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Proceedings of a workshop on "Wheat productivity in the EU: determinants and challenges for food security and for climate change"

Prepared by Mauro Vigani, Koen Dillen and Emilio Rodríguez Cerezo

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Contents

Executive summary

Wheat is one of the world's key staple products, with a global production of 654.7 million tons in 2010. Currently, wheat is providing 21% of the food calories and 20% of the protein to more than 4.5 billion people. Wheat production is highly concentrated in a few countries, and the European Union is by far the most important producer accounting for 21% of total world harvest (EUROSTAT).

In the next decades it is expected an increase in the global demand of food, and of wheat in particular. Towards 2050 the world population may rise from 7 to 9 billion people, and the expected improved economic conditions will allow for greater food consumption. To help reaching the goal of improved wheat productivity for global food security, many important initiatives and research programs started both at national and international level. The G20 Agricultural ministries in their 2011 action plan endorsed the Wheat Initiative, to promote coordination and collaborations among national and international research programs for wheat improvement.

However, the annual increase in wheat yields has fallen globally from 2.9% to 1.3% since 1966, and this rate will be not sufficient to meet the expected future food demand without a large expansion of crop production area. Given the limited possibilities of increasing the amount of cultivated area, the efficiency of the wheat production factors must improve. In this respect, Europe has a key position as main global wheat producer and exporter.

Wheat yields in Europe have shown a constant growth trend during the second half of the 20th century, mainly thanks to the progress in breeding and in the use of inputs such as fertilizers, pesticides and irrigation. These constant yield improvements allowed Europe to satisfy the growing internal demand after the Second World War and to consolidate its position on the global wheat market. However, since the mid 1990's, there seems to be a decline in wheat yield growth rates, especially in the most important European producing countries, like France, Germany and the UK.

Considering this background, the Institute for Prospective Technological Studies (IPTS) of the European Commission's Joint Research Centre (JRC) is starting a new research line with the aim to describe the current situation and analyze the elements affecting wheat yields and wheat farming productivity. To scope the issue, the JRC organised a workshop on "Wheat productivity in the EU: determinants and challenges for food security and for climate change" in Seville on 22nd and 23rd November 2012. In this JRC Scientific and Policy Reports we report the main conclusions of the meeting. It appears that the causes of this stagnation in yields are diverse, and identifying them and their individual contribution to this phenomenon is a very complex task. In some cases, scientists have carefully studied the role of specific factors, such as the genetic potential of wheat varieties, yet research addressing the other factors potentially affecting this change in yield trends such as changes in agricultural input use, agronomic and risk management practices, climate change, policy reforms and market signals is not particularly abundant. The analysis of these factors affecting wheat yields and productivity in Europe is now a priority in order to clarify present and future food security challenges and the evolution of the European wheat sector.

Proceedings of the Workshop

Session 1: Wheat productivity trends in Europe and world-wide

This session aims to explain and discuss global and European trends in wheat production, consumption and productivity, providing also insights on the relationship of these trends with market prices and price volatility. Moreover, this session identified major elements responsible for the slowdown in wheat productivity in Europe, taking into account the heterogeneity of European wheat farming and discussing the strategies to improve wheat productivity.

Presentation S1-1: Global wheat productivity trends

Amy Reynolds, *International Grains Council, London, UK*

Global wheat production

Since the first international wheat agreement in 1934, the global wheat production grew strongly, passing from 150 Mio. tons in 1945 to almost 700 Mio. tons in 2011. However, the pace of output growth has been highly fluctuating and slowing. Today the major actors on the international wheat markets are the EU, North America, Australia, China and India.

In the last 15 years the global area of wheat crop remained constant. In some countries the wheat area decreased (about 1.3% in China, 1% in North and Central America and Argentina and 0.3% in North-East Asia) while in other countries increased (about 1.3% in Australia, 0.8% in former Soviet Union countries and India and 0.5% in Africa), and the world balance showed a reduction of about 0.2%. Wheat area faces the competition with other important crops, such as maize and soybean, which are increasingly cultivated in key exporting countries like the US.

The world average yield of wheat was about 2.8 t/ha in the last 15 years. Yields are still growing globally, but at a very low rate, not higher than 1% annually. Yields significantly vary across countries, and the low-rate increase of yields is stronger in some countries, but not in the most important producers. Europe has the highest yields per hectare, with an average of 5 t/ha from 1998 to today. However, this average remained constant during the period, without significant improvements. In the same period, China showed an impressive increase in wheat yields, of about 30%, almost reaching the European average yield. Lower yields (about 1.7 t/ha) are found in Australia and former Soviet Union countries. Within major producer countries, Australia showed a slight decline in yields of 10% from 1998 to 2012.

Global wheat consumption

The demand of wheat is less variable than the production. From 1945 the global wheat consumption increased following the improvements in production. The highest increase in consumption is in developing countries, being stable in developed countries, where the per capita use may have peaked. The average annual consumption of wheat in the period 1994-2012 was 350 Mio. tons in developing countries and 250 Mio. tons in developed countries. The consumption of wheat for feed use is expected to increase more than the one for food use.

Consumption is increasing faster than production of wheat, and this is described by the trend of the stocks-to-use ratio in the period 1975-2012. The stock-to-use ratio is a key measure of the carryover stock of wheat as a percentage of the total use. However, in the wheat sector there are some uncertainties on this indicator due to the low quality data coming from some big producer countries, such as China and Russia. Data provided by the International Grain Council show that the stocks-to-use ratio is declining in the last 35 years, suggesting a reduction of the world stocks of wheat. The period 1986-1988 showed the highest carryover of stocks, with a stocks-to-use ratio of about 38%, while in 2004-2007 the ratio was significantly lower, of about 22%.

Global wheat prices volatility

Prices and volatility of wheat significantly increased from 2000 to 2012, Price volatility negatively affects small rather than big farms, given that small farms have high risk aversion. The main effect of variability is unpredictability, meaning that, if planting decisions are made far in advance with respect to crop marketing, volatility provides unclear market signals making planning more difficult. Moreover, price volatility contributes to revenues volatility, which may induce risk adverse farmers to reduce investments and input use, with final negative effects on yields. The most sensitive areas affected by price variability are marginal areas where

wheat farming (as well as farming in general) can be abandoned in favour of less risky enterprises.

Presentation S1-2: Wheat productivity trends in the EU

Gilles Charmet, *French National Institute for Agricultural Research - INRA, Clermont-Ferrand, France*

The wheat sector in the EU: harvested area and production

Europe is the most important wheat grower in the world, with the highest average yields (5200 kg/ha in 2010). Global wheat area is about 217 Mio. Ha, the top five wheat growers in 2010 were India (27 Mio. ha), the EU (25.5 Mio. ha), China (24 Mio. ha), Russia (22 Mio. ha) and the US (19 Mio. ha). In the period 1975-2010 the wheat area in China and the US significantly decreased, while it increased in India and remain almost stable in the EU.

Despite the EU is second in terms of wheat hectares, it is the first producer in terms of quantity. In 2012 the total world production of wheat was 653.05 Mio. tons, 131.58 of it produced in the EU, 118 Mio. tons in China, 93.9 Mio. tons in India, 61.76 Mio. tons in the US and 38 Mio. tons in Russia (which encountered exceptionally bad weather conditions, it was 62 Mio tons in 2008). From 1975 to 2010, wheat production increased in the EU, China and India, while remained globally stable in the US and Russia.

At European level, 55% of wheat production is concentrated in three countries: France (41 Mio. tons), Germany (24 Mio. tons) and the UK (15 Mio. tons). Wheat production is also important in Poland (10 Mio. tons), Italy (6 Mio. tons), Romania, Spain and Denmark (almost 5 Mio. tons each), Bulgaria and Hungary (almost 4 Mio. tons each). The production of wheat significantly increased in the period 1975-2010, in particular in the top three countries.

The importance of wheat in the food industry in the EU

In the last 20 years the production of wheat followed the consumption at world level, while in the EU production exceeded consumption, showing a positive balance. Some 40% of European wheat is domestically consumed as feed, while 10% is exported. From 2006 a growing share of European wheat is used for bio-ethanol production, and this use is expected to increase in the next 10 years.

Main export markets for European wheat are North and Sub-Saharan Africa, Far and Near East Asia. In 2010, the total amount of European wheat exports was 11.75 Mio. tons, almost 50% of it exported to North African countries, in particular to Algeria (17%), Egypt (15%), Morocco (10%), Libya (5%) and Tunisia (2%). East Asia as a whole accounted for the 26% of wheat exports, while Sub-Saharan Africa accounted for 19%.

Changes in wheat yields in the EU: genetic potential and yield stagnation

Wheat yields in Europe almost double the world average, while in India and the US the yields are in line with the world average. Within the EU there are two groups of producing countries. The first group includes Denmark, France, Germany, the Netherlands and the UK. This group is characterized by very high yields (7-8 tons hectare) and by increasing yields trends in the last 35 years. However, yields improvement became almost steady from the 1995 on. In the second group there are countries with lower yields (3-4 tons hectare): Bulgaria, Hungary, Italy, Poland, Portugal, Romania and Spain. In these countries yields are almost steady already from 1975 on. Italy and Spain primarily produce durum wheat instead of bread wheat. Durum wheat accounts for the 10% of the European wheat sector.

The possible causes of the stagnation in yields that Europe is experiencing from 1995 are:

- Slow down in genetic progress;
- Selection for high quality but less yielding varieties;
- Lower use of inputs for economic or environmental concerns;
- Loss of input efficiency (in particular of fungicides);
- Adoption of different agronomic practices, such as shorter rotation with less legumes, no or simplified tillage, soil exhaustion;
- Higher frequency of limiting climatic conditions.

With respect to the first cause, studies show that the genetic progress of wheat varieties in France and in the UK has not slowed down. In the UK, yields improvement due to the genetic progress linearly increased during the period 1960-2009, and this improvement concerned both food and feed varieties. Food varieties provide higher quality wheat (higher protein content), but on average they are 1 ton less productive than the feed varieties. In recent years high-quality bread varieties are more and more dominant with respect to varieties for feed, and in France they represent the 91% of the wheat area.

