

SNAP BEANS AND AGRICULTURAL DEVELOPMENT

Snap bean consumption is strongly dependent on income per capita and urbanization degree. It improves the quality of the diet. At the same time snap beans

offer a high income per hectare to predominantly small farmers. Since snap bean production technology has certain parallels to dry bean production technology, it is a crop that facilitates the transition of poor small agricultural producers to wealthier vegetable producers.

Snap beans appear highly compatible with agricultural development. Its development potential can be most easily exploited in small farm production regions, located close to urban markets. In these areas snap beans might form one of the first crops in the development of intensive, less land dependent production systems. As can be observed in the highlands of the Philippines and Indonesia, snap beans might afterwards be replaced by even higher value crops, such as ornamental flowers.

The advantage of climbing snap beans in the fresh market and the problems of mechanizing its production have made the crop a small farm, labor demanding production activity. Development of snap bean production can bring considerable benefits to producers whose resources will not permit an adequate livelihood in traditional agriculture. There is little chance that large farmers will move into snap bean production in case the market potential expands, because the cultural practices of the crop do not fit their needs.

Snap bean development is strongly dependent on the timely availability of seed. Snap bean producers will very probably also grow other vegetable crops and will switch between these crops according to market expectations. The economic harvest comes available in the form of pods and not in the form of seed. Although a farmer can leave part of his field to mature, this will decrease his cash income and will occupy the plot for another month.

In such a situation it cannot be reasonably expected that the farmer saves his own seed. Since snap beans have a short growing cycle, there is a large influence of seed quality on the health of the crop and therefore

on the final production. Seed availability is essential to permit year-round planting and to allow farmers to harvest their whole crop in the form of green pods. The integration of small farmers in a well functioning seed system is also instrumental for the introduction of improved varieties.

IMPLICATIONS FOR RESEARCH

Snap beans presently grown in the tropics are often poorly adapted to the existing agro-ecological conditions. The imported varieties in current use are susceptible to many diseases or are sensitive to photoperiod length. Often they do not flower sufficiently well or the growth habit becomes deformed in tropical conditions. Genetic improvement is a key to the development of better snap bean production systems. Adaptability and disease resistance should have highest priority, while insect resistance, yield potential and nutrient efficiency should have second priority. Drought resistance or nitrogen fixation ability should not receive major attention, because the intensive production systems where snap beans are found most often have access to irrigation and fertilizers. In the genetic improvement of snap beans the importance of consumer quality characteristics cannot be overemphasized. The final value of a snap bean crop is strongly defined by the price that the consumer is willing to pay.

The lead time for genetic improvement is relatively long. In the meantime cultural practices should be developed to provide temporary solutions to adaptability and resistance problems. By the time improved genetic material becomes available, research into cultural practices can be directed towards enhancing the potential of the improved varieties. Cultural practices research involves the development of integrated pest control and biological pest control strategies.

Rotational patterns with other vegetable crops is a second area of attention. In certain areas weed control might be critical. Development of cheap trellising systems would have a large impact on snap bean production costs.

A third important area of research would be postharvest management. This involves the development of appropriate packaging methods in order to prevent bruising, methods to prevent humidity losses and wrinkling and methods to prevent pathogenic development on the pods.

A final area of attention should be the production of high quality seed. What are the conditions at which this seed can best be produced and what are the optimal seed treatments before it is planted? Other questions include the relation between seed color and vigor, the location specificity of varieties and the optimal distribution mechanisms of improved seed.

Snap beans are underresearched in developing countries, unlike some other vegetable crops such as tomatoes and onions. Effective research could improve the appropriateness of the crop in these countries. Consequently, the availability of the crop could improve strongly, allowing present snap bean growers to earn a better income, while encouraging other small farmers to start obtaining part of their income from snap beans. Concurrently such research could contribute to increased vitamin availability for the urban segments of the developing world.

