SNAP BEANS : THEIR CONSTRAINTS AND POTENTIAL FOR THE DEVELOPING WORLD

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ABSTRACT

The paper presents results from an international survey of snap bean production in developing countries. To assess the economic potential of snap beans, production and marketing constraints were first identified. Survey results show that labour, disease and insect susceptibility of commonly used cultivars, poor seed quality and associated distribution problems, and the high risk from fluctuating producer prices are the major constraining factors. Snap bean production in developing countries amounts to currently about 4.5 million mt, with China producing 3.0-3.5 million mt of that amount. Demand growth estimates show that snap bean demand will have increased by 45% by the year 2000. Unavoidable demand growth, from population and urbanization effects represent 31% demand growth. The latter is equally shared by China and the rest of the developing world (RODW). Preliminary results from Colombia are presented, suggesting yield potential of more than 30% from integrated pest management (IPM) techniques and improved varieties. These components of technology will be important in increasing yields to satisfy growing world demand and to improve small farmers income.

Introduction

This paper presents results of a study assessing the economic potential of snap beans in the tropics. Little has been published about the green-harvested pod of *Phaseolus vulgaris L.* in the tropics. In 1988-89 a study was conducted at the Centro Internacional de Agricultura Tropical (CIAT), to determine whether expanded research efforts on this crop would be justified within the International Agricultural Research System (IARC). CIAT has the world mandate within this system for dry common bean research and consequently holds a comparative advantage with respect to other research centers through its extensive germplasm collection and information base. As such, it is visualized that CIAT may expand its research agenda by including snap baens.

An initial data survey revealed, that existing country data on snap beans were either non-existing, incomplete or inaccurate. As a consequence, country case studies were implemented to generate primary data on production, consumption and marketing of snap beans. Detailed information is now available from Colombia, Brazil, Costa Rica, Rwanda, Turkey, Indonesia, Taiwan, the Philippines and China. From analyses of preliminary information, several production constraints became evident and these were investigated in more detail in projects in Colombia. These multidisciplinary projects fully cooperate with the Colombian national agricultural research program (ICA) and have already resulted in some transfer of technology to the small farmers of the research region of Sumapaz.

The first section of this paper discusses current Third World production, consumption/trade and marketing estimates. The second part assesses major production constraints, while the third section treats the potential for improvement of constraints in lieu of future demand projections. The paper concludes with a discussion and recommendations for future research.

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Worldwide overview of snap beans

In addition to the dry bean, *Phaseolus vulgaris* L. is highly valued in the developing world for several other uses, i, e, bean leaves, snap beans and green bean seed. In Latin America and Africa dry beans constitute an important part of the human diet. In the latter, also bean leaves are highly appreciated for their high vitamin A contents (Janssen *et al.*, 1988), Snap beans are cultivated in Latin America, the Middle East, Africa and Asia (Table 1). However, African production is chiefly geared towards the European (and to a minor extent, Middle Eastern) off-season fresh export market and is only marginally important for local consumption. As is presented in Table 1, total Third World snap bean production is estimated at about 4.0-4.5 million mt of which the Latin American share is 250-300,000 mt, the African share is 40,000 mt and the Middle East and Northern African share (Egypt and Morocco) is 600,000 mt. These figures appear small in comparison with Asian production of 3.6-4.0 million mt. This result is highly biased towards China's share of 3.0-3.5 million mt.

Snap beans, in general, are cultivated by small farmers. Average farm size is less than 1 ha. The majority of snap bean farms in the developing world are near urban centers. Most often snap beans are produced as part of a system, in rotation with other vegetables like tomatoes, cucumbers and peas, which are also grown on trellises. Climbing bean varieties are predominant in the developing world. However, bush type varieties are grown in Costa Rica, China and Middle Eastern countries (among others). Cultivation of bush type beans demands less labour, but yield less and can only be harvested once or twice (Van Loohuizen, 1989).

The aggregated monetary value of snap beans is significant. With an average producer price of US$ 0.25 per kg this would amount to a value of US$ 1.1 billion at the farm level, and US$ 1.8 billion at the retail level. But like many perishable fresh vegetables, producer prices fluctuate dramatically and marketing margins are large (50-250%). Data from Colombia, Philippines, Indonesia and Sri Lanka show farm-gate prices varying by more than a 100% within a week (CIAT, 1988,1989).

