1.5 Theses of Graduate Courses

(1) Doctoral Theses

Bat-Oyun, T.

Estimation of pasture productivity in Mongolia: Field survey and model simulation

Summary:

Mongolia is a country of nomadic livestock husbandry and its economy is dependent on livestock products. Natural grasslands are the main source of forage for these animals, and grassland productivity is strongly influenced by the country's dry, continental climate. The production of natural grassland is regulated by many factors, such as soil moisture, temperature, solar radiation, soil nutrient availability, and grassland utilization and management. Of these, soil moisture is the most critical and limiting factor determining the efficiency of plant radiation utilization and vegetation productivity in the country. A drying trend has recently been observed in soil moisture, further limiting pasture growth. This background emphasizes the importance of gathering accurate and timely information about pasture productivity for livestock survival. However, direct measurements can be difficult to gather, especially in remote areas of a large country like Mongolia. It is therefore essential to develop and validate models against observed measurements to estimate pasture productivity widely. The main aims of this thesis were to quantify input parameters (PAR/SR: the ratio of photosynthetically active radiation to solar radiation; and RUE: radiation use efficiency) of Production Efficiency Model (PEM) and to examine the suitability of PEM modified using the quantified parameters to estimate pasture productivity in the following vegetation zones: desert steppe, dry steppe, steppe, and forest steppe. A list of the main findings from this study given below:

First, the relationships between aboveground biomass (AGB) and precipitation were revealed. In this analysis, datasets for 15 sites were used, spanning the years 1986–2005. The results demonstrated that cumulative precipitation during the growth period had the highest significant correlation with AGB. When considered on a monthly basis, these data showed that precipitation in June had the most significant impact on AGB in forest steppe, whilst precipitation in July was most significant in desert steppe and steppe zones. Moreover, at the desert steppe sites, where conditions are relatively dry, precipitation was strongly correlated with AGB, independent of event size, and even small precipitation events ($\leq$ 5 mm) significantly affected AGB. Conversely, in the steppe and forest steppe zones, where conditions are relatively wet, AGB did not alter at small precipitation events, whereas large precipitation events ($\geq$ 5.1 mm) tended to contribute to plant growth. This result suggests that more frequent and small precipitation events do not benefit vegetation growth in steppe and forest steppe zones. The results of this study provide an important contribution to experimental studies on the water requirements of natural grassland.

Second, the input parameter of PAR/SR for the PEM was quantified at Bayan Unjuul. The lowest monthly ratio occurred in April and December (0.42), while the highest ratio occurred in July (0.459). The annual mean was 0.434, which is lower than that reported in many previous studies due to drier conditions in the region. During the growth period (April–September), the ratio was 0.438 and this was used in the PEM to estimate aboveground net primary productivity (ANPP). The variation of PAR/SR is largely attributed to differences in sky condition (clearness index) and water vapor in the atmosphere (water vapor pressure). A significant and negative correlation was found between the clearness index and PAR/SR ($r = -0.36$, $p < 0.05$), while a significant and positive correlation was found between water vapor pressure and PAR/SR ($r = 0.48$, $p < 0.05$). These findings are consistent with previous studies. This is the first time that PAR/SR, a key input parameter for radiation-based models, has been determined for Mongolia.

Third, to quantify RUE, AGB and above and below-canopy PAR were measured at Bayan Unjuul

under different conditions of soil water and air temperature during the growing season of two years. A wide range of RUE (0.23–1.06 g AGB/MJ intercepted PAR (IPAR)) was found in negative correlation with soil water and low temperature stresses. Compared with the temperature stress, the water stress was a strong down-regulator on RUE, verifying that drought is a major concern for radiation utilization in the study area. The maximum RUE was 2.34±0.16 g AGB/MJ IPAR by excluding the effects of water and temperature stresses, and this was used in the model to estimate ANPP. This is the first study to provide the important model parameter of RUE for natural grassland in Mongolia under various levels of seasonally varying water and temperature conditions.

Koike, T.