ACKNOWLEDGMENTS

The research for this paper was financed by the Netherlands Ministry for Development Cooperation, who also shares copyright.

whole document, the Section for Research and Technology of the aforementioned Ministry (P.O. Box 20061, 2500 EB The Hague) should be notified in advance. Responsibility for the contents and for the opinions expressed rests solely with the author. Publication does not constitute an endorsement by the Netherlands Ministry for Development Cooperation.

The author wants to acknowledge the valuable suggestions and comments that were made by Douglas Pachico and Luis Sanint. Crissan Zeigler and Lynn Menendez are thanked for the editorial revision. Matt Silbernagel and Jeremy Davis provided valuable insights in the preparation of this paper.

REFERENCES

Bittenbender, H.C.; Barret, R.P.; Indire-Lavusa, B.M. 1984. Beans and cowpeas as leaf vegetables and grain legumes. East Lansing, Michigan State University. Bean/Cowpea Collaborative Research Support Program. Monograph no.1. 24p.

Bouazza, S. 1985. Bean production in Morocco. In Regional Workshop in Potential for Field Beans (Phaseolus vulgaris L.) in West Asia and North Africa-, Aleppo, Syria, 1983. Proceedings. Cali, Colombia, Centro Internacional de Agricultura Tropical. pp.59-62.

Centro Internacional de Agricultura Tropical (CIAT). Bean economics; internal data. Cali, Colombia.

Chile. Ministerio de Agricultura. Oficina de Planificación Agrícola. 1984. Boletín de Noticias de Mercado Nacional de Hortalizas.

Companhia Brasileira de Alimentos (COBAL). Brasilia. (Unpublished data).

Davidson, S. 1975. Human nutrition and Dietetics, 6ed. London, Churchill Livingstone.

Davis, J.H.C., ed. 1987. Procedimientos de la Reunión de Trabajo sobre Mejoramiento de habichuelas. Documento de Trabajo. Cali, Colombia, Centro Internacional de Agricultura Tropical. Programa de Frijol.

Due, J.M.; Anandajayasekeram, P.; Mdoe, N.S.; White, M. 1984. Beans in the farming systems in Langali and Kibaoni Villages, Mgeta area, Morogoro region, Tanzania: a report. Tanzania, University of Dar es Salaam. Department of Rural Economy. Technical Report no.2. 58p.

Egypt. Ministry of Agriculture. Agricultural Economic Department. Dokki, Egypt. (Unpublished data).

El Salvador. Ministerio de Agricultura. Dirección General de Extensión Agropecuaria. 1983. Precios promedios mensuales al consumidor en Plaza de San Salvador.

Food and Agricultural Organization of the United Nations (FAO). Production Yearbook 1982-86. Rome, Italy.

Food Budget Survey. 1981. Jakarta, Susenas.

Instituto Nacional de Nutrición. 1967. Tabla de composición de alimentos colombianos. 3ed. Bogotá, Colombia.

International Trade Centre (ITC). 1981. Selected European markets for tropical and off-season fresh fruit and vegetables. Geneva, Switzerland.

Kintena, J. 1986. Regional food consumption patterns. Diliman, Quezon City, Philippines, Ministry of Agriculture and Food.

Mesa Redonda para el Establecimiento de una Red de Cooperación Técnica en Producción de Cultivos Alimenticios para América Latina y el Caribe, Santiago, Chile, 1986. Informe. Chile, Organización de las Naciones Unidas para la Agricultura y la Alimentación. 1v.

Perú. Ministerio de Agricultura. Oficina de Estadística. 1981. Estadística Agraria Perú 1981. Perú.

Perú. Ministerio de Agricultura. 1986. Boletín de Precios de Productos Agrícolas. Lima.

Platt, B.S. 1962. Tables of representative values of foods commonly used in tropical countries. London, Medical Research Council. Special Report Series No. 302. 46p.

Plucknett, D.L.; Beemer, H.L., eds. 1981. Vegetable farming systems in China. Boulder, Colorado, Westview Press.

Programa de Desarrollo Rural Integrado (DRI-PAN). 1981. National Nutrition Survey of Colombia. Bogota, Colombia.

