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We are happy to pass on comments and questions to the author to allow him to respond.

CROP SCENE

A bi-monthly review reflecting on technical, commercial and policy developments that affect crop production and uses world wide

CONTENTS May 2014

COMMODITY CROP PRICE TRENDS

The prices of key commodities in the table are mainly based on FAO monthly average figures. Details of definitions and sources are given on the web sites:
www.fao.org/es/esc/prices/CIWPQueryServlet.
http://www.oryza.com/tags/oryza-white-rice-index-wri
http://www.indexmundi.com/commodities/?commodity=cotton
All prices are in US $ per tonne.

Commodity	January 2014	March 2014	May 2014
Wheat (US soft red)	250	285	280
Corn (US yellow)	198	222	222
Soya (US yellow)	516	555	571
Rice (oryza weighted avge)	440	451	456
Cotton (USDA upland)	1775	1932	1756

Notes:

1. Cotton prices are based on USDA data and calculated from US$ per lb @ 2200 lb per ton.
2. Historical prices may differ from those quoted in the last issue of Crop Scene based on revised figures from FAO and USDA

There has been little movement in grain prices in the last few weeks although Chicago wheat prices dropped to the lowest level since mid-March. Recent rain in the US plains may be too late to overcome deterioration of quality expected from the earlier drought conditions. Easing tensions in Ukraine have also held prices down.

Argentina has increased the estimated maize output for 2013/4. Globally production is still likely to exceed demand which will result in low prices being maintained.

Soya bean prices have risen as the US runs down stocks to meet export demand particularly from China.

Cotton prices outside of China were relatively flat during April but there were decreases in the Chinese index. In 2014/15, the USDA is forecasting a reduction in production (-1.7 million bales, from 117.1 million in 2013/14 to 115.5 million in 2014/15) and an increase in consumption (+2.5 million bales, from 109.4 million in 2013/14 to 111.8 million). Even so the world cotton harvest is expected to exceed global consumption for the fifth consecutive crop year in 2014/15

There has been little change in the global price of rice. The market is waiting to see the impact of the Thailand military coup and the outcome of the nation’s political crisis. So far, the caretaker government has ruled out paddy price support but has also said it will stop selling from rice stockpiles.

BIOTECHNOLOGY

The second green revolution

A feature article in the Economist implies that the introduction of flood resistant rice in Asia heralds a new ‘Green Revolution’. (**The Economist, May 17, 2014, pp 21-23**). It is probably too much to expect that this development will match the impact of Norman Borlaug’s dwarf wheat or that of the dwarf rice varieties introduced in the 1970s. But there is every sign that this, and similar developments from the International Rice Research Institute (IRRI), in the Philippines, will help to bring about a much needed recovery for the rice crop in Asia where average yields have stagnated and in some cases declined.

Flood resistant rice – first reports - 2009

In 2009 reports from IRRI described the results of the first trials with rice varieties that showed high tolerance to submersion under water for extended periods. Across the rice growing regions of Asia tropical storms regularly bring about major economic disasters as rice crops are left submerged in brown stagnant water.
(www.irinnews.org/fr/report/82760/philippines-could-flood-resistant-rice-be-the-way-forward)

At the time the David McKill, the head of IRRI’s plant breeding division, described how a number of varieties with built in flood tolerance had been developed in the Philippines (in Los Banos, Laguna Province) and India. Other varieties from Laos, Bangladesh and India were also being developed at Los Banos. David McKill explained: "These new varieties do not show any differences from the originals, except for submergence tolerance." Work on the genetics of submergence tolerance began in the 1990s when researchers first mapped rice DNA to isolate a gene responsible for the phenomenon - *Sub1 gene.*

David McKill in the 2009 news release explained: "Rice is considered a semi-aquatic plant, and it thrives in the wettest agricultural environments. However, most rice varieties will be heavily damaged and die if they remain underwater for more than four days." It was reported that the new varieties were designed to withstand up to three weeks of submergence and recover after flood waters subside.

The problem of flooding is most acute in the vast rain-fed lowland areas of Asia where intermittent flooding causes frequent submergence. Crop losses due to flooding were estimated at around $1 billion annually. It was also noted that ‘submergence stress’ is more common in areas where poverty is a major problem, as these impoverished areas invariably lack proper flood control infrastructure.