Synoptic climatological study on extreme weathers in Mongolia

Summary:

Mongolia's territory is landlocked and sits at relatively high altitudes. This geographic location has a continental, dry and cold climate. In such a severe climate, people have continued nomadic life for long time. Stock-farming is still one of basic industries in Mongolia. However, stock-farming is affected directly by weather and pasture conditions. Especially, extreme conditions such as dzud and drought leads to marked loss of livestock. Dzud is a Mongolian word for disastrous livestock loss caused by harsh winters, but often influenced also by drought in the previous summer. There are several forms of dzud, depending on the characteristics, contributing factors and causes. For example, cold dzud is caused by extremely low temperature. White dzud is caused by of deep snow cover, which prevents livestock from feeding fodder. Melted snow cover and liquid precipitation freeze, and form icy ground surface which prevents livestock from feeding fodder. That is called iron dzud. Combination of these different dzuds is called combined dzud. So far, there have been very few systematic investigations to relate the dzud-causing extreme weathers to large-scale synoptic patterns. This background motivated us conduct a synoptic climatological study on extreme weather in Mongolia. The present study focused on two typical extreme weathers; One is deep snow cover which may cause white dzud, while the other was temperature drop. This may cause cold dzud and iron dzud, and often occurs in conjunction with snow storm and/or dust storm.

As for the white dzud, Eurasian snow cover in spring has followed a decreasing trend since the mid-1960s, but winter conditions remain unknown because of a lack of data. To address this issue with a regional focus on the eastern part of Eurasia, we conducted an observational study of winter temperature, precipitation, and snow depth in Mongolia and the associated atmospheric circulation. We used the meteorological data at 21 representative Mongolian weather stations for four winter months (November to February) from 1960 through 2007. Time series analysis was applied to three indices: standardized deviations from the mean for this 4-month period averaged over the 21 stations in Mongolia for snow depth (SI), precipitation (PI), and temperature (TI). This time series analysis revealed a significant multi-decadal trend in temperature, but not in snow depth. We focused on deep-snow winters with SI values higher than 0.5. During the 1960s and 1970s deep-snow winters coincided with extreme cold. However, beginning in the winter of 1992–1993, a new type of deep-snow winter with warmer conditions has occurred in some years. We defined deep-snow winters with a positive TI as warm-deep-snow winters and those with a negative TI as cold-deep-snow winters.

Moreover, a synoptic analysis was applied to the composites for the cold- and warm-deep-snow winters. The synoptic analysis at the 500-hPa level demonstrated that a trough that is usually climatologically located east of Mongolia extended westward to Mongolia during the cold-deep-snow

winters. This indicates that enhanced cold surges from the north to Mongolia led to the historically typical deep snow conditions. On the other hand, the warm-deep-snow winters were characterized by a weakened trough, weakened cold surges, and concurrently intensified moisture transport from the west into Mongolia at the 775-hPa level. Two maximum axes of westerlies are climatologically located north and south of Mongolia. In the cold and warm winters, the southern and northern maximum axis, respectively, of the westerlies were enhanced in conjunction with the intrusion of cold air towards the areas delineated by the axis. The new circulation pattern observed here shows that warm winters, which may become more frequent in the future. In cold-winter regions such as Mongolia (with temperatures largely below 0 ºC), warm winters still have the potential to produce deep snow owing to increased water vapor flux, even though the spring snow cover is decreasing in Northern Hemisphere. Therefore, in future investigations, attention should be paid to the possibility that white dzud may occur more frequently in conjunction with increased warm-deep-snow winters.

Not only deep snow but also drastic temperature decreases after precipitation in the cold season, and sometimes even in the warm season, can harm livestock, often leading to high stock mortality. We investigated seasonal and regional temperature changes before and after precipitation in Mongolia. We conducted a time-series analysis of changes of temperature relative to daily mean temperature at 25 weather stations (including the 21 weather stations for snow data above mentioned) before, on, and after days of precipitation. We categorized the relative temperature time series into three types: peak shaped (P), valley shaped (V), and reverse S-shaped decreasing (D), which characterized spring–summer, winter, and autumn, respectively. We produced 11-day time series of relative temperature centered on precipitation days for each precipitation event at each station from 1961 to 2007 and applied principal component analysis to the relative temperature time series. Our results show that the first principle component (PC1) pattern is V-shaped, and the principal component analysis scores tended to be negative in winter and positive in spring. The PC2 pattern was closely related to the D-shaped trend of relative temperature, and the scores were positive from autumn to early winter and negative from spring to summer. Synoptic weather pattern analysis and time series analysis of temperature, wind, advection, and precipitation at the representative weather station and/or its nearest grid point of the reanalysis data before and after precipitation days elucidated the spatial patterns of temperature advection forming each temperature change pattern. In general, both the P- and V-shaped trends accompanied the passage of a cold front. The P- or V-shaped was determined by the thermal conditions of the background air mass into which the contrasting air mass invaded to produce a precipitation-bearing front. The D-shaped RT trend is accompanied by the southward migration of a cold air mass occurring mainly during the transition from autumn to winter.