Table 1 Global snap bean indicators on production and consumption

	Total production (mt)	Production as % of total vegetable production	Yield (kg/ha)	Value of production (US$ 1000)	Consumption (kg/cap/year)
Latin America					
Argentina	41,900	1.7	9,300	12,570	1.3
Brazil	92,000	2.0	7,000	27,600	0.7
Chile	39,500	3.2	7,900	11,850	3.2
Colombia	76,000	5.8	7,000	22,800	2.7
Africa + Middle East					
Turkey	400,000	6.2	2,000	200,000	8.0
Egypt	117,500	1.5	8,700	100,000	2.5
Morocco	17,880	1.3	10,200	8,000	0.9
Kenya	10,000	2.3	5,000	5,000	Export
Rwanda	1,000	0.6	2,000	800	Export
Asia					
China	3,500,000	3.0	15,000	800,000	3.5
India	46,133	0.1	2,135	13,839	0.1
Indonesia	43,498	1.6	6,200	13,047	0.3
Philippines	19,500	1.2	3,250	5,850	0.2

Source : Data collected from National Statistics, Food Budget Surveys, FAO production yearbooks 1982-86, ITC and personal communications.

Nonetheless, snap bean cultivation still proves to be a profitable small farm activity. Country data show that the benefit-cost (B/C) ratio, although the lowest in Turkey with 1.15, can be as high as 1.7 as demonstrated in Indonesia (Table 2). Typically, Asian countries show a much better performance than other developing countries, This is due to a higher input usage, especially fertilizers, and significantly higher yields (CIAT, 1988, 1989).

Snap beans generally are recognized as a good-tasting, easy to cook, medium-nutritious vegetable that fits in many kinds of local food dishes. However, different countries produce and consume different kinds of snap beans that vary in length, shape, taste and color (from white to black). Therefore, the highly preferred type of snap bean in China (or Turkey) would receive a significant discount in a Costa Rican or Colombian market. Table 1 shows snap bean consumption levels and its relative importance with respect to total vegetable intake. Apart from countries like China, Turkey and Chile, per capita consumption in developing countries is less than the U. S. consumption of 3 kg/year. A similar phenomenon exists for the snap bean share of total vegetable consumption.

Although the majority of snap bean production in the developing world is for domestic consumption, some 85,000 mt is traded on the international market every year, either as a high-quality fresh product or in canned form (International Trade Centre, 1988). In general, LDC's utilize their comparative advantage of lower labour costs to cut in on the higher-priced European and Middle Eastern markets. Moreover, because of climatic advantages, they can supply fresh produce during Northern off-season periods. As such, the African countries exporting fresh snap beans are able to generate a hard foreign currency inflow of US$ 1,500-4,800 per hectare of snap beans, with additional benefits from increased employment opportunities (Schasfoort and Westerhof, 1988). China and to a much smaller extent, Turkey and Kenya export in total about 35,000 mt of canned snap beans annually with a wholesale value of US$ 10-20 million.

Snap bean consumption is highly income-dependent. In general this means that when people's purchasing power improves, more snap beans are bought. Evidence also shows that, in Colombia for example, snap beans are more responsive to income than tomatoes, green peas, onions, carrots and cabbage (CIAT, 1988). In most countries snap beans are considered a "luxury item". The income elasticity of vegetables and snap beans in particular, is typically twice that of dry beans, suggesting that with rising incomes, people will purchase relatively more green beans than dry beans. Although there are variations among countries, the income elasticity is estimated at 0.2-0.4. Consumption in the richest income group is often 5-7 times that of the poorest.

Snap bean consumption is affected not only by increasing incomes but by urbanization as well. Data from Colombia, Brazil, the Philippines and Indonesia show evidence of

Table 2 Snap bean production statistics for selected developing countries

	Colombia	Costa Rica	Brazil	Turkey	Rwanda	Philippines	Taiwan
Average farm size (ha)	2-5	3-4	5-20	3	.2-.5	.5-3	1-2
Average yield (mt/ha)	10	5.4	3	8	2	17.5	20
Average farm price (us$/mt)	270	357	200	350	120	153	294
Net value of production (us$/ha)	832	689	—	235	500	751	2210
Labour costs (% OF total costs)	39	44	28	49	16	35	20
Seed costs (% OF total costs)	7	20	8	5	10	7	7
Chemical control costs (% OF total costs)	9	8	13	10	10	11	7
No of chemical applications	11	14.8	16.5	5	7	6	12
Fertilizer costs (% OF total costs)	12	5	20	4	14	20	46
Return to costs	1.3	1.5	—	1.2	1.2*	1.6	1.7

* Returns to costs for export firm.

urban snap bean consumption being two to four times higher than rural consumption (CIAT, 1988,1989). Latin America is already considered highly urbanized with a degree of urbanization of 70%. However, Africa and Asia (China) show that only 35% and 20% of the population live in cities, respectively. Given an estimated annual growth of 3-4% of urban areas (World Bank, 1987), this presents a significant potential for future snap bean consumption growth.