There was some concern that the flood resistant rice would not be accepted. Previously introduced hybrid rice varieties had proven to be unreliable in some cases and there was also a misconception that the new varieties were genetically modified.

David MacKill saw considerable potential for the varieties in Bangladesh and India, where crop losses are estimated at four million tonnes a year - enough to feed 30 million people for nearly a year.

He observed: "The potential impact is huge …submergence-tolerant varieties could make major inroads into Bangladesh's annual rice shortfall and substantially limit import needs."

It was also explained that the flood resistant varieties were not genetically modified. The varieties are produced through 'marker assisted selection' techniques using a selected marker which is linked to the specific flood tolerant gene.

Comparison of submersion effect with flood tolerant and conventional rice

Feedback from Indian farm trials

In November 2013 encouraging information was published based on experience with the varieties in India **(Scientific Reports, 22 November 2013)**. Researchers from IRRI and the University of California, Berkeley, US, conducted randomised field trials in 128 villages in the eastern Indian state of Odisha, on *Swarna-Sub1* – a new variety based on the introduction of the flood tolerance gene into *Swarna*, a rice variety commonly cultivated in India.

The trials showed that yields of *Swarna-Sub1* could be 45% higher, even when it was submerged under water for one to two weeks, compared to *Swarna.* The report from India stated: "flood-tolerant rice can deliver both efficiency gains, through reduced yield variability and higher expected yield, and equity gains in disproportionately benefiting the most marginal group of farmers."

It is reported that flash floods are common on 44 million hectares where rice is grown in India and that Swarna Sub-1 would prove beneficial if grown on 12-14 million hectares, or almost a third of the rice cultivated area.

Manzoor Dhar, lead author of the study and senior associate scientist at IRRI’s New Delhi unit explained that although other flood-tolerant rice varieties were developed earlier, *Swarna-Sub1* is the first to be released to farmers for cultivation.

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J K Roy, former joint director of India’s Central Rice Research Institute, in Cuttack in Odisha, stated that the success in Odisha's coastal districts is being replicated in some other districts in the state, and also in Bihar and Assam states. The variety has also been released in Bangladesh and Nepal, and in some South-East Asian countries.

Pakistan takes an interest

This January Pakistan has also announced its intention to try flood tolerant rice. Pakistan currently produces enough rice to meet both domestic and export needs, but rising demand for the crop and increasingly extreme weather are threatening the country's long-term food security.

The FAO had downgraded its forecast of rice production in Pakistan because of torrential rains and flooding in 2013. Raja Ali Khan Baloch, the parliamentary secretary at the Pakistan Food Security and Research Ministry, said: "Despite the crop losses, adequate rice will still be available for achieving export targets and domestic consumption." He added that Pakistan would suffer on both fronts if extreme weather events continued and if flood-resistant rice was not introduced to farmers.

Farmer examining flood hit paddy field. Sialkot district near Islamabad

Abid Suleri, a food security expert and executive director of the Islamabad-based Sustainable Development Policy Institute, said: "Any downward change in rice production means escalation in hunger and malnutrition." Inadequate state funding, bureaucratic bottlenecks and an absence of political will are being blamed for the lack of research, to date, into flood-tolerant rice varieties. Iftikhar Ahmad, the chairman of the Pakistan Agricultural Research Council said: "We have recently approached the Philippines-based IRRI to help Pakistan introduce flood-tolerant rice. Besides we are pushing the government to play its active part on this count to avoid food insecurity in the country and (losing the) export market to other countries." It is hoped that flood resistant varieties, and drought resistant varieties could be introduced to farmers by the end of this year.

In the review article in *The Economist*, the current director of IRRI, Bob Zeigler, described how five years after the first field trials up to five million farmers are planting 'Sub 1' flood tolerant varieties, the first generation of such seeds. Dr Zeigler said: "If all goes well over the next few year's plants that tolerate drought, salinity and extreme heat will revolutionise the cultivation of mankind's most important source of calories."

New uses for tobacco crops ?