To investigate temporal variations of temperature, radiation components, and precipitation, a detailed time series analysis before and after a precipitation event was made. The time series in summer showed that in addition to the effect of advective cold air, reduced solar radiation due to increased cloud cover and reduced sensible heat flux on the precipitation day suppressed diurnal temperature increases and contributed to the relatively low daily mean temperature of the V-shaped trend. In contrast, time series in winter showed that daily temperature was highest on the precipitation day, even though solar radiation was reduced. Increased solar radiation after the precipitation day did not immediately cause an increase of daily mean temperature; rather, the daily temperature continued to decrease. Low solar radiation due to low angle and short time day light, high albedo due to snow cover, and very low downward long-wave radiation from the cold air mass resulted in low net radiation, causing a low sensible heat flux.

The spatial distribution of the weather station averaged PC1 score for January showed large negative

values (P shape) in the west and north of Mongolia. the weather station averaged PC1 score was negatively correlated with the weather station averaged precipitation intensity. The spatial distribution for May exhibited large positive values (V shape) in the east and south of Mongolia. The PC1 score for May was positively correlated with precipitation intensity. Correlations of individual PC1 scores with precipitation intensities (mm d-1) at each event were significant for some stations. Significant negative and positive correlations were observed for January and May, respectively, which implies that when precipitation is more intense the amplitudes of the P- and V-shaped patterns increase. Larger amplitudes indicate a large contrast in temperature between two air masses forming a cold front. Intense precipitation events were associated with large temperature changes, that is, with large thermal contrasts in two air masses.
In brief, larger amplitude of temperature change before and after precipitation, caused by stronger contrast of two air masses which forms a cold font, produced larger amount of precipitation. Both in cold-deep-snow winters which had enhanced cold surges, and in warm-deep-snow winters which had enhanced warm wet air intrusions, the contrast between cold and warm air masses was strong producing more amount of precipitation leading to deep snow cover.

Derege Tsegaye Meshesha

Spatial analysis of soil erosion and sediment yield in Central Rift Valley of Ethiopia

Summary:

The Central Rift Valley (CRV) is one of the most environmentally vulnerable areas of Ethiopia. Because since it is a closed basin, relatively small interventions in land and water resource can have a profound effect in the ecosystem and sustainable use of the land and water resources. Most of the low land in the CRV is arid or semiarid, and drought is a frequent phenomena. The land and water resources of the CRV is highly deteriorating and negatively changing overtime. The soil erosion and sedimentation amount is also significantly high and increasing through time following a series of vegetation degradation. Soil erosion by water during the rainy season is a serious problem in the region, 1eading to declining agricultural production, decreased food security, and a sedimentation risk for lakes. To maintain this ecologically sensitive basin, there is an urgent need for improved resource use of land and water that takes into account the carrying capacity of the ecosystem. Hence, economical, social and technical measures must be taken with no further setback.

However, the government, stakeholders and local policy makers look reluctant and seem to have not yet understood and realized the ongoing land and water deterioration in the region and its future impact on the livelihoods of the community and ecosystem, and hence are not in a position to take any action to mitigate the problem or reverse it. It is mainly due to lack of adequate information about the magnitude and seriousness of the soil erosion from agricultural lands, sedimentation to the lakes and the problem that they cumulatively pose in the future; as there has been no systematic study of these problem or of possible management solutions in the region. Meanwhile, development of effective erosion control plans requires the identification of areas vulnerable to soil erosion and quantification of the amounts of soil erosion from various areas. Especially, a move should be started to prolong the life of the local lakes whose size and level is significantly decreasing overtime due to mainly land use change, otherwise, they may face the same fate like reservoirs of north Ethiopia and lakes of eastern Ethiopia which dried up for similar reasons.

