**WHEATAMIX**

*Increasing within-field wheat diversity to foster ecosystem services in the Parisian basin*

**THE WHEATAMIX CONSORTIUM**

**Key words:** Variety mixture, low input, GxE interactions, ecosystemic services, participatory ideotyping

**Summary:** Crop genetic diversity should play an essential role in the context of global change, as it can promote various ecosystem services essential for yield stability, adaptation to climate change and resistance to pests and diseases. In this context, the National Agency for Research project WHEATAMIX investigates mixing wheat genotypes to reinforce the sustainability of agricultural production in the Paris Basin, France. WHEATAMIX analyses the interactions among genotypes and with the environment, to develop new methods for breeding and/or combining wheat varieties to obtain blends performance, in terms of yield and quality, as well as other ecosystem services.

**Background**

During the 20th century, agriculture experienced major gains in productivity via homogenization and intensive use of inputs, two key components of the dominant model of agriculture in developed countries. This model is jeopardized by the awareness of rapid global change, increased environmental stochasticity and the need for greater agricultural sustainability. A new paradigm is emerging in which biodiversity is considered as a crucial asset for sustainable agriculture, relying more on ecological functions within agroecosystems. Crop genetic diversity should play an essential role in this context, as a key element contributing to agricultural multi-functionality and to the resilience of agroecosystems under rapid climate change and decreased chemical inputs. However, the use of genetic diversity within agroecosystems faces ecological, socio-economic, organizational and regulatory challenges.

**Variety Mixtures for wheat production in the Paris basin**

The main goal of the WHEATAMIX, a four years project started in January 2014, is to better evaluate the possible roles of within-crop genetic diversity to reinforce the multi-functionality and resilience of cropping systems under global change. WHEATAMIX focuses on a major cereal, wheat, in a central area of production, the Paris basin. The research is based on a highly multidisciplinary approach involving geneticists, agronomists, ecophysiologists, ecologists, economists and management scientists, as well as key stakeholders (“Chambres d’Agriculture”, farmers). It is structured in four complementary work-packages (fig. 1):

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2UMR Génétique Diversité et Ecophysiologie des Céréales (UMR 1095)-5 chemin de Beaulieu 63100 Clermont-Ferrand. 3UMR Environnement et Grandes Cultures (UMR 1091)-Route de la Ferme 78850 Thiverval-Grignon. 4UMR Institut d'Ecologie et des Sciences de l'Environnement de Paris (UMR 1392)-Univ. Paris 6 UPMC 7 quai Saint-Bernard 75005 Paris. 5UMR de Génétique Végétale (UMR 0320)-Chemin du Moulon 91190 Gif-sur-Yvette, Ecole Normale Supérieure-UMR 7144 Ecologie Microbienne de Lyon (UMR 5557USC1364)-Univ. Lyon 1 43 43 Boulevard du 11 Novembre 1918 69002 Villeurbanne, 6Chambre Régionale d' Agriculture du Centre-13 Avenue des Droits de l'Homme 45000 Orléans, 7UMR Sciences Action Développement Activités Produits Territoires (UMR 1048)-Bât. EGER BP01 78850 Thiverval-Grignon, 8UMR Biologie et Gestion des Risques en Agriculture (UMR 1290)-Bât. BIOGER CPP avenue Lucien Brégnier BP0178850 Thiverval-Grignon, 9Chambered d' Agriculturedu Loir-et-Cher-11 Rue Louis Joseph Philippe 41000 Blois, 10Chambre d'Agriculture de l'Indre-24 Rue des Ingrains 36000 Châteauroux, 11UMR Agronomie (UMR 0211)-Bât. EGER avenue Lucien Brégnier BP0178850 Thiverval-Grignon, 12FDGEDA du Cher-2701 Route d'Orléans 18230 St Doulchard, 13UMR Centre d'Écologie et de Sciences de la Conservation (UMR 7204) - 55 rue Buffon 75005 Paris, 14Chambre d' Agriculture du Loiret-21 Bis Rue des Hauts Champs 45380 Chapelle St Mesmin, 15UMR Laboratoire d'Economie Appliquée de Grenoble (UMR 1215)-Univ. Pierre Mendès France BP47 38040 Grenoble Cedex 09, 16Chambre d' Agriculture de l'Eure-5 rue de la Petite Cité BP 882 27008 Evreux, 17Chambre d' Agriculture Seine et Marne-418 rue Aristide Briand 77350 Le-Mée-Sur-Seine.
- WP1 characterises key morphological/ecophysiological traits and genetic variability of wheat genotypes. We examine the plastic response of these traits to plant-plant interactions and test how trait complementarity affects the performance of wheat genotypes in blends through experiments and modelling.
- WP2 quantifies multiple ecosystem services provided by variety diversity within wheat fields: yield (including grain quality) and its stability, regulation of foliar diseases, insect pest and weed biocontrol, maintenance of soil fertility, along with biodiversity conservation. We analyse trade-offs and synergies among ecosystem services, as well as links between particular groups of services and bundles of variety traits.
- WP3 studies the techno-economic performances of blends and associated groups of services for -and their acceptability by- key stakeholders. We explore the organisational and economic bases of blend choice by the wheat chain (from seed companies to millers), with a focus on the Paris basin. Existing lock-in to the use of associations of wheat varieties will be analysed.

These three WPs use common, complementary experimental approaches: i) individual plant phenotyping to characterize traits and their plasticity for 50 wheat varieties; ii) a main diversity experiment (sixty-five 100m$^2$ wheat plots with 1, 2, 4 or 8 varieties, under low input) to quantify variety diversity effects on ecosystem services; iii) replicates of the same diversity experiment in 5 sites across France using smaller (7m$^2$) plots, under low and high inputs, to test the robustness of wheat diversity under a wide range of environmental conditions; iv) a network of 50 farms, encompassing agro-climatic variability in the Paris basin, to compare the ecological and techno-economic performance of blends with that of monocultures, using indirect links with key stakeholders.
- WP4 combines results from WPs1-3 and mobilizes key stakeholders to build scenarios for the development of wheat variety blends in the Paris Basin considering various future climatic and economic contexts. Opportunities offered by and impacts of the introduction of wheat variety blends in the Paris production basin will be assessed on the basis of these scenarios. Furthermore, new breeding methods will be developed for an efficient selection of genotypes with high combining ability in mixtures.

Figure 1:

Figure 1: General organisation of the WHEATAMIX project.

Description of the three common experimental designs: Measuring ecosystem (dis)services associated with blends necessitates parallel work of the different teams on shared experiments. Three main designs will concentrate our experimental efforts: 1) one central diversity experiment, 2) a related multi-site experiment, 3) a network of on-farm experiments.