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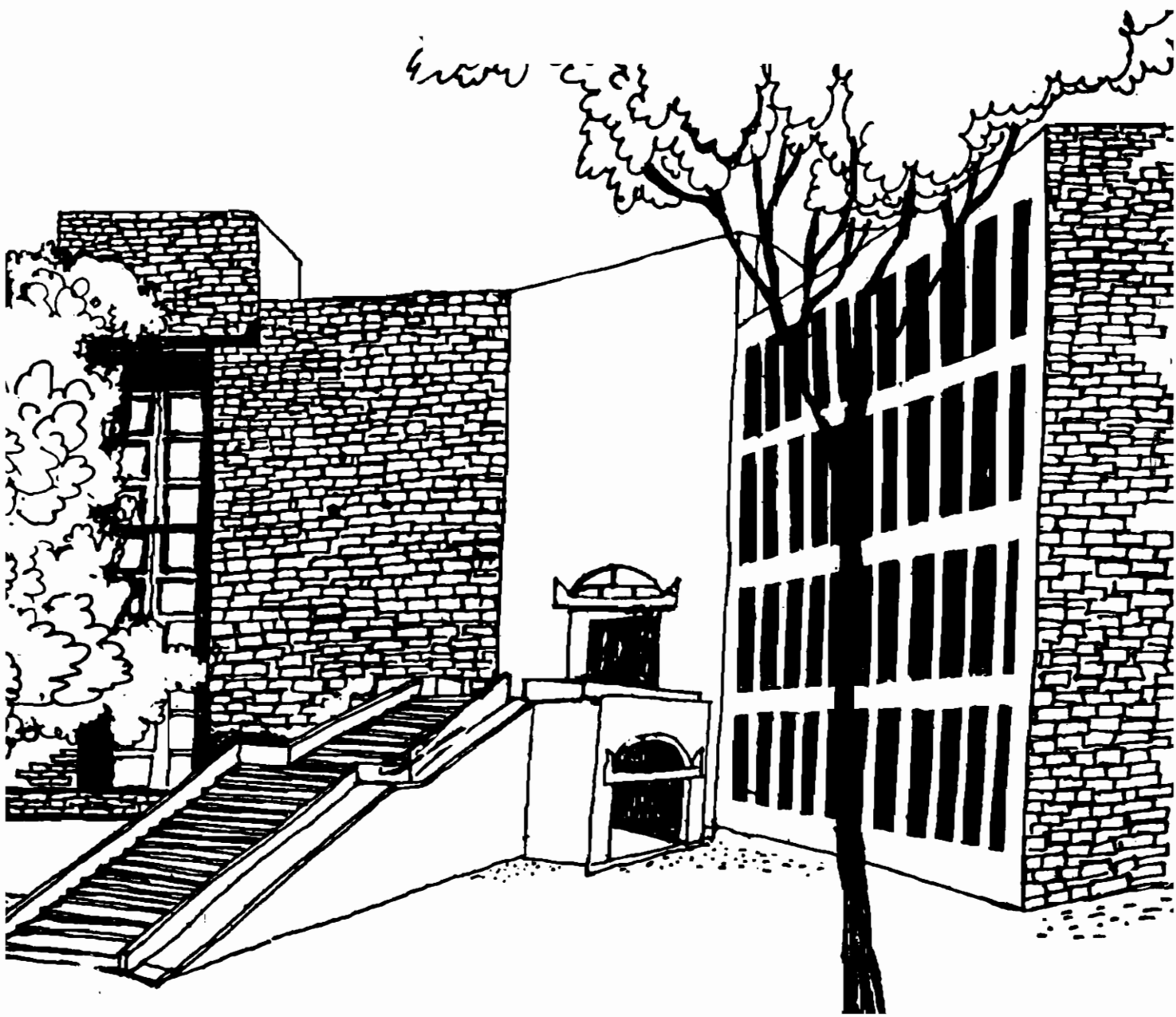

CASTOR REVOLUTION IN GUJARAT, INDIA: WHAT MADE IT SUCCESSFUL?*

By

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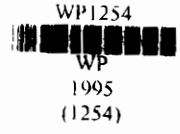

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CASTOR REVOLUTION IN GUJARAT, INDIA: WHAT MADE IT SUCCESSFUL? *

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Castor Revolution in Gujarat, India: What Made it Successful?

Introduction

Castor is a non-edible oilseed crop; the output of this crop is in the form of castorbean which when crushed produces oil and cake. Castor oil has a large international market unlike beans market which is small but growing slowly. International market in castor cake is very small, almost negligible. In 1989, international trade in castor oil and beans valued at about a quarter billion US dollars ($ 255 million, of which castor oil alone accounted for about $ 188 million)[1]. Two large exporters of castor oil in the international market are India and Brazil; and, currently, both countries together account for about two-thirds of world castor beans production and acreage and contribute almost roughly the same--about two-thirds to three-fourths--of the world castor oil exports. Although historically Brazil has occupied the place of the largest producer and exporter of castor in the world, its production and relative share in the international market has been shrinking over the past few years as opposed to the fact that India's castorbean production and castor oil exports have risen significantly, in particular, since mid-or late 1970s[2].

India's castorbean production has come a long way. For example, average annual production during the 1961-65 was only 105 thousand tonnes, rising to the annual average of 198 thousand

tonnes during the 1976-80 period, 348 thousand tonnes during 1981-85, and further increasing to 500 thousand tonnes in 1990, although there were three bad years from 1986 to 1988 owing to drought in Western India. In 1994, production further climbed up to 650 thousand tonnes. The tremendous increase in the Indian castorbean production and castor oil exports is primarily attributed to the introduction of castor hybrids in mid- or late-1970s. Castor hybrids were successful particularly in Gujarat province of India wherein large scale adoption of hybrids has taken place within a short span of time. The impact of this was so much that Gujarat today accounts for about 70% of country's total castorbean production with only one-third of the total castor acreage in the country[3]. Also, today castor yields on Gujarat farms are perhaps the highest in the world, and more than twice of the world average. Factually speaking, Gujarat has now become the "castor-bowl" of the country. The rapid spectacular success of castor hybrids in Gujarat lures one to compare it with "wheat revolution" of 1960s in the country.