Researchers at the NUP/UPNA-Public University of Navarre and the related IdAB-Institute of Agrobiotechnology, in northern Spain, have indicated that genetically modified tobacco could be a valuable source of biomass which could then be suitable for producing bioethanol. Their work suggests that it could be possible to increase the ethanol derived from such plants by between 20 and 40%.

Professor Jon Veramendi, head of the plant agrobiotechnology research group, said: “Tobacco plants as a source of biomass for producing bioethanol could be an alternative to traditional tobacco growing which is in decline in the USA and in Europe because it cannot compete with emerging countries like China".

The commercial cultivars *Virginia Gold* and *Havana* have been genetically modified to increase their production of starch and sugars, and consequently the yield of ethanol.

Professor Veramendi explained that traditional tobacco growing allows the plant to develop and the leaves to become quite large, as the nicotine is synthesised when the plant is more mature. However, if the plants are used for producing biofuels, the researchers are looking to grow a higher-density crop similar to that of forage crops. He said: “The tobacco plants are sown very close to each other and various mowing’s are made throughout the cycle. When the plant has grown to a height of about 50 cm, it is cut and the output is taken to the biomass processing factory. That way, it is possible to obtain up to 160 tonnes of matter per hectare over the whole cycle.”

Furthermore it is reported that when the tobacco is integrated into a bio refinery, it is possible to extract interesting by-products like proteins such as solasenol (used to produce vitamins E and K) and xanthophylls (an additive used in chicken feed).

To date trials have been conducted on small plots. High-density cultivation tests will now need to be carried out to see whether the results can be repeated on a larger scale.

FOOD SECURITY

Maintaining global food security: Policy makers state what has to be done.

A number of influential policy makers gathered in London in April at a Westminster Forum to address the conference titled: *Food security: global priorities and the UK's role*.

Professor Jonathan Brooks, Senior Economist for OECD, listed the quite well known needs that are necessary to ensure that access to food can be improved and maintained worldwide:

- Increase agricultural productivity, by making more efficient use of inputs such as land, labour and water. Although there is limited scope to expand productive land areas, there is scope for expanding yields.
- Reduce post-harvest losses, particularly in developing countries where losses can account for as much as a third of the value of agricultural production.
- Implement climate change adaptation.
- Repeal mandates which subsidise the use of crops for biofuel purposes when they do not make economic sense.
- Take other actions on the demand side: such as reducing meat consumption and over consumption, particularly when there are more people who are overweight in the world than are underweight.
- Reduce consumer waste.

Eugene Philhower, a USDA agricultural counsellor, agreed with the list but argued that the support of biofuels through subsidies was only a temporary solution necessary until the second generation of biofuels came available.

He stressed how important it is for governments to create an environment that is conducive to innovation with strong protection of intellectual property and strong science based transparent regulatory systems. He referred to: "…the misuse and misunderstood application of the precautionary principle…precaution is absolutely essential in regulatory development, but it really should not be abused as a public policy instrument to create stumbling blocks to innovation."

He spoke highly of UK's Agri-Tech Strategy, describing it as well thought out, well planned and really addressing the gap that exists between the laboratories and the research centres.

Dr Bernard Rey, deputy head, Rural Development, Food Security and Nutrition Unit, European Commission (EC) explained how since the food price crisis of 2007/8, a total of €1 billion had been made available to support a food facility to improve the food security and livelihoods of 59 million people in 49 countries worldwide. In 2010 the EC developed an EU Policy framework on how to reach food security under the four internationally agreed pillars of food security - access, availability, nutrition and stability. This was followed by an implementation plan in 2013.

Particular emphasis is being given to responding to extreme food poverty and nutrition needs in the Sahel region (south of the Sahara desert) and the Horn of Africa. So far €500m has been made available to support the countries in these regions and a further €2.2 billion will follow under a new financing cycle.

The objectives and actions set out by these organisations are clearly laudable. But meeting such a massive and diverse challenge will require well co-ordinated actions rather than just good intentions. As a leading American scientist and government advisor put it a few years ago solving global hunger needs to be tackled with the same commitment and planning that put man on the moon (Crop Scene, February 2011).

