# Production and Productivity Trends of ICRISAT Mandate Crops





ICRISAT
International Crops Research Institute for the Semi-Arid Tropics
Science with a human face

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# Production and Productivity Trends of ICRISAT Mandate Crops

## **Sorghum** [*Sorghum bicolor* (L.) Moench]

Sorghum is a self pollinating, diploid (2n=2x=20) with a genome (1C=735 Mbp), about 25% the size of maize or sugarcane.

Sorghum is the fifth most important cereal crop and is the dietary staple of more than 500 million people in more than 30 countries. It is grown on 42 m ha in 98 countries of Africa, Asia, Oceania and the Americas. Argentina, China, India, Mexico, Nigeria, Sudan and the USA are the major producers. Other sorghum producing countries are Burkina Faso, Chad, Gambia, Ghana, Mali, Mauritania, Mozambique, Niger, Somalia, Sudan, Tanzania and Yemen.

Grain is mostly for food purpose (55%), consumed in the form of flat breads and porridges (thick or thin); stover is an important source of dry season maintenance rations for livestock, especially in Asia; it is also an important feed grain (33%), especially in the Americas.

## Asia

Sorghum area in Asia decreased continuously from 23 m ha to 11 m ha between the early 1970s and 2006 (Figure 1). However, production increased from 19 m t in the early 1970s to 21 m t in the late 1970s, but decreased thereafter to 11 m t in 2006. Yield has increased from 800 kg $ha^{-1}$ in the early 1970s to 1000 kg $ha^{-1}$ in 2006.

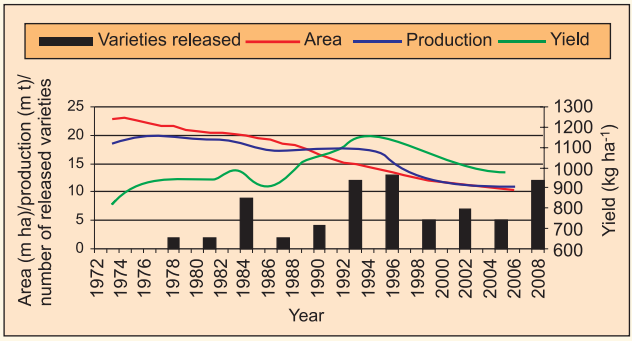


*Figure 1. Three-year moving average for sorghum area, production, yield and number of released varieties (3-year total) based on ICRISAT-bred material in Asia.*

## India

In India, production level increased from 9 m t in the early 1970s to 12 m t in the early 1980s and was almost maintained at this level for over a decade until the early 1990s, followed by a steep decrease to 7.2 m t (Figure 2). Despite decrease in sorghum area over the years, the production level during 2006 was almost similar to that in the early 1970s, which could be largely attributed to adoption of improved varieties and hybrids.

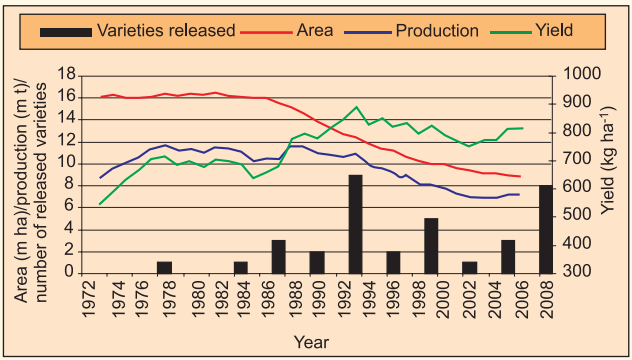


*Figure 2. Three-year moving average for sorghum area, production, yield and number of released varieties (3-year total) based on ICRISAT-bred material in India.*

Sorghum was grown on 8.7 m ha in India (20% of world's sorghum area), 3.9 m ha in rainy (*kharif*) season and 4.8 m ha in postrainy (*rabi*) season in 2006/07. Its productivity is 1345 kg ha$^{-1}$ in the rainy season and 480 kg ha$^{-1}$ in the postrainy season.

In India, the area under high-yielding cultivars has increased from 0.7 m ha in the early 1970s to 6.5 m ha in the late 1990s. Most of the area under high-yielding cultivars is planted with about 70 private sector (PS) hybrids, of which over 50 are based on ICRISAT-bred parental lines or their derivatives.

