Impact of Public- and Private-Sector Maize Breeding Research in Asia, 1966-1997/98

Roberta V. Gerpacio, Technical Editor

CIMMYT MR

Chapter 7

Impact of Maize Breeding Research in Thailand: Public- and Private-Sector Collaboration

Benchaphun Ekasingh, Phrek Gypmantasiri and Kuson Thong-Ngam

Maize is a crop recently introduced in Thailand and is largely produced commercially (there is very little subsistence production). Over the last 30 years, the growth of maize production in the country has been the result of intensive R&D. In close collaboration with CIMMYT, public-sector research in Thailand developed several locally adapted and disease resistant OPVs of maize, which dominated the market and area under maize until 1990. The nearly 2 m ha planted to maize (out of about 4 m ha planted to major field crops) and an annual production of 4 m ha attested to the success of these OPVs. In the 1990s, total output of maize grain has continued to increase steadily, while the average area planted to maize has fallen somewhat and stabilized at around 1.4 m ha.

Beginning around 1990, there was a fundamental shift in the maize seed industry of Thailand, marked by substantial changes in production technology and market outlets. Several private multinational and national companies started to produce maize hybrids that began to dominate in farmers' fields. Active promotion of hybrids by the public and private sectors helped farmers rapidly learn to use the new hybrids and were one indication of productive collaboration between the two sectors. The private sector developed hybrids based on the locally adapted, disease resistant OPVs and inbred lines developed by the public sector. Active competition among private companies gave farmers a wide selection of hybrids.

Thailand is no longer a major exporter of maize. Domestic use of maize has increased over the years as a result of the expanding livestock industry. Rising urban income, associated increases in the consumption of meat and dairy products, and rising exports of chicken meat to Japan have resulted in a rapid growth in demand for animal feed, including maize. In 1966, most maize output was exported. In 1996, almost all of Thailand's maize production was used domestically, mainly as animal feed. In some years, imports of maize were necessary.

Organization of Maize Research in Thailand

Public-Sector Research

National

The two national public organizations undertaking substantial maize research in Thailand are Kasetsart University and the Department of Agriculture (DOA). Kasetsart University has a 368 ha experiment station in Nakhorn Ratchasima called the National Corn and Sorghum Research Center (NCSRC, commonly called Suwan Farm),

which has conducted maize research, particularly breeding, since 1966. Maize research at Suwan Farm is conducted jointly by the staff of the university and NCSRC. The DOA is officially responsible for government research and policies for the development of maize cultivars. Maize breeding by the DOA is relatively recent compared to that by Kasetsart University.

International

The two public research organizations in Thailand have good collaboration with CIMMYT. For 30 years, CIMMYT had an Asian regional office in the DOA, housed within Kasetsart University in Bangkok. Scientists from these institutions conduct collaborative field trials, regular seminars and training programs. The collaboration between CIMMYT and Kasetsart University scientists dates to the 1970s, when scientists began working on Suwan OPVs.

Private-Sector Research

Multinational Companies

Until 1998, only five multinational seed companies operated in Thailand: Pioneer Hi-Bred, Pacific Seeds (Advanta/ICI/Zeneca), Novartis, Cargill Seeds and the Charoen Seeds Group (CP Group). CP Group is a Thai company involved in all lines of agribusiness, including seed. Charoen Seeds collaborates with US-based DeKalb Seeds, which provides access to DeKalb's germplasm and technology. In 1991, Charoen Seeds successfully commercialized the single-cross hybrid CP-DK888, which has accounted for around 50% of the hybrid maize seed market for the last nine years. Farmers have become very knowledgeable about hybrids and have shown a preference for certain hybrids.

Most germplasm used for breeding by these multinational companies comes from their mother companies. Within each company, research results, activities and outputs are shared among the regional branches. Three of these companies established offices in Thailand during the late 1970s or early 1980s. With their Thai staff, they are able to operate with adequate research backup and efficient management. After 15-20 years of operation in Thailand, these companies have acquired experience and skill in working with farmers, whose strong participation has also helped the private breeding programs to succeed. Competition among the private companies has provided the industry with a healthy working environment and many positive results.

National (Thai) Companies

Of the seven private companies involved in maize research in Thailand, three are domestic companies. The biggest one is the multinational CP Group. The other two companies (Uniseeds and Royal Seeds) are much smaller.