Different time series analysis show that the use of nitrogen did not increase or even decreased in many countries. In the UK the quantity of nitrogen application per hectare of wheat remained stable from 1985, even though yields continued growing. In France, the quantity of nitrogen per hectare decreased of almost 20kg from 2001 to 2007, but this was compensated by a better supply fractionation, thereby increasing efficiency. This reduction in nitrogen application in France occurred later than the starting date of the yield stagnation in 1995, thus it seems that a lower application of nitrogen is not correlated with the wheat yields stagnation. However, there is still room for a better optimization in nitrogen use.

Within the agronomic practices, the most important factor affecting the growing of wheat yields is rotation, and the decline of legumes, in particular of pea, preceding wheat is a major cause of lower yields.

The most sensitive climatic parameters that affect wheat yields are drought during stem elongation (that leads to less grain per square meter) and high temperatures during the grain-filling phase (that reduces grain size). In France, climate change since 1990 led to an increase of mean annual temperature of 0.05°C/year and to a higher frequency of spring drought. The number of heat stresses during grain filling increased in the last 50 years, for example in the provinces of Chalôns, Nîmes and Toulouse and these temperature anomalies are expected to increase in the next 50 years.

Actual wheat yields in France are 1-1.5 tons/ha lower than the expected yields according to the linear increasing trend of yields of the last 60 years. In the case of France, estimated yield losses are due to climate evolution (responsible for - 0.6-0.9 tons/ha), rotation (- 0.1 to 0.4 tons/ha), nitrogen fertilization (- 0.15 tons/ha), no tillage (- 0.1 tons/ha), fungicides (- 0.15 tons/ha). The contribution of the genetic progress to yields is just sufficient to compensate adverse climate factors. However, this estimation does not take into account market effects such as input and output prices that also might have played a role.

Because at European level genetic progress was constant and linear in the last 20 years, major causes of yield stagnation seems to be the worse agro-environmental conditions. In particular, agronomic factors (slight reduction of inputs efficiency, simplified crop rotations and management) and climate change (higher occurrence and severity of limiting factors in most EU regions, rising temperature and drought) seems to play a major role. Finally, while the expectations on climate change for 2050 benefits the wheat sector in some countries such as Canada and Russia, they indicate a worsening for Europe, with the exception of Scotland and Scandinavia.

Presentation S1-3: Russia, Ukraine and Kazakhstan wheat productivity: history and prospects

Dmitry Rylko, *Institute for Agricultural Market Studies, Moscow, Russia*

Over the last two decades Russia, Ukraine, and Kazakhstan (RUK) made an impressive shift from being the world biggest grain importer (20 Mio. Tons of grains imported in 1990-1991) to the world largest grain exporter region (almost 60 Mio. Tons of grains exported in 2011-2012). Wheat plays a major role in this historical shift. In the last 12 years RUK's share of the world wheat export market varied from 20 to 35% and it is gradually growing. Russia represents almost the half of RUK's share, with nearly 20 Mio. Tons of wheat exported in 2011-2012.

The three countries significantly differentiate productions. Russia is the major producer of wheat, including milling, high protein and feed wheat, while Ukraine main production is maize and feed wheat and Kazakhstan produces mainly high protein wheat. This production structure suggests a good level of complementarities between the three countries. Russia's exports supply neighbouring developing countries, like Turkey and Egypt (but also Sub Saharan Africa), with cheapest milling wheat (11.5-12.5% content of proteins).

From 1991 to 2010 Russia constantly achieved wheat yield gains. With an average yield increase of 2.22% per year, Russia is the country with the highest yield gains at world level, followed by China (2.08%) and Kazakhstan (1.67%), while in the same period France only achieved 0.29% of increase and Ukraine showed a decrease in yields of – 0.43%. This picture changes when looking at the shorter period. The yield gains in 1999-2010 are even higher for Russia (2.75%) and China (2.72%), and Ukraine reverse its trend gaining the 2.46% of wheat yields. In this decade, Kazakhstan's yields stopped growing, most likely because of drought problems. The productivity gains in the RUK countries occur in spite of lack of new varieties and of institutional R&D. Achievements are mainly due to personal initiatives at farm level.

Different factors explain the changing position from net importer to net exporter of the RUK region. First of all, part of the success can be explained through a potential bias in the statistics, due to the incentives that some farms have in reporting higher yields in order to obtain bank's financing and lower insurance costs. Second, climate change in this region is not an alarming factor, because the main effect is the winter's softening. Third, an important factor is the structural change coupled with the growing export orientation of the production activities and new infrastructures on the Black Sea and Don River. Finally, important institutional changes are significantly modifying the farming structure, inducing the emergence of family farmers and of agro-holdings, and increasing the government support (mostly in Russia and Kazakhstan).

Almost all wheat production gain in the three countries is due to the growing export orientation, and this is suggested by the stable domestic consumption of wheat in Russia and Ukraine and by the decreasing consumption in Kazakhstan of the last decade. Over the last decade, Ukraine more than tripled its annual grain export capacity and Russia erected 5 deep water and more than 25 shallow water terminals of 30 Mio. tons annual export capacity.

The structure of the Russian agro-holdings is significantly different from the ones in the rest of the world. They incorporate in one holding different production processes, taking the most successful practices adopted in other countries. For example, one agro-holding may incorporate Argentine bags, Canadian temporary bins and American grain drier in one production unit.

The agricultural sector in the RUK is highly concentrated under the control of a few companies of impressive land dimensions. In Russia, about 16 Mio.ha are controlled by companies, and the first 50 companies control about 9.6 Mio. ha. In Ukraine 15 companies control about 3.3 Mio.ha, while in Kazakhstan first 8 companies control 5.1 Mio.ha.

Agro-holdings originally started by huge non-agricultural investments into crop production. Their strategy is by highly hierarchical interventions, with aggressive crop rotation shifts and testing of new technologies, such as precision farming and minimum or no tillage. Agro-holdings are private companies, but are highly supported by governments given that their big size would provoke serious damages to the sector in case of failures.

Wheat areas and yields in Russia and Ukraine

In the last 10 years there has been a decline of total planted areas in Russia, despite a constant growth of areas under oilseeds, and stable areas under grains. Within grains, the area under wheat is rather stable while maize area is growing. However wheat area represents more than 50% of total Russian grains area. From 2000 the winter wheat area increased of about 4%, while the spring wheat area declined of 1.2%. Despite this decreasing area, spring wheat showed a higher rate of yields improvement (2.41%) with respect to winter wheat (2.17%). Higher productivity gains are achieved in the Russian regions closer to the export markets, like Kursk (3.89%), Chelyabinsk (3.34%) and Krasnodar (2.98%).

General trends in the Ukrainian planted area in the last 10 years are similar to Russia: steady growing areas under oilseeds, and rather flat areas under grains. Within grains, a sharply growing area under maize, some decline of barley, and wheat area is stable. Wheat area in Ukraine is predominantly under winter wheat (nearly 6.5 Mio.ha with respect of less than 0.5 Mio.ha of spring wheat in 2011). Ukrainian yield gains are similar to Russia in the last decade: 2.34% increase in spring wheat and 2.04% in winter wheat. However, these gains are much more spatially homogenous, with no dramatic geographical differences across regions: 3.52% of yield increase in the central region in the last decade, 2.63% in the east region and 2.31% in the south of the country. The lower yields increase in the south it is mainly due to constant droughts.

Fertilizers use is growing both in Russia and in Ukraine, but in Ukraine the use of fertilizers is higher. This mainly because the costs of ammonia fertilizers are very low and in Ukraine it is mainly organic ammonia.

Taking the sum of the above arguments, the three RUK countries (and especially Russia) seems to have taken the opportunity of "filling the gap" between the growing international wheat demand and the low wheat productivity gains among traditional exporting nations. This is mainly explained by the revolutionary move to markets economy of the RUK countries. More specifically, the success of RUK countries can be explained by the following factors: the shift to winter wheat; the shift of the production towards southern regions that are more productivity and closer to export markets; the rapid development of market infrastructure; the dual organizational structure based on family farms and agro-holdings; and the growing governmental support to agriculture in Russia and Kazakhstan.

Potential factors threatening all these achievements are: the competition of alternative crops, such as corn, legumes and oilseeds and the unpredictable risky weather patterns.

Presentation S1-4: Micro-based country studies across the Eurasian wheat-belt and beyond

Sébastien Mary, *Agriculture and Rural Development Unit, European Commission JRC-IPTS, Seville, Spain*

The Agrilife Unit of the JRC-IPTS is carrying out a project on the "Prospects of the farming sector and rural development in European Neighbourhood Policy Countries". The main objective of the research is to identify the role of the farming sector and rural areas in view of food security in the short and medium run in four key agricultural producers of the Black Sea region, namely Ukraine, Russia, Turkey and Kazakhstan.

The Black Sea region has become a key actor in wheat markets and could substantially improve future world food security, despite the existence of several elements which might limit its great potential in wheat production and exports. Among many reforms, land market reforms have played a key role in shaping the evolution of these countries in world markets, but climatic and environmental variables also affect the performance of the region.

The four countries taken together represent about 4% of the world population and 10% of the world cereal surface, consisting of 13% of global wheat production and 21.5% of world wheat exports. The agricultural sector in this region is not only producing grain crops, but also meat and fruits.

For each of the four countries the JRC-IPTS is conducing farm-level analyses with respect to productivity, the role of government support or classification of farms. Ukraine possesses 25% of the most fertile black soils in the world, it has strong potential to increase its grain production and to contribute to national development and global food security. The main objectives of the study are two: to identify and analyse main current and future challenges for agriculture and rural development in Ukraine from an economic, social and environmental point of view; to assess to what extent Ukraine can contribute to global food security, looking at the main challenges and opportunities.

The farming structure in Ukraine is characterised by a dual farm structure, consisting of both family farms and big agro-holdings. Up to 90% of the land cultivated is rented and small-holders rely on high investment returns. Preliminary results on the Ukraine study show that the dualisation of agriculture leads to unemployment and depopulation in rural areas and the dualisation of markets leads to the monopolization of exports, causing inefficiencies in the production system and delays in agricultural reforms. Moreover, underdeveloped land markets limit capital investments into the farming sector and the increase of production. Insufficient and obsolete transport and storage infrastructure and the lack of ad-hoc policies are also limiting factors of grain exportation.