There is something unique in the spectacular success of castor crop in India. First, castor is perhaps the second crop in the country, after wheat, having successful breeding and commercialization. Despite large investments made in the breeding programs of other crops like sunflower, groundnut, maize, sorghum, pearl millet, pigeonpea, etc., these crops never met with an over all spectacular success as did castor. Second,

unlike wheat revolution, which succeeded on account of exotic Mexican seeds, castor revolution took place with the spread of indigenously developed castor hybrids. The above facts invoke several questions: What was so special about castor crop? Why was castor breeding program more successful than breeding programs for other crops like sunflower, millet, etc.? Why did Gujarat turn out to be a castor-bowl of the country?, and so on. In this article, an attempt is made to answer these questions. In the second section, I develop a conceptual model or paradigm of success. The subsequent sections are devoted to discuss three stages discussed under the paradigm, followed by summary and conclusions at the end.

The Paradigm of Success

The success story of castor hybrids in Gujarat can be explained in terms of the following facts: (i) that there was a successful castor hybrid breeding program in the country; (ii) that these hybrids were successfully adopted and retained by the Gujarati farmers and diffused over a very short span of time; and (iii) finally, that there was a well-developed infrastructure which helped in quick commercialization of the crop. Let me call this the **"paradigm of successful breeding, adoption, and commercialization"** in short **"the paradigm of success"**.

The basic tenor of the above paradigm is that an over-all success of a crop hybrid/variety, or an agri-biotech innovation[4]

in more general sense, requires sequential successes at all the three stages, i.e., breeding, adoption, and commercialization. That is, the innovation in question must pass some critical success criteria for all three stages. For example, successful breeding cum adoption of a HYV/hybrid may not lead to over-all success if there are not sufficient infrastructures for commercialization of the product or innovation in question. The paradigm is hence based upon an integrative concept of success at all stages of development of the HYV/hybrid.

A schematic representation of the paradigm is shown in Fig. 1. Note that three stages through which the innovation passes are interlinked and interconnected through producers or farmers objective of profit maximization and risk minimization. Government or research and extension bureaucracy's role in a democratic society is to gear this system so as to meet producer's objective in particular and society's objective at large.

[Insert Fig. 1 around here]

Stage 1 basically involves development of new variety or hybrid whose production basically depends upon three major inputs: (1) a pool of scientists including breeders; (2) scientific instruments, (3) germplasm stock. The calibre of scientific pool is the key here as it determines how effectively

other two inputs--scientific instruments and germplasm material--would be used for producing new hybrids or variety and at the same time is responsible for developing new breeding techniques--in particular those related to genetic engineering which can enhance the rate of growth in innovation-making. But, this does not mean that creative ingenuity of scientists may not be constrained by the availability of germplasm stock in the nature and by the investment available to purchase new scientific instruments[5].

In stage 2, the hybrid or HYV is passed on to the targeted producers and becomes a study object for social scientists. Here, the innovation in question passes through processes of adoption and diffusion. Adoption is a mental process that goes on in an individual producer's mind from the time he knows about the HYV until he adopts it; more specifically the process of adoption is divided into the following substages such as awareness, interest, evaluation, trial, and finally adoption[6]. Having adopted the HYV/hybrid, individual producers may continue or discontinue to use the innovation depending upon his/her satisfaction and expected level of performance of the HYV. This experience is then passed on to those who have chosen to be non-adopters yet so far. The interaction between adopters and non-adopters continues to take place; this induces some non-adopters to adopt the innovation in question. The process goes on until all the targeted producers have adopted the HYV/hybrid--this is called

diffusion. The diffusion period is measured from the date when first producer in an area or social system is aware of HYV until it has reached the every targeted producer in the system. Note that the diffusion is basically a social interaction process while adoption is a mental or cognitive process; yet both are roughly related. It is said that innovations which have shorter adoption period are likely to have a shorter diffusion period too.

The stage 3 is commercialization of the innovated product, i.e., searching or developing markets for it and its derivatives. Here, it is important to mention that the time gap between stage second and third is a crucial variable in determining the success of innovation in question. Generally, it takes a lot of time to create or produce a variety or HYV, but having produced and delivered to targeted producers for adoption the need for an already existent markets or verifying the potential ones for the product in question is an urgent necessity for successful commercialization. In point of fact, the second and third stages should occur simultaneously or there must pre-exist required infrastructure for verifying the commercialization potential so that targeted producers may be able to realize the expected profit from the innovation under adoption. There can be several aspect or angles with which the commercialization issue can be examined; moreover, these issues would vary with the type of innovation or product in question.

We can now analyze all three stages in the case of castor hybrids and identify factors which have contributed to its success.

Stage 1: Castor Breeding Program

The improvement in castor crop in the world was first started in the US through selection in early 1900 AD and work on exploiting hybrid was taken up as early as 1946. Indian castor breeding program started sometime during 1920s and 30s at Tindivanam (Tamil Nadu), Rajendranagar (Andhra Pradesh), Hebbal and Raichur (Karnataka), Nagpur and Jalgaon (Maharashtra), Nadiad and Junagadh (Gujarat), Jallandhar (Punjab), Kanpur (Uttar Pradesh). Breeders at that time focussed on improving yield, branching habit, and non-shattering characteristics. However, during the 1950s, increasing oil content was also added to the breeder's objectives. The major breeding method then used was selection through which breeders could increase yield by 10-20% and oil content by 1-2% over the local varieties. During the 1960s India experienced green revolution through high yielding varieties of wheat and rice brought from CYMMIT in Mexico and IRRI in Philippines, respectively. The success of these high yielding varieties impelled Indian agricultural policy planners to augment the indigenous breeding potential with a hope to have successful experiments in other crops including castor.