The smaller domestic companies are more dependent on public sector germplasm and research, both from CIMMYT and Kasetsart University's Suwan Farm. These companies have limitations on their research capacity (personnel and budget) relative to multinational companies. However, with the coordination and support of the public sector, they can make an important contribution. They foster competition in the industry and also provide alternative modes of research and business operation to those offered by multinational companies. For example, the smaller companies are more interested in pursuing further research on and marketing of improved OPVs and public sector hybrids.

In 1999, the structure of the Thai seed industry changed again as the US-based agrochemical company, Monsanto, acquired both Cargill Seeds (international section) and DeKalb Seeds. Since CP and DeKalb, together with Cargill Seeds, control around 70% of Thailand's seed market, the merger will substantially reduce market competition.

Impact of Maize Research

Varietal Releases

During the last 30 years, Kasetsart University's Suwan Farm has released at least 4 OPVs, 10 field maize hybrids, and 3 baby corn and 4 sweet corn varieties, apart from 46 inbred lines (Tables 1 and 2). Suwan Farm released 2 hybrids in the 1980s and 6-7 more in the 1990s. Inbred lines from Suwan Farm are especially valuable for breeding, both in the public and private sectors. Meanwhile, the DOA's Nakorn Sawan Field Crops Center developed and released the OPV called NS-1 in 1989 and has some hybrids in the pipeline for release.

Table 1. Maize OPVs and hybrids developed by the public sector from 1975 to 1997 and hybrids marketed by the private sector in Thailand, 1997-98

	Field maize					
Sector and seed agency	**OPV**	**Single-cross hybrid**	**Double-cross hybrid**	**Three-way-cross hybrid**	**Baby corn**	**Sweet corn**
Public sector						
Suwan Farm	Suwan-1 Suwan-2 Suwan-3 Suwan-5	Suwan-2301 Suwan-3501 Suwan-3502 Suwan-3503 Suwan-3504 Suwan-3601 Suwan-3851		Suwan-2602 Suwan-3101 Suwan-3602	Suwan-2 TSC1-DMR Kasetsart-1	TSC1-DMR HSX-27127 HSX-11476 Insee-1
DOA	NS-1					
Private sector						
Charoen Seeds		CP-DK888 CP-DK999	CP-DK818	CP-DK822		
Cargill Seeds		C-922 BIG-919 BIG-929 BIG-717 (MSC) BIG-727 (MSC)			C-501	
Pacific Seeds		Pacific-328 Pacific-700 Pacific-626 Pacific-848	Pacific-11		Pacific-421 Pacific-116[a] Pacific-129[a]	Hibrix-5 Hibrix-10
Novartis Seeds		Red Iron-45 Venus-49		Hercules-31 Convoy-93 G-5384	G-5414	
Pioneer Seeds		3011 3012 3013		3248 3006 30A10 3014		
Uniseeds		Uniseeds-89 Uniseeds-90		Uniseeds-38	Uniseeds-B50	Uniseeds-SW-1
Royal Seeds		Royal I Royal III				

Source: CIMMYT Maize Impact Survey 1998/99.
Note: MSC = modified single-cross hybrid.
a Released in 1998.

Table 2. Characteristics of field maize cultivars released by the public and private sector in Thailand from 1966 to 1997/98

	Public sector (cultivars released from 1966-97/98)		Private sector (cultivars sold in 1997/98)	
Characteristic	**Number**	**Percent**	**Number**	**Percent**
Maize cultivars released, 1966-97	15	100	58	100
Improved OPVs	5	33	0	0
Hybrids				
Single cross	7	47	30	52
Double cross	0	0	7	12
Three-way cross	3	20	20	34
Other	0	0	1	2
Adaptation				
Lowland tropical	15	100	58	100
Grain color				
White	0	0	1	2
Yellow	15	100	54	93
Other	0	0	3	5
Grain texture				
Flint	5	33	26	45
Semi-flint	10	67	24	41
Semi-dent	0	0	8	14
Maturity class				
Extra early (<100 days)	0	0	1	2
Early (100-110 days)	2	13	28	48
Intermediate (110-120 days)	13	87	24	41
Late (120-135 days)	0	0	4	7
Releases by period				
1970-79	2	13	0	0
1980-89	4	27	8	14
1990-97/98	9	60	50	86

Source: CIMMYT Maize Impact Survey 1998/99.
Note: Sums may not add up to 100% because of incomplete description for some cultivars.