## Eastern and Southern Africa (ESA)

While both area and production in ESA has increased from the early 1970s to 2006, there is marginal (15%) increase in yield from 800 kg ha$^{-1}$ in the early 1970s to just over 920 kg ha$^{-1}$ in 2006 (Figure 3).

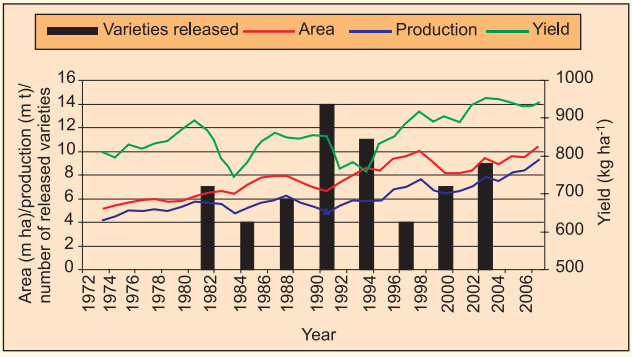


*Figure 3. Three-year moving average for sorghum area, production, yield and number of released varieties (3-year total) based on ICRISAT-bred material in ESA.*

## West and Central Africa (WCA)

While the area increased by almost two-folds, production increased nearly 2.5 times from the early 1970s to 2006 (Figure 4). Substantial improvement in productivity was achieved (from 700 kg ha$^{-1}$ in the early 1970s to 1080 kg ha$^{-1}$ in 2006) indicating increased productivity by 54%.

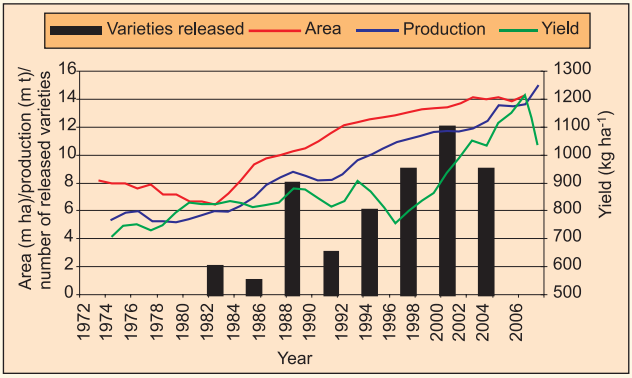


*Figure 4. Three-year moving average for sorghum area, production, yield and number of released varieties (3-year total) based on ICRISAT-bred material in WCA.*

## Latin America

The area increased marginally from 4 m ha in the early 1970s to 5 m ha in the early 1980s followed by a slight decrease till 2006, almost maintaining the level (4 m ha) of the early 1970s (Figure 5). The production increased 1.7 times from the early 1970s (9 m t) to the early 1980s (15 m t), then decreased steeply thereafter to 9 m t in the early 1990s. However, the production increased thereafter to 11 m t by 2006. The productivity increased from 2000 kg ha$^{-1}$ in the early 1970s to 3100 kg ha$^{-1}$ in 2006.

## Cultivars released

A large number of cultivars have been released (220) based on ICRISAT-bred improved germplasm and hybrid parents, over the years in all regions (Asia, India, ESA, WCA and LA) (Figures 1-5). The number of cultivar releases have been highest in Asia (73), closely followed by ESA (62), WCA (50) and Latin America (35). While released cultivars include both hybrids and varieties in Asia, it is mostly varieties in WCA and ESA (the exception being one hybrid released in Sudan).

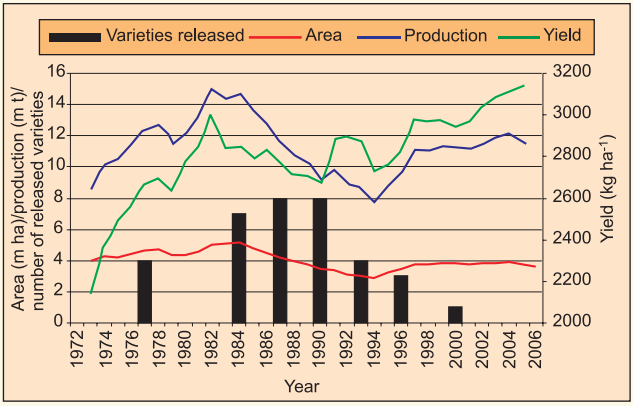


*Figure 5. Three-year moving average for sorghum area, production, yield and number of released varieties (3-year total) based on ICRISAT-bred material in Latin America.*