Therefore this research is designed to address these research gaps with objectives of providing scientific based information and understanding of the valley in terms of land use and cover change, soil erosion, and sedimentation issues, and to propose options or scenarios whose efficiencies are tested through

models for sustainable use of land and water resource in the future. The research specifically gave attention to the above mentioned points and organized with the following objectives: analysis of the spatial and temporal pattern and the magnitude of LUCC for the period 1973-2006, explore the interaction between LUCC and land degradation, and identify the most proximate cause of the change (anthropogenic) and its impact on livelihoods of locals and entire ecosystem; examine long term (1973 to 2006) soil erosion rates that happened following the LUCC, identify erosion hotspots and the major factors responsible for high rates of soil loss to support conservation planning, and propose and evaluate different soil conservation scenarios that could be adopted in the area to decrease the existing soil erosion amount; evaluate spatial variability of area-specific sediment yield and determine the primary factors that control it and test performance and feasibility of FSM model to predict SSY in the region.

The dynamics of land use and cover and land degradation was examined through analyzing Landsat data from 1973, 1985 and 2006 using Geographic Information Systems and remote sensing techniques. The classification accuracy of each images was validated based on GPS recorded ground truth data and other reference maps and aerial photos. The change analysis result revealed that in the last 30 years, water bodies, forest and woodland decreased by 15.3, 66.3 and 69.2 % respectively; whereas intensive cultivation, mixed cultivation/woodland and degraded land increased by 34.5, 79.7 and 200.7 %. The major causes of land use and cover change (LUCC) and land degradation in the area were population and livestock growth, unsustainable farming techniques, the land tenure system and poverty. Lake level and size decline, and accelerated land degradation are recognized as major environmental impacts of LUCC observed in the region. The environmental and socio-economic consequences of LUCC and land degradation are far-reaching. As a result of the expansion of land degradation overtime, agricultural productivity has decreased and worsened food insecurity (shortages) and poverty in the Ethiopian CRV. In addition, if current trends in LUCC continue, Lake Abiyata will dry up by 2021.

The magnitude and dynamicity of soil loss was evaluated using the universal soil-loss equation (USLE) and Geographical Information System (GIS) software, considering the land use change from 1973-2006. The model result was validated by comparing it with others' research output, national average and using photo validation techniques. The result showed that soil erosion increased markedly from 1973 to 2006, with annual rates of 31, 38, and 56 t ha^{-1} in 1973, 1985, and 2006, respectively, as a result of vegetation degradation and particularly the conversion of thousands of hectares of forest or woodland into cropland. The observed soil erosion rates are far from the tolerable rate of soil loss of the country and hence require urgent soil conservation interventions, especially in the hotspot areas. To this end eight different scenarios were proposed and their effectiveness to reduce existing soil loss was evaluated. Rehabilitating degraded land (using enclosures and planted vegetation) and installing of stone-erosion control structures (stone bund) in cropland reduced the total soil loss by 12.6 % and 63.8 %, respectively. Treating hotspot areas, which accounts about 45 % of the total area and with annual soil loss of more than 20 t ha^{-1}, by integrated management (erosion, control structures and enclosures) was the most effective approach, reducing soil loss by 87.8 %.

The soil erosion in the highlands surrounding the Ethiopian Central Rift Valley is not only affecting the productivity of crop lands due to nutrient loss but also becoming a serious threat to lakes of the valley. The measured specific sediment yield (SSY) of 214 – 611 t km^{-2} yr^{-1} for six catchments in the Rift Valley shows that there exists a significant sedimentation problem for lakes in the region. Although accurate predictions of SSY are needed to plan and implement policies to mitigate these problems, so far there is little reliable data on sediment yield and no adoptable model to predict SSY has yet been developed for the

region. Adoption of previously developed factorial scoring model (FSM) that calculates SSY as a function of topography, vegetation cover, gully morphology, lithology, and catchment shape strongly helped to determine which of these factors have the greatest effect on SSY variability in the region. It is found that gully morphology is the primary factor that controls SSY, followed in order of decreasing importance by catchment shape, topography, vegetation cover, and lithology. Then, the model was modified by adding a climate factor to account for the effect of rainfall on SSY in the Central Rift Valley. It revealed that both calibrated models that used modified factors of FSM and our modified version that included climate provided reasonably good matches between observed and predicted SSY during calibration and validation. However, because of significant differences in rainfall among the six catchments, the calibrated model with indices that include climate (I_C: R^2=0.82) performs better than that without climate (I_O: R^2=0.77) to predict SSY. Statistical analysis of the validation results also revealed that the mode. whereas +63 that incorporating index without climate (I_O) explained only about 60%.