The first successful improved OPV developed by the public sector, Suwan-1, was developed from 36 maize landraces from many areas of the world. Downy mildew resistance was incorporated through the introduction of two Philippine varieties. From 1975 to 1990, Suwan-1 was very well received by Thai farmers and was also used in other Southeast Asian countries. Suwan-1 is still widely used in breeding because of its broad genetic base.

As noted, the 1990s were the decade of the private sector. Private companies released about 3-5 hybrids per year. In 1997, there was a record release of 8 new hybrid varieties by the private sector, 6 of which were single crosses. During 1988-97, at least 36 hybrids developed for different ecological zones were released and sold in Thailand by the private sector. The share of individual companies in the seed market ranged from 2-3% for a small company to 50% for a large company. Farmers' association with specific private companies influences their preferences for different hybrids. A few of the more advanced farmers have also become contract growers of hybrid maize seed for the bigger private companies.

In 1997-98, approximately 60% of all hybrid maize seed sold in Thailand was seed of single-cross hybrids. The private sector was selling 19 single-cross hybrids, 1 double cross and 11 three-way

crosses. Out of the 20 cultivars produced by Suwan Farm, 12 were single-cross hybrids and 3 were three-way-cross hybrids.

Seed Production

With widespread adoption of improved cultivars in Thailand, the production of improved seed has become a major activity for both public and private organizations. In the public sector, public-sector staff and hired workers produce seed; in contrast, private companies work mostly with contract farmers, who are closely supervised by company personnel, to produce seed. Some small local companies buy the right to produce Suwan parent lines, acquire parent seed, hire technical assistants, and produce F1 hybrid seed for sale under their own brand names. These companies do not conduct any research and do not produce new hybrids; they just produce and sell Suwan hybrid seed. They are essentially producers and marketing agents for Suwan improved OPVs and hybrid seed. Suwan Farm encourages these small companies to operate in this way and sells its inbred lines for the production of the hybrids. With an estimated 15,000 t of hybrid seed produced and sold in 1997 (Suwantaradon 1997), around 6,000 farm households and 12,000 ha[1] of land (0.8% of all maize area) appear to be devoted to hybrid maize seed production. At least 90% of maize farmers planted some form of hybrid seed, although some farmers reportedly used F2 seed in 1998-99.

Seed Prices

In 1997, small local private companies sold improved maize OPV seed for about baht 20/kg (US$ 0.77/kg). The average cost of hybrid seed ranged from about baht 45/kg (US$ 1.73/kg) for double-cross hybrids to about baht 80/kg (US$ 3.08/kg) for single-cross hybrids (Table 3). At that time, ordinary maize grain prices averaged about baht 4/kg (US$ 0.15/kg).[2] Seed-to-grain price ratios averaged from about 5.0 for improved OPVs to 20.0 for single-cross hybrids. A comparison of seed-to-grain price ratios in 17 countries by Krull *et al*. (1998) showed that OPV seed-to-grain price ratios ranged from 3.0 to 7.6 while those for private sector hybrids ranged from 6.4 to 26.7. Krull *et al*. pointed out that in mature markets, extensive use of improved seed is frequently associated with high seed prices. Experience has shown that farmers quickly appreciate that using improved maize seed does not cost more; it pays more. In a particular country, whether hybrid seed pays for the higher prices or not depends on the level of incremental yield the seed can provide. In Thailand, for example, an increase of only 0.4 t/ha yield (at baht 4/kg) will pay for the cost of single-cross hybrid seed used on 1 ha (at baht 80/kg and a seed rate of 18 kg/ha), provided that all other input costs are the same.

Adoption and Diffusion

In the 1970s and 1980s, maize farmers extensively adopted improved OPVs. During the 1990s, farmers began to switch to hybrid maize. Adoption of hybrid maize increased from 20% of total maize area in 1990 to 49% in 1993 and to 60% in 1995

Table 3. Seed prices and seed-to-grain price ratios, Thailand, 1997 (grain price = baht 4.00/kg=US$ 0.15/kg)

Seed type	Seed price		Seed-to-grain price ratio
	Baht	US$	
Single-cross hybrid	80	3.08	20.0
Three-way-cross hybrid	60	2.30	15.0
Double-cross hybrid	45	1.73	11.3
Improved OPV	20	0.77	5.0

Source: CIMMYT Maize Impact Survey 1998/99.