The technique of ionizing radiations did wonders to the castor breeding program; dwarf varieties, maturing within 120 days as opposed to traditional ones which matured within 250-270 days, with high oil content, and responsive to fertilizers and irrigation were developed. The major improvement came through exploitation of hybrid vigor or heterosis; several attempts went into it[7]. The most successful exploitation was then made by Gopani, et al whose F_1 yielded 124% over cultivated variety[8]. This hybrid was then commercially exploited in Gujarat. Since then continuous breeding efforts were made in particular at Sardar Krushinagar (SK) in Gujarat and in Department of Oilseed Research (DOR) at Hyderabad under the all-India coordinated project on castor.

The breeding program at SK has been specially successful in producing hybrids suitable for agroclimatic conditions in Gujarat. The systematic castor breeding program was started in Gujarat in 1962. A number of cultures were obtained from USA from which some 100% postulate lines TSP-10-R from Texas gave way to develop hybrids. The first hybrid GCH-3 (TSP-10RXJ-1) was found to give 88% more yield than local varieties. Later a superior 100% postulate line VP-1 was developed (at Vijapur centre in Mehsana District, Gujarat) and from which a combination VP-1, and XVI-9 or GAUCH-1 was developed; this gave 16% more yield than GCH-3. The GAUCH-1 was released for commercial cultivation in 1973 and became very popular on account of its high yield and

mild resistance to jassids and whiteflies. But, overtime it was found to be very susceptible to root-rot and wilt diseases.

Other hybrid GCH-2 (VP-1 XJ1-35), which gave 13% higher yield over GAUCH-1 and showed relative tolerance to root-rot diseases, was commercially released to supplement GAUCH-1 in 1985. Very high yields of these hybrids and their short maturity periods made castor very remunerative crop, but also disturbed the usual rotation in the farmer's land. As a result, incidence of wilt disease increased and it became limiting factor in increasing castor production[9]. To offset this disadvantage of GCH-2, a superior hybrid GCH-4, was released in 1987; this had marginal advantage in terms of yield over GAUCH-1 and GCH-2 but had major advantage in being wilt resistant[10]. A large proportion of total castor acreage is coming now under this hybrid. A list of selected old strains and new varieties and hybrids of castor with their special characteristics and yield potential are reported in Table I.

[Insert Table I around here]

An issue that clearly emerges out from Table I is that new varieties, like Aruna, and castor hybrids such as GCH-3, GCH-4, etc., were far superior to those previously developed strains in respects of : (i) duration, and (ii) yield. The old improved strains took about eight months long period and gave only 10-15%

increased yield over the local varieties. In contrast, the hybrids took half the time taken by old strains to mature. It made feasible to take two crops of castor in row. At the same time, these hybrids were responsive to irrigation and fertilizers and yielded more than twice of the old strains. For example, on an average, yields were as high as 1000-1200 kgs./hectare under rainfed conditions and as high as 2500-3000 kgs./hectare under irrigated conditions.

The success of castor breeding at SK can be attributed to two critical factors. First, the SK centre had wide spectrum of segregating material which was necessary for developing new postulate lines. The super-ordinary traits of these postulate line can be used in desired direction by crossing with suitable male parents[11]. In addition, the SK possessed as large as 608 germplasm entries of castor--the basic input for developing superior quality male inbred lines. With enriched germplasm stock in hand, the SK breeders put efforts to continuously refine and develop new breeding materials. The castor hybrids yielded 7-8 times of the local or traditionally grown castor seeds unlike improved varieties of other crops (Table II). This may alone explain that the innovation of the SK breeders was far superior.

[Insert Table II here]

The second important fact which led to breeding success is that there was a feedback mechanism from farmers to breeders. The performance results of hybrids on farmers fields were passed on to breeders who then worked upon in overcoming the shortcomings. For example, when GCH-2 became wilt-susceptible on farmers fields the breeders at SK developed a wilt resistant GCH-4 hybrid. This feedback mechanism kept breeders aware of what farmers wanted; this very fact helped in speedy adoption of new hybrids which were developed bearing farmers' interests in mind.

Stage 2: Adoption and Diffusion of Castor Crop

Until the third Five Year Plan (FYP) very little emphasis was laid on castor, and whatever efforts were made were primarily aimed at increasing castor acreage with little emphasis on improving yield, as discussed above. The package approach to increase production was introduced in the terminal year 1965-66 of the third FYP, this approach aimed at using a package of inputs together, improved seeds, irrigation, fertilizers, plant protection measures[12]. However, expected pay-offs were not high in the absence of hybrids/mutants. Even the producers response toward adopting these old strains was not encouraging. For example, some 174 thousand hectares were sown with old improved strains of castor--about one third of the total castor acreage in the country--but production results were disgusting and yield levels were extremely low (Table III).

It is believed that success in adopting new strains was primarily due to government push and perhaps producers did so to take advantage of input subsidies given under the package program. Moreover, the adoption acreage figures collected thorough government machinery are perhaps biased upward and their reliability is considered to be low.

[Insert Table III around here]

Adoption is a well-researched area. Based upon the past studies, Rogers have propounded a middle range theory of adoption[13]; this describes that adoption rate is dependent upon the following set of variables: (i) perceived attributes of innovation which include relative advantage, compatibility, complexity, triability, observability; (ii) types of innovation decisions which could be optional, collective, and authoritative; (iii) communication channels such as mass media or interpersonal; (iv) nature of social system; and (v) change agency's promotional efforts. Several studies have further strengthened the Roger's model by empirical testing. For example, the US subcommittee of Rural Sociological Society found that in the US farm ownership, education, income, size of farm, and social participation are positively correlated with the readiness to adopt new practices[14]. Some researchers have found that if a farmer was efficient, had initiative and was progressive he was likely to adopt improved farm production[15]. Mass media exposure is also

found to be significantly correlated with readiness to adopt new practices[16]. The literacy, newspaper exposure, opinion leadership, and use of technology have been found positively related to initial levels of technical knowledge[17]. Farmers in Eastern States of Nigeria had a high degree of knowledge of farm innovation but low adoption rates[18]. Other subsidiary activities such as access to roads, water supply, health services are as necessary as seed, fertilizers, or technical know-how to increase adoption rates[19]. An integrated approach to agricultural development helps in rapid adoption of innovations[20], other factors such as resource availability can also affect adoption rate; for example, the decline in mortality in Taiwan contributed to the increase in the labor-land ratio, which finally led to the adoption of new labor using and output-increasing rice variety[21]. In the U.S., the adoption of dry season irrigated farming is explained in terms of economic, socio-cultural, and geographic variables[22].

