International Workshop
on
Dryland Science for Food Security and Natural Resource Management under Changing Climate

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ABSTRACTS

Background and Objectives

Drylands cover more than 40 per cent of the Earth and are home for nearly two billion people -- one-third of the world's population. Unsustainable land management and climate change are exacerbating the desertification phenomenon, ultimately leading to hunger and poverty.

It is estimated that 10 – 20 per cent of drylands are already degraded. Dryland degradation is a serious obstacle to alleviating extreme hunger and poverty. It hinders all efforts to ensure environmental sustainability. The negative and expanding effects of rapid desertification on the implementation of the UN Millennium Development Goals - to be met by 2015, are deeply concerning.

Dryland science, defined as *"science and technology which contribute to maintaining and improving the sustainability of the nature–society system in drylands"* should play a significant role in improving food security and natural resource management in the context of changing climate.

This workshop aims to:

- sum up the past academic/capacity building achievements carried out by the collaborative projects between the Tottori University (TU) and the International Center for Agricultural Research in the Dry Areas (ICARDA)

- discuss the appropriate way in which the collaborators can advance their future joint activities with their international partner institutes and experts

- offer an opportunity to facilitate networking of international research and activities within the field of dryland science.

Organizing Committee

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Oral presentation

O-1-1

Multiple derivatives to utilize wild diversity for drought tolerant crop breeding

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In breeding of common wheat, the most promising wild species is *Aegilops tauschii*. This species distributes wildly in central Asia and possesses common genome with common wheat. We measured drought-related physiological and morphological characters of 33 lines of *Ae. tauschii* in well-watered condition and drought condition. Simultaneously, the same characters were measured for the synthetic hexaploid wheat lines that were produced by crossing between durum wheat and the same *Ae. tauschii* lines. Although both *Ae. tauschii* and the synthetic wheat lines showed great genotypic variation, there were no correlations between the performance of the *Ae. tauschii* and the corresponding synthetic wheat lines. This indicates that traits of the diploid wild species (*Ae. tauschii*) are not reflected in the hexaploid synthetic wheat and suggests that drought-related characters controlled by many genes should be evaluated in hexaploid level.

Synthetic wheat has the same genomes as common wheat, but its morphology is quite different from modern wheat cultivars. This may suggest that drought tolerance expressed in synthetic wheat may not appear in the genetic background of common wheat. Thus, the genes of synthetic wheat should be introduced to common wheat background as being synthetic derivatives. However, if we choose one synthetic wheat in this process, we may lose the genes of *Ae. tauschii* that may express high performance only in the common wheat genetic background. Thus, I propose to produce 'Multiple Synthetic Derivatives' (MSD) population. The MSD population is defined as a population of practical common wheat cultivar including variety of genes of *Ae. tauschii* and durum wheat.

To produce the MSD population, many strains of synthetic wheat are crossed two times with a leading cultivar. The obtained BC_1F_1 seeds were mixed for making bulked population and increasing seeds in well-conditioned field. The population including 3/4 of the genes of practical cultivar and 1/4 of synthetic wheat could be initial source for selection in different conditions. Once this population could be produced, it will be used for other breeding purposes.

Breeding is basically a process to generate variety of haplotypes by recombination and to select a plant with the most desired character. Mischose of the parents in the initial cross does not lead to good results. MSD population would be useful source for breeding especially targeting drought tolerance controlled by many genes.

O-1-2

Identifying and applying novel genes for tolerance and adaptation to dryland stresses

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ICARDA's mission is to contribute to the improvement of livelihoods of the resource-poor in dry areas by enhancing food security and alleviating poverty through research and partnerships to achieve sustainable increases in agricultural productivity and income, while ensuring the efficient and more equitable use and conservation of natural resources. Climate change, depleted ground water reserves, population growth, desertification, salinity, demand for bio-fuels create a potential uncertain future for agriculture. The need to collect and conserve biodiversity has never been more urgent. Plant breeders will increasingly have to *screen collections* for traits essential to keep pace with rapidly changing agro-ecosystems. Water availability is the major challenge for production of cereals and food legumes in dry areas. Proven technologies are the development of water efficient cultivars which can be tailored to these environments and new cropping systems. Exploitation of landraces and wild relatives have boosted the level of drought tolerance measured as yield increases and enhanced WUE in these crops under Mediterranean environments. ICARDA with its partners have developed the Focused Identification of Germplasm Strategy (FIGS) to choose subsets of accessions from the global collection that have a high probability of containing the trait of interest. This strategy has already been successfully applied to some biotic stresses and the search for abiotic stress will follow. Identification of the genes responsible for drought tolerance will facilitate the understanding of the molecular mechanisms of drought tolerance, and serve for biotechnology-assisted genetic improvement through marker assisted selection or gene transformation. We are using several genomic tools to identify such key genes. We have used microarray analysis to identify candidate genes. These candidate genes are mapped onto mapping population or association panels and analysis of quantitative traits loci (QTL) is performed. Ultimately, these candidate genes are used in plant transformation to improve drought tolerance.

O-1-3

Genomics of dry land crops

Dina Aziz El-Khishin

O-1-4

Synthetic hexaploid wheat: Panacea to sustainable wheat production

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The challenges of feeding a world population of 9 billion people, as projected by mid-century, are immense and sustainability of the natural resource base must be preserved. In order to meet the food and fiber needs of the ever increasing population, far-reaching increases in agricultural output are required. However, the demand for wheat and wheat products is projected to increase by 20-30% in the future particularly in developing countries. This is against the backdrop of continuing stagnation in current production with wheat demand outstripping supply in 6 out of the last 10 years. At the same time, climate-change induced temperature increases as well as the constant threats of evolving disease virulence continue to undermine current efforts.

Incorporation of genetic diversity into elite wheat cultivars has long been recognized as a means of improving wheat production and securing global wheat supply. Synthetic hexaploid wheat (SHW) recreated from its two progenitor species, the tetraploid, *Triticum turgidum* (2n=4x=28, AABB) and its diploid wild relative, *Aegilops tauschii* (2n=2x=14, DD) are a useful resource of new genes for bread wheat improvement. Within the last decade, it has been demonstrated that SHW can be used to improve abiotic and biotic stresses that limit wheat production. We present results on previous and on-going efforts at the characterization of SHW for various foliar and root diseases, the identification of novel multiple disease resistance, their transfer into bread wheat including development of wheat germplasm with enhanced biotic and abiotic stress tolerance. We also examined the yield of synthetic derived wheats grown as a means of improving yield potential and found for most agronomic traits investigated that the synthetic-derived wheat have greater range of yield and yield enhancing variation than commercial cultivars under marginal and optimal environments worldwide. The surges in exploiting this mode of genetic variability hold the greatest potential in meeting the targets of projected wheat productivity gains and secure global food security.

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O-2-1

Challenges for reconstruction of wheat breeding systems for sustainable crop production in Afghanistan – JST/JICA SATREPS scheme

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Rapidly growth of the global population and climate change are great concern for sustainable food production and environment conservation in developing countries. Wheat breeding and genetic studies will find a way of great advantage for sustainable wheat production and food security for sustainable development with global food security. In Afghanistan, the re-establishment of farming system is one of the major contributions to poverty reduction and social welfare. The accumulation of scientific knowledge, technology development, researcher’s training, the restoration of related facilities and effective extension services are essential. Wheat is the most important crop as Afghan staple food, but its production volumes are not able to meet demand due to low productivity under the unfavorable natural condition, such as drought. While wheat production currently depends on rain fall, the expansion of irrigation system and wheat breeding system adapted to marginal lands in the Afghan climate will be critical. Our new five years project ‘Development of wheat breeding materials for sustainable food production in Afghanistan’ supported by SATREPS program of JICA/JST, Japanese government launched in full swing from 2011 April. Aim of this project is development of wheat breeding system for sustainable food production in Afghanistan to conserve the local varieties and wild relatives of wheat maximizing their potential as a breeding material for high yield and good quality. Overall goal of this project is that national crop breeding system provides a core function to increase wheat production in Afghanistan.

O-2-2

Wheat improvement and sustainable production in Afghanistan

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Afghanistan over most of the country, the climate is arid and semi-arid, with rainfall ranging from 100 mm to 400 mm per annum. Cold winters and hot summers contribute to the harsh climate found in many parts of the country. Due to its steep topography or dry deserts only 7.6 million ha or about 11% of it is arable.