Snap bean production constraints

Snap beans are a "high-input high-output" crop. Thus in order to generate possible high returns on investment, besides being very labour-intensive, the crop requires high levels of fertilizer and pesticides. In addition, irrigation has shown to have a significantly positive effect on production in several countries. Table 2 summarizes snap bean production input shares. Labour can account for half of total production costs, while fertilizers and pesticides can take up 20-30%. In addition, in some countries tutoring materials have recently become increasingly more expensive and may become an economic constraint in the near future. In this case a possible alternative could be the introduction of appropriate bush varieties.

Farm survey results demonstrate that producers worldwide are fairly consistent when questioned about snap bean production constraints. The constraints most frequently cited were : labour ; seed quality and seed distribution ; pest and disease pressure (and the need for frequent pesticide applications) ; and farm-gate price fluctuations. Inherent to high input usage, is the further problem of availability of capital. From a survey in Colombia it was found however, that only 50% of snap bean farmers utilized commercial credit (CIAT, 1989). The remaining half of farmers relied on their own (family/friends) resources, were either unable to obtain credit or found it too risky.

Traditionally, vegetable seed production has been monopolized by major US and European seed companies. Seed has been bred and selected for more temperate climates and targeted to the specific demands of developed countries consumers and canning/freezing industries. As a consequence, developing countries experience major problems with the adaptability of imported seed to their different climatic (tropical) conditions. Some of these LDC markets are viewed by the seed export companies as residual or monopoly markets and hence do not offer incentives for product improvement. Most often local commercial seed production is on a small scale and targeted to multiply seed from the "adapted" imported variety, while at least half of the farmers rely on seed multiplied on their own farms (Belt, 1989). Hence, farmers face heavy disease pressures from rust, anthracnose, BCMV, bacterial blight, downy mildew and others, besides poor seed germination and vigor. In addition, snap beans from imported seed often do not satisfy local consumer preferences as is the case in Colombia, Turkey and China.

Weekly or depending on the season, twice-weekly fumigations with pesticides are required throughout the developing world. An in-depth diagnostic study on pesticides management of Colombian snap bean farmers in the Sumapaz area shows that cocktails of 1-2 kinds of insecticides mixed with 3-5 different fungicides at a time are applied to control white fly, leaf miner, anthracnose and rust. Laboratory findings show that out of 22 insecticides commonly used for snap beans in Colombia, only 4 were effective against white fly (*Trialeurodes vaporium*), an important production-limiting pest. It was also diagnosed that the high rate of applications caused resistance among white fly and leaf miner and significantly decreased the natural enemy populations of these pests (CIAT, 1989).

Farmers risk behaviour does influence pest management. An assessment of the importance of risk in the Sumapaz area, demonstrated that small farmers are not as risk-adverse as was hypothesized. However, weekly pesticide applications can, to some extent, be interpreted as payment of a "risk-premium" against possible future insect and

disease attacks (CIAT, 1989). Consequently the frequency of applications by the farmer will be higher than as may be advised by entomologists.

Besides the high economic cost to the farmer in terms of labour and chemical expenses this pesticide mis-management has dangerous repercussions on human health and welfare and on the ecology in general. Blood samples from villagers (farmers included) in the Sumapaz region demonstrated that 2% and 17% of the samples in two consecutive rallies showed levels of intoxication by chemicals (organo-phosphates and carbamates). However, laboratory tests on chemical residues in snap beans have not yet shown any levels of possible damage to consumers (ICA, 1989). These results are preliminary and more tests still need to be conducted. However, they do indicate that the mis-use of pesticides poses a serious health threat to farm workers and their families, but not to urban consumers.

Depending on the country, the labour requirement for a 90-day climbing snap bean crop is on the average 250-680 man-days per ha, or 3-7 persons a day. Typically, Asian farmers use more than double the labour that their African or Latin American colleagues require. This is roughly comparable to the cultivation of other vegetables like tomatoes or peas. However, it is at least more than double the labour needed for a common bean or potato crop (Janssen *et al.*, 1988). The labour issue has a dichotomous nature. While individual snap bean farmers regard it as a major constraint, at the country level, the labour intensiveness of vegetable farming in general and snap beans in particular is viewed as an employment generator and as such, benefitting economic growth and development.