The study on Russia is in partnership with the Russian Institute of Agrarian Problems and Informatics. Russian agriculture has a great potential in reducing food security problems at world level. However, the rate of abandoned land is still high and high production costs are negatively affecting the agricultural sector's profitability.

The Russian agricultural sector is characterised by government intervention in the form of farm subsidies that have significant impacts on the farming profitability. Indeed, without subsidies, the profitability of many farms would be negative. In the near future, it is expected that the access of Russia to the WTO may prevent the federal government to use export bans. Moreover, it is expected an increase in productivity and output.

Presentation S1-5: Wheat productivity : expectations of EU farmers

Arnaud Petit, *Copa-Cogeca, Brussels, Belgium*

70% of the world food and feed consumption consists of cereals, and more specifically of maize, wheat and rice that together represent almost 85% of the world cereal consumption. The supply of cereals follows the demand both at world and European level.

Average world wheat yields are 2.95 tons/ha. 50% of the global wheat area is below the world average of yields. Major producers are EU and China, which also show higher yields with respect to world averages. On the contrary, major maize producers are the US and China. Despite the importance of wheat in the European agriculture, gains in wheat productivity are higher outside the EU. In the period 2000-2007, the cereal yield annual growth rate was negative in the EU (- 0.3%), while it was +3.9% in China and in the US. Europe is the only world region experiencing wheat yields stagnation.

Wheat is a strategic production for the EU. First of all, wheat represents the major crop production in EU with 23 Mio. ha. The destination of 30% of the wheat produced in the EU is domestic human consumption, but wheat is still a relevant component of the feedstuff, mainly used for the poultry and pig meat sector in France and Germany where it represents the 30% of the animal rations. The competitiveness of wheat is crucial for the competitiveness of the white-meat sector in the EU.

The availability of arable land is the most sensitive factor affecting wheat production in the EU. In the UE27, total arable land in 2011/2012 was 56.2 Mio. ha (- 3,3% of 2009-2010). Soft wheat is around 22.9 Mio.ha, barley 12 Mio.ha (-12% since 2009 and continuing decreasing) and maize surface is variable from 7.9 to 8.5 Mio.ha. The area of other cereals is decreasing due to lower profitability in comparison with wheat, while the durum wheat is less and less attractive in traditional areas.

There are different trends between the UE15 and the UE10. The cereals area contraction is more significant in the UE15, while there is a better resistance of barley and other cereal crops in EU10. Rapeseed area is stabilized, but sunflower is increasing as rescue plan for rapeseed in EU15.

In general, weather conditions are changing the farming practices in the EU. The frequency of the lack of rain during the spring period affects the yields and the fertilizer uptake.

The expectations of the European wheat sector for 2012-2013 are characterized by major increase of other cereals area due to increasing wheat production costs and price uncertainties that increase farmers' revenues volatility and reduces liquidity at farm level. This will lead also to negative trends of wheat feed use. Main drivers of the compound feed sector will likely be wheat and maize, while the oilseed area in EU27 should be stabilised due to a good production forecast of soymeal and canola for 2012, meaning that the market has been sufficiently supplied.

Factors constraining wheat farming

The factors constraining wheat farming are multiple. The most important are the need of new tools for diseases resistance and tolerance to adverse environmental conditions (e.g. drought, frost, etc.), a better optimization of fertilizers use and the effects of regulations on the farming activity.

New crop protection and fertilization tools should take into account the climate conditions. In particular, it is important to develop wheat varieties adapted to different climate conditions, but, in order to achieve new varieties, the public and private research must be supported to be competitive. Moreover, European wheat farming is highly dependent on the nitrogen use, thus it is important to improve nitrogen use optimization.

From the regulations perspective, sanitary regulations are the ones with greater impact on wheat productivity. Farmers have to be compliant with the mycotoxine regulation, but the 30% of the EU production is exceeding the limits required by the regulation. The content of mycotoxines strongly depends on weather conditions, hence it strongly varies from one year to the other. The legislation on contaminants may also put constraints to the wheat farming, but its pressure depends from region to region, due to the presence (or not) of contaminants such as cadmium and heavy metals. Moreover, the biofuels directive of the EC may have major impacts on European farming, as biofuels may represent a source of value added for the farmers and not only a simple shift of the use of raw materials. However, main biofuel opportunities are for the rapeseed sector rather than for wheat.

International trade negotiation on cereals markets may have an important impact on European wheat farming. As a matter of fact, greater productivity improvements occur where there are exports opportunities. In particular the EU-

Canada free trade agreement (FTA) with a possible duty free for cereals and the EU-Mercosur FTA on Maize can have huge impact on prices. Moreover, the EU–Mercosur FTA would limit the use of feed wheat by a contraction of poultry meat exports, estimated around 800 thousands tons of wheat.

Session 1 discussion and prospects

Many important elements concerning the production and productivity of wheat emerged from the discussion following Session 1.

First, it emerged that, while on the one hand wheat price volatility is carefully monitored and analyzed, on the other hand there is a lack in the monitoring of the production costs of wheat. The variability of the input costs, along with price volatility, induces variability in the farms revenues, affecting the farmers' production decisions. However, the predictability of wheat price volatility is difficult and a lot of research is devoted to improve the robustness of predictability. To date, the most promising measure for price volatility predictability is the stock-to-use ratio. Markets are segregate across different types of wheat, but the bulk is represented by soft wheat that is leading the world prices. On average the share of feed wheat consumption is increasing, but for African countries the most important use of wheat remains food.

Second, land availability is a constraining factor and land competition is mainly between grains and oilseeds, hence the potential to increase wheat area is at detrimental of other crops. An increased area of wheat depends on the local profitability of the wheat farming. For example, in China the lack of irrigation is constraining wheat farming profitability, but the higher importation of maize with respect to wheat is leading the Chinese agriculture towards higher maize surfaces rather than wheat.

Third, the genetic improvement of new varieties is a slow process and it takes time to reach farms. On average, the breeding programs need 7-8 years to achieve a final product. In France, most of the wheat breeders aim to reach the market as soon as possible and to this purpose breeders have greater incentives in improving varieties for yield stability for specific regions where there are specific needs.

Fourth, the effects of climate change are underestimated for southern European countries, which are likely the most affected in the near future. So far, the strategy adopted by farmers to face climate change is to switch from spring to winter wheat varieties, but in the near future it will be important for farmers to have new agro-chemical tools for new environmental conditions. Moreover, farmers need new agro-chemical tools also because new diseases are emerging as potential problems, such as the wheat blast transferred from rice crops.

Finally, the same countries where yield stagnation is more acute show lower public investment in R&D. In Eastern Europe the changing policy environment, from state to private R&D, can change the yield trends. However, the potentialities of the eastern European countries in producing wheat are limited mainly because of the lack of infrastructures, increasing transport costs. Some countries such as Latvia and Lithuania have sufficient infrastructures, but exports opportunities are limited due to problems with the quality level of wheat. To adjust these problems, these countries are purchasing high-quality inputs from Germany and they are investing in the breeding sector in order to adapt wheat varieties to their specific agro-ecologic conditions.

Session 2: Innovation in production factors affecting wheat productivity

This session analyzes the innovation in wheat farming in Europe. The session starts discussing trends and effects of the public and private investments in R&D on the agricultural productivity. Following, main innovations in breeding, production factors and management practices in the EU are presented and discussed. At the end of the session stakeholders had the opportunity to express their point of view.

Presentation S2-1: Innovation in production factors affecting wheat productivity: current and future pressures

William W. Wilson, *North Dakota State University, USA*

Research funding is an important parameter for understanding the wheat innovation pathway in the last decade. In the US public funding for wheat breeding research predominantly comes from 3 sources. The USDA-ARS has different funding schemes ranging from research grants to in-house research efforts, accounting for 55% of total investment. This is complemented by funding from State appropriations, 31% of the total amount, and commodity organisation. From 1998 to 2007, the total public funding for wheat research increased from $22 million to $36 million. The increase on a per acre basis is even more pronounced with a doubling to $0.7/acre/year. This is however mainly an effect of the reduction of acreage as can be seen from the stagnating funding per bushel of wheat. The private investment in GM crops in the US, $8/acre/year, puts the figure in context.

State commodity organisations are an important source of support funded by check-offs on the sale of wheat in different states. The type of expenditures varies through time and across classes as breeders direct the funding distribution during an annual meeting. The last couple of years the total spending has been stable at around $1.6 million/year.

Within the federal funding, a trend from direct USDA funding to other federal agencies could be observed over the last years. A trend which is expected to continue beyond 2009 as proposal to decline USDA spending with a further 16% is on the table. State appropriations seem to be on a similar path towards of decline in funding.

This trend towards decreased public spending in wheat breeding comes at a time where the demand for food is expected to grow with 3-4%/year and yield is only increasing 1-2%/year. High prices might induce new technology and increase the land in production in the next couple of years. However in the US, wheat has to compete with GM technologies that have proven a game changer in competing crops. GM crops have changed the geography of production displacing other crops and change the technology growth rate increasing both the value of production and land in these regions. Soybean and maize have expanded in all different directions with the maize belt recently moving into Canada. Part of the success can be explained by the business strategy of focusing on elite seed combined with genetic traits, seed and traits, providing opportunities for private returns leading to much higher investment in R&D compared to conventional breeding. These investments lead to a continuous stream of new traits and an expected escalation in yield growth rates.

The loss of competitiveness of wheat production is observed in international outlook tools by a significant decrease in area cultivated with wheat in the US. For North Dakota the area with wheat decreased already 25% since the introduction of GM crops and the battle for acres is still ongoing, wheat being replaced by soybean, maize and canola. A similar trend is observed in Canada. A look at the net return per acre shows that margins for wheat have been passed by maize. Moreover, wheat is risky with regard to yields, prices and quality, further eroding the competitiveness of the crop vis à vis GM crops.