Wheat is grown in all 34 provinces of Afghanistan either under irrigation or rainfed. It is major crop, accounting for roughly 70%of the cultivated land area. It is a staple food crop, accounting for approximately 60% of the caloric intake of the population. The average per capita consumption of wheat per annum is about 160-180 kg.

National wheat production levels range from 1.5 million to 5.0 million tons per year over the past 5 years. Biotic and aboitic stresses are main production constraints, diseases, pests and weeds are main constraints to productivity. Water/rainfall quantity, quality and distribution in the season are important in predicting crop season and wheat yield. Two important issues in improving of crop productivity in moisture limited environment are improving productivity of crop and improving WUE through agronomic measures. Replacement of old varieties with modern, high yielding varieties will both protect farmers against diseases, and benefit by at least 15% higher yields even in the absence of wheat diseases.

Wheat research in the country has so far emphasized the release of new resistant varieties agronomy and pathology issues. Research conducted in five main areas 1) identify suitable varieties 2) developing/adapting appropriate wheat production technologies 3) capacity building, 4) Pre release seed multiplication, and 5) establish linkages and partnership. The over all impact of research is reflected in total production and productivity. Wheat productivity increased from 1.15 t/ha prior to unrest to 1.97 t/ha in 2009 registering an increase of over 72%. The total wheat production during the same period increased from 2.35 million metric tonnes to 5.06 million metric tonnes with a growth of 116%. Research oriented for making wheat choice of farmers and customers include high stable yield, drought tolerance, resistance to rusts, white/amber grain colour, early maturity, Afghan bread making quality and palatable straw.

O-2-3

Development of drought tolerant winter wheat genotypes for drylands of CWANA

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Drought is the most important environmental constraint that reduces the crop yield in Central West Asia and North Africa (CWANA). Because it is not predictable in the region that makes it difficult to take measurements in advance or develop drought genotypes for a certain type of drought as it may come in early or late growth stage of the crop. Winter Facultative Wheat (WFW) has been grown around 18 million ha in CWANA, starting from Atlas Mountains in North Africa to highlands of Afghanistan where primary target of the International Winter Wheat Improvement Program (IWWIP). IWWIP is a joint program carried out by Turkey, CIMMYT and ICARDA that operates since 1986 and develops and provides WFW germplasm to about 150 collaborators in around 50 countries in the world. Within 25 years, more than 40 cultivars selected from the germplasm provided by IWWIP have been released in 12 different countries covering around 1.7 million ha.

One of the main aims of the IWWIP is to develop drought tolerant germplasm that performs well under CWANA agroecological conditions and provide that germplasm to its collaborators. For this purpose, one site in each location, Konya and Eskisehir in Turkey has been established to test the material under field conditions. The diverse and advanced germplasm have been planted in the fields of each location after safflower. Safflower consumes most of the soil moisture that allows us to control the soil moisture by applying drip irrigation. While grain yield difference of same genotypes between Supplemental Irrigation (SIR) and Rainfed plots is 2-3 times in 2009-2010 growing season, dry season, it is around 40-50 % in 2010-2011 growing season, rainy year. The other approach for selecting drought tolerant germplasm is to test the material in multilocation trials where the amount and distribution of precipitation differs in time and space.

By doing so, IWWIP compiles diverse and advanced germplasm and distributes to IWWIP collaborators.

O-2-4

Identification of high yielding and drought tolerant facultative/winter wheat genotypes at ICARDA

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Drought is the principal yield limiting factor for wheat production in the CWANA region. As water is becoming scarce even in the irrigated areas of the region, ICARDA's germplasm development approach is to identify genotypes with high yield potential and water use efficiency in order to minimize and maximize yield gains during drought and good seasons, respectively. With this end, we carry out annually more than 500 crosses, and evaluate the segregating populations using the modified pedigree/selected bulk approach under irrigated conditions while the preliminary and advanced yield trials are evaluated under both irrigated and rain-fed conditions. With this approach, we have identified genotypes which yield as high as 6.5 and 2.5 t/ha under irrigated (450 mm) and rain-fed (232mm) conditions, respectively. These germplasm combine high yield potential, drought tolerance, yellow rust resistance and grain quality. The performance of these elite drought tolerant genotypes in selected countries is also included in this report.
Key words: Drought, resistant genotypes, wheat

O-2-5

Winter wheat breeding for drought tolerance in Turkey

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Turkey is one of the biggest wheat producers in the world, with annual production of 17 to 20 million metric tons (MMT) and area of 8 to 9 million hectares (MH). Winter wheat (WW) production and area in Turkey are annually 6 to 6.5 MH where cover mainly Central and East Anatolian and Trakya Regions and 12 to 13 MMT, respectively.

Before wheat research and training project (WRTP) was started in 1971, National WW breeding program had been carried out to develop pure line mixtures (e.g. Ak702, Sertak52 and Yayla305) from landraces and multiline varieties (Melez13) from crossings. After WRTP was started, WW yield, production and area of Turkey doubled because of breeding of high yielding varieties from crossings and improving of agronomy practices (e.g. application of fertilizers, pesticides and advanced equipment etc.). Today, 5 Institutes in which WW breeding program is conducted have developed more 60 WW varieties.

The last three decades have witnessed substantial progress on quality and diseases resistance as well as yield potential in WW breeding program of Turkey. Many WW cultivars have been released due to their good end-use quality traits and high levels of resistance to diseases. Undoubtedly, international collaborations of Turkey with CIMMYT and ICARDA (e.g. IWWIP) have enhanced the progress in WW breeding program of Turkey.

Majority of the WW production area of Turkey is of the rain-fed characteristic, where precipitation amount and distribution are unpredictable. Long term precipitation amount ranges from 300 mm in Konya to 600 mm in Edirne. Therefore, variation between years is larger than those of within years and between and within locations in the WW production area of Turkey. Soil characteristics of locations on which 5 institutes are located are also mainly diverse.

Yield potential of recently released WW cultivars in Turkey is quite high, but there is a gap between on farm yield and trial plots yields, because improper practices of agronomy still continue on farm and the drought has been much more severe ever than before as a result of climate change and/or global warming.

To cope with the drought, Turkey established the Center of Excellence in Drought Research in Konya in 2010. It will serve not only Turkey but also other countries in the CWANA.

Key words: Winter wheat, breeding, drought, Turkey.

O-3-1

Survival strategy of salt-loving plants in salt-affected soils

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Many Chenopodiaceae plant species grow healthily in salt-affected soils. The salt-loving characteristics of Chenopodiaceae plants are not clearly understood. In experiment 1, the degree of dependence of Chenopodiaceae plants on Na was investigated. Common glasswort (*Salicornia bigelovii* Torr.), table beet (*Beta vulgaris vulgaris* L.), Swiss chard (*Beta vulgaris* L.) and Mexican tea (*Dysphania ambrosioides* L.) were grown under 0, 20, 40, 80, 120, 160, 180, 200 mol m^{-3} NaCl in nutrient solution for 7 days. The optimal Na concentration for common glasswort was 200 mol m^{-3}. That for Swiss chard and table beet was 80 mol m^{-3}, with 148% and 135% larger DW than that of 0 mol m^{-3}. Growth of Mexican tea decreased with increasing NaCl concentration. The degree of dependence on Na, therefore, decreased in the order, common glasswort, Swiss chard, table beet and Mexican tea. In experiment 2, the relationship between absorption of N and that of Na and K in common glasswort, table beet and Swiss chard was investigated. They were grown under six K : Na ratios with 4 mol m^{-3} NO_3^- in nutrient solution. Growth of common glasswort was stimulated under low K : Na ratios. Swiss chard could use both K and Na for satisfactory growth. In common glasswort and Swiss chard, NO_3^- absorption depended on Na absorption. This was not observed for P, Ca and Mg. Na, therefore, specifically stimulated NO_3^- absorption. The role of Na was not replaced by K. Table beet showed a better growth under low K: Na ratios, but the absorption of NO_3^- did not depend on Na. The dependence of NO_3^- absorption on Na decreased in the order, common glasswort, Swiss chard and table beet, same order as in growth. It is suggested that salt-loving property is related to the dependence of N nutrition on Na.