Severe producer price fluctuations of snap beans are evident throughout the developing world. Colombian data show price variations of up to 200% within one week. In most other countries monthly fluctuations of 50-150% are not uncommon (CIAT, 1988, 1989). The extensive marketing channel absorbs much of the oscillations with the consumer only facing the tail-end of it, i. e. the retail price, which does not remarkably differ from other produce. The perishable nature of snap beans and the many pricing points in the channel are largely responsible for the high marketing margin. Farm-gate prices are to a great extent a function of lagged quantity supplied. The latter is influenced by farmers' price expectations, short-term and seasonal climatic conditions. Farmers to a certain degree "hedge" against the high risk caused by price fluctuations. Some of the bigger farmers in Colombia deliver on contract directly to urban retail outlets. In the Philippines a large number of farmers are on contract with input suppliers, who pay them on average a lower, but more stable guaranteed price. For the same reason a small marketing coop was formed in Silvania, Colombia. Moreover, in China, a large number of the semi-and peri-urban vegetable farmers sell their produce directly on the "free" retail markets (Henry and Li, 1989).

Besides marketing practices to reduce revenue instabilities, agronomic practices, like staggered planting, are widely utilized. This increases the number of harvests and subsequently evens out the "high" and "low" prices. At the same time this method will improve the farmer's cash-flow. However, it may have an adverse effect on insect infestations of the crop. Clearly not all farmers value the advantages of this practice as is shown by Colombian data. This demonstrates that only 58% of the farms stagger planting, with a significantly higher frequency among "small" farms (<6 ha) and "big" farms (>6 ha) than intermediate-sized farms (CIAT, 1989). Another agronomic practice is irrigation. Under certain (seasonal) climatic conditions the use of irrigation can also be considered as a means of risk spreading.

Of the constraints discussed so far there is no clear consensus about priorities, since they vary by country. However, it can be concluded that seed quality, insect and disease resistance appear to be of global concern among all the countries surveyed. Tackling these problems would seem to offer the best strategy for improving production of snap beans.

Future potential of snap beans

Given a current LDC snap bean production volume and disappearances of 4.0-4.5 million mt and assuming an average population growth rate of 1.3-2.0%, an urban growth of 3-4%, and an income growth of 0.5-4.8%, coupled with an income elasticity for snap beans of 0.2-0.4 (World Bank, 1987 ; CIAT, 1989), a snap bean demand for the developing world is estimated at 6.5 million mt for the year 2000 (Table 3). This represents an average annual demand growth of 4%.

Given current LDC snap bean production of 4.5 million mt and no evidence of significant increases, a future deficit is most likely. In order to overcome this 2 million mt gap and to keep up with snap bean demand growth, production levels need to be increased, either by alleviating existing constraints, increasing acreage, both in traditional and new areas, and/or increasing the number of crops per year.

Besides investigating pesticide management practices in snap bean production, the Sumapaz project in Colombia has attempted to assess the impact of introduction of Integrated Pest Management Practices (IPM) and improved snap bean varieties. Although the project has not been completed yet and several trials need to be repeated, preliminary results are quite promising. In one trial 3 management systems were evaluated with varying levels of insecticides, using the local snap bean variety. As Table 4 shows, there was a significant difference between the IPM system* and the Traditional system**. The IPM method decreased chemical applications by 50%, thus reducing pesticides and labour expenses by 20%. Moreover, the same system demonstrated an increase in yield of 22%, with no significant difference in product quality. The yield increase and cost reduction translate into an increase of the B/C ratio from 1.14 to 1.37. This trial only treated insect management ; fungicide applications were constant (CIAT, 1989). Other trials, still in progress, will assess IPM systems with varying fungicide levels.

In 1986 an improved CIAT snap bean variety (HAB-229), resistant to rust, BCMV and anthracnose, was introduced in the Colombian Cauca Valley and demonstrated a potential for yield improvement of 30% (CIAT, 1987). Considering the IPM method and the improved variety as one package, one can make a conservative estimate that the introduction of this package corresponds to a potential to increase yields by 30-40% and farmers revenues from snap bean cultivation, by 25-35%. In the longer run not only farmers, but also consumers would benefit from lower retail prices and a "healthier product" due to the reduction in the exposure of crop to chemicals.

Table 3 LDC's projected snap bean demand growth for the year 2000

	China	RODW*	Total
1989 demand (million mt)	3.00	1.50	4.50
2000 demand growth % from :			
population effect	15%	34%	21%
urbanization effect	8%	14%	10%
income effect	11%	2%	8%
2000 demand (million mt)	4.30	2.25	6.55

* RODW=Rest of Developing World.
Source : Snap Bean Project, Internal data, CIAT, 1989 ; World Bank, 1987.