## Energy and nutrition

- Sweet sorghum is emerging as a feedstock for ethanol production. It gives food, feed, fodder and fuel without significant trade-offs in any of these uses in a production cycle. ICRISAT is pioneering the sweet sorghum ethanol production technology, and its commercialization.
- Sorghum grain has high level of iron (>70 ppm) and zinc (>50 ppm), and hence is being targeted to reduce micronutrient malnutrition globally.

## **Pearl Millet** [*Pennisetum glaucum* (L.) R. Br.]

Pearl millet is a highly cross-pollinated, diploid (2n=2x=14) annual with haploid genome size of 2450 Mbp. Pearl millet is annually grown on more than 29 m ha in the arid and semi-arid tropical regions of Asia, Africa and Latin America.

### India

India is the largest producer, both in terms of area (9.3 m ha) and production (8.3 m t) (Figure 1). As compared to the early 1980s, pearl millet area in India declined by 19%, but production increased by 28%, owing to a 64% increase in productivity (from about 450 kg $ha^{-1}$ to 870 kg $ha^{-1}$ during 2005-07).

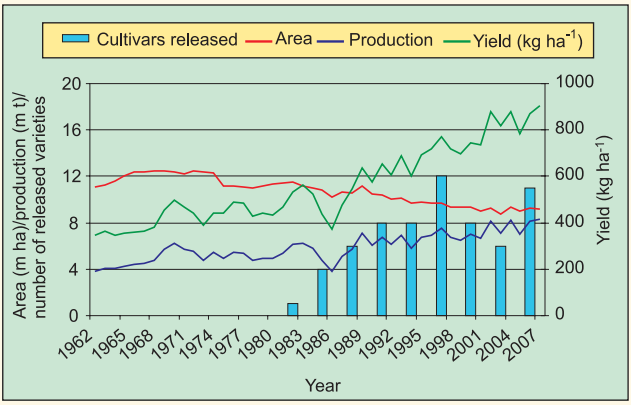


*Figure 1. Three-year moving average for pearl millet area, production and grain yield; and number of varieties released (3-year total) based on ICRISAT-bred material in India.*

Since 1986, the year when WC-C75 (the first ICRISAT-bred open-pollinated variety (OPV)) was released for cultivation in India, 63 cultivars (14 OPVs and 49 hybrids) have been released in India that have significant input from ICRISAT.

Improved pearl millet cultivars are grown on more than 4.5 million ha out of 9.3 m ha under this crop. A recent survey shows that more than 80 hybrids (by name) were reportedly cultivated in 2006. Of these about 50 hybrids are based on ICRISAT-bred parental lines. These hybrids cover about 4 million ha of the total pearl millet area, with improved OPVs occupying another 0.6 to 0.8 million ha.

*HHB 67-Improved (developed through marker-assisted selection).*

This enormous cultivar diversity since 1990 has contributed not only to increased productivity, but it has also halted the recurrence of any downy mildew epidemics witnessed quite often on pearl millet hybrids in India during the 1970s and 80s.

## West and Central Africa (WCA)

West and Central African (WCA) region has the largest area under millets in Africa (15.7 m ha), of which more than 90% is pearl millet. Since 1982, millet area in WCA has increased by 91% (up from 8.2 to 15.7 m ha) and productivity by 12% (up from 800 to 900 kg $ha^{-1}$), leading to 130% increase in production (up from 6.1 to 14.1 m t) (Figure 2). Thus, most of the increase in production has come from increase in cultivated area.