O-3-2

Influence of intercropping of bread wheat and faba bean on phosphate uptake and yield under Mediterranean conditions

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Intercropping, i.e. the simultaneous growth of at least two crops in close proximity, may provide synergistic effects that in comparison to mono-cropped crops stimulate increased productivity, quality of products and nutrient uptake or a reduction in weeds or losses of nutrient by leaching. Research on the intercropping of cereals and legumes has shown that the legume component may increase plant-available soil phosphate by the release of organic root excudates (organic acids), benefiting both the cereal and legume component. To test the effectiveness of such mechanism, we planted bread wheat and faba bean in alternating rows with two different row spacings and three levels of P fertilizer application (0, 20 and 50 kg P ha^{-1}) at ICARDA research farm in northern Syria during the cropping season 2010/11. Even though the final P content in wheat grains was indeed higher under wide row-spacing intercropped conditions (pointing towards improved P-uptake), the yield of wheat as well as of faba bean was significantly lower than the mono-cropped control irrespectively of row spacing or P fertilization. To some degree this may have been due to the unusually dry weather conditions stressing especially the intercropped faba bean component, and which only partly could be offset by supplemental irrigation. Repetition of the experiment in the coming season – then eliminating any influence of severe droughts by drip-irrigation – will reveal whether the system is a viable alternative for enhanced production of cereals and legumes in Mediterranean soils.

O-3-3

Strategy of cultivar selection for improving both water use efficiency and yield in dryland

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Stomata, as the main switch for controlling water efflux and CO_2 influx, controls both photosynthetic assimilation and water loss through transpiration. Studies up to date indicated that stomatal conductance is an important factor affecting water use efficiency (WUE) of crop cultivars, also the main factor that limits yield. Though the trait has large variability under different water conditions, its effect on WUE and yield depends on water conditions of the whole growing period in the local areas. Under well-watered conditions, the goal for high yield is apt to be conflicting with that for water saving, due to the fact that high stomatal conductance confers both higher photosynthetic rate and higher transpiration rate, while low stomatal conductance restricts both water loss and photosynthetic assimilation in the meanwhile. Under water deficit conditions, difference exist among genotypes in the sensitivity of stomata to soil and air drying, which resulting in larger difference in WUE. Sensitive genotypes strongly reduce stomatal conductance in relatively mild levels of drought, which may conserve soil water and benefit growth in later stages. Less sensitive genotypes show smaller reductions in stomatal conductance under drought, which can maximize water extraction. Higher yield and higher WUE can be obtained through appropriate strategy of cultivar adoption. For the areas under limited irrigation, where long term or serious drought seldom occurs, cultivars with low stomata sensitivity to soil drying and larger stomatal conductance when released from water stress at irrigation or rain may maximize water use and gain high yield. For the drought rain-fed areas, where wheat crop grows partly depending on the stored moisture, lower stomatal conductance under no water stress and higher stomata sensitivity to soil drying may result in a higher yield.

O-3-4

Phenological variation and water productivity in dryland wheats in response to climate change over last decades

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Over last five decades, the Loess Plateau of China tended to become climatically drier and warmer from southeast to northwest. A significant tendency in climate change is the increased average air temperature in winter as major contribution. This is directly caused a noticeable difference in phenological cycle, field productivity and water use between winter wheat and spring wheat. For winter wheat, whole growth period has been shortened for 6-9 days over last decades and the sowing period has been postponed for 4-8 days. The data indicated that shortened overwintering period was major factor leading to reduction in whole growth period since there was not obvious difference in days of pre- / post- wintering periods. The reduction in days of overwintering period might play a critical role to improve the rate of seedling regreening and the grain yield per unit. Comparing with winter wheat, there was not obvious difference in growth cycle length in spring wheat. However, sowing period of spring wheat was early shifted for 2-7 days. Critically, the period from seedling to booting was prolonged for 4-5 days, which maybe a cue of more photosynthetic products distributing into vegetative growth. Regional warming led to a reduction of 10-20% in grain yield in spring wheat. Climate simulation models predict that mean temperature on the Loess Plateau of China will increase by 2.5 to 3.75 ℃ by 2050, which leads to a great change in phenological variation and water use efficiency in dryland wheats. Our results indicated that breeding for tolerance of increased temperatures will be necessary to counter the regional warming, while a greater emphasis on breeding for increased drought resistance and shortened growth cycle will lesson the impact of climate change. Importantly, winter wheat might be preferable than spring wheat regarding phenological variation and water productivity in response to climate change.

O-3-5

Sodium transport in wheat: Variation in exclusion and sequestration

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Genetic improvement for salinity tolerance in wheat is one of the options of maintaining and/or increasing wheat productivity and reducing the impacts of increasing salinization on else whilst productive land. There are a number of possible mechanisms by which cereals can tolerate relatively high levels of salinity. In this study, we report the results from the evaluation of 150 hexaploid wheat genotypes for the rate of transferring sodium from root to the shoot (xylem loading) and the capacity of the leaf sheath to extract and sequester sodium as it entered the leaf (leaf sheath sequestration) both important mechanisms underlying salinity tolerance. The 150 bread wheat genotypes consists of five groups: 48 genotypes from the Focused Identification Germplasm Strategy for salinity (ICARDA Gene Bank), 40 genotypes previously reputed as possessing salinity tolerance, 21 synthetic hexaploid wheat (SHW), 31 uncharacterized elite ICARDA germplasm and 10 Syrian cultivars, and were screened in hydroponics system in 100 mM NaCl.

A large variation in xylem loading and Na^+ leaf blade concentration of the 3rd leaf were identified, ranging from 2.65 to 61.22 µmol Na^+ and from 56.28 to 1216.11 mmol Kg^{-1} DW respectively. In contrast, a low variation in sheath storage % (the proportion of Na^+ entering the leaf that was withdrawn into the sheath) was observed ranging from 14.79 to 40.49%. On concentration basis, Na^+ retention %, (the proportion of the difference between Na^+ concentration in sheath and blade to the total Na^+ leaf concentration, varied from -51.8% (no preferential withdrawn of Na^+ into sheath cells) to 134.3%. Na^+ leaf blade concentration correlated significantly with the xylem loading (R^2= 0.71), whereas no correlations were found with both sheath storage% and Na^+ retention%, indicating that the rate of Na^+ delivery from root to shoot is much important than leaf sheath sequestration since the later in itself would delay the accumulation of Na^+ in leaf blade but could not maintain low blade Na^+ levels for very long (due to the small size of the sheath) if Na^+ delivery to the shoot were rapid. The significant genetic variation identified for different mechanisms offers breeders' opportunity to transfer these into elite locally adapted wheat cultivars which can be used in improving wheat production in marginal environment where salinity problems persists.

O-3-6

Drought adaptive traits and wide adaptation of spring wheat advanced lines and lines derived from resynthesized hexaploid wheat

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Strategic trait-based crossing has combined complementary physiological traits in a new generation of progeny that when compared to conventionally bred advanced lines show superior expression of yield. High yielding advanced lines have been identified in several environments in North Africa, Western and South Asia, as well as in Mexico. Traits associated with yield in these environments will be presented and advanced lines showing the most appropriate expression of physiological traits will be shown. An important source of drought adaptive traits has been shown previously for synthetic hexaploid derived wheat lines outperformed recurrent parents in part due to increased root mass at depth and better water extraction capacity. A group of four elite synthetic derived (SYN-DER) lines and parents was grown under full irrigation and drought conditions to dissect some of the physiological features conferring tolerance to drought. SYN-DER wheat lines showed on average a 26% yield increase as compared to the parental hexaploid wheats under terminal drought. Different strategies for drought tolerance were observed including: earliness to flowering, greater root mass at depth, greater water extraction capacity and increased water use efficiency (WUE) at anthesis. Some degree of independence was identified between these traits when comparing SYN-DER lines suggesting that these traits are regulated by different genes. The elite SYN-DER 'Vorobey' was an important source of improved root mass at depth under drought. We conclude that the use of wild species of wheat has the potential to improve a range of stress-adaptive traits, and may permit modern bread wheat to become adapted to a wider range of environments including climate change scenarios.