Generally, the current soil erosion amount in the area (56 t ha^{-1}) is by far more than the tolerable rate (2-18 t ha^{-1}), and the sedimentation amount from catchments to the lakes is also very high that can significantly affect their storage capacities. The continuous land use change, particularly, "from vegetation cover to intensive cropland" is one of the main factor for increasing erosion and sediment yield. Therefore, to maintain this ecologically sensitive basin, there is an urgent need for improved resource use of land and water that takes into account their carrying capacities. Hence, economical, social and technical measures must be taken no further setback to mitigate or if possible avert the existing environmental change. Moreover, further studies should be conducted to understand the hydrological and erosion process of the upper stream of the watersheds (escarpment of the valley) with adaptation of process based model that incorporate field measurement of soil erosion at runoff plot level and sediment yield in the catchment outlet.

Cho, S.W.

Studies on *Leymus* Species as Genetic Resources for Wheat Breeding

Summary:

Wheat related wild species having valuable genes for drought and salt tolerance and disease resistance are useful genetic resources for wheat breeding. Many wheat addition lines carrying a pair of alien chromosome from wild relatives have been produced because a vast field of genetic diversity exists in the wild relatives of wheat. However, these lines cannot be directly used for wheat breeding because of genetic imbalance by aneuploidy. Development of technique to introduce the segment of the alien chromosome with a useful gene to a wheat genome is required. When alien chromosomes are transferred to wheat, it is needed to identify behavior of alien chromosomes during meiosis in wheat genetic background.

This study involved information about effect of the chemical with particular function on wheat addition line carrying alien chromosomes and about homology between alien chromosomes in wheat genetic background.

In the first chapter, I investigated effects of zebularine on wheat mitotic chromosomes. Zebularine, cytidine analog is known as DNA methylation inhibitor such as 5-azacytidine and 5-aza-2'-deoxycytidine, and it is more stable in aqueous solution than the others. A wheat disomic addition line carrying a pair of alien chromosomes (*Leymus racemosus* chromosome ℓ) was treated with zebularine at various concentrations. The alien chromosomes were discriminated from the wheat chromosomes by genomic *in situ* hybridization, facilitating observation of any rearrangements between the wheat and alien

chromosomes. Root growth was obviously inhibited by zebularine because of reduction of the mitotic division cells. Rearrangements such as ring chromosomes, insertions, deletions, and translocations were observed in the treated mitotic chromosomes. The aberrations were increased in a concentration-dependent manner of zebularine.

In the second chapter, meiotic chromosome behavior of different chromosome relationships in allopolyploid species (homologous, homoeologous or non-homologous) was studied. To discern the behavior of chromosomes in each of these relationships, wheat double monosomic addition lines (DMAs) in different combination were produced by crossing between wheat-*Leymus racemosus* and wheat-*L. mollis* addition lines as disomic additions. These DMAs have two alien chromosomes. One chromosome was from *Leymus racemosus* and the other chromosome was from *Leymus mollis*.

I observed the *Leymus* chromosomes in meiosis by differential genomic *in situ* hybridization. First I observed the distribution of these alien chromosomes in tetrad cells and measured their homology by an index of their interaction. Values differed greatly among DMAs. I observed prophase to anaphase cells of meiotic division I and elucidated the differences in homology through chromosome behavior in meiosis. A line carrying chromosomes [l^r] of *L. racemosus* and [M^m] of *L. mollis* formed bivalents in about half of the prophase cells, but these chromosomes became univalent in metaphase because of a lack of chiasmata, and segregated normally to each pole. The chromosomes in the other half of the prophase cells did not associate and behaved randomly from anaphase to tetrads. The DMAs proved useful in studying the homology of chromosomes.