One way out for wheat might be the embracement of GM varieties. The technological barrier is not the main hurdle to commercialization but the consumer perceptions that halted the development of an herbicide tolerant wheat variety in 2004. However, since 2009 all big biotech firms reinforced their investment in GM wheat being pushed by a whole set of changes including: increased end-user demand, biofuels, drought tolerance development, geopolitical changes and producers' pressure. The investment is mainly targeted towards novel more complex traits such as fungal and disease resistance, drought resistance and increased nitrogen use efficiency as these are the main parameters affecting wheat yield in the major producing regions. Under Australian conditions the predictions for drought tolerance are high with a potential jump in yields of 20%.

However, this will not happen soon as the development of these traits will take more than 10 years prior to being ready for commercialisation. In this timeframe new traits for the competing crops will have further eroded the competiveness of wheat production. Australia is in a leading position and will probably be the first to bring a GM trait to market in wheat. For biotech companies the stakes are high but with major challenges to overcome such as being the first mover in an intensely competitive market, definition of the right traits for GM, and the need for the best germplasm in order to succeed in the seed trait approach.

Presentation S2-2: Innovation for wheat breeding in the EU

Hélène Lucas, *INRA, France*

There is a worldwide need to increase the production of wheat in order to fulfil the future wheat demand. Under the assumption that wheat cultivated area remains stable, an increase in yield growth rate from 1.1% annually to 1.6% until 2050 is needed to meet demand trends. In order to

reach this objective, policy, agronomy and breeding should be aligned. Against this background the Wheat Initiative has been founded. The Wheat Initiative was endorsed by the G20 Agricultural ministries in their 2011 action plan to improve food security and will work as a mechanism to identify synergies and nurture collaborations for wheat improvement.

The Wheat Initiative aims to encourage and support the development of a vibrant global wheat public-private research community sharing resources, capabilities, data and ideas to improve wheat land productivity, quality and sustainable production around the world. To answer the challenges of wheat research internationally, the Wheat Initiative will:

- Develop a global strategic agenda for wheat research
- Encourage efficient investment in wheat research (which is low compared to other crops)
- Initiate the development of collaborative programs and coordinated actions
- Develop and coordinate knowledge sharing amongst the international wheat community
- Improve access for all to resources, services and facilities.
- Support education and training for researchers and farmers

The Wheat Initiative is a science led initiative that seeks synergy by bringing alongside funders and other stakeholders. Its governance structure integrates the wheat research community as well as national and international funding bodies, public and private. The Wheat Initiative is not a research funding mechanism: it provides a coordination platform for wheat researchers and funders to bridge national and international programmes and to define research and investment priorities, without competing with other national or international initiatives. The first meeting of the Wheat Initiative funding partners took place in November 2012.

Among other activities, the Wheat Initiative wants to facilitate access to wheat genetic variability and related information, by supporting the creation of an integrated Wheat Information System, and to share experiences to help prioritize and implement new breeding strategies for wheat complex traits improvement. The Wheat Initiative has also identified the need for international public-private cooperation to set up phenotyping platform networks for improved prediction of performance under different environmental conditions.

The European wheat research community is strong with recent large national initiatives such as in France (BREEDWHEAT), the UK (WISP and Wheat 20:20), Germany (Proweizen) and in Italy for durum wheat. These initiatives will team up with the Wheat Initiative in order to fulfil the mission of the Wheat Initiative and increase the worldwide productivity of wheat.

Presentation S2-3: Innovation in fertilizers, pest and weed control and machineries for wheat cultivation

Jean-Paul Bordes, *Arvalis Institut du végétal, France*

With a production of 35 million tonnes of wheat from which it exports 50%, France is a major wheat producer and exporter. Being it an important crop, the rate of innovation is high in France, e.g. 20-25 new varieties registered each year. Over the years a relative shift from pure agronomic innovations towards more quality attributes has taken place. From the agronomic point of view efforts where mainly done with regards to disease resistance, now it takes into account other new criteria like drought tolerance via different pathways and increased nitrogen use efficiency. However, despite these genetic improvements, yields have been stagnant in the last 10 years, hence increasing the yield gap between genetic potential and obtained yields. Reasons are plenty and include mainly climate change, but also changes in crop rotation, adoption of minimum tillage, decreased weed control and fertilizer use, policy effects, etc. Therefore no one off solution to bridging the yield gap exists.

Average yields are high at around 7.5 tonnes/ha in France. To reach this yield level input costs are high, about 480 €/ha. When including mechanization and labour, it is about 1230€/ha or 77% of the total provisional production cost for 2012. Fertilizers and pesticides together amount to 30% of the total cost. Interestingly, the last 6 years the production costs where only covered once by the market price for wheat. To mitigate this effect, farmers adapt their input use on the price level of the different inputs and outputs in order to remain competitive.

Over the last years price for pesticides have been steadily increasing. As a result farmers are adjusting the rate of pesticides and fungicides conditional on the expected wheat price. The higher the anticipated price for wheat the more the yield is protected through increased use of inputs. Another important change in input use can be observed in the application of N (PK) which has been decreasing since 2000. Farmers are using fewer fertilizers and are splitting the application from 2 bigger applications in 5 years to 3 smaller application doses.

In the near future new management changes will be observed induced by new environmental policies. The Ecophyto 2018 program in France for instance has as a goal to reduce the use of pesticides of 50% by 2018. But also the nitrate directive, drinking water regulations, quarantine pests etc., will require the farmer to adapt and change his input use.

New technologies can help farmers to protect or improve productivity by optimizing the use of inputs in wheat production. From 2000 onwards, farmers are using remote sensing, FarmStar, to optimize their input management. At different stages in the production cycle farmers are supplied with information on the status of their crop, the inputs needed and the timing of different applications. Farmers

adopted the technology swiftly, increasing by 60 000 ha/year. In 2012, 340 000 ha of wheat are being monitored by FarmStar. Results from a comparative study reveal that the use of FarmStar leads to an average yield increase of 0.25 tonnes/ha. Instead of remote sensing, the industry is also developing N-sensors that can aid the farmer in optimizing the fertilizer application in his field. Controlled traffic farming is an example of a technology that provides the opportunity of increasing yields by limiting compaction associated to the passage of vehicles through the fields.

The future of wheat productivity is uncertain as a consequence of all the factors described. In the scenario analysis presented it is assumed gains are to be expected through adaptation of varieties to the environment and genetic progress while regulation and climate change will further decrease productivity. The resulting extent of yield change for the future ranges from -0.06 tonnes/ha year to +0.12 tonnes/ha year.

Round table S2: Innovation in production factors affecting wheat productivity

Arnaud Petit, *Copa-Cogeca, Brussels, Belgium*

Farmers see the need for funding of research in order to keep competitive. The main question is how this research should be funded. Funding through the private sector would mean that farmers have to pay royalties on the technology. This is probably only feasible when farmers see the effects of research on a short term. For longer term developments public funding and public facilitation of technological progress to farmers is therefore essential. Initiatives such as the European Technology Platforms are very important in that regard.

From a breeding point of view it seems there is good genetic variability in wheat. An important point missing is an attempt to create new varieties with reduced phosphate use as this is a limited resource.

It has to be noted that wheat is a risky production choice for farmers; therefore they need the best toolbox possible in order to cope with production risks. When looking at new technologies it is important to consider the land impact of the technology. Remote sensing which was discussed is theoretically very interesting to optimize input use but is it feasible, cost effective, on smaller areas? After all, the average wheat growing area within a farm is only 18ha.

Carlos Palomar, *European Crop Protection Association, Brussels, Belgium*

Crop protection as such does not close the observed yield gap between genetic potential and obtained yields. However without crop protection tools the yield gap might be as high as 50% while the use of crop protection reduces it to 28%. The industry is trying to close this gap further in the future. One key aspect there is the reduction of fungal infestations as they are responsible for a 10% yield gap. Hence, fungicides are the main working area for crop protection producers in wheat.

However this is not an easy task in a policy environment where the amount of available active ingredients decreased drastically from about 1000 to about 300 for environmental reasons. Another novelty is that the globalisation has led and will lead to an increase of diseases in European agriculture, increasing the need for good crop protection. On the other hand, the returns on crop protection have decreased over the last years as GM crops have replaced conventional active ingredients in big parts of the world. This tendency decreases the investment in R&D, one of the reasons why very little new mode of actions have been introduced in the last years. Innovation therefore also aimed at resolving resistance problems in for existing active ingredients. This is not an easy task as some of the novel crop protection agents are so specific in their mode of action that resistance can develop within 3 to 4 years.

The main question for the future is how to protect the working of crop protection agents assuring that the yield gap does not increase.

Ermis Panagiotopoulos, *Fertilizers Europe, Brussels, Belgium*

The world population is expected to grow by 9.1 billion people by 2050. This means that we need higher productivity for cereals in general and wheat in particular. At the same time we face some major constraints:

- Resource availability with land area and water availability being the major ones
- Agronomic constraints with rotational requirements, soil structure and balanced nutrition (N, P, K)
- Economic constraints with high and unpredictable energy prices and high price volatility of agricultural commodities
- Natural and environmental constraints with extreme weather events (droughts, floods) and the climate change impacts on cereal yields

Another important constraint is the organizational one with lack of appropriate dissemination of good practice into farms.

It is therefore straightforward that the European farming sector should produce more with less. To achieve the latter we will need to innovate more.

According to the University of Copenhagen and several other sources, the increase in productivity should come from cultivation technology, biotechnology, irrigation systems and fertilizers.

From the Fertilizers Europe's point of view, good fertilizer practice towards a more productive agriculture is the key. The missing link of the science on the good practice and the

knowledge transfer into the farm has to be strengthened. The Nitrogen Use Efficiency must be improved and monitored because it reconciles productivity with environmental protection. In the last 20 years the nitrogen consumption has decreased while the crop production has increased due to the nitrogen use efficiency. The use of precision farming techniques (right rate at the right time and place) while using the appropriate nitrogen form, nitrate vs urea (right product), it could considerably improve the current situation. Another very important aspect is the more precise utilization and update of recycled products of organic origin on farm and better use efficiency of their nutrients so all the nutrient sources should be better and safely coordinated. It is also relevant to highlight that the new fertilizer regulation, currently under preparation, will set the context for more precise evaluation of organic fertilization.