O-4-1

ICARDA approach in coping with water scarcity in dry areas

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Drought, water scarcity and land degradation are the main limiting factors of agricultural sustainability and production in CWANA region. This will be exacerbated by the climate change as predicted by the general models. To cope with these problems, the Integrated Water and Land Management Program of ICARDA has developed a research program based on 4 pillars: Water and Land resources Assessment, Water and Land Productivity Improvement, Combating Land degradation and Drought and Climate Change Management. In addition to these three orientations, there two cross-cutting aspects: the institutional set-ups and policies and NARS training conducted jointly with the socio-economy program and the capacity development unit of ICARDA, respectively. The research programs are community based, participatory and integrated with the NARS as full partners and it is based on the benchmark approach. The research themes are the development and out-scaling of integrated techniques of water saving and water productivity improvement such as supplemental irrigation system in rainfed areas, deficit irrigation, raised bed planting and salinity management in irrigated areas, water harvesting systems in agro-pastoral areas and soil conservation and irrigation management in mountainous agro-systems. Parallel to the work in the field, modeling tool is used to simulate different scenarios of natural resources management and impacts at a large scale. In fact, models have been validated/calibrated and tested for watershed management in the agro-pastoral and mountainous areas, water and nutrient/salinity flows at the tertially canal level in irrigated areas and basin water allocation in rainfed areas. Moreover, a growth model was used to predict the effect of climate change on wheat production and the impact of improved technologies such as supplemental irrigation. Studies on genotypic variation of drought and heat tolerance and nitrogen use efficiency have been studied with breeders to characterize ICARDA genetic material and identify agro-agro-physiological and markers that the can be used in breeding programs for drought and climate change.

O-4-2

Irrigation practice of paddy rice dominant areas in the lower Ili River Basin, Kazakhstan

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The lower Ili River Basin in Kazakhstan is located in an arid region where large-scale irrigated agriculture has been developed since the late 1960s. Lately, there has been water-use adjustment between agriculture in the lower part and hydropower in the middle part. Moreover, farmland in this area has been faced with salinity problem. The characteristics of irrigated agriculture in this area are summarized as follows; (1) Conveyance and distribution efficiency is very low due to the earthen canals in the system, (2) Continuous irrigation is practiced in paddy rice fields while irrigation for upland crop fields is only once or twice, and (3) Upland crop uses the groundwater which is raised by seepages from canals and paddy rice fields. Therefore, to control groundwater level by proper irrigation practice is quite important for agriculture in the area.

This study analyzed temporal and spatial distribution of water delivery in the irrigation system and relationship between irrigation practice and groundwater level fluctuation in this area since the land development in order to assess the sustainability of paddy rice and upland crop rotation system. The results are summarized as follows; (1) Fluctuations of groundwater levels range from 1 m to 2 m in irrigated area and groundwater level reaches to the ground surface at some observation points during the mid irrigation season because some areas are relatively low and drainage does not function, (2) Water withdrawal from the Ili River has recently reduced and it is observed that there has been a tendency that the groundwater levels at most of observation points have slightly decreased, and (3) Paddy rice and upland crops rotation system might work well in the area where the farmland was properly developed in terms of the elevation of the farmland and drainage facility.

O-4-3

Grain production and sustainable management for rainfed agroecosystem based on rainwater harvesting technology in the semi-arid Loess Plateau of China

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Natural regional vegetation and soil quality in the semi-arid Loess Plateau of China have been seriously degraded due to over-grazing and frequent reclamation of natural grassland. Farmer's food demand and activity are the dominating factors. Transformation of natural vegetation to farmlands and repeated reclamation of wasteland resulted in water loss, soil erosion and land degradation. To restore natural vegetation and soil quality, we have to find a way to meet food demand by increasing productivity in the small portion of more fertile lands so as to reduce the pressure on the vast but infertile lands in the region. The key step of increasing grain yield per unit area in semi-arid zones is to improve field environmental conditions, including soil moisture supply, topsoil temperature and soil nutrient level. We have accomplished this through the combination of rainwater-harvesting technology with plastic film mulching and fertilizer application, and demonstrated to increase water use efficiency by at least 40% and the unit grain yield twice or more. Based on these technologies, we propose an approach of water-harvesting ecological agriculture (WHEA) and associated landscape configuration. Under the WHEA, unit yield of grain and cash crops can be increased greatly through rainwater harvesting technology, and the watered cropland can be interspersed with improved pastures and restored natural vegetation in a continuous landscape (e.g. a typical hill). Various types of grasslands will replace cropland in a large proportion of the landscape; animal feeding will be mainly dependent upon pen feeding in order to decrease grazing pressure. These strategies help maintain the agro-ecological sustainability and meet the industrial planning in the region. In summary, WHEA can lead to significant improvement for the gain productivity, restoration of degraded ecosystems and regional sustainable development in the semi-arid Loess Plateau of China.

O-4-4

Economic and environmental impacts of supplemental irrigation in rainfed agriculture: the case of wheat in Syria

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In the face of rapid depletion of ground water in Syria, some farmers continue to apply excessive amounts of irrigation water. Market and non-market valuation methods are employed in this study to measure the economic and environmental impacts of the shift from traditional supplemental irrigation (TSI) to improved supplemental irrigation (ISI) of wheat farms in the relatively wetter zones (zones 1 and 2) of the Aleppo, Deraa and Al-Hassakah provinces of Syria. At the low (22.3%) level of its current adoption, ISI helps the conservation of at least 120million m^3 of water per year. Under different scenarios, the estimated total economic and environmental impact of ISI could be as high as 223 million SYP per year. The impact of ISI is more pronounced when coupled with sprinklers where the combined impact of the introduction of the ISI and sprinkler technologies is estimated at 666 million SYP. On the other hand, our results also show that given the 16% chance of receiving higher than 450mm precipitation and the high current application rates of irrigation water, soil salinity is not a threat in the study areas. At the current average precipitation of 358mm, the application of 630 mm irrigation is sufficient to reduce salinity from 6dS/m to under 1dS/m in one season. Introducing a prohibitively high water user charge for every cubic meter applied in excess of the recommended application rate of 1800m^3 may ensure adoption of ISI by most (if not all) farmers leading to further conservation of about 234 million m^3 of water per year. Such a policy not only promotes ground water conservation but also increases farm profits and the productive value of water.

O-5-1

Ecosystem restoration using Tamarisk in drylands of China

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Extensive degradation of irrigated lands due to salinization is a major problem in northwestern China. Afforestation using salt tolerant tree species, such as *Tamarix* spp., can restore ecological function and improve the productivity of highly salinized lands.

Tamarisk (*Tamarix* spp.), a halophyte shrub native to Eurasia and Africa, is capable of utilizing a groundwater source and secreting salts from salt glands in their leaves.

To reveal whether tamarisk plantation can improve degraded saline lands in drylands of Inner Mongolia, China, we investigated salt movements in a regenerated Tamarisk (*Tamarix austromongolica*) forest and also investigated salt contents in soil in the forest and a bare land. Vegetation survey was conducted in plots in the forest, and biomass was estimated by harvesting ten trees outside of the plot. The samples of soil, litter falls, throughfall, and stem flow were collected in the forest. We also collected soil samplings in a bare land. Cation concentrations in the soil, tree, litter falls, and rainfall were analyzed. In the forest, the Na accumulated in the biomass was less than that included in litters, throughfall, and stem flow. However, soil Na content in the forest was much lower than that in the bare land, and the Na in the forest soil was not concentrated in the surface. Furthermore, soil in the forest had more K, Ca, and Mg contents than in the bare land. These results suggest that tamarisk forest can decrease salinity levels.

O-5-2

Conservation and sustainable utilization of agrobiodiversity of Aralo-Caspian desert margins

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The ecosystems of the Aralo-Caspian desert sub-province (Iran-Turanian province) with a mosaic of clay, stone, salt and sandy deserts being geographically and ecologically marginal supports the highest level of biological richness and rates of endemism (of above 20%), which might serves as unique wild gene pool for crops domestication and sustainable utilization. The area is dominated by rarefied semi-shrub communities formed by the perennial saltworts, *Haloxylon* (*Chenopodiacea*), large genus of *Artemisia* (Asteraceae), woody shrubs of Calligonum (Polygonaceae), wild relatives of *Allium*, legumes (*Astragalus*, *Vicia, Onobrychis, Cicer, Alhagi Glychyrryza* and others. These phytogenetic resources play a very important role in the rehabilitation of degraded saline affected lands, improving of arid fodder production of large open areas of rangelands, controlling elevated water tables, utilization of non-conventional water resources, and stabilization of sand dune systems. Under currently going climate changes these Aralo-Caspian Desert Corridor being considered as one of the most fragile are characterized by reduced species-richness, especially trees and shrubs and, thus, by having a low resistance to local extinctions. Additionally, increasing human population and expanding agricultural areas have resulted in heavier grazing pressures on rangelands in spite of the increasing role of crop residues and grains in livestock production. As the result of erratic cropping in low rainfall zones, overgrazing of the best ranges, uprooting and cutting of shrubs by local population for firewood, the natural vegetation of Aralo-Caspian desert margins is under pressure from antropogenic degradation factors, especially agriculture. Irrigated agriculture in marginal lands has significantly accelerated wind erosion and salinization of soils. Expanding of agriculture into the virgin desert areas induces deterioration in water and soil conditions and exacerbates the poverty, leading to out-migration and, so loss of local traditional knowledge and experience of land and water use.