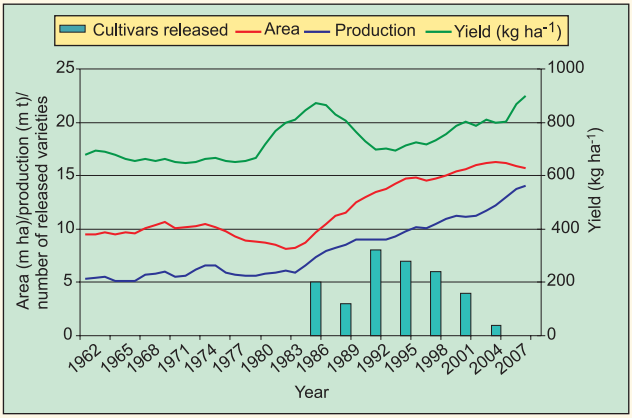


*Figure 2. Three-year moving average for pearl millet area, production and grain yield; and number of varieties released (3-year total) based on ICRISAT-bred material in West and Central Africa (WCA).*

Research in WCA has concentrated on OPV development although hybrids in WCA are likely to have similar grain yield advantage over OPVs as observed in India. Eighteen OPVs, developed by ICRISAT in partnership with NARS, have been released and adopted in nine countries in the region. Total varietal releases in WCA were 34, as some of these OPVs were released in more than one country. For instance, the most popular variety SOSAT-C88 has been released in six countries, while another popular variety GB 8735 has been released in four countries. Lack of seed production in

the region has been a major bottleneck in spread of improved cultivars.

## Eastern and Southern Africa (ESA)

Pearl millet is cultivated on about 2 m ha in Eastern and Southern Africa (ESA). Sixteen OPVs developed by ICRISAT in partnership with NARS, have been released in 10 countries in the region. Of these, ICMV 88908 (renamed as Okashana 1) has been released in more than one country. Okashana 1 and Okashana 2, supported with seed production, have been adopted on a large scale, covering more than 50% of the total pearl millet area in Namibia. Oka is another variety that was released and adopted in Tanzania. ICMV 221, developed at ICRISAT-Patancheru in India, was released and adopted in Kenya and Eritrea.

Similar to the situation in WCA, lack of seed production continues to be the major bottleneck in varietal spread in the ESA region.

# **Chickpea** [*Cicer arietinum* L.]

Chickpea is a self-pollinating, diploid (2n=2x=16) with genome size 1C=740 Mbp.

Chickpea, the world's third most important food legume, is currently grown on about 11 m ha, with 96% cultivation in the developing countries. Chickpea production has increased during the past 30 years from 7.3 m t (average of 1977-1979 triennium) to 8.4 m t (average of 2004-06 triennium) because of increase in productivity from 693 to 786 kg $ha^{-1}$ during this period.

## South and South-East Asia

This region contributes about 80% to the global chickpea production, and India is the principal chickpea producing country (83% share in the region). The chickpea area marginally declined from 9.3 m ha to 9.0 m ha during the triennium 1975-77 to 2004-06 (Figure 1). However, production slightly increased from 6.0 to

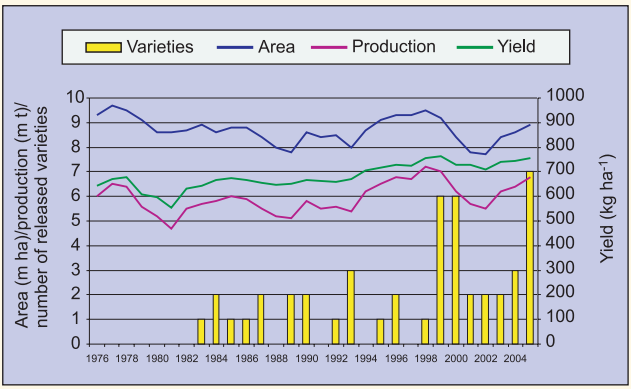


*Figure 1. Three-year moving average for chickpea area, production and grain yield; and number of varieties released based on ICRISAT-bred material in South and South-East Asia.*

6.7 m t and productivity from 642 to 733 kg ha$^{-1}$ during this period. Severe drought in several parts of India during 2001 to 2003 led to sudden decline in chickpea area during that triennium.

There has been a major shift in chickpea area (about 2.5 m ha) from northern India (cooler, long-season environments) to southern India (warmer, short-season environments) during the past four decades (Figure 2). The short-duration cultivars developed through ICRISAT-NARS partnerships have played a key role in expanding area and productivity of chickpea in central and southern India.