Impact of climate change on global crops: more negatives than positives

The latest report published at the end of March by the UN Intergovernmental Panel on Climate Change (IPCC), IPCC WGII AR5, *Climate Change 2014: Impacts, Adaptation, and Vulnerability,* gives attention to the likely future impact on crop productivity due to global warming. (www.ipcc-wg2.gov/AR5/images/uploads/IPCC_WG2AR5_SPM_Approved.pdf)

The IPCC report, so far just in summary form, is based on contributions from 309 authors and editors, and inputs from many more contributors and experts drawn from 70 countries. It details the impacts of climate change to date, the projected future impacts and the opportunities for effective action to reduce risks. It is the second of a three-part review which the IPCC publishes every five to six years.

The report is quite general in terms of which crops will be most affected or in which regions of the world. Climate change impacts that have already occurred are summarised and with high confidence.

> "Based on many studies covering a wide range of regions and crops, negative impacts of climate change on crop yields have been more common than positive impacts."

- Based on a small number of studies the positive impacts relate mainly to high latitude regions.
- Climate change has negatively affected wheat and maize yields in many regions and globally.
- Effects on rice and soya bean yields have been smaller.

As could be expected there is only medium confidence, and not very much precision, on what will happen by 2050:

> "For the major crops (wheat, rice and maize) in tropical and temperate regions, climate change without adaptation is projected to negatively impact production for local temperature increases of 2°C or more above late 20th century levels, although individual locations may benefit."

- 10% of projections for the period 2030-2049 show yield gains of more than 10%.
- 10% show yield losses of more than 25%.
- After 2050 the risk of more severe yield impacts increases, depending on the degree of warming.

Although not spelled out in detail the report reiterates previously published conclusions that crops in regions in northern latitudes, such as in Canada, will most likely benefit from higher average temperatures. Whereas in southern Europe, and particularly in sub-Saharan Africa, crop yields can be expected to be under threat due to a combination of drought and extreme temperatures.

In general it is observed that higher yields can be expected as a result of rising levels of atmospheric CO_2. Those crops that operate through the C3 metabolic pathways, which includes the majority of food crops, but not maize, clearly respond best under higher levels of CO_2, leading to the effect referred to as 'carbon fertilisation'.

However, the IPCC studies indicate that food crops will gain little in nutritional value. A review of some 228 experiments found that decreases of 10 to 14% in the edible protein portions of wheat, rice, barley and potato, occurred when the crops were grown at higher levels of CO_2.

(Gerard Wynn, Crop benefits of higher CO2 may fall short – IPCC. 27 March 2014. www.rtcc.org)

Previous studies, published in 2009 and 2010, indicated that mineral concentrations were also affected, as well as protein levels.

The conclusions of the IPCC report on the impact of climate change on nutritional quality of food were summarised:
"Overall, there is robust evidence and high agreement that elevated CO_2 on its own likely results in decreased nitrogen concentrations ….Nutritional quality of food and fodder, including protein and micronutrients, is negatively affected by elevated CO_2."
The impact on human health will depend on what is the limiting factor in the diet. Calorie intake is the primary concern in many populations where access to food is critical. In these situations any negative effects from decreased mineral intake could well be outweighed by the benefit of the increased calorie intake.

In releasing the IPCC report Vicente Barros, co-chair of Working Group II, left no doubt that the risks associated with climate change will be severe and that the consequences are man-made. He said: "We live in an era of man-made climate change…In many cases, we are not prepared for the climate-related risks that we already face. Investments in better preparation can pay dividends both for the present and for the future."

Co-chair Chris Field put a more positive emphasis to the report findings: "Understanding that climate change is a challenge in managing risk opens a wide range of opportunities for integrating adaptation with economic and social development and with initiatives to limit future warming. We definitely face challenges, but understanding those challenges and tackling them creatively can make climate-change adaptation an important way to help build a more vibrant world in the near-term and beyond."

R & D PROGRAMMES

15 agricultural technologies that will change the world

Policy Horizons Canada, is described as a foresight and knowledge organisation within the Canadian federal public service. It recently published a report coming out of a collaboration with emerging technology strategist Michell Zappa of Envisioning. The study, called *MetaScan 3: Emerging Technologies and accompanying infographics,* included a summary for emerging agriculture technologies, most of which relate to crop production and applications. The technologies are listed below, perhaps with a bias towards electronic and engineering developments, together with the expected date when they will first deliver. Just a few notes of interpretation have been added in italics to the original summary report.
(www.businessinsider.com/15-emerging-agriculture-technologies-2014-4#ixzz31U1L7mv7)

1. **Sensors**

(i) Air & soil sensors: Fundamental additions to the automated farm, these sensors would enable a real time understanding of current farm, forest or body of water conditions.