Considering the regional nature of the problem of conservation of plant diversity of globally important northern Desert Margins (Aralo-Caspian sub-province as a case study) we are suggesting to protect not only individual species but also a number of unique plant communities, their diversity and sustainability - essential for the optimal environment for biological productivity. Special focus is given to studies on reproduction system and genetic variability and genetic differentiation of drylands C3/C4 woody species along gradients of elevation, salinity and moisture content. It was found that genetic processes within inter- and intra- populations level of majority desert species leads to the establishment of the variability reserve and adaptive potential changes, which ensure fitness and long-term survival of species and risk of their extension. Loss of genetic variation hampers adaptation to new selective regimes, such as climate change, increasing of desertification process, where the soil salinization might play an essential role. Marginal ecosystems being more vulnerable to changes of dry continental climate are exposed under extremely strong selection regimes. The degree of environmental and geographical marginality induces changes in the genetic structure of populations. Marginal populations of majority of woody desert species become more isolated and the evolution trend might be strongly influenced by local selection a pressure that is more pronounced at the microrelief level. A positive interrelation was described between enzyme polymorphism and reproductive processes, especially seed formation and quality. In this article we are supporting the restoration and conservation of the multifunctional dryland agroforestry landscape-corridors of Aralo-Caspian Desert Margins that protect saxaul (Haloxylon and other woody species) forests with a high conservation value. An important point is also to connect this multifunctional landscape corridor with both positive livelihood and environmental benefits, managed by smallholder farmers, herders and land managers through agroforestry system.

O-5-3

Water harvest and soil temperature increase improve resource use efficiency of maize in semiarid Loess Plateau

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Semiarid Loess Plateau is among areas most susceptible to erosion and low in productivity and thus poor in livelihood of farmers in China. An essential prerequisite for ecological restoration is to enhance crop productivity and thus to alleviate poverty. For this purpose, plastic film mulched ridge-furrow (MRF) maize cropping pattern has been designed and widely extended on the semiarid Loess Plateau. Set up before winter or one-month earlier than sawing, MRF can significantly increase top-soil temperature by greenhouse effect and enlarge soil water storage due to reduction in evaporation and temporally-spatially overlapping rainfall onto root zone in the earlier growth period of maize. Improved soil temperature and moisture can further stimulate mineralization of soil organic matter and nitrogen and thus speeds up supply of nitrogen to maize. An assemblage of improved soil temperature, moisture and nutrient supply enhanced maize growth and yield performance respective to no mulched treatment. The more critical the limitation of temperature and rainfall, the more the increase in grain yield under MRF compared to no mulching on semiarid Loess Plateau. However, under MRF cropping pattern maize water consumption during whole growth season and nutrient content of biomass at harvest were not affected compared to no mulched treatment. We concluded that MRF cropping pattern can significantly increase maize resource use efficiency due to the improved yield performance on the semiarid Loess Plateau.

O-5-4

If you can't monitor it, you can't improve it: A new tool for monitoring and assessing rangeland biodiversity in arid ecosystems

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Vegetation and soils of arid lands are changing across the face of the globe. These changes are the result of shifting managerial strategies, climatic parameters, and the expansion/contraction of plants and animal populations. Because changes in agro-ecosystems affect the livelihoods and development of rural communities, it is important that rangeland managers and ecologists be able to document land/ecosystem condition and trend in relation to managerial actions at specific locations. Quantification of ecosystem parameters that are used for condition and trend assessment has been difficult, time consuming, and expensive resulting in very few locations worldwide with detailed records. Tilled agricultural lands have been altered from their original conditions even more than either rangelands or natural plant communities, yet have largely been ignored because their change has been profound and establishment of reference points is difficult. We have developed monitoring technologies and protocols that can be used at local scales which speed the collection, processing, and storage of indicators of agro-ecosystem health. By coupling digital photography, differential global positioning systems technologies, information collected with accessory devices, and computer software applied in a strict monitoring protocol, we are able to rapidly sample and record the geographic position of quadrats ($1m^2$ to $25m^2$) with the following vegetation, litter, and soil parameters: 1) green leaf cover of plants, 2) cover of litter, 3) percent bare ground, 4) soil pedestal/rill presence, 5) vegetative canopy gap, and 6) water flow pattern. If vegetative species are visually distinctive, plants can also be identified. Repeated measurements over time at the same locations provide information regarding environmental trend and rate of change. When we couple our local scale measurements with landscape scale remote sensing data such as satellite or high altitude aerial photography, we have a more complete picture of vegetation dynamics and system change which facilitates interpretation.

O-6-1

Applied research and international cooperation in the Mediterranean drylands: CIHEAM-MAI Bari achievements and prospective

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This paper focuses on the use of modern technologies and tools for integrated management of land and water resources and increasing land/water productivity in agricultural sector of the Mediterranean countries. The operational programs for improvement of agricultural water productivity are structured on the principles of sustainable development and recognize dynamic, stakeholder-driven approach as the best option for land and water management. Irrigation management strategies are based on the interaction of agronomic, engineering and economic options and best management practices at different scales aiming at the optimal use of resources under specific environmental conditions and limited land and water availability. Accordingly, the mitigation options are sought combining the agronomic practices and water saving strategies with the engineering solutions for a more efficient water supply. The Master of Science programme of CIHEAM – MAI Bari is structured on the above mentioned principles with the aim to improve the effectiveness of theoretical teaching through the student's involvement in applied research and "problem solving" activities and to trigger off the international partnership for the promotion of the sustainable solutions at local and regional scale. A number of examples of implementation of the modern strategies and tools for land and water management in the arid and semi-arid Mediterranean areas are presented including a) the development of a regional GIS-based irrigation management system for Apulia region (Southern Italy), b) the integration of agronomic and engineering models and management tools (e.g. AcquaCard) for water saving and increasing of agricultural productivity in some areas of Tunisia, and c) the implementation of a real-time monitoring system and internet-based support for water availability and irrigation management in an Italian Consortium ("Bonifica della Capitanata") located in the north of Apulia region.
Keywords: Irrigation, Master of Science Programme, GIS, integrated approach, AcquaCard, web-based management.

O-6-2

JICA's cooperation and partnership on capacity development in dry land agriculture and rural development

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The Japan International Cooperation Agency (JICA) was established in August 1974, and it provides bilateral aid in the form of technical cooperation, grant aid and ODA loans for development countries. JICA conducts various types of projects on dry land agriculture and rural development in many countries such as China, Ethiopia, Egypt, Kenya, Mari, Myanmar, Niger, Palestinian Authority, and Syria. Some outputs and good practices of the following technical cooperation project and third country training programs in Syria by JICA are introduced in the Workshop especially from view points of capacity development. And, effective approaches for capacity development including further strengthening of relation between research works and development activities are identified.

1. Technical Cooperation Project for Development of Efficient Irrigation Techniques and Extension in Syria
2. Third Country Training Programs for Human Capacity Development in Agriculture for Iraq and Afghanistan

O-6-3

Japan and ICARDA: Partnering to strengthen the capacity of researchers and research institutions in research for development

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Japan and ICARDA have had long and continued collaboration and partnering to promote academic exchange and cooperation in the fields of capacity development and research. This collaboration has mainly been between Japan International Cooperation Agency (JICA), Tottori University and ICARDA on multiple forms of agricultural researchers' capacity development: group courses, individual training, long term and short term, and degree as well as non-degree training. Collaboration has also included scientists/ researchers' visits and exchange. Researchers from different parts of the dry areas have benefitted from this collaboration, including Iraq, Afghanistan, Syria and Japan, among many others.