In summary, correct application methods of fertilizers is of paramount importance both towards productivity and towards fewer losses to the environment. The industry has in place precision farming tools, such as software and crop monitoring tools (N-tester, N-sensor) which can assist the farmers in calculating the right nutrient rate and apply it at the right place and time towards a climate smart European agricultural sector.

Tanja Gerjets, *European Seed Association, Brussels, Belgium*

Plant breeding is the beginning and the most important aspect of the agricultural value chain. Subsequent elements and processes, like soil cultivation, fertilization and plant protection, will develop their potentials depended on the quality of plant breeding. The genetic potential of the variety determines the yield potential. In Europe not only the production of food is of interest, but also other aspects of bioeconomy chain such as the exploitation of biomass are important. In wheat, for example, the grain will be used for food production and the remainder of the plant can be used for bioethanol production or for soil health.

In Germany, the structure of the breeding companies has proven to be very successful. However, wheat breeding in Europe has to compete against other crops, especially in the aspects of yield increase and stability. In the end the farmer will choose the most profitable crop for him.

For the future of wheat breeding the following actions should be resumed:

- The development and intensification of national activities in wheat breeding and research with financial support from the government is one of the necessary key actions. Furthermore, these national programs have to be linked to European and international activities to establish a global network.
- The connection between private and public research has to be closely linked and in line, especially in regards with the usability of results.In this regard, prebreeding has to play a major role in public research. One of the most promising technologies, for example, will be the hybrid technology in wheat in order to use the heterosis effects for increasing wheat productivity.
- The duration of research programs has to be extended to at least 15 years, as the development of new wheat varieties can last up to 25 years (from idea to variety).

Session 3: Policies and regulations affecting wheat productivity

The objective of this session is to identify the EU regulations that may have an impact on wheat farming, taking into account the impacts on farm revenues and technology adoption. The mechanisms of these impacts are analyzed and discussion on how to overcome these problems is provided. Moreover, in the session stakeholders had the opportunity to express their point of view on the effects of the EU regulations on wheat farming.

Presentation S3-1: Market signals and EU policies effects on wheat productivity

Martin van Ittersum, *Plant Production Systems Group, Wageningen University, the Nederland*

Roel Jongeneel, *LEI, Wageningen University, the Nederlands*

The economic and the agronomic approach in studying wheat productivity

Agricultural productivity analysis has both an economic and an agronomic approach. The current economic approach is based on the production function theory that defines the economic optimal yield as the interaction between the profit function and the economic technology frontier. This theory assumes the economic optimization of the production factors, focusing on the optimization of the factor (inputs and output) productivity. There is a yield gap between the economic optimal and observed yields, in particular in those farmers facing economic or allocative and technical inefficiencies. The economic approach relies on price indicators and takes into account the scarcity of production factors, inputs and outputs. This latter factor is usually ignored in the agronomic approach. However, in the economic approach the production technology is often largely reduced to a black box, not describing the farming activities and physical conditions, such as soil, temperature, etc. in any detail. As such it ignores or not properly takes into account the impacts these factors have on yields. Indeed, there is also the agronomic optimum yield, given by the interaction between the agronomic yield potential and the agronomic frontier. This agronomic optimum takes into account farm and environmental mechanisms that are not considered in the profit function. Hence, farms face two different types of yield gaps: one with respect to the economic optimal yield and the second to the agronomic optimal yield. The presenters advocated an integral approach, combining economic and agronomic drivers into one coherent whole and they argued that also is a prerequisite for studying how various policy measures could impact yield growth and contribute to yield gap closure.

As an example, the presentation of wheat in CAPRI, an economic (partial) equilibrium model of EU agriculture was discussed. Its baseline calibration has detailed procedure for determining production, yields and balances, which accounts for current legislation and policy, and trend estimates are integrated with external forecasts and consistency requirements (CAPTRD). CAPRI includes the typical economic mechanics, taking into account inputs (N, P, K, pesticides, energy and others) and intensive (high yields and inputs) and extensive (low yields and inputs) technologies per crop activity. For selected crops yields are assumed to be a function of relative output price level with a fixed yield-price elasticity. Essentially, technological progress in wheat yields is based on trend extrapolations that do not take into account agronomic potentials and limitations.

In agronomic terms, yield potential (Yp), also called potential yield, is the yield of a crop cultivar when grown with water and nutrients non-limiting and biotic stress effectively controlled. Potential yield is location specific because of the climate, but in theory not dependent on soil properties assuming that the required water and nutrients can be added through management (which, of course, is not practical or cost-effective in cases where major soil constraints, such as salinity or physical barriers to root proliferation, are difficult to overcome). Thus, in areas without major soil constraints, Yp is the most relevant benchmark for irrigated systems or systems in humid climates with adequate water supply to avoid water deficits. For rainfed crops, water-limited yield, (Yw), equivalent to water-limited potential yield, is the most relevant benchmark. Definition of Yw is similar to Yp, but crop growth is also limited by water supply, and hence influenced by soil type (water holding capacity and rooting depth) and field topography (runoff). The yield gap (Yg) is the difference between Yp (irrigated crops), or Yw (rainfed crops) and actual yields realized by farmers (Ya). Agronomic modelling takes into account all these factors and are used to analyze the yield gaps at farm level and to study different scenarios: type of farming (traditional and organic), water limitation, climate change and future genetic progress.

The information from the agronomic approach, such as the agronomic factors affecting yields (weeds, pests, water, radiation etc...), can be integrated into the economic models enhancing a explicit treatment and direct control of the farm mechanisms, and thus provide a framework showing the interaction of economic and agronomic drivers and human activity (farmers decision making, research and development efforts) and their impact on actual and potential crop yields.

Understanding the role of the EU policies in wheat farming

Within the Common Agricultural Policy (CAP) many measures have impacts on cereals production and productivity. First, the transition from the traditional price support to decoupled payments lowered cereal prices relative to input prices. Second, new policy proposals on crop rotation requirements are likely to have some effect on supply (however, the potential effects on yields are not yet clear). Third, the

planned abolishment of sugar quota, combined with expected high market prices for cereals, is likely to increase cereals' competitiveness compared to sugar beet and formerly coupled crops, such as starch potato. On the contrary, set-aside & ecological zone measures are usually applied to low yielding fields and field margins, thus these measures have limited effects on the total production (slippage).

Within the environmental policies, the Nitrates Directive (Directive 91/676/EEC) requires a more effective and efficient application of nitrogen, through precision application of both fertiliser and manure (in time and space), hence requires more efficient nutrient utilising varieties adapted to these new practices.

The Water Framework Directive (Directive 2000/60/EC) introduced the control of diffuse pollution to improve water quality. Agricultural systems are currently operating at a phosphorus surplus, which is however declining in Europe, and the principal loss pathway of phosphorus is surface run-off. This Directive has effects on farm management practices: inducing a matching between phosphorus and nitrogen applications with actual crop requirements; promoting the sowing of winter cover crops, the reduced or no-till and the contour-tillage; establishing in-field riparian buffer strips that improves organic matter content; applying organic practices in vulnerable zones. The adjustment in management practices is likely to limit yield growth for selected groups of farmers.

Farmers adopt different strategies to face changes in market prices. Farmers' response to higher wheat prices depends on the level of farming specialization. On the one hand, specialized cereal growers in the EU will opt for strong productivity increase and scale up production in order to decrease per unit cost of production. On the other hand, non-specialized cereal farmers will opt for cereals in rotation only if they become more attractive.

Price volatility affects farmers' behaviour as decisions are based on long-term prospects. A strategy to protect against price volatility is to use risk management tools, but the sensitivity to volatility-risk might differ between crops.

Presentation S3-2: European nitrate and pesticides regulations impact on wheat productivity

Jørgen E. Olesen, *Aarhus University, Aarhus, Denmark*

In 1991 the Nitrates Directive (Directive 91/676/EEC) was introduced in the EU to prevent pollution of nitrates from agriculture to surface and ground water, concerning mineral fertilizers and manure. Under this Directive, European regions were classified in Nitrate Vulnerable Zones (NVZ), and according to this classification codes of good agricultural practices (e.g. avoid overuse of manure) were established.

The Nitrates Directive is now part of the Water Framework Directive, introduced in 2000. The Water Framework Directive aims to achieve good status for all ground and surface waters, through spatial management of river basins. The target is the local quality of water, but this directive can indirectly lead restrictions on water and nitrogen use for agriculture.

The majority of NVZ are in the North-West of Europe. Nitrogen fertilization has important interactions with crop susceptibility to diseases. A good disease control induces also an improved efficiency use of fertilizers, and this can be achieved by improved farm management. Increasing the nitrogen efficiency at farm level is not always possible, because good farm management is conditional on sufficient machinery endowment, in particular for manure application.

As a consequence to the Nitrates Directive, the level of fertilisation in winter wheat in Denmark was reduced by about 22 kg N/ha of mineral fertiliser and 33 kg N/ha of manure in the last ten years. This reduction induced a yield loss estimated at 0.5 tons/ha.

The Pesticides Framework Directive (Directive 2009/128/EC) was published in 2009, and it requires Member States to enforce National Action Plans to reduce damages from pesticides. The National Action Plans should have quantitative objectives, targets, measures and timetables.

The most effective fungicides can improve yields by about 0.5-0.6 tons/ha. The use of pesticides depends on costs that strongly differ across Member States. Costs depend also on governmental regulations. For example, in Denmark the high taxation pressure significantly raise pesticides costs. The local pests' pressure and costs affect the number of treatments, and these two factors explain the heterogeneity in the number of treatments between Member States.

Three families of fungicides are used in wheat farming. The first is the family of triazoles. Their efficiency is linked to a low risk of fungicide resistance in fungal populations. However, triazoles are suspected of having hormonal effects on humans, and new cut-off values during the approval process may remove some, if not all, triazoles, from wheat farming. It is estimated that a ban of triazoles in wheat farming would cause 5.6-8.4% yield loss in the short term (2013) and 9.7-14.6% losses in the long term (2020). New criteria for triazoles evaluation will be decided in the EU in 2013 and their assessment will be carried out during 2014 to 2019. The second family are the Strobulurins, but they have the disadvantage to quickly develop resistance. Finally, the last family is the DHI, but also this family shows medium to high risk of fungicide resistance.