- scientifically viable in 2013
- mainstream and financially viable in 2015

(ii) Equipment telematics: Allows mechanical devices such as tractors to warn mechanics that a failure is likely to occur soon. Intra-tractor communication can be used as a rudimentary "farm swarm" platform. (*Note: Farm swarms are defined in section 3 (v) below*)

- scientifically viable in 2013
- mainstream in 2016
- financially viable in 2017

(iii) Livestock biometrics: Collars with GPS, RFID (*Radio frequency identification*) and biometrics can automatically identify and relay vital information about the livestock in real time.

- scientifically viable in 2017;
- mainstream and financially viable in 2020.

(iv) Crop sensors: Instead of prescribing field fertilisation before application, high-resolution crop sensors inform application equipment of correct amounts needed. Optical sensors or drones are able to identify crop health across the field (for example, by using infra-red light).

- scientifically viable in 2015
- mainstream in 2018
- financially viable in 2019
  (*Note: the significance of this is that the application relies on real time*

data collection compared with the currently adopted pre- planned application maps)

(v) Infrastructural health sensors: Can be used for monitoring vibrations and material conditions in buildings, bridges, factories, farms and other infrastructure. Coupled with an intelligent network, such sensors could feed crucial information back to maintenance crews or robots.

- scientifically viable in 2021
- mainstream in 2025
- financially viable in 2027

2. Food

(i) Genetically designed food: The creation of entirely new strains of food animals and plants in order to better address biological and physiological needs. A departure from genetically modified food, genetically designed food would be engineered from the ground up.

- scientifically viable in 2016
- mainstream in 2021
- financially viable in 2022

(ii) In vitro meat: Also known as cultured meat or tubesteak, it is a flesh product that has never been part of a complete, living animal. Several current research projects are growing in vitro meat experimentally, although no meat has yet been produced for public consumption.

- scientifically viable in 2017
- mainstream in 2024
- financially viable in 2027

3. Automation

(i) Variable rate swath control: Building on existing geo-location technologies, future swath control could save on seed, minerals, fertiliser and herbicides by reducing overlapping inputs. By pre-computing the shape of the field where the inputs are to be used, and by understanding the relative productivity of different areas of the field, tractors or agbots can procedurally apply inputs at variable rates throughout the field.

- scientifically viable in 2013
- mainstream in 2014
- financially viable in 2016

(ii) Rapid iteration selective breeding: The next generation of selective breeding where the end-result is analysed quantitatively and improvements are suggested algorithmically.

- scientifically viable in 2014
- mainstream and financially viable in 2017

(iii) Agricultural robots: Also known as agbots, these are used to automate agricultural processes, such as harvesting, fruit picking, ploughing, soil maintenance, weeding, planting, irrigation, etc.

- scientifically viable in 2018
- mainstream in 2020
- financially viable in 2021

(iv) Precision agriculture: Farming management based on observing (and responding to) intra-field variations. With satellite imagery and advanced sensors, farmers can optimise returns on inputs while preserving resources at ever larger scales. Further understanding of crop variability, geo-located weather data and precise sensors should allow improved automated decision-making and complementary planting techniques.

- scientifically viable in 2019
- mainstream in 2023
- financially viable in 2024

(Note*: The main elements of precision agriculture described here have been in operation in Europe for several years. Connection with weather data is, however, not yet fully automated*)

(v) Robotic farm swarms: The hypothetical combination of dozens or hundreds of agricultural robots with thousands of microscopic sensors, which together would monitor, predict, cultivate and extract crops from the land with practically no human intervention. Small-scale implementations are already on the horizon.

- scientifically viable in 2023
- mainstream and financially viable in 2026

4. Engineering

(i) Closed ecological systems: Ecosystems that do not rely on matter exchange outside the system. Such closed ecosystems would theoretically transform waste products into oxygen, food and water in order to support life-forms inhabiting the system. Such systems already exist in small scales, but existing technological limitations prevent them from scaling.