From these studies, it was suggested that the phenomenon of zebularine-induced chromosome breakage might be useful for introducing useful genes from wild relatives. In DMAs of wheat, the recognition level of homology between alien chromosomes during meiosis is strict in wheat genetic background. However, occurrence of association between alien chromosomes even in strict condition indicates the DMAs will be useful for study to reveal the factors to chromosome pairing and recombination in meiosis. The results obtained in this doctor thesis will be used for wheat breeding by transfer of alien chromosomes.

Quahir Sohail

Molecular genetic and physiological studies for drought tolerant wheat production

Summary:

Bread wheat (*Triticum aestivum* L.; $2n = 6x = 42$, AABBDD) is genetically hexaploid and true breeding species with its ancestry linked to three wild grass species. Wheat crop has been widely cultivated throughout the world in very diverse environments, this means it is exposed to different biotic and abiotic stresses. One of most important of the abiotic stresses is drought. Under drought condition wheat undergoes severe physiological and biochemical changes which in the end result yield loss. Breeding for drought is big challenge because of the complex and unpredictable nature of drought environments and complex nature and interaction of the crops with the environment. Not many genes are known which may increase tolerance to drought.

The wild relatives of wheat have adapted to various environmentally harsh conditions including drought. Some of these wild relatives are expected to have drought tolerant genes. *Aegilops tauschii* Coss. is wild relative of wheat, it is widely adaptable and a direct ancestor of bread wheat, and, therefore, *Ae. tauschii* appears to be the most desirable species for wheat improvement among the more than 300 wild species in the tribe Triticeae. It is the D-genome donor to hexaploid bread wheat and is the most promising

wild species as a genetic resource for wheat breeding.

The first part of this study discusses the population structure and diversity of the *Ae. tauschii* accessions studied using diversity array technology (DArT) markers, and the second part is about the applicability of *Ae. tauschii*'s drought-related traits for breeding by comparison of their morphological and physiological traits with their corresponding synthetic wheat (SW) lines. SWs are hexaploid amphiploid (AABBDD) produced by crossing *Ae. tauschii* (DD) with durum wheat (AABB).

The population structure and diversity of 81 *Ae. tauschii* accessions collected from various regions of its geographical distribution were analyzed by DArT marker array made by the genomic representation of these line and a previously developed DArT wheat array. Out of 7500 markers (5500 wheat and 2000 *Ae. tauschii*), 4449 were polymorphic (3776 wheat and 673 *Ae. tauschii*). Phylogenetic and population structure studies revealed that the accessions could be divided into three groups, A, B and C. All the accessions of ssp. *strangulata* clustered in one clade in Group C. On the other hand, the three varieties of ssp. *tauschii* did not cluster into a particular clade. Accessions classified as var. *anathera* were present only in Group A, while those classified as var. *meyeri* appeared in Group C, with only one (KU2109) in Group A. The two *Ae. tauschii* subspecies could also be separately clustered, suggesting that the current taxonomy might be valid. DArT markers are effective to detect very small polymorphisms. The information obtained about *Ae. tauschii* in the current study could be useful for wheat breeding. In addition, the new DArT array from this *Ae. tauschii* population is expected to be an effective tool for hexaploid wheat studies.

Few genes are available to develop drought-tolerant bread wheat cultivars. One way to enhance bread wheat's genetic diversity would be to take advantage of the diversity of wild relatives of wheat, i.e. to introduce useful genes from this wild species into common wheat. In this study, I compared the expression of traits encoded at different ploidy levels and evaluated the applicability of *Ae. tauschii* drought-related traits (photosynthesis, stomatal conductance, intercellular CO_2, transpiration rate, SPAD reading, water potential, water use efficiency and dry weights of roots and shoot) using 33 *Ae. tauschii* of the above mentioned 81 accessions along with their corresponding SW lines under well-watered and drought conditions. I found wide variation in *Ae. tauschii,* and even wider variation in the SW lines.