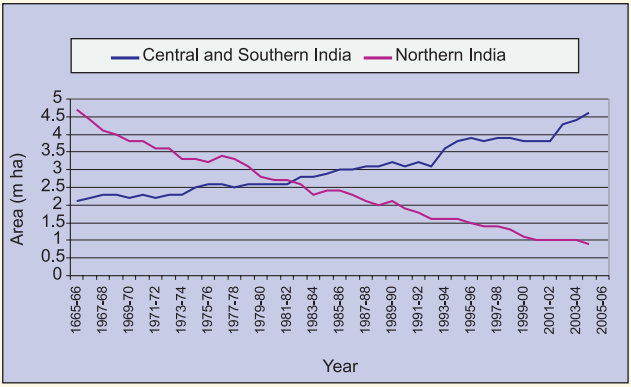


*Figure 2. Regional shift in chickpea area from northern India to central and southern India (three-year moving average).*

An example is the phenomenal increase in area and productivity of chickpea in Andhra Pradesh state of southern India, largely because of the adoption of fusarium wilt resistant, short-duration varieties. During the past 10 years (1996/97 to 2005/06), the chickpea area has increased 3.7 times (from 106,000 ha to 394,000 ha), yield has increased 1.9 times (853 to 1596 kg ha$^{-1}$), and the production has increased 7 times (90,000 t to 629,000 t).

ICRISAT-bred chickpea cultivars covered 82% of chickpea area in Myanmar during 2005-06. Adoption of improved cultivars has led to increase in area and productivity of chickpea. During the past decade (1995/96 to 2005/06), the chickpea area in Myanmar

has increased by 23.5% (from 166,000 to 205,000 ha), production has increased 2.6 times (from 92,000 t to 239,000 t) and yields have almost doubled (from 588 to 1171 kg ha$^{-1}$). Myanmar has emerged as an important exporter of chickpea.

## Eastern Africa

New cultivars that combine early maturity and resistance to fusarium wilt have been rapidly adopted in Ethiopia, Tanzania, Sudan and Kenya. This led to increase in area from 0.22 m ha to 0.34 m ha, production from 0.12 to 0.24 m t and productivity from 0.58 to 0.70 t ha$^{-1}$ during the triennium 1975-77 to 2004-06 (Figure 3).

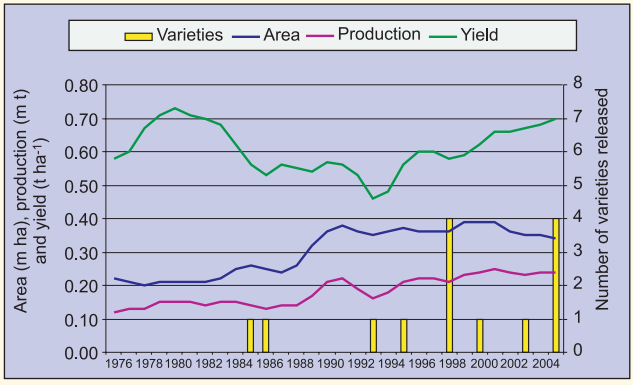


*Figure 3. Three-year moving average for chickpea area, production and grain yield; and number of varieties released (3-year total) based on ICRISAT-bred material in eastern Africa.*

Chickpea export from eastern Africa has substantially increased after 2001 and ranged between 13,000 to 89,000 t per year.

The introduction of new large-seeded kabuli cultivars in eastern Africa, particularly in Ethiopia, opened new opportunities for farmers to earn extra income through export of these high-valued chickpeas.

## Cultivars released

Sixty-six cultivars based on improved germplasm developed by ICRISAT have been released in different countries - India (34), Bangladesh (6), Ethiopia (9), Sudan (4), Myanmar (5), Nepal (3), Pakistan (1), Kenya (1) Australia (2) and USA (1).

## **Pigeonpea** [*Cajanus cajan* (L.) Millspaugh]

Pigeonpea is an often cross pollinated (20–70%) crop with diploid number 2n=2x=22 and genome size 1C=858 Mbp.

Globally, pigeonpea area has recorded a 56% increase in area since 1976. It is currently grown on 4.8 m ha. It is grown in Asia, eastern and southern Africa, Latin America and Caribbean countries.