- scientifically viable in 2015
- mainstream in 2020
- financially viable in 2021

(ii) Synthetic biology: Synthetic biology is about programming biology using standardised parts as one programmes computers using standardised libraries today. Includes the broad redefinition and expansion of biotechnology, with the ultimate goals of being able to design, build and remediate engineered biological systems that process information, manipulate chemicals, fabricate materials and structures, produce energy, provide food, and maintain and enhance human health and our environment.

- scientifically viable in 2013
- mainstream in 2023
- financially viable in 2024

(iii) Vertical farming: A natural extension of urban agriculture, vertical farms would cultivate plant or animal life within dedicated or mixed-use skyscrapers in urban settings. Using techniques similar to glass houses, vertical farms could augment natural light using energy-efficient lighting. The advantages are numerous, including year-round crop production, protection from weather, support urban food autonomy and reduced transport costs.

- scientifically viable in 2023
- mainstream and financially viable in 2027

MARKET TRENDS

GM seed projected to account for 56% of the global market value by 2018

A market study recently produced by Transparency Market Research projects trends in the global seeds market, conventional and GM, covering the period from 2011 up to 2018. (www.transparencymarketresearch.com/commercial-seeds-market.html).

The market research organisation reports that the global commercial seeds market was valued at $34.50 billion in 2011 and is forecast to reach $53.32 billion by 2018. In 2011 45% of the market value, $15.60 billion, was in the form of genetically modified seeds. By 2018 they estimate GM seeds will have achieved 56% of the global market at $30.12 billion.

These forecasts are based on the assumption that GM seed market growth will continue at double digit levels annually over the next six years, and based on existing as well as yet to be introduced traits.

Maize accounted for over 40% of the overall market revenue in 2011. Soya bean 17% and vegetables 15% were the next most important in terms of revenue. Cereals at 6% and rice, cotton and canola each at around 5% made up the total market. Maize is projected to show the most rapid growth over the forecast period as a result of the increased demand for bio ethanol. Geographically, North America was the largest market for commercial seeds, accounting for over 30% of the total revenue in 2011 followed by Asia Pacific and Europe.

Within the GM seed sector soya bean was the largest market in 2011 and accounted for over 40% of the total revenue. Maize accounted for the second largest demand for GM seeds followed by cotton. The high population regions of Asia Pacific and Latin America are expected to drive the market for GM seeds over the forecast period.

The rise and rise of soya beans

Brazil continues to represent one of the most significant growth areas in terms of crop areas planted particularly for GM soya bean. According to a recent survey by consulting company Céleres, Brazilian genetically modified soya bean occupied 91.8% of the crop planted in the 2013/14 season. 27.4 million hectares of GM soya beans out of 29.86 million hectares were planted, 11% up on the previous year. 25 million hectares were planted with herbicide tolerant varieties and a further 2 million hectares with both herbicide tolerance and insect resistance.

Soya beans with herbicide tolerance accounted for 25 million hectares. And just over 2 million hectares were planted with the crop with herbicide tolerance and insect resistance.

According to Cèleres, the evolution of the adoption of GM varieties in Brazil has now stabilised. Conventional varieties in Brazil in future will be no more than a niche market. The exception is with cotton in which conventional technology is still attractive and is still grown on around 35% of the 1.1 million hectares. Over 80% of the 15 million hectares of maize are already GM varieties in Brazil.

Soya beans are also rapidly becoming an important crop in Canada, a country generally dominated by cereals and canola. The soya bean area could reach another high in 2014, which would mark the sixth consecutive year for setting a new record for the planted area. According to Statistics Canada farmers expect to plant less wheat in 2014 compared to 2013. It could be down by as much as 5% to 10 million hectares.

The big change is expected to be with soya beans. In March Canadian farmers were reported to be planning to plant a record soya bean area of 2.1 million hectares in 2014, up 16.5% from 2013. Producers in Quebec, Ontario, Manitoba and Saskatchewan were all planning to seed record levels in 2014. If achieved this would make soya beans a significant crop in Canada and would represent an almost doubling the area in ten years.