In the current study I utilized a cross section sample of 30 farmers in the Mehsana district to explain the castor hybrid adoption rate through the following equation:

AC = f (GC, NP, FC, WT, ED, LB, U)

where,

AC = acreage under castor hybrids (acres)

GC = gross cropped area

NP = net returns per acre from castor (Rs./acre)

FC = fertilizer consumption in nitrogen equivalents (Kg.)

WT = numbers of irrigation

ED = education (number of schooling years)

LB = family labour days available

U = random factors

The estimated model, as felt appropriate, is given below:

$$AC = \underset{}{-1.20} + \underset{(1.45)}{0.1634\ ED} + \underset{(2.56)^{*}}{0.2081\ GC} + \underset{(5.37)^{**}}{0.0030\ FC} \quad \underset{(0.34)}{}$$

N = 30 R^{-2} = 0.55 D.W. = 1.9076 F = 12.93

The estimated results suggest that education and size of holding (reflected through the gross cropped acreage), are two important determinants of castor acreage at the farm level. That is, farmers who are progressive, educated and have large holdings prefer to set aside relatively larger acreages for castor in their portfolio of crops. These two determinants however explain only 55% of the total variation in the castor acreage in the sample. Several other factors also determine the adoption and diffusion of castor crop; these factors being intangible in nature are not amenable to be captured through regression analysis. To this end, we resorted to survey of 70 castor-growing households in Mehsana district in January-February, 1995. These respondents were interviewed about various aspects of

castor hybrids, bearing in mind Roger's model of adoption and diffusion; the survey results are summarized in Table IV.

It is interesting to note that all sample farmers expressed that castor is more profitable than other crops despite it being a two-season crop. Farmers preferred castor for various reasons: less risky than others (91% farmers agreed to this); 87% farmers accepted it as a drought-prone crop; and almost 97-99% farmers liked castor as it was a cash crop and improved oil quality.

The central/state government agencies did not provide any special incentive to promote diffusion of castor crop. Not many people took to trial of crop as most of them felt convinced with the efficacy of crop.

The news of castor hybrids, spread through neighbours, friends, Village-level workers or others. Interestingly enough, mass-media played important role. Some 15% of sample farmers learnt about castor crop from mass-media (Table-IV).

All sample farmers accepted that it has changed their income significantly and about 24% of sample farmers also accepted that growing castor crop measured their status too.

It is obvious that the real change in adoption and subsequent impacts upon castorbean production can be seen in

particular after the introduction of hybrids. Castor hybrids were introduced sometime in 1972. Most farmers recalled that, within 4 to 5 years of time, almost all farmers switched to castor hybrids. It is estimated that some 98% of total castor acreage in two major castor growing districts--Mehsana and Banaskantha--came under castor hybrids within five years or so. As a result, the average castor yield in Gujarat, which was once below world and Brazilian levels, increased continuously and surpassed both of them (Fig. 2). The average castor yield in Gujarat stands now more than 1500 kg/ha or so.

[Insert Fig. 2 here]

There are three major reasons why the adoption and diffusion of castor hybrids in Gujarat was so quick. First, castor hybrids with high yielding potential and remunerative castor seed prices in the market, became economically competitive crop to farmers[23]. Second, besides being economically attractive, various other advantages, as revealed from Table IV, turned the planting decisions of farmers in favour of castor crop. These included: it generated cash income to farmers which helped them withstand liquidity problems; it required less supervision and management time too; it could grow in less fertile soils in which other crops could not do well[24]. It was also a discomfort-saving and less-risky crop which perfectly matched the objectives of absentee landlordism (Table IV). Third, the already built-up

infrastructure of marketing and retailing hybrid seeds by various private seed companies such as Nav Bharat Seeds and other and public seed companies such as Gujarat Agro Industries facilitated the process of adoption and diffusion without any hindrance. The well-organized and reliable seed multiplication system built up by these firms in which quality was accorded utmost consideration, won the farmer's confidence.

Stage 3: Commercialization

The third stage calls for commercialization which means basically finding remunerative markets and building up required infrastructure to promote business and trade. In fact stage 2 and 3 should occur simultaneously in back-and-forth manner. And, there must pre-exist all necessary elements that are required for marketing and trade of the new crop. Interestingly enough, there existed a well-developed marketing and trade framework prior to the introduction of castor hybrids in Gujarat by Jayant Agro company. The company was launched in 1950s by a Gujarati family who were familiar with local markets and people. It had its network for collection of castor seed throughout Gujarat where castor crop was in predominance. The company procured castorseeds from farmers, transported the produce to Bombay, where seeds were crushed and castor oil was further refined for the resale in the export market. As Mr Udeshi, Managing Director, Jayant Agro, recalls that the procurement in those days

was a pretty difficult task; he had to roam from village to village.

In 1970s, when hybrids were introduced, Jayant Agro felt the need for promoting local milling of castor seed and processing of castor oil so that cost economies could be obtained in transportation. They decided to set up a processing plant in Baroda. Also, instead of buying seeds directly from farmers they started buying castor oil from millers for further refinement. As a result, a large number of castor seed millers sprang in various districts in Gujarat; a large proportion (about 40 to 50% of the total) of that being in the industrial city of Ahmedabad.