[1] Assuming a yield level of 1.25 t/ha and farm size of 2 ha per household.

[2] These prices were calculated at the rate of US$ 1 = baht 26 in June 1997, but the baht had devalued to US$ 1 = baht 45 by December 1997.

(Suwantaradon 1997). In 1997, it was estimated that 81% of the total maize area was planted to private-sector hybrids, 4.7% to public-sector hybrids, 13.9% to improved OPVs and only 0.3% to traditional varieties (Office of Agricultural Economics 1997).

A 1994 study of 200 maize farmers in Nakorn Sawan found that, despite an 85% increase in cost of materials and 13% increase in labor costs, farmers who adopted hybrids had a 32% increase in yield, 36% increase in net return, 29% increase in profit per kilogram and a 69% increase in profit per hectare (Jumroonpong 1996). It also reported that the higher yield is farmers' most important reason for using hybrids. The farmers who continue to use OPVs do so because of their lower price and better pest resistance compared to hybrid seed.

Despite the widespread adoption of hybrid varieties, there has not been a significant increase in the national average maize yield. Given the potential of the new hybrids, many experts feel that the national average yield should be at least 5.0 t/ha. Currently, the national average is only 3.4 t/ha, with some areas reporting significantly lower than average yields because of drought and inadequate use of chemical fertilizers. Some studies have suggested that, in shifting to hybrids, yields increase at a much slower rate than costs (Office of Agricultural Economics 1998).

Profitability

In experimental trials, hybrid maize has a substantial yield advantage over improved OPVs. The value of the incremental yield of hybrid maize offsets the incremental cost of higher seed prices and fertilizer costs. Aekatanasawan (1997) and Aekatanasawan *et al.* (1997) reported that in the Cooperative Hybrid Yield Trials during 1994-96, superior single-cross hybrids had an average yield of 9.5-9.9 t/ha, compared to 5.9-7.0 t/ha for Suwan-1 OPV and the national average of 2.9-3.3 t/ha.

Estimating yields in farmers' fields, Wuttiwan *et al.* (1993) found that maize yields in export, special promotion and all other zones[3] were 3.87 t/ha, 2.85 t/ha and 2.5 t/ha, respectively. A study by Kao-la and Wattanutcharitya (1993) conducted during the 1992/93 crop year in Sa Kaew Province found that the average yield for single-cross hybrids was 4.85 t/ha with a profit of baht 8,063/ha (US$ 322/ha). Other hybrids yielded an average of 4.4 t/ha for an average profit of baht 7,330/ha (US$ 293/ha). Meanwhile, the OPV Suwan-3 yielded, on average, about 3.58 t/ha and a profit of baht 5,654/ha (US$ 226/ha). The choice of seed (and its cost) explains these differences in profits because the cost of other production inputs did not vary much (Kao-la and Wattanutcharitya 1993). Similarly, Masjaroon *et al*. (1994) found that, in three provinces in northern Thailand, the average yield of improved OPVs was 3.2 t/ha with a profit of baht 255/ha (US$ 10.20/ha), while the yield of hybrid maize was 4.2 t/ha with a profit of baht 2,556/ha (US$ 102.20/ha). Hybrid yields were found to be higher while variable costs or grain prices were not significantly different for hybrids and improved OPVs.

Few studies confirm the overall impact of hybrid maize cultivation in Thailand, particularly in relation to farm profitability and income. Many studies show farm-level benefits of hybrid maize, but most are outdated. Over the last five years, the types of seed, as well as the prices of hybrids used by farmers, have changed substantially. Although there is a sense that hybrid maize has increased the incomes of maize farmers, there is not enough information on the extent of such impact on problems of marginal areas with suboptimal agronomic and environmental conditions, and on the gap between potential and actual yields.

[3] An export zone is an area where maize is produced for export and usually has good infrastructure. A special promotion zone is an area with special government projects. All other zones are areas that are not dedicated to these special export and promotion functions.