ICARDA is currently revisiting its capacity development direction and interventions to meet the rising global challenges, stakeholders' demands, available opportunities to strengthen partnerships with international advanced research institutes, and also available opportunities to benefit from technological advances. ICARDA aims to establish a state of the art capacity development function that will contribute to the development of the capacity of NARS scientists and institutions in the dry areas to conduct research for development. To realize this aim ICARDA now focuses on expanding the geographic and thematic coverage of the capacity development interventions of ICARDA, establishing a quality assurance system for its interventions, supporting the institutional strengthening of NARS in the dry areas, widening the network of international partners and donors and developing systems to measure the realized impact on the ground.

The presentation will introduce the direction of ICARDA with regard to partnering to strengthen the capacity of NARS for research for development including the above mentioned goals and the twelve components that form ICARDA's capacity development direction. It is hoped that the presentation will stimulate discussions of possible collaboration and partnering with Japan to realize the discussed goals.

O-6-4

Achievements of the Global Center of Excellence Program and our next step

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“Global Center of Excellence for Dryland Science” Program has been conducted by Tottori University (TU) for five years since FY 2007 in cooperation with International Center for Agricultural Research in Dry Areas (ICARDA) and Desert Research Institute in Nevada, USA. A wide range of collaborative activities have been made under Memorandum of Understanding signed by Director General of ICARDA and President of TU in 2007, which aims at personnel training, joint research and regional dry area network. Research activities were focused on “Developing drought and heat tolerant cereal germplasm and its utilization for the drylands of Central and West Africa and North Africa” with a goal of enhancing the tolerance of cereals to abiotic stress in the Mediterranean region in order to improve productivity in the dryland and reduce risks in unfavorable agricultural environments. In the area of capacity building, ICARDA held short courses both in Aleppo and Tottori, and the graduate students and young researchers of TU were trained through them. The ninth and tenth International Conference on Development of Drylands (ICDD) were held in 2008 and 2011, respectively, sponsored by ICARDA, DRI, TU and other organizations. Along with Global Center of Excellence for Dryland Science Program, ICARDA and TU have been also jointly carrying out “Joint Master’s Degree Program on Integrated Dryland Management” and “Institutional Program for Young Researcher Overseas Visits”. So, what is our next step? TU is interested in further collaboration in the area of capacity building of young researchers and research activities on crop breeding and agronomy. In addition, other possible areas of common interest should be explored such as soil and water resources management, ecosystem restoration and environmental monitoring.

P-1-1

Improved abiotic stress tolerance through enhanced cellular recycling of antioxidants

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Abiotic stresses such as drought, salt, and use of herbicides accelerate the accumulation of the reactive oxygen species (ROS) in plant cells. Also known as free radicals, ROS are believed to be the major factor responsible for rapid cellular damage under stressing environments due to their high reactivity with membrane lipids, proteins, and DNA. ROS such as singlet oxygen, superoxide radicals, hydrogen peroxide and hydroxyl radicals are capable of unrestricted oxidation of many cellular components and can lead to oxidative destruction of the cells.

Ascorbate (AsA) and glutathione (GSH) are powerful antioxidants and scavenger of free radicals and maintaining their reduced pools is crucial for the continuous detoxification process. Here, we demonstrate that engineering the pathways to recycle either AsA or GSH has remarkably improved abiotic stress tolerance. We developed transgenic potato (*Solanum tuberosum* L. cv. Atlantic) overexpressing either *Arabidopsis thaliana* dehydroascorbate reductase (*AtDHAR1*; EC 1.8.5.1) or glutathione reductase (*AtGR1*; EC 1.6.4.2) which are functioning in reducing the oxidized forms of AsA and GSH, respectively. Genes were constructed in suitable plant transformation vectors, introduced into *Rhizobium radiobacter* (C58C1) and used for *Agrobacterium*-mediated gene transfer. Molecular analysis by genome PCR, RT-PCR and western blotting confirmed the successful generation of DHAR or GR transgenic potato. DHAR transgenic potato exhibited up to 4.5 folds higher DHAR activity and up to 2.8 folds of AsA, while GR transgenic potato maintained up to 6.5 folds higher GR activity and 5.8 folds GSH compared to control plants. Both types of transgenics maintained an enhanced tolerance to the herbicide methylviologen and drought stress. Moreover, DHAR transgenic potato showed enhanced tolerance to salt stress, while the GR transgenic maintained greater protection under cadmium stress. These results demonstrate that recycling the oxidized forms of either AsA or GSH provides reliable approach for the development of abiotic stress tolerant potato.

P-1-2

Identification of drought stress responsive genes from *Leymus mollis,* a wild relative of wheat (*Triticum aestivum* L.)

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The dune grass *Leymus mollis* (Triticeae; Poaceae, genus *Leymus*) is a wild relative of wheat and grows mainly along sea coasts and in inland dry areas. The tolerance *L. mollis* to various biotic and abiotic stresses makes it very useful genetic resource for wheat breeding. Wide-hybridization between *L. mollis* and wheat allowed the introduction of Leymus chromosomes into wheat genetic background and facilitated the integration of useful traits into wheat. However, the genetic bases controlling *L. mollis* physiological tolerance to multiple environmental stresses remain largely unexplored. Using suppression subtractive hybridization, we identified 116 drought stress responsive genes from *L. mollis* and confirmed their differentially expression by drought. These gene were categorized into 13 functional category including cell defense and stress response, transcriptional regulation, signal transduction, biosynthesis of compatible solutes and metabolism of cell walls in response to drought stress. Furthermore, analyses of the expression patterns in response to drought stress and abscisic acid treatment by northern blot and RT-PCR were validated for selected genes. The identified genes in this study represents valuable source as expressed sequence tags (ESTs) for analysis and identification of alien chromosomes introduced into wheat. Furthermore, being highly conserved, genetically associated with drought tolerance and transferable to wheat, these ESTs provide significant tools for the development of EST-derived markers and for assaying variations in the transcribed parts of the complex and highly redundant wheat genome.

P-3-1

Post-anthesis assimilation and its contribution to drought resistance in wheat

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Under Mediterranean climate, drought is the most serious constraint in wheat production. As most of assimilates produced from flag leaves and ears in later growth stage are used for filling grains, terminal drought reduces assimilation of these organs and hence increases contribution of pre-anthesis assimilates to grain yield. However, the relation between drought resistance and contribution of pre- anthesis assimilates to the grain has been still unclear. To evaluate the relative contribution of pre- and post-anthesis assimilates to grain yield under drought stress, durum wheat, synthetic wheat derivatives, and winter and facultative bread wheat genotypes were tested under different water regimes. Several genotypes showed higher grain yield under severe drought condition than the check varieties, and their drought stress-induced reductions in grain yield were less than those of the check. Those drought resistant genotypes had higher post-anthesis assimilation and harvest index, and lower contribution of pre-anthesis assimilates to grain yield under severe drought condition. A synthetic wheat derivative, SYN-10, selected from a population of Cham 6/3/Haurani/*Aegilops tauschii* ig47259//Cham 6, showed higher grain yield than a recurrent parent genotype Cham 6, a dryland check under severe drought. Photosynthetic rate of ear in SYN-10 and Cham 6 was decreased similarly under severe drought condition, while that of flag leaf was higher and less affected by drought in SYN-10 than in Cham 6. The drought stress-induced reduction in stomatal conductance in the flag leaf of SYN-10 was lower than that of Cham 6. Water potential of the flag leaf of both SYN-10 and Cham 6 was similarly decreased under severe drought. These results suggested that the higher grain yield of wheat under severe drought could be attributed to higher post-anthesis assimilation, rather than higher contribution of pre-anthesis assimilates to the grain yield. High flag leaf photosynthetic rate during grain filling under drought, resulted from high stomatal conductance even at low leaf water potential, may constitute promising selection criteria for drought resistance in wheat.

P-3-2

Efficient removal of salt accumulated on soil surface by the Surface Suction Leaching Method

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Salt accumulation occurs in a very thin soil surface layer and a spot state in an early stage. In this stage, leaching should be conduct for only the salt accumulation zone. Surface Suction Leaching Method (SSLM) developed by authors, can do such salt removal using a little water.

An instrument for SSLM consisted of three parts, water supply, drainage and insert parts. The water supply part had a storage tank for leaching water and a flowing pump. The drainage part had a vacuum pump and a collection tank for soil water. The insert part was a disc-shaped container with a stainless guide for inserting into soil, a ceramic filter, and an inlet/outlet pipe with a bidirectional cock. It was directly inserted into a salt accumulated zone on soil surface. Through the cock, the inlet/outlet pipe was connected with the water supply and drainage parts, respectively. An operator could select the stages of water supply for leaching and collection of soil water for removal of salts by changing the cock.