Since international castor oil prices remained buoyant, this helped the trade to flourish uninterruptedly. If there was any problem, it was basically related to production planning and stabilizing it due to varying monsoon from year to year. Drought posed a severe strain in meeting the export demand for castor oil. During the drought years of 1986 to 1989, exports slumped primarily due to reduced production, but not due to slackness of demand.

In the wake of the above the castor prices soared. Since then various firms have entered into the export of castor oil business. Prominent among them is the N.K. Industries Limited (NKIL). The NKIL has embarked upon a huge expansion and diversification program, envisaging an investment of Rs.20 crore

in the Mehsana district--the castor growing heartland of Gujarat. It plans to double the expelling capacity to 120 t.p.a., enhancing refining capacity from the existing 30 t.p.a. (tonnes per annum) to 75 t.p.a. It also plans to produce some castor oil derivatives too. The most interesting feature of NKIL is its price support to the castor growers. The aggressive procurement by the company has already shot up prices from Rs.550 per quintal to Rs.1000 per quintal within a year or so.

It is important to emphasize here that the process of commercialization brings finally remunerative prices to producers and leads to the development of infrastructures for further promotion of business in question. High castor prices were well-received by Gujarat castor farmers. This led to spurt in castor acreage in Gujarat since 1970s.[25]

The other positive points that Gujarat had were: (1) a well-developed network of 300 assembly centres for agricultural produce in the state, (2) well-developed transportation system linking primary to secondary markets, (3) a well-developed institutional finance. The infrastructures were hence quite conducive to the promotion of business. Presumably due to above, the market imperfections, particularly for commercial crop like castor, were hardly discernible in Gujarat.

Nearness of Bombay to Gujarat contributed to the commercialization process in very many ways. First, futures trading in castor seed developed in Bombay around 1900 A.D. which continues till today provided much needed hedging facilities to the traders in the market. This may have had some stabilization effect on castor prices the fact which ultimately helped the castor business to grow. The availability of hedging facilities through future trade proved quite helpful in the first half of the 20th century to castor seed business and in the second half, i.e. after 1950s, to the castor oil business. Second, the futures trade also helped to meet export commitments more smoothly. Traders were benefitted to conclude maximum export business and processors were benefitted from the facility of trading in castor oil. Third, Bombay, being business capital of India, became a source of finance to Gujarat. Big companies came to Gujarat to explore the market; Jayant Agro Company was one of them. The company started the innovative approach of collection of castorseeds from door-step of the farmers at predetermined prices and transport the same to Bombay for processing and exports.

The government of India also took suitable steps to promote export of castor oil from India by providing cash compensatory support, duty draw back incentives, refund of excise duty and income-tax, etc. Yet, many exporters felt that full potential of

castor oil export was not utilized and hence demanded exports under "Open General Licence" (OGL).

The buoyant international castor oil prices helped the trade to flourish uninterruptedly. However, the problems related to farm production planning and its stabilization continued due to varying monsoon conditions from year to year. Drought posed a severe strain in meeting the export demand for castor oil. For example, during the years 1982-85, exports slumped primarily due to reduced production and not to slackness of demand. Consequent upon increasing prices, various new firms entered into the export business of castor oil.

Summary and Conclusions

In this article, the reasons for a successful castor revolution in Gujarat province of India are explored and studied. The spectacular success achieved in various stages of development castor hybrids, including breeding, adoption, and commercialization. The success of breeding can be ascribed to the followings. First, India possessed: a wide spectrum of segregating materials which are required for developing new postulate lines; a large stock of germplasm entries which are required for developing superior quality male inbred line; and above all the breeders who put whole-hearted efforts. Castor breeders produced castor hybrids which could yield 6-8 times more than the traditionally grown strains. This laudable jump in yield

made castor attractive to farmers and as result castor became a competitive crop in Gujarat. Second, the breeding programme was strengthened and upgraded in terms of new techniques and importing of skills to breeders after the green revolution success and was carried out with continual feedback from farmers. Thus procedures, objectives, were kept first while developing new castor hybrids or varieties the fact which these new innovations easily adoptable on farms.

Castor hybrids when introduced to Gujarat farmers were speedily adopted within 4-5 years of time. Almost 98% of total castor acreage in two major castor growing districts--Mehsana and Banaskantha--came under castor hybrids. Survey data revealed that the multiple advantages arising from these hybrids, in addition to their being economically competitive, attracted farmers. These multiple advantages included: generating cash to meet farmers needs, requiring less supervision time; it can grow in less fertile soils as well in soils where other crops could not do well.

The critical factor in making adoption of castor hybrids speedier and persistent was the well-organized and reliable seed multiplication system in which quality was given utmost consideration. Although hybrid seed was very costly to farmers, yet farmers purchased it for it gave superior results in terms of yield and marketability. The success in adoption of castor hybrid was reinforced by the ready international market for castor oil

to which India had access historically. But this alone was not enough, a marketing framework existed in Gujarat, pioneered by Jayant Oil Mill--a private firm which had been operating in Gujarat for the last 50 years or so, with full-fledged processing, and research and development facilities. So farmers did not realize any problems in selling their produce. And since, international castor oil market had been always buoyant, producers were guaranteed good prices. Hence, market risks were of lower order; rather, yield related risk due to weather and pest attack were more serious.