Public-Private Sector Linkages

Thailand's success in the widespread adoption of new maize technology, i.e., improved OPVs and hybrids, can be attributed to effective collaboration between the public and private sectors. The public sector laid the foundation with improved OPVs and quality inbred lines, to be followed by the private sector's intensive research on hybrids and successful seed production and marketing. The public sector has also provided strong promotion and extension as well as a supportive policy environment.

Germplasm Exchange

The first important linkage between the private and public sector (including international public organizations) involved flows of improved germplasm. The private sector can obtain breeding material from the public sector, especially from CIMMYT, whose maize germplasm bank houses some 13,000 accessions of seed collected from around the world. Private companies can also directly access CIMMYT germplasm, which they evaluate regularly. CIMMYT has been very open and helpful in distributing germplasm free of charge. CIMMYT material is also accessible to national public agencies like Kasetsart University and DOA, whose strong breeding programs, in turn, provide research support to multinational and domestic private companies.

The impact of CIMMYT germplasm is more pronounced among national research organizations and small domestic companies than among large multinational companies, national companies and their partnerships. These latter groups of companies have access to germplasm developed by their own mother or overseas branch companies. They reportedly use a small proportion of CIMMYT material for breeding (around 16% of germplasm used) and obtain the bulk of their breeding materials elsewhere. Approximately 56% of the germplasm used in breeding consists of in-country selections made by the company, 10% comes from their foreign branches and 18% comes from other public sources, within and outside Thailand.

Interviews conducted with seven private companies revealed that Suwan-1 is still used extensively for breeding. It was reported that CIMMYT material was not well adapted to local conditions. On the other hand, private companies extensively use inbred lines, OPVs and hybrids from Suwan Farm for further breeding.

Inbred Line Development

In the past, the private sector benefited from public sector research to develop inbred lines. Suwan Farm, for example, has successfully developed 46 inbred lines that public organizations as well as private companies use extensively to develop hybrids. Suwan Farm sells its inbred lines at reasonable prices, occasionally with instructions on how to develop hybrids from them. These inbred lines have provided support to small- and medium-scale seed producers. Large private companies buy the lines to develop them further or to limit the access of, and eventually weed out, competition. These inbred lines thus benefit both small and large private seed businesses.

Varietal Testing and Evaluation

Suwan Farm, DOA and the private sector work together for regular varietal testing and evaluation. The Department of Agricultural Extension (DOAE) has also established a seed quality testing program. The varietal testing and evaluation program provides a mechanism for comparing and contrasting material produced by the private sector and material produced by the public sector. Private companies use the results as reference points for working with farmers and with

government agencies. At the international level, CIMMYT and FAO established the Tropical Asian Maize Network to provide a venue for varietal testing and evaluation across South and Southeast Asia. Trials conducted through this network show that the yield potential of many new hybrids is around 8-9 t/ha (Chantachume *et al.* 1998; Vasal 1998; Aekatanasawan 1997).

Human Capital Development

Another important public-private linkage is evident in the area of human capital development. The human capital in Thailand's public- and private-sector maize research consists of highly qualified, efficient and motivated people committed to their work. Universities provide degrees and short-term training for private-sector personnel. CIMMYT also trains both public- and private-sector researchers, all of whom have their initial training in the public universities. These researchers also relate with each other on a personal basis in many ways, either as friends, alumni, friends of friends, junior-senior, ex-students and teachers, and so on. Frequent personal contacts between public- and private-sector researchers make maize research more interesting yet competitive and clearly have contributed to the success of maize research in Thailand.

Information Exchange

There are several important venues for information exchange between the public and private maize sectors in Thailand. Regular workshops and conferences on maize research focus on plant breeding, agronomic work, biotechnology, or maize farming systems, among other topics. At an annual conference on national corn and sorghum research, delegates from public and private organizations actively participate. CIMMYT and other international organizations, such as the Bangkok-based Asia-Pacific Seed Association, conduct regular regional and international conferences attended by national maize scientists and researchers.

Another important public-private sector linkage occurs through national and international publication. Although the channels of information are relatively closed in the private sector, public organizations regularly produce research papers, journal articles, books and other publications. Knowledge is abundant in the private sector, but issues of confidentiality, patents and trade secrets make much of it inaccessible to the public. As more knowledge is accumulated in the private sector, there is a danger that public knowledge will become more limited and learning will be inhibited. It is the role of the public sector to diffuse and disseminate knowledge to counteract the private sector's need to protect its information.