### Asia

In Asia, pigeonpea is grown in an area of 4.3 m ha and production of 3.3 m tons (Figure 1). India has the largest area (3.6 m ha) under pigeonpea, followed by Myanmar (560,000 ha), Kenya (196,000 ha), China (150,000 ha), Malawi (123,000 ha), Uganda (86,000 ha), Mozambique (84,000 ha), Tanzania (68,000 ha) and Nepal (21,000 ha).

Maturity duration in pigeonpea varieties (at 17°N latitude) varies from about 90 days for extra-early varieties to more than 260 days for long-duration varieties.

Extra-short and short-duration pigeonpea varieties fit well in various cropping systems, providing greater crop diversity. One good example has been the adoption of ICPL 88039 (extra-short duration variety) in pigeonpea-wheat rotation in the rice-wheat cropping system in north-west India. It is also showing promise in rice fallows in lower latitudes.


In Asia, between 1976 and 2006, pigeonpea recorded:

-56% increase in area (2.76 to 4.32 m ha).

-54% increase in production (2.14 to 3.29 m t).

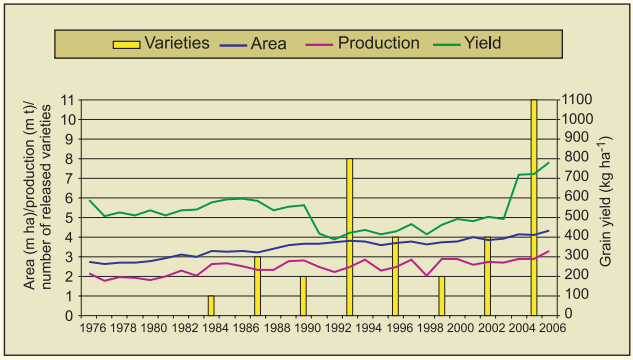


*Figure 1. Three-year moving average for pigeonpea area, production and yield; and number of varieties released (3-year total) based on ICRISAT-bred material in Asia.*

## Myanmar

Pigeonpea grown in Myanmar is mainly for export to India. Therefore, the production trends in Myanmar have a direct bearing on the domestic pigeonpea prices in India. Pigeonpea area in Myanmar has increased from 57,060 to 560,000 ha and production

from 37,110 to 530,000 t during 1990 to 2006. Five pigeonpea varieties, based on ICRISAT-bred material have been released in Myanmar.

## China

Pigeonpea in southern China is primarily used for soil conservation, food and fodder. ICRISAT variety ICP 7035 has shown high adaptation in different provinces. Currently pigeonpea is grown on 150,000 ha in Guangxi and Yunnan provinces.

## Eastern and Southern Africa

In Eastern and Southern Africa (ESA), pigeonpea is grown on 0.56 m ha (Figure 2).

It is an important crop of Kenya, Malawi, Mozambique, Tanzania and Uganda.

Between1976 and 2006, pigeonpea recorded:

-133% increase in area (0.24 m ha to 0.56 m ha).

-178% increase in production (0.14 m t to 0.39 m t).

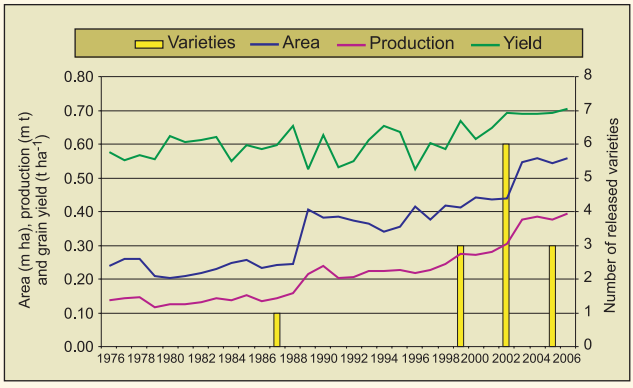


*Figure 2. Three-year moving average for pigeonpea area, production and yield; and number of varieties released (3-year total) based on ICRISAT-bred material in eastern and southern Africa.*

In eastern Kenya, about 20% of the farmers have adopted new varieties. Farmers have also started adopting the medium duration pigeonpea varieties (ICEAP 00554 and 00557) for both grain as well as green vegetable.