The interesting thing to note here is that there was spectacular success at each stage. A good breeding program resulted in high yielding hybrids which were readily adopted as producers found a ready market for their produce at reasonable prices. This may be sheer coincidence but it does tell us why some biotech innovations succeed and why others do not. In essence, this article concludes that mere development of variety or an innovation by scientists does not offer a guarantee of its success; rather adoption and commercialization are far more and equally important processes that must be ensured for achieving successful application of an agro-biotech innovation. [26]

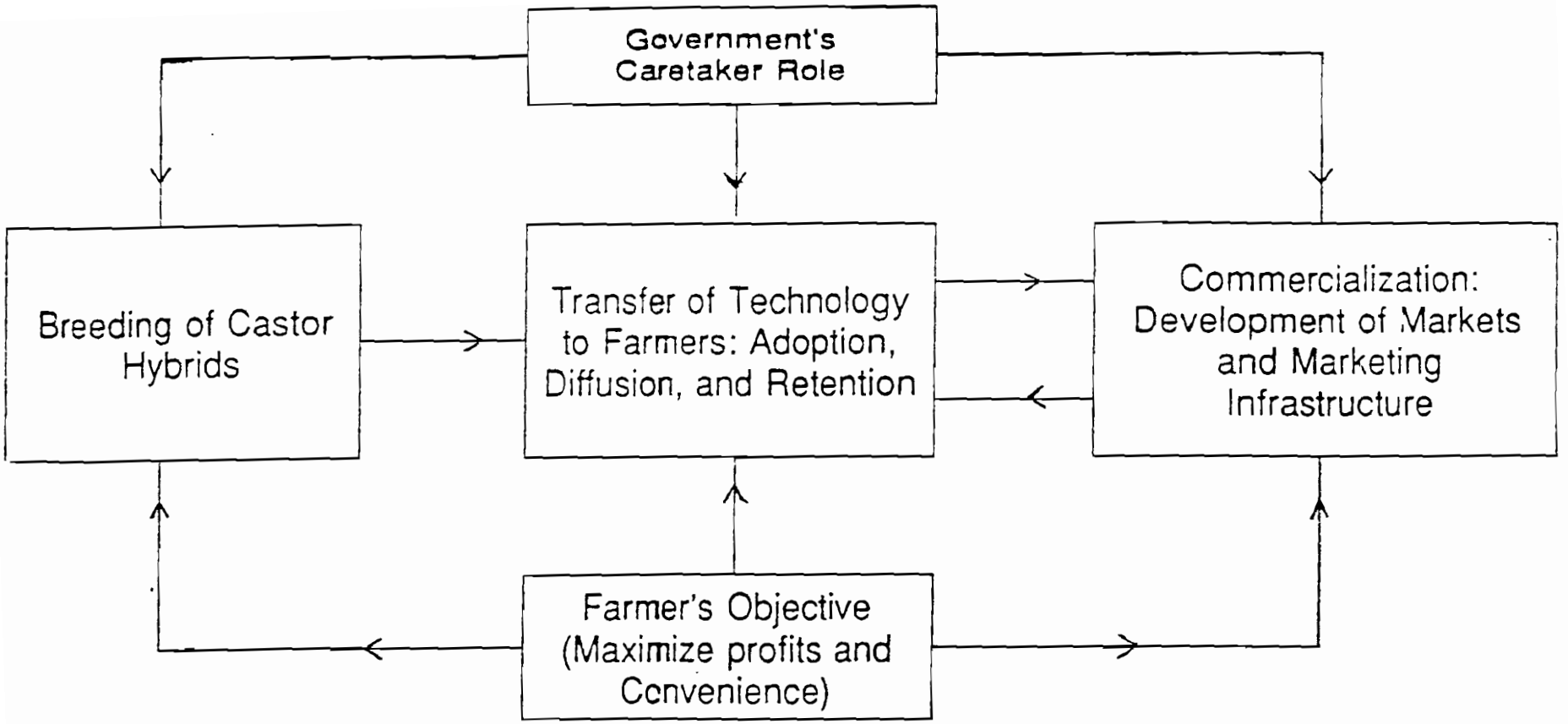

Figure 1: **A Schematic Representation of the Paradigm of Successful Technology Development and Transfer**

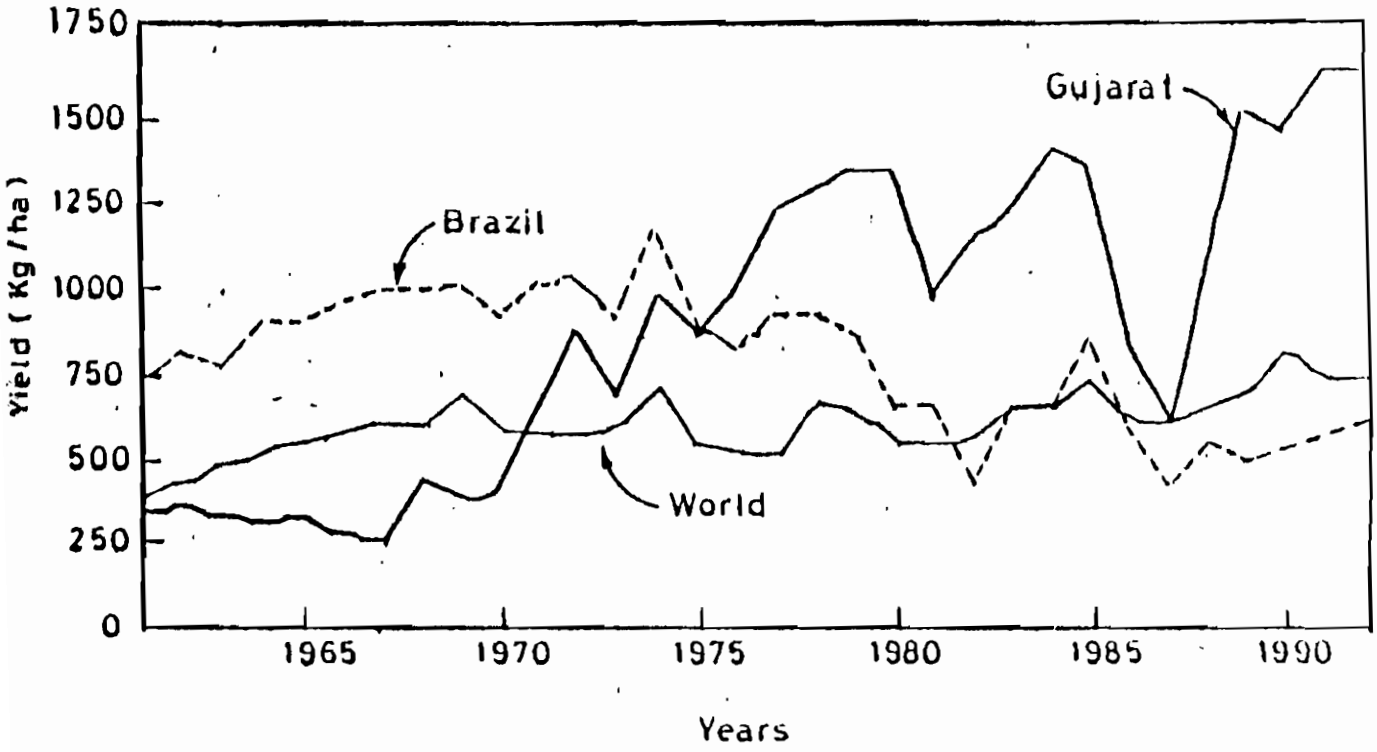

Figure 2: Average Castor Yield in Gujarat, Brazil and the World.