Concluding, there is the need to reduce nitrate losses to the environment, but a reduced nitrogen fertilisation in response to solve the pollution problem may reduce wheat yields by 0.5 t/ha. Some fungicides (triazoles) are at risk of being prohibited, but a loss of triazoles may reduce wheat yield by 0.2-0.5 t/ha. These elements suggest the needs for improved management systems: breeding that focuses on both

improved nitrogen use efficiency and disease resistance; more diversity in the cropping systems to prevent diseases; other measures in the landscape to reduce nitrate loading of ground and freshwater.

Presentation S3-3: Biotechnology regulations and wheat productivity

Huw D. Jones, *Department of Plant Biology & Crop Science, Rothamsted Research, UK*

Current status of biotech wheat

To date there is no commercial planting of genetically modified (GM) wheat anywhere in the world. No company has released commercial GM wheat varieties, despite some companies invested in GM wheat R&D in the past years. For example, Monsanto was close to the commercial release of Glyphosate-tolerant (R.R.) wheat in 2004, but pulled at last stage after pressure from US and Canadian growers.

Today all major biotech companies have wheat biotech programmes. Monsanto is likely developing a GM wheat with stacked events for herbicide tolerance, drought tolerance and yield stability, and Syngenta has history of developing a Fusarium-resistant wheat.

Also some public research centres are developing GM wheat. The Chinese Academy of Agricultural Sciences is investing 500 million € in biotech wheat, to achieve varieties resistant to yellow mosaic virus (YMV), head scab, powdery mildew, and insects etc. The first YMV-resistant wheat is expected to reach the markets by 2015-2018. The Australian CSIRO is active in wheat biotech for traits including drought tolerance and enhanced yield.

In the EU there is little investment in biotech wheat, only 2 field trial applications in 2011, and a total of 11 since 1991. These numbers are very small in comparison with other countries. In Australia authorities received 10 field trial applications in the last 5 years, and applications in the US are even more numerous (24 in 2012 alone).

Wheat has many advantages as a target biotech crop, thanks to its biological and ecological characteristics. It is a self-pollinating plant, with closed flowers and heavy pollen. It is not pollinated by insects, it has no sexual compatibility with wild relatives and there is temporal separation of flowering between spring and winter types. All these characteristics ensure a very low risk of gene flow. Moreover, wheat is not an invasive or persistent species. Wheat has low levels of natural toxins (eg. Lectins) but gluten has known allergenic properties and mycotoxins can be a problem.

EU legislation to regulate GMOs

The EU regulatory framework that rules the use of biotech crops and products is structured in four main regulations:

- Directive 2001/18/EC on the deliberate release into the environment of GMOs. It includes experimental and commercial cultivation of GMOs;
- Regulation (EC) No 1829/2003 that regulates the placing on the market of GM food and feed, or food and feed products which contain or consist of GMOs;
- Regulation (EC) 1830/2003 on the labelling and traceability conditions for GMOs and food products to be placed on the market;
- Directive 90/219/EEC on the contained use of genetically modified microorganisms.

The company who wants to introduce a GMO into the European market, either for cultivation or for the importation of food/feed products, first has to seek for approval of the GMO event. The company must identify hazards and evaluate risks associated with human and animal health and environment, compile a dossier describing the genetic modification and provide a risk assessment following guidance published by the European Food Safety Authority (EFSA) . The risk assessment strategy for GMOs seeks to compare the GMO and derived products with their non-GM comparators. The underlying assumption is that traditionally cultivated crops have a history of safe use, hence the risk assessment aim to answer the following question: 'Is the GMO substantial equivalent?'.

The average time required for a GM product approval in the EU is about 45 months, while in other countries is: Canada 30 months, Brazil 27 months and in the US 25 months. In the EU the number of approved GMO for cultivation is significantly lower than in these countries, only 2 products with respect to 66 in Canada, 28 in Brazil and 90 in the US.

The cost incurred seeking regulatory approval is high. For example, for insect-resistant maize in ten key producing and importing countries (Argentina, Australia, Canada, China, the European Union (EU), Japan, Korea, the Philippines, Taiwan and the United States) the range of cost incurred is 7-15 millions of US dollars.

The EU GMO regulation has different implications for wheat productivity and imports. The technically-demanding risk assessment and application process is costly in time, resources and money, provoking long and unpredictable time–scales to approval of new event. This restricts the development of wheat biotechnology to few multinationals, excluding small breeding companies and public sector institutes, which are more locally oriented. Moreover, biotech wheat research is further limited because it is hard to justify public research funding when the route-to-market is so complicated and expensive.

The longer-term potential effect of GMO regulations on EU wheat production has three possible scenarios. First, new biotech wheat varieties are developed outside the EU and synchronous approval is achieved for cultivation, food, feed, import and processing, with the result that the EU is free to import/export wheat and that biotech varieties are available to growers. Second, new biotech varieties are approved for

food, feed, import and processing but not for cultivation in EU, allowing wheat import but preventing EU growers' access to biotech seeds making them less competitive. Third, companies choose not to apply for approval in the EU for new biotech wheat varieties or the EU fails to authorise. In this last scenario, wheat growers in the EU cannot access biotech seeds, and because the EU has essentially a zero tolerance of unapproved GM events, any trace of new GM variety in imported load makes whole shipment illegal. This worst-case scenario could block all wheat imports into EU from GM wheat-growing regions.

Round table S3: Policies and regulations affecting wheat productivity

Arnaud Petit, *Copa-Cogeca, Brussels, Belgium*

The most important limiting factor in the European agricultural sector is land, and this constraint is as important as the yield issue to be considered in the EU policies. With limited possibilities in increasing the arable land, the access to new technologies is crucial, and policies should enhance the access to innovation.

The policies oriented to improve the productivity and the competitiveness of the European agriculture should be based on socio-economic impact assessments. Each farm has its own optimal profit function, based on locally-specific factors, and same policies can have opposite effects in different European regions given the differences in the production structures. For example, the decoupled payments introduced by the CAP are improving the farming system in Eastern European countries, but are damaging the farm productivity in Western countries.

In Europe is emerging the need for policies ruling the risks that farms face as production activities. These risks are related both to the agricultural activity as such, hence exposed to climatic variability, and to the market risks, such as price volatility. So far in the EU farmers relied on the financial market to seek protection from risks, but the financial market is not self-sufficient to this purpose. It helps with regard to risks related to the farming output, but not for inputs. Today is important to obtain proper tools to protect farmers' activities, such as insurance systems and crop compliance, and this is possible only developing specific policies at the EU level.

Carlos Palomar, *European Crop Protection Association, Brussels, Belgium*

Today regulations are set without proper socio-economic assessment on their potential effects on the production sector. To avoid negative effects of the regulations on farm productivity and on the use of crop protection products, the policy making process needs detailed criteria for policy design.

In December 2013 a discussion between the EU parliament and DG ENER is expected to provide criteria for regulations in the energy sector. DG SANCO is the Directorate General in the European Commission that takes decision on pesticides, and similar discussions for regulatory criteria are desirable. Without proper criteria during the formulation of regulations, the risk is to ban important products for the agricultural sector and to lose specific important tools of crop protection.

This risk is not only crucial for the farming productivity, but it has also important market consequences. For example, a recent study conducted by Nomisma (2012) shows that a ban of azoles can seriously decrease the competitiveness of the European wheat sector, reducing the wheat self-sufficiency from 107% to 99%. The negative effect can be even stronger, transforming the EU from net exporter to net importer of wheat. Moreover, banning the azoles would also have important negative effects on production prices.

The Directive on sustainable use of pesticides can also threat the productivity of wheat farming in the EU. In particular, the most sensitive issue regarding this regulation is the introduction of a threshold on the number of application and the imposition of fixed dates for applications. Treatments must be flexible in order to meet specific needs of the farm. Moreover, to achieve an environmentally optimal spraying of products is important that farmers receive a proper training.

More effective policies on the use of pesticides can come only through a higher integration between the three Directorate General SANCO, ENVI and AGRI.

Ermis Panagiotopoulos, *Fertilizers Europe, Brussels, Belgium*

The European policies of the last 20 years promoted extensification of agricultural production for environmental reasons, consequently limiting the total production. Having realized the need of more productivity at EU level, the new CAP is potentially a good opportunity to reverse this effect and move towards sustainable intensification. But unfortunately, the Commission's proposal to leave 7% productive land out of production is not going in this direction. Food security is not a European issue but Europe must play its role towards global food security.

European agriculture is one of the most efficient and productive worldwide. Nevertheless, the European Union has been for many years one of the world's largest importers of agricultural commodities. Europe's agri-food imports exceed its exports by 65 million tons, with an increase of 40% over the last decade. The area outside the European Union required for producing these imports amounts to almost 35 million hectares, approximately the size of Germany.

If the CAP policy seeks supporting agricultural productivity, then it should boost the competitiveness of the European agriculture sector and therefore ensuring farmers' income. It should also assist the EU agriculture and forestry sectors

to cope with the new demand for renewable resources. The main target should be to increase productivity while protecting the environment. This could be done by promoting sustainable productive farming systems (such as Integrated Farm Management) which reconcile productivity and the respect for the environment. As far as the mitigation of the environmental impact is concerned, the EU would save GHG emissions by increasing the productivity in existing cropland and by avoiding cropping more land outside.

Finally, a very important policy instrument which could bring science into the field is the Farm Advisory System which became an obligation for the Member States in 2007. It has to be invigorated and respected by the Member States in order to assist the farmers in making right choices to meet the good agriculture and environmental conditions (GAEC).

Tanja Gerjets, *European Seed Association, Brussels, Belgium*

Plant breeding is the beginning and the most important aspect of the bio-based value chain. Subsequent elements and processes, like cultivation, fertilization and plant protection, will develop their potentials depending on the quality of plant breeding. The genetic potential of the variety determines the yield potential.

In Europe not only the production of food is of interest, but also other aspects of the bioeconomy chain, such as the exploitation of biomass. In wheat, for example, the grain can be used for food production and the remainder of the plant can be used for bioethanol production or for soil health.