In Tanzania, about 50% of the farmers in Babati district adopted new varieties and production area expanded beyond the traditional Babati district to reach the neighboring districts of Karatu and Mbulu. In some areas, farmers are adopting long duration, compact growth habit genotype (ICEAP 00053) in maize intercropping systems.

The use of long duration, fusarium wilt resistant and consumer/market preferred variety (ICEAP 00040) in northern and central Tanzania, Kenya and Malawi resulted in increased grain yields and lowered production costs in comparison to local genotypes.

NARS partners have released pigeonpea varieties in Kenya (3), Malawi (4), Mozambique (1), Tanzania (3) and Uganda (2).

## Hybrid Technology

ICRISAT and partners have developed the world's first commercial cytoplasmic male-sterility (CMS) based hybrid in pigeonpea.

CMS based hybrids in extra short, short and medium maturity groups have recorded grain yield superiority of 20-80% over the popular check varieties across different locations in India. This technology is also being transferred to China, Myanmar and Eastern Africa.

## Cultivars released

Fifty-seven cultivars based on improved germplasm developed by ICRISAT have been released in several countries of Asia (38), Africa (13) Australia (3) and USA (3). The short and medium-duration types and disease resistant cultivars have made a significant impact in Asian countries. However, long and medium duration varieties have generated strong impact in eastern and southern Africa.

# **Groundnut** [*Arachis hypogaea* L.]

Groundnut is a self pollinated, allotetraploid (2n=4x=40) with genome 1C=2891 Mbp.

Groundnut is currently grown on nearly 22.2 m ha worldwide with a total production of 35 m t and an average yield of 1554 kg ha$^{-1}$ (www.faostat.org, 2006). Developing countries account for over 97.6% of world groundnut area and about 95.5% of total production. Production is concentrated in Asia (56% of the global groundnut area and 67% of the global groundnut production) and Africa (40% of the global groundnut area and 26% of the global groundnut production), where the crop is grown mostly by smallholder farmers under rain-fed conditions with limited inputs. Between 1995 and 2006, the global groundnut area grew annually by 0.06%, production by 1.71% and yield by 1.65% (Figure 1).

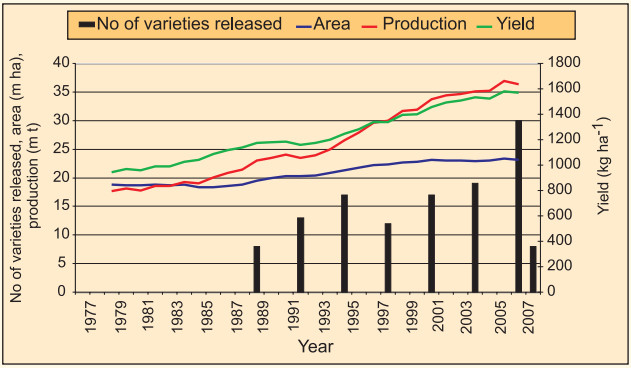


*Figure 1. Three-year moving average for groundnut area, production and pod yield; and number of varieties released (3-year total) globally.*

During the same period in Asia, groundnut area grew annually by 0.06%, production by 1.76% and yield by 1.70% (Figure 2). The major gains in growth rates in Asia came from China, India, Indonesia and Vietnam.

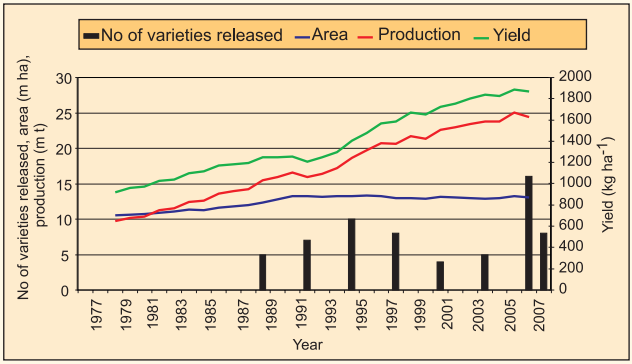


*Figure 2. Three-year moving average for groundnut area, production and pod yield, and number of varieties released (3-year total) in Asia.*

Unlike the 1980s, groundnut production showed a good recovery in Africa. The annual growth rates for groundnut in Africa between 1997 and 2006 became positive: 0.37% for area, 2.04% for production and 1.66% for yield (Figure 3). Chad, Congo, Ghana, Nigeria, Senegal and Sudan contributed to positive growth rates in Africa.