Programa Nacional de Desarrollo Rural Integrado. Encuesta nacional de consumo de alimentos. Colombia. (Unpublished data).

QTA-28 Technical Assistance Project Indonesia. Jakarta, Indonesia, Marketing Vegetables and Fruits in West Java. Progress Report no.2-3.

Secretaria de Estado de Agricultura y Ganaderia. Buenos Aires. Consultations.

United States Department of Agriculture (USDA). Economics, Statistics and Cooperative Service. 1986. Foreign Agricultural Trade of the United States.

Venezuela. Ministerio de Agricultura y Cria. 1984. Boletin de Precios de Productos Agropecuarios. Caracas.

Zandstra, H.G.; Price, E.C.; Litsinger, J.A.; Morris, R.A. 1981. A methodology for on-farm cropping systems research. Los Banos, Laguna, Philippines, International Rice Research Institute. 147p.

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0001

7102 CARR, D. J. and SKENE, K. G. M. **Diauxic growth curves of seeds with special reference to french beans (*Phaseolus vulgaris* L.).** Australian Journal of Biological Sciences 14:1-12. 1961. Engl., Sum. Engl., 28 Refs., Illus.

Phaseolus vulgaris. **Pods. Seed. Anthesis. Embryo. Growth. Cotyledons.**

The results of growth studies of pods and seeds of a variety of french beans, *Phaseolus vulgaris* L., are reported. Pod growth commences immediately after anthesis and is completed in 16-17 days. Seed growth begins about 9 days after anthesis; and irrespective of whether fresh wt, dry wt, or length is measured, it is diauxic, 2 phases of high growth rate being separated by a lag phase. During the phases of high growth rate, growth is initially exponential but eventually declines. The lag phase lasts about 3 days, from about the 20th to 23rd day. The literature shows that diauxic growth probably occurs in many seeds although few studies have been sufficiently detailed to reveal it. At the onset of the lag phase, extensive modifications are initiated in the metabolism of the seed and fruit, leading to the changes associated with seed maturation (such as a fall in sucrose in pea seeds and of water content of bean pods), which have been widely reported in literature. It is suggested that mechanical restriction imposed by the surrounding structures causes the growth rate of the embryo to slow down (onset of lag phase). During the lag phase a considerable revision of the pattern of metabolism of the seeds must take place; when growth is resumed, all those changes associated with the onset of maturity begin. During this final phase, growth of bean and pea embryos must depend on continued growth of the seed coat, which may be regulated by the hormone production of the embryo itself. (*Author's summary*) A00

0002

11188 COERTZE, A.F. **Introductory aspects on the production of green beans.** Farming in South Africa. Series: The cultivation of vegetables in South Africa. Green Beans and Green Peas no. A.1/1977. 3p. Engl., Illus.

Phaseolus vulgaris. **Taxonomy. Production. Yields. Consumption. South Africa.**

Brief information is given on the taxonomic position, plant characteristics regarding consumption, economic importance, and production areas of green beans in S. Africa. Between 1970-73 production was estimated at 27,300 t and for 1975, 9000 t were processed from a total production of 37,000 t. Transvaal and Cape Province, that have green bean processing industries, are the highest producing states; other states of minor importance are Orange Free State and Natal, whose production is for the domestic market. *(Summary by C.P.G. Trans. by L.M.F.)* A00 J00

0003

11975 LEE, J.M. **A study of factors influencing interlocular cavitation in pods of snap bean (*Phaseolus vulgaris* L.).** Ph.D. Thesis. Minneapolis, University of Minnesota, 1973. 149p. Engl., Sum. Engl., 107 Refs., Illus.

Phaseolus vulgaris. **Pods. Cultivars. Cell structure. Plant anatomy. Field experiments. Host-plant resistance. Podding. Plant tissues. Anthesis. Yields. Interlocular cavitation. Seed.**

Developmental anatomy and the effect of cultural and environmental factors on the incidence of interlocular cavitation (IC), the formation of cavities between the seed locules, in french beans