The SW group showed better tolerance to drought in terms of higher rood dry weight, shoot dry weight and total dry weight and less percent reduction in these values due to drought. The *Ae. tauschii* group had higher average photosynthetic rates than the SW group under both well-watered and dry conditions, but the SW accessions had a smaller reduction in photosynthetic rate (20.4% vs. 21.8%). Based on the Euclidian distance, the *Ae. tauschii* group showed greater variation under WWC than under DC, while in SW it was vice versa. Some SW lines were more drought-tolerant than the standard cultivar Cham 6. *Ae. tauschii* from some regions gave better performing SW lines. The traits of *Ae. tauschii* were not significantly correlated with their corresponding SW lines, indicating that the traits expressed in wild diploid relatives of wheat may not predict the traits that will be expressed in SW lines derived from them. I suggest that, regardless of the adaptability and performance of the *Ae. tauschii* under drought, production of SW could probably result in genotypes with enhanced traits due to gene interactions. Based on the results of the present study, it is recommended that the useful traits of the SW lines observed at the hexaploid level be used not only for improving drought tolerance but also for breeding wheat cultivars capable of improving other quantitative characters.

The molecular information provided by the present DArT analyses will elucidate the genetic basis of the morphological and physiological characters at both ploidy levels. The new *Ae. tauschii* array developed, which represents a large and diverse collection, could be an effective tool for hexaploid wheat studies. The

aim of this research project is to compare the physiological and morphological characters with molecular information. The results obtained in this thesis will be used to study the genetic disequilibrium of the *Ae. tauschii* lines and also construct association map for drought related characters for SW.

Uzoma, K. C.

Effect of biochar application for improvement of sandy soil

Summary:

A study was conducted at the Arid Land Research Center, Tottori University, Japan to evaluate the application effect of biochar for sandy soil improvement in a combination of both laboratory and greenhouse experiment because information concerning the agronomic effects of biochar in drylands sandy soils is scarce.

In the laboratory study, the effect of pyrolysis temperatures of black locust wood biochar (300, 400 and 500^{o}C) on sandy soil hydraulic properties and nutrient retention were analyzed. Three application rates of biochar (0, 10 and 20 Mg ha^{-1}) were used. It was found that biochar amendment improved hydraulic properties and nutrient retention of sandy. The application rate of 20 Mg ha^{-1} reduced the hydraulic conductivity with increasing moisture content, as a result, the available water capacity increased by 97%, when compared to unamended sand. The results of the study showed that biochar produced at 500^{o}C pyrolysis temperature significantly improved hydraulic properties of sand better than other treatments whereas, biochars produced at 300^{o}C has the highest nitrate retention among the treatments. In general, the results of the study demonstrated the importance of pyrolysis temperature of biochar and biochar could be used to improve the agronomic side of the soil.

In the field study, the agronomic values of three biochars types produced from three different feedstock sources (black locust wood, cow manure and chicken manure) on maize production and quality of sandy soil were investigated. The biochars were produced at pyrolysis temperature of 500^{o}C based on the results of laboratory study. A randomized complete block design with four replicates was used. Four biochar application rates (0, 10, 15, and 20 Mg ha^{-1}) were used for each biochar type. It was observed that cow manure biochar significantly increased maize growth, yield, water use efficiency and nutritional quality as well as the physico-chemical properties of the post harvest sandy soil at the higher application rates of 15 and 20 Mg ha^{-1}. It was observed that the increases were significantly affected with increasing the biochar amendment rates. The increase in maize growth and yield may be largely due to the improvement in the cation exchange capacity of the soil, and an increase in the carbon, nitrogen and phosphorus contents of the soil. The application rate of 15 Mg ha^{-1} had the highest effect on maize growth and yield and consequently on water use efficiency and grain nutrient uptake. This was attributed largely to the higher soil phosphorus availability in conjunction with higher nitrogen availability at 15 Mg ha^{-1} rate, as compared to other application rates. The pH, phosphorus, total carbon and nitrogen, exchangeable cations (potassium, calcium, and magnesium) contents and the cation exchange capacity of the post harvest soil was significantly increased in the biochar amended soil.

In the study with chicken manure biochar, additional study on the effect pyrolysis temperature (500, 600 and 700^{o}C) on the yield and quality of chicken manure biochar was conducted. It was observed that pyrolysis temperature strongly affected the yield and properties of chicken manure biochar. Biochar produced at 500^{o}C had higher biochar and carbon yield (17-35%), and cation exchange capacity (500-581%) than the other materials pyrolyzed at 600 and 700^{o}C. Biochar application significantly

increased maize yield, water use efficiency and grain nutrient uptake at the higher application rates of 15 and 20 Mg ha^{-1}. The 20 Mg ha^{-1} had the highest impact on the improvement of the yield components. It was observed that maize grain utilized more nitrogen than other nutrient elements and nitrogen uptake increased with increasing the biochar application rate and this suggests the ability of the chicken manure biochar to improve the supply of nitrogen. Biochar application increased the pH, total carbon and nitrogen, exchangeable cations (potassium, calcium and magnesium) and cation exchange capacity of the post harvest sand. The field saturated hydraulic conductivity of the post harvest sandy soil was reduced as a result of biochar amendment.