Table I : Selected Improved Castor Varieties and Hybrids, India

Improved Variety	Duration	Wt. of 1000 seeds (grams)	Yield kg/ha.	Oil (%)	Suitable Agro-climatic Zones
HC-1	240-270	305	280-375	51	
HC-2	240-270	275	312-438	49	
HC-3	240-270	295	280-438	49	
HC-4	240-270	265	312-438	49	Andhra Pradesh
HC-5	240-270	250	312-438	48	
HC-6	240-270	210	312-438	48	
HC-7	240-270	220	312-438	48	
HC-8	240-270	280	1000-1150	56	
TMV-1	240-270	---	375-438	57	
Punjab Castor No.1	275	38	1700	52	Haryana only
Rosy	200-300	320-350	700-750	50	Karnataka
MC-1	210	---	538	49	
EB-9	105	---	250	47-48	Madhya Pradesh
EB-16	150	---	485	51-52	
EB-16A	220	400	1418	50.9	Madhya Pradesh & Bihar
EB-31	150	---	535	44-45	Madhya Pradesh
TMV-1	195	240	930	51	Tamil Nadu
TMV-2	210	290	960	50	Tamil Nadu
	200	440	500	42	West Bengal
TMV-3	240	320	930	55	Tamil Nadu
SA-I	145	275	900	53.8	Tamil Nadu
SA-II	95-100	200	1100	52.6	Tamil Nadu
T-3	235	578	1100-1400	55-72	
T-4	240	480	1100-1400	52	Tarai, U.P.
KELP-6	245	505	1200-1400	51	
B-1	120-130	225	300	45.3	West Bengal
Hybrids					
GAUCH-1	---	---	1960(I) 1000(D)	---	
GCH-2	---	---	1840(I) 1040(D)	---	
GCH-3	140-150	242	1543	49.5	Gujarat
GCH-4	---	---	2230(I) 1220(D)		

Source: Adapted from: (1) Directorate of Oilseed Research (1987, pp.8-9); and (2) Kulkarni et. al. (1977, pp. 46 a & b).

Table II: A Comparison of Yields between Improved and Traditional Varieties of Castor and Other Crops, India

Crop	Traditional Seeds (1)	Improved Seeds (2)	Ratio (%)
	.. .. kg./ha.		
Rice	1660	8750	5.27
Wheat	1200	4600	3.83
Maize	968	6000	6.19
Small Millet	360	1300	3.42
Linseed	433	600	1.38
Castor (Irrigated)	245	1927	7.86

Source: Constructed from data obtained from Thakur (1975), Sharma and Malick (1978), Rai (1987), Agrawal (1982), Seetharam (1989), Tewari and Rao (1991).

Table III: Progress Made in Adoption of Old Strains of Castor in Different Provinces, India

Province	Total acreage (ha.)	Acreage under improved strain (ha.)	Proportion (%)	Beans production (tonnes)	Production from improved strain (tonnes)	Proportion (%)
Gujarat[1]	56,000	10,960	19.57	15,000	695	4.63
Andhra Pradesh[1]	2,70,000	1,03,220	38.22	38,000	3120	8.21
Tamil Nadu	---	56,936	--	---	7231	--
Karnataka	42,000	1,020	2.42	12,000	30	0.25
Orissa	21,000	1,020	4.85	11,000	305	2.77
Total						

1. Except in Gujarat and Andhra Pradesh, elsewhere castor was grown as mixed crop.

Source: Constructed from data obtained from Kulkarni (1979, p.90).

Table IV: Factors Affecting Castor Adoption Rates in Mehsana, Gujarat.

Particulars	No. of households who replied in favor (1)	Number of total respondents (2)	Proportion (%) (½)
1. More profitable than other crops	70	70	100
2. Special advantage in growing castor			
a) less labour required	0	70	-
b) less capital required	0	70	-
c) less supervision and management time needed	6	70	8.6
d) time-saving	-	-	-
e) easy cultivation	3	70	4.3
f) less risky than others	64	70	91.4
g) compatible with objectives of absentee landlordism	1	70	1.4
h) drought-prone	61	70	87.1
i) produces cash in time	69	70	98.6
j) improves soil texture, soil tilth, etc.	68	70	97.1
k) stored for long time	22	70	31.4
3. Incentives given by change agencies (central and local govts.) for castor growing.	6	70	8.5
4. Since how long have you been growing castor:			
a) last 20 years or more	0	70	0.0
b) last 15-20 years	8	70	11.4
c) last 10-15 years	18	70	25.7
d) last 5-10 years	27	70	38.6
e) from last 5 years	17	70	24.3
5. Castor growing accords social prestige	0	70	0.0
6. Castor-production practices are difficult to understand	4	70	5.7

Table IV: Factors Affecting Castor Adoption Rates in Mehsana, Gujarat (contd.)