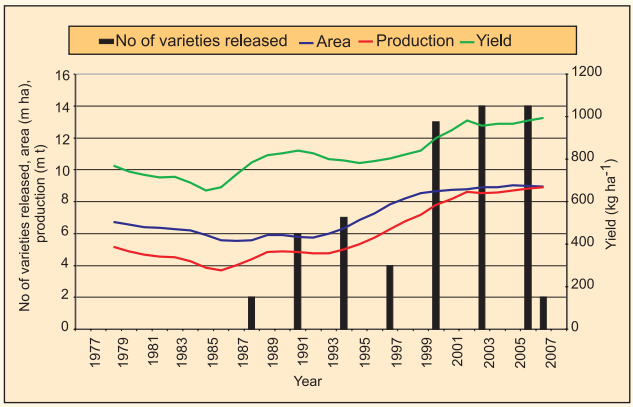


*Figure 3. Three-year moving average for groundnut area, production and pod yield; number of varieties released (3-year total) in Africa.*

## Cultivars released

Since 1986, our NARS partners have released from ICRISAT-developed breeding materials:

- 61 improved cultivars in 15 countries in Asia, including 20 in India
- 62 improved cultivars in 20 countries in Africa

A large number of improved varieties are being tested on-farm in several countries.

## Impacts in Asia

With the introduction of new autumn-winter cropping season and improved varieties in Vietnam, the groundnut area and productivity have increased from 1,42,000 ha and 1.55 t $ha^{-1}$ in 2002 to 1,86,000 ha and 1.77 t $ha^{-1}$ in 2005 in the country.

Improved bacterial wilt resistant farmer-preferred varieties, Zhonghua 6, Yuanza 9102 and Yueyou 200 (developed from ICRISAT's advanced breeding lines) are slowly replacing the local varieties in 65% area in Hubei province in China.

A new drought tolerant groundnut variety, ICGV 91114, is becoming very popular in Anantapur district in Andhra Pradesh, India, where it is now replacing a 7-decade old variety, TMV 2. ICGV 91114 has also been released in Orissa and is doing very well in Karnataka, India.

Spring season cultivation of groundnut is expanding in North India. In Uttar Pradesh alone 85,000 ha are reported to be under the crop. In Punjab, SG 84 (ICGS 1) and SG 99 (ICGV 89280) and in Uttar Pradesh, Avatar (ICGV 93468) are the popular varieties for spring season cultivation.

## Impacts in Africa

Four groundnut varieties adapted to the Koulikoro and Kayes regions of Mali occupy 43% of cultivated area (up from 32% in 2003). Five groundnut varieties adapted to the Dosso, Maradi and Zinder region of Niger are on 13% of cultivated area (up from 3% in 2003) and

three groundnut varieties adopted in Kano, Jigawa and Katsina States of Nigeria on 32% of cultivated area (up from 12% in 2003). Five varieties are recommended for release in Senegal. Farmers using modern varieties have derived significant yield gains of 23%, 43% and 31% over local varieties in Mali, Niger and Nigeria, respectively.

Five rosette resistant varieties (three of them in the last 5 years) have been released in six ESA countries (Malawi, Mozambique, South Africa, Uganda, Zambia, Zimbabwe), where they provide a yield advantage of 100% in epidemic years.

Two of these varieties (ICGV-SM 90704 and ICG 12991) are gaining popularity in Uganda where they are estimated to occupy approximately 50% of the area grown to groundnuts in the major production zones of the country.

Improved groundnut varieties released in the past decade currently occupy close to 50% of the major production zones in Malawi (the central region) and 68% of the major production zones in Zambia (the Eastern Province).

# About ICRISAT

ICRISAT
Science with a human face

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a nonprofit, non-political organization that does innovative agricultural research and capacity building for sustainable development with a wide array of partners across the globe. ICRISAT's mission is to help empower 600 million poor people to overcome hunger, poverty and a degraded environment in the dry tropics through better agriculture. ICRISAT belongs to the Alliance of Centers of the Consultative Group on International Agricultural Research (CGIAR).

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