Wheat is one of the most important crops of world food security. Wheat breeding in Europe, especially in Germany, is very successful and competitive thanks to the structure of the breeding companies. But Europe is loosing this competitiveness due to a lack of legal framework in wheat research. We have to think about our regulations regarding biotechnology. In this respect, Europe has a big disadvantage in comparison with the North America. The establishment of innovation enhancing framework is essential. Deregulations of strict rules on biotechnology need to be implemented.

Wheat as a self-pollinating crop can be re-used by the farmer as farm saved seeds. A significant amount of royalties is not collected partly due to lack of clarity in the legislation, which has a negative effect on investment in breeding and breeding for improved varieties. In order to secure further investment of plant breeders in research, we have to ensure that refinancing is sufficiently provided. A system of fiscal consideration for research and development activities following the French examples has to be realized.

Session 3 discussion and prospects

First it was highlighted that price volatility and market uncertainty affect farmers' decision on production and on input use. In the US there are specific policies addressing market risks faced by farmers, but in Europe there is not a common strategy, and each Member State has its own approach. A common policy on market risk management at EU level is actually under discussion.

Second, some innovative wheat varieties can be obtained only through biotechnology. As an example, Spain started a public research to develop a wheat variety for celiac people (Gil-Humanes et al., 2010), but conventional breeding approaches to obtain wheat varieties with reduced gluten content are very difficult, due to the complexity of the genes involved, therefore, genetic engineering seems to be the only way to achieve wheat for celiac people.

Third, the problem of water contaminants differs strongly across regions and there are different techniques to avoid contaminants leaching. For example, the concentration level of herbicides in water is low in France. The majority of the contaminants are not coming from the field applications, but from the wrong management of the agro-chemicals residues in the machineries. An effective strategy to reduce the runoff of residues is to develop riparian buffer string permanently covered with weed. However, to achieve a good water management the regulation itself is not sufficient, but it needs time for farmers to adapt to new practices.

Session 4: Outlook on wheat productivity

The goal of this session is to overview the main factors concerning future food security and climate change related to wheat farming. Starting with an outlook on future wheat markets, the session continues presenting actual work conducted by JRC-IPTS on the characteristics of the European public breeding sector and concludes explaining the major effects of climate change on wheat yields and productivity.

Presentation S4-1: Wheat outlook 2012-2021

Sophie Hélaine, *JRC-IPTS, Spain*

Each year the OECD and FAO produce an outlook on the trends in agricultural markets for the next 10 years. The European Commission (JRC-IPTS) is a collaborator to this project as it runs the EU module of the project. The outlook should be interpreted as a projection and not an exact forecast of the future. The outlook mainly presents a frame for discussion and for policy evaluation through scenario analysis. Moreover it is important to note that the results of the forecast are conditional on exogenous assumptions on macro economic parameters such as inflation and oil prices.

Major exporters generally increase production for agricultural commodities with wheat production increasing by 12% by 2021 to 760 million tonnes. The USA however reduces wheat production further replacing it with other crops. The increase in Europe comes both from an area increase and an assumed yield increase of 0.7% per year and is pulled by increased feed demands and biofuels. Overall the use shares do not change that much in Europe in the next years with feed and food use consuming almost 60% of the production. Use-to-stock ratios remains low, as most of the production is needed domestically. Looking at trade shares it is mainly the RUK regions that expand their share from 22% of trade volume to 35% of traded volume surpassing the USA as the main exporter.

Many more players are involved in the imports of wheat with 83% of the imports going to developing countries. Imports in developing countries are mainly for food use as the biofuel sector is not developed while imports in the EU mainly serve feed producers. The importance of imports for the EU means that the exchange rate is an important factor in the total feed cost. Total worldwide imports are assumed to increase with 21% while consumption grows with 17%. Consumption increases significantly in Africa with 29% while imports only increase with 17%. The reason is that yields are assumed to grow significantly in Africa in the next ten years.

World agricultural prices are high and follow a slightly increasing path but are lower for wheat than for coarse grains or oilseeds. This can be explained by the high price assumption for oil which drives up the prices of biofuels and hence maize.

The modeling exercise is confronted with a whole set of uncertainties which are typically explored through scenario analysis. With regard to wheat markets potential export restrictions from the RUK countries, as has been the case following an important drought in 2010, is such an uncertainty. The modeling exercise suggests that the impact on world wheat prices could range from an 11% increase in case of a full ban to a 1% increase in case of a 9% export tax. Climate change and adaptation to it is another important uncertainty. The outlook bases itself on a biophysical model predicting the impact of climatic changes on yields. The results show that within Europe there will be winners and losers. Losers mainly located in southern Europe and winners in the north. On average the yields effects range from +2% until +13% in the case farmers are able to technically/agronomically adapt to the new conditions. Interestingly, taking into account the effect of increased production, the model results indicate that there is no effect on average farm income in case of non-adapting farmers, but an erosion of farm income of 9% occurs in the adapting scenario. These results have to be interpreted with care as biophysical models are not well adapted to cope with climate change and because technical adaption might not be feasible economically.

Presentation S4-2: Plant breeding for a EU-bio-based economy (Breeding 2020)

Maria Lusser, *JRC-IPTS, Spain*

The study "Plant Breeding for an EU bio-based Economy 2020" was initiated and financed by JRC-IPTS under the European strategy and action plan "A Bioeconomy for Europe: Innovating for Sustainability". The study was carried out by Arcadia International, Brussels in 2012. At the time of the workshop only the draft final report was available.

The general objective of the study was to analyse the potential of public and public/private plant breeding in the EU to fulfil the needs of the EU sustainable biobased economy by 2020 and for the adaptation and mitigation of climate change. The following tasks were carried out using methodologies such as literature search, interviews with experts, a workshop and a survey directed at public breeding institutes:

- Review of main breeding needs for the EU bioeconomy 2020
- Analyses of the R&D investment and short and medium term commercial pipeline of the private breeding sector
- Evaluation of the breeding needs which are currently not or insufficiently covered by the private sector
- Review of the public breeding sector in the last decades
- Review of complementary developments in the private breeding sector, global situation
- Mapping of the current status, capacity and potential of the public plant breeding sector (including public/private co-operations).

Preliminary results of the survey directed at public breeding institutes were presented. The scope of the study was

restricted to breeding activities leading to the release of new cultivars including molecular breeding activities in support to germplasm characterisation and to variety development. Some 47 relevant institutes were identified in the EU27 and the contractor received 32 completed questionnaires.

The main results of the survey are the following:

- In eight member States no public breeding activities falling under the scope of the study take place (Austria, Cyprus, Czech Republic, Denmark, Ireland, Luxemburg, Malta and Slovenia).
- According to the most recent data available, 677 staff with academic degree (400 of which have a degree in breeding) are involved in public breeding activities in 18 EU Member States.
- Public spending in most recent years was 13,400 k EUR per annum in these 18 MS.
- Staffing and expenditure decreased for the institutes under the survey by some 20 staff and 400 000 EUR compared to 2000. (This does not take account of possible decrease in staff or expenditure because of institutes being closed or privatised during this time).
- Only public institutes in seven Member States reported breeding activities in winter wheat (Bulgaria, Estonia, France, Italy, Portugal, Romania and Slovakia).
- 56 new winter wheat varieties were released by public institutes in the years 2000-2010 (compared to 773 released varieties for all crops).

Presentation S4-3: Climate change effects on wheat productivity

Jørgen E. Olesen, *Aarhus University, Aarhus, Denmark*

Temperature has been rising worldwide in the last decades; about 0.5 degrees since 1980. The changes over land are even more pronounced as oceans tend to buffer the heating above them. At least as important is the fact that the frequency of heat waves has increased, profoundly affecting the agricultural production. The warming in combination with displacement of rainfall patterns and an increased variability of rainfall means that climate change has an important effect on agricultural production. From an impact assessment point of view, climate change causes a set of challenges as some of the variables are not present in existing crop models or effects cannot be considered simultaneously. The major effects that should be included to understand the overall impact of climate change on agriculture and design appropriate adaptation strategies are:

- Increased atmospheric CO2 concentration
- Increasing temperatures
- Changes in rainfall
- Changes in extreme events (drought, hail, storms, heat waves).

Some of the factors have an antagonistic effect on wheat yields. Increased CO2 potentially leads to higher yield while the increased temperature decreases yields. Analysis based on observed yields from 1980-2008 seem to indicate that the combined effect has led to a 2.5% decrease in wheat yields. In more northern countries increased temperature affects the flowering date in winter wheat and extends the growing season, potentially increasing the yields. Moreover, simulation models seem to suggest that not only the average change but also variability in temperature has a detrimental effect on yields.

Observed data from Denmark over 16 years shows that there has been no significant yield increase but high variability. Detailed regression analysis reveals that the temperature in spring has limited effect but high summer temperatures reduce yield as no grain filling takes place. High winter temperatures however seem to increase yield, potentially through increased root development. With regard to rainfall it seems that rain later in the season is detrimental to yields due to problematic harvesting and disease development. Based on this information a model was build to predict future wheat yields and it seems the effect on average is limited and depending on the extent of the temperature change but variability will increase significantly. A similar exercise on Czech wheat yields shows similar tendencies but shows that the detrimental effect of temperature depends on current temperature in the region. The higher the initial temperature is, the higher the potential yield reduction. This effect seems to be more pronounced with modern management practices than with the management practices in the 19th century.

Depending on the assumptions in the different models the predicted effect of climate change on yields differ. The discrepancy between models increases with the assumed change in temperature. A common result over different models gives a clear North-South division in the effects, with conditions for wheat cultivation deteriorating in the Southern parts of Europe. This finding leads to the conclusion that a northward shift in wheat production will take place and all farmers have to adapt their practices in order to mitigate the effect of climate change. A whole variety of tools exists including changed timing, changed input use, changed cultivars, water saving technologies, increased monitoring and crop insurance. It will be key to use the right combination of tools in each situation. Special attention should be given to the implementation and development of tools to overcome the increased climate variability.