* Integrated Pest Management system based on biological and chemical control and improved agronomic practices.
** Traditional insect management based on weekly insecticide applications.

Table 4 On-farm insect management trial for snap beans in Sumapaz, Colombia, 1989

Management system :	No of applications insecticides	Total insect management costs (US$/ha)	%[d]	Yield (kg/ha)	%[d]	B/C ratio
1. Traditional[a]	10	416	0	13,408	0	1.14
2. Chemical[b]	5	388	− 7	14,194	+ 6	1.20
3. IPM[c]	5	330	−21	16,337	+22	1.37

a) Traditional insect management based on weekly insecticide applications.
b) "Rational" management based on insecticide application according to infestation levels.
c) Integrated Pest Management based on biological and chemical control and improved agronomic practices.
d) Percentage difference with respect to traditional system.

Conclusions and recommendations

In this paper evidence has been presented suggesting that the major constraints to snap bean production in the developing world are ; seed quality and distribution, disease resistance, high labour and input costs, and the high risk from fluctuating producer prices. Further, an estimate was made of projected snap bean demand in the developing world for the year 2000, implying a significant future production deficit. And finally it was shown that a package of IPM-alternatives and improved varieties has the potential for yield improvement, decreasing pesticide applications and subsequent lowering of input costs.

Based on the above and on the demand projections in Table 4, the following observations might be made :

* China accounts for 2/3 of total developing world snap bean consumption.
* The exponential snap bean demand growth for the developing world is estimated at 45% for the year 2000.
* Approximately 60% of total demand growth will take place in China, while 40% in the RODW.
* Most probable demand growth, from population and urbanization, is estimated at 31%, shared equally by China and the RODW.

Population and urbanization growth is a "near certainty" and unavoidable. The income effect of the demand growth is an endogenous variable with a much lower probability. Hence the major observation that can be made is that, although China production is twice that of the RODW, equal attention should be paid to China with respect to the RODW for future snap bean research activities.

The production constraints in most developing countries could to a great extent be lessened by the introduction of IPM alternatives and higher-yielding resistant varieties. However, China and the RODW differ significantly in research needs. China shows yields of up to 20 mt/ha for which extreme high levels of labour and inputs are required. Otherwise, production constraints, although to a somewhat lesser degree, are comparable to those in other developing countries. In order to achieve major impact for China's much needed supply increase, the research agenda should include, besides work on disease resistance, breeding for earliness and cold tolerance. In addition, introduction of high-yielding bush type varieties may alleviate labour constraints in the recently opened horticulture areas of China's North-East.

As vegetables in general form an important part of daily food consumption in China, snap bean research has advanced relatively further in the latter, than in other developing countries. However, inadequate agriculture extension, due to severe lack of resources, will prove to be the major obstacle for rapid technology transfer.

CIAT holds the world mandate for common beans. In addition to its extensive experience and information base, it holds the world's largest *Phaseolus* germplasm collection. To a large extent this could be applied to snap beans. In addition, CIAT has recently started minor collaboration with research institutes in the major snap bean-producing countries in terms of germplasm anf information exchange. Consequently, because of these comparative advantages, it is envisioned that CIAT may expand its future research agenda by including snap beans.

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Discussion

Saharan, H. A. (Malaysia) : Since China is the largest producer of snap beans, may I know how much research is carried out in China ?

Answer : Major research is carried out by BVRC and VRI (CAAS) on disease and insect resistance-breeding and VRI is attempting to classify the 2,000 (snap) bean accessions for protein, resistance and fiber contents. Indeed, among the countries, the amount of research on snap beans is larger in China than in other countries as vegetables play a major role in the diet of Chinese people. In other countries where research is not carried out extensively, the role of CIAT could be important.

Ram Phal (India) : You mentioned that the leaf miner was one of the most important diseases in Colombia. Is it an insect pest or a disease ?

Answer : I apologize for the slip in the tongue. The leaf miner is an insect which causes extensive damage to snap beans with marked yield decrease in Colombia.

Midmore, D. J. (CIP) : You indicated that the imported seeds were preferred to the locally produced ones and were twice as expensive. Will CIAT-developed varieties have the same low acceptability if locally produced ? Will CIAT stimulate the production of good quality seed that can be locally produced ?

Answer : The imported seeds are preferred due to constant quality which may not be necessarily good. CIAT as an international research institute can only offer the National Research Programs an improved technology, i. e. improved varieties. The National Programs through their extension efforts have the responsibility to transfer the new varieties to the farmers. CIAT can assist in this aspect by teaching National

Program people methods of improved seed selection and production strategies.