The desalinization process was as follows; 1) Leaching water was poured into soil surface by the flowing pump. 2) It dissolved salts accumulated in a soil surface layer. The saline remained in the layer, because supplied water was too small to percolate into lower layers. 3) After changing the cock, the vacuum pump of the drainage part sucked the soil saline through the insert part. The process was continued until the soil salinity decreased to the objective concentration.

In this study, the method was applied into sandy soil with artificial salt accumulated soil layer with 15 dS/m. As results, it could remove 80 % of accumulated salts and collect 93 % of leaching water from the soil layer. It cleared that SSLM was useful as a saving-water desalinization method.

P-3-3

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Transpiration is strongly affected by stomatal conductance (g_s) which varies with changes of environmental factors.

This study tried modeling g_s of durum wheat (*Tricticum durum*) applying Jarvis model which used photosynthetically active radiation (PAR), vapor pressure deficit (VPD), leaf temperature, and soil moisture to estimate g_s. The experimental field was located in ICARDA Tel Hadya station in northern Syria which was classified as arid and semi-arid region. Seeding and harvesting were conducted on the 9th of December in 2010 and the 11th of June in 2011, respectively. There were four irrigation treatments (rainfed (0 %) and full irrigation (100 %) with two intermediate levels of 33 % and 66 % of full irrigation) with three replications.

Under 100 % irrigation treatment, changes of measured g_s from March to the middle of April corresponded to that of soil moisture content, so it found that soil moisture influenced g_s considerably. However, g_s measured after the end of April were averagely low and did not relate to soil moisture. It was considered that the growth stage had reached the reproductive growth and the amount of photosynthesis had decreased.

Jarvis model was used for estimating g_s, which was calculated by multiplying some environmental factors, and here effects of PAR, VPD, leaf temperature and soil moisture were adopted. Jarvis used a function of leaf water potential to express the effect of water stress, but this study used the function of soil moisture instead of it. Parameters were identified by the method of nonlinear least squares, and this model gave good agreement with the observations. However estimation did not correspond to observation of after the end of April, therefore it became clear that this model was required to improve by introducing the effect of crop growth stage.

P-3-4

Characterization of stable soil organic fractions as means of carbon sequestration in conservation agriculture systems under semi-arid Mediterranean region

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In the semi-arid Mediterranean region, minimum soil disturbance by adoption of zero tillage (ZT) has the potential to contribute to the mitigation of climate change by sequestration of carbon in the soil. The effectiveness of carbon sequestration may be affected by the quality and quantity of humic substances, such as the stable organic carbon in the two soil organic matter (SOM) fractions; particulate organic matter (POM) and mineral associated organic matter (MOM). The objective of this study was to assess the potential of carbon sequestration under ZT. We studied the characteristics of humic substances in SOM fractions under ZT, and in contrast under conventional tillage (CT) in a long-term conservation agriculture experiment at ICARDA headquarters south of Aleppo in northern Syria. Therefore, soil samples were taken from 0-2, 2-5 and 5-10 cm depth in March 2010. Analysis revealed that soil organic carbon (SOC) contents under ZT were significantly higher than under CT in 0-2 and 2-5 cm depth. Carbon content in POM fraction (POM-C) also significantly higher under ZT, and was correlated with SOC (r=0.655). A higher humic acid (HA) content was found under ZT than CT. Also HA in the POM fraction tended to be higher under ZT. A stronger humification of HA was occurring under ZT than CT. The humification level of HA in the POM fraction was lower than in the MOM fraction. This explains why ZT could enhance carbon sequestration in 0-5 cm depth within a period of only three years. HA in POM fraction is an early indicator of carbon sequestration under conservation tillage in semi-arid Mediterranean region. However, it may be difficult to maintain SOC sequestration in the long-term run due an increase of SOC in the POM fraction, which has a much shorter turnover rate than the MOM-C.

P-3-5

Influence of intercropping of bread wheat and faba bean on phosphate availability and uptake in semi-arid land

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Considerably more P fertilizer is usually applied than the crops' actual demand, because the inorganic P fertilizer in the soil easily and rapidly becomes unavailable for crops. Some crops release organic exudates into the rhizosphere which dissolve unavailable P and contribute to an improved crop P uptake. To investigate whether this mechanism can improve the P-uptake efficiency of bread wheat (*Triticum aestivum* L.), this crop was intercropped with faba bean (*Vicia faba* L.) from November 2010 to April 2011 in an experimental field at ICARDA. Bread wheat and faba bean were mono-cropped or inter-cropped with two P fertilizer levels; 0 (P0) and 50 kg P ha^{-1} (P50). Sampling of plant and soil was done in January (1st sampling) and April (2nd sampling) 2011. Dry matter, Leaf area, P uptake of plant, and Olsen-P was determined and further analyzed.

Dry weight and P content at 1st sampling were larger in P50 than P0 for both crops, but an effect of cropping was not observed. At 2nd sampling dry weight of P0 inter-cropped bread wheat had grown significantly larger than that of wheat of the two mono-cropped reference treatments and was similar to wheat biomass of the P50 inter-cropping treatment. Highest Relative Growth Rate (RGR) in P0 of inter-cropping among treatments in bread wheat was mostly explained by increased Leaf Mass Ratio (LMR) and Leaf Area Index (LAI). Olsen-P concentrations were higher in P50 than in P0, at 1st and 2nd sampling, and at shallower layers within the rows of both crops.

The above results indicate that an effect of inter-cropping on P uptake and growth of bread wheat was confirmed in late vegetative stage and that an accelerated growth was explained by larger ratio of leaf weight to total dry weight and more expanded leaf area.

P-3-6

Impact of some agronomic and physiological traits on productivity of bread wheat in Mediterranean environments

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Drought is arguably the most important abiotic stress that affects bread wheat productivity in many rainfed environments, and improving yield under drought is a major goal of wheat breeding. Most climate-change scenarios predict an increase in drought events in many wheat growing areas of the world. If this eventuates, it may likely result in considerable impact on wheat production, especially if the amount and distribution of rainfall continues to change, with global warming. It has therefore become imperative to investigate adaptation options for improving yield and yield stability under these conditions.

This study aims to investigate the agronomic and physiological traits in wheat associated with drought adaptation under rainfed conditions in Mediterranean environments. One hundred and seventy F_8-derived recombinant inbred lines (RILs) from a cross between Cham-6 and Cham-8 were grown in 5 sites; Breda (200mm rainfall), Tel-Hadya (300mm), Kfar-Dan (400mm), Terbol (500mm), Malkiya (550mm) in 2010-2011growing seasons from December to July.

The results show clear differences between lines within and between the sites. The predicted mean of Grain yield were 2.4, 3.29, 4.7, 5.27, 5.71 tha^{-1} in Breda, Tel-Hadya, Kfar-Dan, Terbol, Malkiya respectively. Many lines were higher yields than both Cham-6 and Cham-8 and were significantly higher ($P<0.05$) yielding than Cham-6. Days to heading negatively correlated with grain yield and it was significant in drought sites. Similarly, grain filling duration (GFD) and early vigor were positively correlated ($P<0.001$) with grain yield. Early vigor possibly reduce tillering time (vegetative period) which resulted in early heading slightly increased grain filling period and contributed to yield advantage under drought. Further advantage include increased leaf canopy which reduces evaporation from the soil surface. Thus, the three traits: earliness per se, grain filling duration and early vigor could be used as surrogates in selection targeted in germplasm development for dry areas.

Key Words**:** Bread wheat, productivity, drought, grain filling, early vigor.