Statistics Canada qualified their March projections by stating that some farmers were still undecided about their strategies for 2014. Many areas of the country were also experiencing a longer winter than anticipated.

BIO FUELS AND ENERGY CROPS

Has biofuel production reached a peak ?

A market study published by the Worldwatch Institute *Vital Signs Online* (www.worldwatch.org) reports that the combined global production of bio-ethanol and biodiesel fell for the first time since 2000, down 0.4% from the figure in 2011.

Global bio-ethanol production declined slightly for the second year in a row, to 83.1 billion litres, while biodiesel output rose marginally, from 22.4 billion litres in 2011 to 22.5 billion litres in 2012. As a result biodiesel now accounts for over 20% of global biofuel production.

The top five bio-ethanol producers in 2012 were, in order of magnitude, the US, Brazil, China, Canada and France. The top two countries dominated production with the US accounting for 61% and Brazil 26% of the global total.

In the US corn is the main feedstock for bio-ethanol production which was 50.4 billion litres, down about 4% from 2011. As a consequence of the summer drought in the mid-west in 2012 corn prices rose and this led the US to, briefly in the autumn, become a net importer of bio-ethanol after being a net exporter for nearly three uninterrupted years.

By contrast Brazil's bio-ethanol production, virtually all produced from sugar cane, rose 3% to 21.6 billion litres. Here the drop in sugar prices helped to stimulate growth. Production volumes of bio-ethanol reported for 2012 from the other countries were comparatively small. China's output totalled 2.1 billion litres, Canada: 1.8 billion litres and the European Union, EU, as a whole 4.6 billion litres.

The US was also the leading biodiesel producing country, mainly from soya bean oil, with a total of 3.6 billion litres. Argentina was the second largest producer, again from soya beans, with 2.8 billion litres, while Brazil produced around 2.7 billion litres from the same crop.

In the EU biodiesel was mainly produced from oilseed rape together with some from sunflowers and waste cooking oil. Most European nations now produce biodiesel, and the EU as a whole still accounted for 41% of global biodiesel output, 9.2 billion litres, in 2012 despite a decline of 7% from the previous year. Germany was the most important producer at approximately 2.7 billion litres.

Although biodiesel production globally had grown at an average annual rate of 17% from 2007 to 2012, the growth rate had slowed considerably particularly in the last year.

Biofuel demand is strongly driven by subsidies and mandates which specify the level of blending to be included in transport fuels. Global subsidies for liquid biofuels were estimated in 2012 to be well over $20 billion. Mandates or targets have been established in 13 countries in the Americas, 12 in the Asia-Pacific region, and eight in Africa.

In the EU a mandate through the Renewable Energy Directive (RED) was put in place, which was to be applied in each member state. The original target was set at 5.75% biofuel content in transportation fuels by 2012. However, following widely expressed public concerns over the effect that biofuel feedstock cultivation was having on food prices and changes in land use, the European Commission, EC, proposed a lower limit of 5% on the use of those conventional biofuels which are derived from food crops..

The US and China have established targets of between 15 and 20% to be achieved at no later than 2022. Brazil has already achieved this target. India has mandated 20% bio-ethanol by 2017.

The report further outlined that biofuels for transport, bio-ethanol and biodiesel, account for 3.4% of global road transport fuels and 2.5% of all transport fuels (aircraft and marine fuels consume proportionally less). This equates to about 0.8% of global energy use.

Considerable uncertainty now exists on the future of biofuels. Much of the investment into conventional biofuel production has been in anticipation of the arrival of advanced cellulosic biofuels. The investors were looking to conventional biofuels as an intermediate step before the advanced biofuels could be produced economically without long term dependence on subsidies and with less impact on food crops. However the breakthrough on cellulosic biofuel production has yet to materialise. In the US the EPA had set a mandate for 33 million litres of cellulosic biofuels for blending in 2012. Only 76,000 litres were actually produced (*Crop Scene, November 2013.*)

Global investment in biofuels was about $5 billion in 2012, which was down 40% from 2011. Of this $3.8 billion was in industrial nations and $1.2 billion in developing countries. Despite the downward trend in investments some observers expect biofuel investment to rise again over the current decade with continuing support through blending mandates.

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