Particulars	No. of households who replied in favor (1)	Number of total respondents (2)	Proportion (%)
7. Was trial taken before going to large scale adoption of castor	Nil	70	0.0
8. The significant difference between castor hybrid and traditional variety exists	63	70	90
9. Households who could name			
a) one castor hybrid	12	70	17.1
b) two castor hybrid	21	70	30.0
c) three castor hybrid	21	70	30.0
d) four castor hybrid	14	70	46.6
e) more than four castor hybrids	2	70	2.9
10. Who made the decision of adoption?			
a)	65	70	92.9
b) head of the family	22	-	-
c) group of villagers	-	-	-
d) sarpanch	-	-	-
e) others	-	-	-
11. How did you get to know about hybrids?			
a) neighbours and others	16	70	22.8
b) communication with friends and relatives	19	70	27.1
c) mass media	10	70	14.3
d) VLW or any others	25	70	35.7
12. Have castor hybrids growing resulted in the change of following:			
a) income composition	70	70	100
b) production composition	60	70	85.7
c) increased social status	24	70	34.3

Source: Constructed from data obtained from the Primary Survey above January-February 1995.

Notes

1. *Tewari, D.D. and V.M. Rao (1991),* ***Castor Economy: A Profile and Analysis of Indian and International Market,*** *New Delhi: Oxford & IBH, p.66.*

2. *Tewari, D.D., "Castor Revolution: A Biotechnological Success,"* ***Vatika, A Magazine of Indo-Hybrid Seeds,*** *April, 1994.*

3. *Tewari and Rao, 1991, p.28.*

4. Author is aware of distinction between "invention" and "innovation" in the literature, see Schumpter, J. (1939). The word innovation here is used in the sense of producing a product or a process change.

5. This involves some kinds of risks and hazards that society has to undertake for increasing social welfare of coming generations.

6. Voluminous literature is written about the adoption, see Rogers (1962), Rogers and Shoemaker (1971).

7. See Pathak, G.N. and Dikshit N.N. (1961), "Expression of Heterosis in F_1 Hybrids of Castor During Germination and Early Seedling Stages", **Indian Oilseeds Journal**, 5(4): 274-79; Sindgi, S.S. and Z.A. Ansari (1969), "A Dwarf Mount in Castor", **Mysore Journal of Agricultural Sciences**, 3(2); Ankineedu, G. and L.G. Kulkarni (1965), "Effect of Irradiation on Nature of Fruit Loculus in Castor", **Indian Oilseed Journal**, 9(2).

8. Gopani, D.D., M.M. Kabaria and R.H. Patel (1969), "Study of

Sex Reversion in Castor", **Indian Journal of Agricultural Sciences**, 39(3): 255-58.

9. Since 1986 castor acreage in Gujarat started declining. But there was a sharp drop from 209 thousand acres in 1987 to 68 thousand acres in 1988 --about 68% form the 1987 level. In addition to drought, severe incidence of wilt is understood to be also and important factor in explaining this fact. See Gujarat Agricultural University (1991).

10. Yield of GCH-4 is higher by 13 and 9% compared to GAUCH-1 and GCH-2, respectively. See Gujarat Agricultural University (1991).

11. Gujarat Agriculture University (May 1991), **Visit of ICAR Quinquennial Review Team for Evaluation of work of All-India Co-ordinated Research Project on oilseeds 1983/84 to 1989/90.** AICORPO, Sardar Krushinagar, Gujarat, India, p.5.

12. The assumption behind this approach was that a bundle or package of interrelated innovations was better adopted than adoption of a single innovation. See Rogers (1971, pp. 171-172).

13. Rogers, E.M., (1962), **Diffusion of Innovations**, Glaney edition, New York: Free Press, p.71; Rogers, E.M. and F.F. Shoemaker, (1971), **Communication of Innovations : A Cross-**

Cultural Approach, second edition, New York: Free Press, 476 pp.

14. Subcommittee of the Rural Sociological Society, (1952), **Sociological Research of Diffusion and Adoption of Farm Practices**, RS-2, Lexington: Kentucky Agricultural Experimentation Station.

15. Holfer, C.R. and D. Strangland (1956), "Farmers Attitudes and Values in Relation to Approved Practices in Corn Growing" **Rural Sociology**, 23: 1112-20.

16. Rogers, E.M., (1965/66), "Mass Media Exposure and Modernization among Columbian Peasants", **Public Opinion Quarterly**, 29: 614-25.

17. See Brown, (1970).

18. Obiuaku, L.O. and G.D. Hursh, (1974), "Farm Practice Adoption in the Eastern States of Nigeria", **Agricultural Administration**, pp. 115-23.

19. See, Obiuaku, (1977).

20. Obiuaku, L.O., (1979), "Technical Assistance and Agricultural Change in Some Anabra State Villages, Nigeria", **The Journal of Developing Areas**, 14: 43-54.

21. Whitney, H. and S.R. Johnson (1979), "Population Growth and the Adoption of New Technology in Colonial Taiwanese

Agriculture", **The Journal of Developing Studies**, 15(4): 289-303.

22. Economic variables included profitability, earning capacity, available farming labor, power available; geographical variables included accesses to roads, markets, distance from the field, etc.; socio-cultural variables included education, prior experience with the use of irrigation.

23. A comparison of net returns across six crops, viz., jowar, bajra, maize, wheat, groundnut, and castor, revealed that castor is more economical than others. For example average net returns per hectare is Rs.3816 for castor; Rs.1117 for wheat, and for the rest of them returns were negative.

24. In Banaskantha district of North Gujarat, castor is grown in sand dominated soils. Many farmers believe that by growing castor on such soils its texture improves over time. Based on impressionistic survey of the area and discussion with soil experts at Gujarat Agriculture University, Sardar Krishi Nagar.

25. The Castor acreage response to prices in Gujarat is estimated to be very high, i.e. 2.28. This explains why there was large expansion of acreage. Under Castor see Tewari and Rao, 1990 pp.49-52.

26. The case of Quality Protein Maize or QPM is worth noting

here. Millions of dollars were spent on developing this samely of maize but without any efferts on adoption and Commercialization programmes at the International Maize and Wheat Improvement Centre (CIMMYT) in Mexico. For details, see Brown F.N. (1995) "Corn of Plenty" Span 36(5): 30-32.