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P-3-7

Overview of status and prospective of wheat improvement in the hot dry environment of Sudan

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Wheat is strategic and stable food crop in Sudan. It has been grown in the north along the River Nile banks thousands of years ago and expanded after the sixties south wards where land and irrigation water are available but winter is shorter and warmer. The demand for bread wheat in Sudan is rising and currently estimated to be 2 million metric tons per year, of which around 80% is imported. Spring wheat is grown during a short, warm and dry winter where air temperatures can reach up to 40°C; therefore, breeding for high yield and good baking quality is major challenge under such environment. Several heat tolerant varieties were released during the last 50 years with a modest increase in grain yield of about 30.2 kg/ha/year. Six improved varieties were released during the last 10 years of which two were through doubled haploid technology. Most of the released varieties have their origin from the nurseries developed by CIMMYT and ICARDA. Efforts are under way to understand the genetic variability of baking quality under the hot irrigated environment. Recently, the Sudanese government has approved a five years plan for self-sufficiency in wheat through expansion of production into the north 40 km east and west of the River Nile where winter is cooler and longer but soil is poorer (high terrace and saline soils). New large scale production systems and irrigation technologies are planned to ensure sustainable production of wheat with good baking quality. National breeding program has to respond by developing heat and salinity tolerant, high water use efficiency, and rust resistant varieties. Prospective lay on the utilization of wheat wild relatives and the power of molecular breeding to generate new genetic variability that is adaptable to the new areas of wheat production in Sudan.

P-4-1

Evaluation of water balance in a water harvesting system in the Loess Plateau, China

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A field experiment was carried out to evaluate water balance in a water harvesting system named “fish scale pits (FPS)” in the Loess Plateau, China. A homogeneous slope (4 m × 4 m, 15 degrees) was chosen as the experimental site. The upper half of the site was runoff area covered with natural short grasses. Two FSPs (0.3 m in depth) were made at the lower half of the site. The bottom surface of one pit was covered with gravel mulch (5 cm in thickness). Soil water content and temperature have been monitored with dielectric soil moisture probes at various depths (e.g., 0.05, 0.15, 0.35 and 0.60 m in depth) of each of the plot. The monitoring results showed that the normal FSP did not have significant water storage ability in a dry year compared with the runoff area. On the other hand, in the FSP covered with gravel mulch, soil water contents at 0.35 and 0.60 m depth were higher than those in the runoff area and the normal pit. It is believed that the gravel mulch reduced water evaporation from soil surface and this allowed rainfall recharges to the deep soil. These results suggest that normal FSPs are not necessarily effective in water storage, and simultaneous use of the gravel mulch and the FSP is effective even in dry years.

P-4-2

The long term effect of wastewater irrigation on heavy metal distribution in soils and wheat (*Triticum aestivum* L.) in the peri-urban areas of Aleppo, Syria

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Irrigation with treated and/or inadequately treated wastewater is widely practiced in peri-urban areas in the Middle East and North Africa region. However, few studies have been undertaken to assess its long-term impact on heavy metal (HM) contamination in the environment. This research assessed HMs (Cd,Cr,Cu,Ni,Zn) contamination in irrigation water, soils, and cultivated plants in the Qweik River Basin, southern Aleppo, Syria. The Qweik River which carries treated-untreated, domestic-industrial mix wastewater has been used for irrigation for over 25 years. River water was sampled at 0.6 and 27km from the wastewater treatment plant, soil at surface (0-10cm) from 17 crop fields under river water irrigation (RWI) and 18 fields under ground-water irrigation (GWI) after crop harvesting. Wheat (*Triticum aestivum* L.) samples were taken from RWI sites where the soil sampling had been done. Results of water total HMs concentration showed only Cr exceeded the water quality guidelines (0.1 mg L^{-1}; Ayers and Westcot, 1985). Other HMs were in the order: Zn>Cu>N≈Pb>Cd. Water soluble Cr was less than 30% of water total Cr. Soil total HMs concentration followed the order: Cr≈Ni>Zn≈Pb>Cu>Cd. In some fields under RWI, soil Ni content exceeded the WHO guidelines (107mg kg^{-1}). Soil Cr and Ni content under RWI were 20% higher than GWI. Crop HM content was within Codex and EU limits. It can be projected that at the current irrigation management (5000 m^3 ha^{-1} yr^{-1}), HM loading limit under WHO guidelines (2006) could be reached in 73 years for Ni and 103 years for Cr. Fields under long term wastewater irrigation, though a slow process, might be accumulating soil HMs, and it would be difficult to ameliorate such soils once they reach their loading limits. Therefore, there is need to mitigate HMs loading into fields through adequate water treatment and irrigation management.

P-5-1

Profitable maximizing the treated sewage effluent reuse for irrigating in newly reclaimed desert soils to produce biodiesel from the grown Jatropha trees

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This study is an important strategy to support the local best usage of marginal desert soils and low quality water as alternative irrigation water resources, whether be under demand for agricultural utilization. Also, it represents a huge challenge and technical solution for an environmental problem, *i.e.*, the utilization of contaminated sewage effluent as an alternative irrigating source for greening the west desert outskirt of Al-Luxer as a touristy city. With no competing food uses, this characteristic turns attention to *Jatropha curcas trees*, which grow in tropical and subtropical climates. Among the non-edible oil sources, *Jatropha curcas* is identified as potential biodiesel source as compared with other sources, which has added advantages as rapid growth, higher seed productivity, suitable for tropical and subtropical regions.

This integrated combination between wastewater as an irrigation source, marginal desert soil and *Jatropha curcas* as potential biodiesel source represents a new agriculture strategy as well as affects the country's economy and its development. That is due to the possible adverse effects on either crop products or human health should be alleviated; besides it represents an ideal solution to meet out higher diesel demand.and oil imports. Also, such biodiesel, as a renewable energy source, is becoming increasingly important due to diminishing petroleum reserves and the environmental consequences of exhaust gases from petroleum fuelled engines. However, the released CO_2 as an air volatile pollutant represents a fewer value equal about 20 % of that derived from petroleum fuelled engines.

The special attention was focused to optimize the first step of the process for reducing the possible adverse effects of contaminated sewage effluent, among being passed through an oxidation or bio-remediation pond. The second attention was focused to optimize for reducing the possible adverse effects of the marginal desert sandy soil, among being applied a suitable irrigation system of drip irrigation system that partially capable to retain enough available soil moisture range for grown plants and biological activity. The obtained field studies and analytical data indicate that the experimental soil is encompassing by the aeolian deposits, and classified as Typic Torripsamments, siliceous, hyper thermic Typic. According to a parametric evaluation system, they could be evaluated as marginally ($S3s_1s_3s_4$), with an intensity degree for soil limitations lies in the range of slight-severe (rating = 90-35).

The suitability criteria of water source for irrigation purpose indicate that it lies in a first category C1S1, *i.e.,* no problems for salinity and sodicity are expected. An elemental composition analysis of N, P, K, Fe, Mn, Zn, Cu, Cd, Co, Pb, Ni and Cr as well as biological criteria (*i.e.,* COD, BOD, total Coli, total Coli, Salmonella and Shighla) was executed on each of the studied irrigation water and experimental soil, and it was found that their available contents still within the permissible limits, since their soluble values in the used irrigation water source are more than the fresh water. Hence, a field experiment was conducted on the chosen soil sites, where *Jatropha curcas* seedlings were planting during May 2009. The agricultural management practices were conducted as usual. The obtained results showed also a beneficial effect of the applied irrigation water source on the grown plants, due to caused more pronounced increments in plant growth, seed yield and seed oil yield with high quality. Also, biodiesel production from seed oil of *Jatropha curcas* with a high content of free fatty acid and its economical feasibility study had been investigated.

Key Words**:** New agricultural strategy, biodiesel, *Jatropha curcas*, marginal desert soil, Luxer Governorate soils

P-6-1

A combination of biochemical analyzers for the efficient ecological analysis (Effective use of the Arid Land Research Center advanced facilities)

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The Arid Land Research Center provides various facilities and analysis systems for environmental (climatological and hydrological), biological (molecular and whole plants levels) and physiological research. Researchers use the most suitable analyzer for their relevant research. However, they commonly use a single analyzer to observe and measure specific data or process.

This presentation proposes a combination of Stable-Isotope Ratio Mass Spectrophotometer (SIRMS) and Reducing Sugar Analysis System (RSAS) by High performance Liquid Chromatography (HPLC) for analysis of plant or microbe metabolisms and ecological observations. SIRMS can measure stable-isotope ratios for carbon and nitrogen in organic samples, and for hydrogen and oxygen in water. RSAS can measure small amounts of sugars (glucose, mannose, galactose etc.) in biological samples. Whereby, sugars metabolic pathways and flows be precisely measured. Moreover, this system can be applied to study ecosystem analysis. Specifically, this system can be very useful to estimate the heavy isotope concentration and distribution within chemical compounds in the trophic level of the food cycle. This combined system provides advantage of obtaining stable isotope ratio of separated sugar compound in addition to more qualitative and quantitative biochemical measurements at once.