Annexes

List of participants to the workshop

EXTERNAL PARTICIPANTS			
	Name	Organisation	Country
1	BEENS Jean Paul	Fertilizers Europe	Belgium
2	BORDES Jean Paul	ARVALIS	France
3	CHARMET Guilles	INRA Clermont-Ferrand	France
4	GERJETS Tanja	ESA - European Seed Association	Belgium
5	JONES Huw	Rothamsted Research	United Kingdom
6	JONGENEEL Roel	Wageningen University	The Netherlands
7	LUCAS Hélène	INRA Versailles	France
8	OLESEN Jørgen E.	University of Aarhus	Denmark
9	PALOMAR Carlos	ECPA - European Crop Protection Association	Spain
10	PANAGIOTOPOULOS Ermis	Fertilizers Europe	Greece
11	PETIT Arnaud	COPA - COGECA	Belgium
12	REYNOLDS Amy	International Grains Council	United Kingdom
13	RYLKO Dmitry	IKAR / IMEMO	Russia
14	VAN ITTERSUM Martin	Wageningen University	The Netherlands
15	WILSON William	North Dakota State University	USA

	EUROPEAN COMMISSION	
16	DELINCÉ Jacques	JRC IPTS - Agrilife Unit, Head of Unit
17	DILLEN Koen	JRC IPTS - Agrilife Unit, Agritech Action
18	GOMEZ Y PALOMA Sergio	JRC IPTS – Agrilife Unit, Sustag Action
19	HELAINE Sophie	JRC IPTS - Agrilife Unit, Agritrade Action
20	IBARRETA RUIZ Dolores	JRC IPTS - Economics of Climate Change, Energy and Transport
21	JAFFRELOT Jean Jacques	Directorate General Agriculture and rural development (DG AGRI)
22	LANGRELL Stephen	JRC IPTS – Agrilife Unit, Sustag Action
23	LUSSER Maria	JRC IPTS - Agrilife Unit, Agritech Action
24	MARY Sebastien	JRC IPTS – Agrilife Unit, Sustag Action
25	M'BAREK Robert	JRC IPTS – Agrilife Unit, Agritrade Action
26	RIZOV Ivelin	JRC IPTS - Agrilife Unit, Agritech Action
27	RODRIGUEZ-CEREZO Emilio	JRC IPTS - Agrilife Unit, Agritech Action Leader
28	VIGANI Mauro	JRC IPTS - Agrilife Unit, Agritech Action

Agenda of the workshop

Workshop on "wheat productivity in the eu: determinants and challenges for food security and for climate change"

22nd & 23rd November 2012
European Commission (EC), Joint Research Centre (JRC)
Institute for Prospective Technological Studies (IPTS)
Unit "Agriculture and Life Sciences in the Economy" (AGRILIFE)

Venue: JRC-IPTS, Isla de la Cartuja, Edificio Expo, 1st floor, Room A30, c/ Inca Garcilaso 3, Seville, Spain
Contact: Mauro Vigani mauro.vigani@ec.europa.eu

AGENDA

Day 1 - Thursday 22nd November		
9:00 – 9:30	Welcome and objectives of the workshop	**Emilio Rodríguez Cerezo** and **Mauro Vigani** (JRC-IPTS)
Session 1 Wheat productivity trends in Europe and world-wide Chair: Emilio Rodríguez Cerezo (JRC-IPTS)		
9:30 – 10:00	Global wheat productivity trends • Regions of origin and current productivity of soft and hard wheat • Harvested areas and wheat yields by region at global level • Wheat productivity sensitiveness to price volatility	**Amy Reynolds** (International Grains Council) London, UK
10:00 – 10:30	Wheat productivity trends in the EU • The wheat sector in the EU: harvested area and production by country • The importance of wheat in the food industry in the EU • Changes in wheat yields in the EU: genetic potential and yields stagnation	**Gilles Charmet** (French National Institute for Agricultural Research - INRA) Clermont-Ferrand, France
10:30 - 11:00	**Coffee break**	
11:00 - 11:30	Wheat productivity in Russia and Ukraine • Wheat production and productivity trends in Russia and Ukraine • Factors affecting wheat productivity in Russia and Ukraine: environment, management and innovation • The potential of Russia and Ukraine in supplying wheat in face of increasing demand and food security	**Dmitry Rylko** (General Director of the Institute for Agricultural Market Studies - IKAR) Moscow, Russia
11:30 – 11:45	Prospects of the farming sector and rural development in Ukraine, Russia, Turkey and Kazakhstan	**Sébastien Mary** (JRC – IPTS) Seville, Spain
11:45 – 12:15	Wheat productivity: views from European farmers • The needs for farmers to improve wheat productivity • Factors constraining wheat farming: costs, revenues and innovation • Wheat producers heterogeneity across EU 27: focus on eastern EU countries	Arnaud Petit (Committee of Professional Agricultural Organisations – COPA, and General Committee for Agricultural Cooperation in the European Union - COGECA) Brussels, Belgium

12:15 – 12:45	Discussion on Session 1	
12:45 – 14:00	**Lunch break**	
Session 2 Innovation in production factors affecting wheat productivity Chair: Mauro Vigani (JRC-IPTS)		
14:00 – 14:30	Returns of R&D on crop productivity with focus on wheat • Global and European spending in R&D for improving productivity • EU public and private research by field of innovation: breeding and farming inputs • The innovation chain for improved productivity: from research to adoption	**William Wilson** (North Dakota State University) Fargo, US
14:30 – 15:00	Innovation for wheat breeding in the EU • Conventional, molecular-based and biotech methods for yield, biotic and abiotic stresses, and nutrient use efficiency in wheat breeding • The International Research Initiative for Wheat Improvement	**Hélène Lucas** (French National Institute for Agricultural Research - INRA) Versailles, France
15:00 – 15:30	Innovation in production factors and management practices for wheat cultivation • Recent wheat varieties in the market: characteristics at stake • Trends in input use and prices • New agrochemical tools to improve wheat productivity • Changes in management practices and wheat yields	**Jean-Paul Bordes** (Institut du végétal - ARVALIS) Paris, France
15:30 – 16:00	**Coffee break**	
16:00 – 16:30	Round Table: Statements by stakeholders	**Arnaud Petit** (COPA – COGECA) Brussels, Belgium **Carlos Palomar** (European Crop Protection Association) Brussels, Belgium **Ermis Panagiotopoulos** and **Jean Paul Beens** (Fertilizers Europe) Brussels, Belgium **Tanja Gerjets** (European Seed Association) Brussels, Belgium
16:30 – 17:00	Discussion on Session 2	
20:30	**Departure to dinner from Hotel NH Plaza de Armas**	

Day 2 - Friday 23rd November		
Session 3 Policies and regulations affecting wheat productivity Chair: Emilio Rodríguez Cerezo (JRC-IPTS)		
9:00 – 9:30	Market signals and EU policies effects on wheat productivity • How grains, inputs and energy prices increase and volatility affects wheat productivity • Yields gap analysis and agronomic interactions for productivity • EU policies affecting wheat farming and effects of CAP • What is new in the CAP towards 2020 and what potentially will affect wheat productivity?	**Roel Jongeneel** and Martin van Ittersum (Wageningen University) Wageningen, Netherlands
9:30 – 9:50	European nitrate and pesticides regulations impact on wheat productivity • The EU nitrates Directive and the use of nitrates fertilizers in wheat farming • The EU legislative framework on pesticides: requirements affecting wheat productivity	**Jørgen O lesen** (Aarhus University) Aarhus, Denmark
9:50 - 10:10	Plant Biotech regulations and wheat productivity • EU biotech regulation and field trials: effects on public and private research on wheat • The approval system for transgenic wheat varieties • The biotech regulatory framework and the on-farm productivity	**Huw Jones** (Rothamsted Research) Harpenden, UK
10:10 – 10:40	**Coffee break**	
10:40 – 11:10	Round Table: Statements by stakeholders	**Arnaud Petit** (COPA – COGECA) Brussels, Belgium **Carlos Palomar** (European Crop Protection Association) Brussels, Belgium **Ermis Panagiotopoulos** and Jean Paul Beens (Fertilizers Europe) Brussels, Belgium Tanja Gerjets (European Seed Association) Brussels, Belgium
11:10 – 11:30	Discussion on Session 3	

Session 4 Outlook on wheat productivity Chair: Mauro Vigani (JRC-IPTS)		
11:30 – 11:50	An outlook on EU supply and demand • Wheat world trade • EU wheat market developments • Consequences of macroeconomic and weather uncertainties on these developments	**Sophie Helaine** (JRC – IPTS) Seville, Spain
11:50 – 12:10	Plant breeding for a EU-bio-based economy (Breeding 2020) • Presentation of the project: "Plant breeding for an EU bio-based economy 2020 – the potential of public sector and public/private partnership"	**Maria Lusser** (JRC – IPTS) Seville; Spain
12:10 – 12:40	Closing presentation: Climate change effects on wheat productivity • Climate trends and wheat production at global and European level • Improved wheat characteristics for climate change • How to adapt wheat farming to climate change in Europe	**Jørgen Olesen** (Aarhus University) Aarhus, Denmark
12:40 – 13:00	Discussion on Session 4	
13:00 – 13:30	**Closing of the workshop and final discussion**	
13:30	**End of the Workshop**	

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Title: Proceedings of a workshop on " Wheat productivity in the EU: determinants and challenges for food security and for climate change "

Author(s): Mauro Vigani, Koen Dillen and Emilio Rodríguez Cerezo

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Abstract
The Institute for Prospective Technological Studies (IPTS) of the European Commission's Joint Research Centre (JRC) is starting a new research line with the aim to describe the current situation and analyze the elements affecting wheat yields and wheat farming productivity. To scope the issue, the JRC organised a workshop on "Wheat productivity in the EU: determinants and challenges for food security and for climate change" in Seville on 22nd and 23rd November 2012.
This JRC Scientific and Policy Report provides the proceedings of the workshop, that covered the following topics:

Session 1: Wheat productivity trends in Europe and world-wide
Session 2: Innovation in production factors affecting wheat productivity
Session 3: Policies and regulations affecting wheat productivity
Session 4: Outlook on wheat productivity

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