Policy

The Thai government has been very supportive of private sector R&D. It has provided policies that support and expand the work of private companies, facilitating the rapid expansion, both in terms of adoption and cultivar development, of hybrid maize. Maize farmers also benefit from expenditures by the public and private sectors on research, extension and infrastructure development. The Ministry of Agriculture and Agricultural Cooperatives, for example, actively promotes maize production in view of increased demand in both domestic and foreign markets. Apart from providing seed subsidies, the government has pledged that it will continuously promote public and private collaboration in maize production. Plant breeders' rights are also high on the government's agenda, although the particular way in which these rights will be implemented will concentrate not only on plant breeders' rights *per se* but also cover plant varietal protection through community and farmers' rights.

In the five years from 1994 to 1998, a DOAE program subsidized the cost of hybrid seed for 128,000 ha or around 10% of the total maize area at that time. Under this program, farmers paid only 10% of the cost of hybrid seed (only baht 8/kg of the actual cost of baht 70-80/kg). After one year, farmers participating in the program had to purchase their own seed at the market price, and the DOAE moved the promotion program to another location. By rotating the areas it covered, this program was able to introduce some hybrid seed to farmers across at least 640,000 ha (45% of national maize area). In 1999, DOAE subsidized 50% of the seed cost on 240,000 ha. The subsidized seed program is jointly administered with private seed companies, which see it as an opportunity to introduce their seed to maize farmers. Thailand's Bank of Agriculture and Agricultural Cooperatives also promotes hybrid seed adoption by granting farmers agricultural loans that partly include credit in the form of seed and fertilizer.

Looking Ahead

Emerging Technologies

It is expected that advances in maize production technology, particularly in biotechnology, will be substantial in the near future. These advances will affect the public as well as private sectors of the maize seed industry. Issues relating to the biosafety, health hazards, costs and competitiveness of the industry will need to be addressed. For example, genetically modified seed promoted by the private sector represents a technology in which the public sector is unlikely to invest many resources, especially in developing countries. Human capital development and the role of private and public organizations (including international research centers such as CIMMYT) will have to be re-evaluated seriously. Impact studies for these emerging technologies will be required.

The Legal Environment

Emerging technologies will require a shift in paradigm with respect to plant breeders' rights and variety protection. In the past, when new varieties were not protected by law, private companies used breeders' "trade secrets" to protect their varieties while relying on contract law to enforce business deals. Because trade secrets are sometimes revealed and/or "stolen," private companies see the need to protect their varieties through legal means. Over the next few years, new forms of plant variety protection, together with the technical means to enforce these rights (e.g., DNA fingerprinting) will be required.

Changes in the Organization of Research and the Role of the Public Sector

As patents and/or plant variety protection laws increasingly protect private research, public-sector researchers and even farmers will be less willing to share information, research results and germplasm. Remuneration will be demanded in many cases. In the context of private funding for future public research, research results can be sold for profit, and some products of public sector research will need to be patented. Beginning in 2000, more universities in Thailand will be financed by the government through block grants, which will force them substantially to revise their research programs. Public research institutions will need to be more income-oriented and cost-effective than in the past. It is possible that public research will be financed increasingly by the private sector, patented, privately owned and eventually more expensive to farmers. If this trend becomes unacceptable, innovations will be necessary in public policy, management and the legal framework, both at the national and international level.

Conclusions

The current success of the maize seed industry in Thailand can be traced back to the 1970s and 1980s, when public breeding of improved OPVs laid a firm foundation for private breeding of hybrids in the 1990s. The expected gains in average productivity per unit area have not been realized in farmers' fields, however. Although some gain in farm income has been observed, additional data are needed for a full assessment of the aggregate impact of hybrids and thus of maize research in Thailand. Given the substantial gap between yield on experiment stations and farms, more research is needed to determine production constraints at the farm level, especially for resource-poor farmers in marginal environments.

Over the next decade, maize research will follow a different approach and provide a new set of impacts, owing to rapid changes in technology as well as in the legal and political environments in which R&D occur. As research becomes increasingly privatized, it will become necessary to rethink the roles of the public and private sectors to identify gaps in knowledge. Public sector research organizations, both national and international, will have to fill in these knowledge gaps.

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