In conclusion, it was observed that the effect of biochar on maize yield depended on the feedstock biomass source. The results also indicated that maize yield and nutrient uptake were significantly improved with increasing the biochar mixing rate. In general, it was observed that biochar effect on soil phosphorus availability was the dominant driver of yield increase. The cow manure and chicken manure biochars significantly improved maize yield than the wood biochar. This was because cow manure and chicken manure biochars improved nitrogen and phosphorus availability in sand, and exchangeable cations and cation exchange capacity more than the wood biochar. Generally, cow manure biochar significantly improved maize yield than other biochars and this was observed to be because of the ability of cow manure biochar to increase the CEC of sand more than other biochars. Therefore, the application of cow manure biochar at the rate of 15 Mg ha^{-1} was suggested as the best treatment to improve crop yield and sandy soil quality. Thus, the conversion farm wastes to biochar, as evaluated in these studies, can be considered a sustainable alternative to the easily degradable agricultural wastes, thus, a strategy for sustainable dryland sandy soil improvement, and also for carbon sequestration.

Ailijiang, M.

Studies on the salt tolerance mechanisms of halophytes growing in Xinjiang, China

Summary:

Progressive soil salinization is a serious issue in worldwide and it becomes a major cause of desertification in arid region. Extensive degradation of irrigated lands due to salinization poses both environmental and socio-economic problem in Central Asia and northwestern China. To combat soil salinization, various methods have been used. A biological method, phytoremediation, is come into employ to decrease the trend of soil salinization and ameliorate degraded land effectively. In this method, using native halophytes has drawn attention and is getting a high priority in several countries. Halophytes, are widely distributed in Xinjiang，where is very rich in halophyte species. Hence, those halophytes offer promising utilization of abandoned salt-affected soils, where others solutions of rehabilitation are not feasible. For appropriately and successfully use those halophytes to amelioration salt affected soil, it is necessary to indentify the tolerance mechanism of those halophytes to saline conditions.

In this study, to elucidate and identify the salt tolerance mechanisms, several aspects of trials including field trials and greenhouse experiments were carried out. One, field trials, concerned with the identifications of salt regulation mechanism and understanding of species-specific characteristics of osmolytes accumulation in halophytes under natural saline habitats. For this, cation concentrations and distributions among plant parts, and osmolytes accumulation in leaves were determined in five halophytes (*Tamarix hispida*, *Halocnemum strobilaceum*, *Kalidium foliatum*, *Karelinia caspica*, and *Phragmites australis*) growing around Aiding Lake, Xinjiang, China.

As results, *T. hispida* has salt glands and contained high foliar Na^+ concentrations. The succulent plants,

H. strobilaceum and *K. foliatum*, accumulated large quantities of Na^+ in the leaves, indicating that a considerable amount of Na^+ was absorbed by the roots and transported to leaves in these species. *Karelinia caspica* and *P. australis* showed the highest root cation selectivity, whereby *P. australis* accumulated high concentrations of K^+ in all tissues. With regard to osmolytes accumulation: *P. australis* showed high concentration of soluble carbohydrates, mainly sucrose, and amino acids such as proline and alanine. *K. caspica* accumulated a large amount of mannitol. *H. strobilaceum* and *K. foliatum* greatly accumulated glycine betaine. Only *T. hispida* accumulated much γ-butyro betaine.

From those findings, I can conclude the five halophytic species growing in Xinajiang, not only reflected different mechanisms for salt regulation as differences in salt tolerance, but the good osmoregulation function are also performed by various osmolytes accumulation in their leaves. That, at least four kinds of osmolytes, such as carbohydrates, polyols, amino acids and betaine functions either alone or in combination in the osmoregulation of those halophytes.

Another one, greenhouse experiments, concerned with the response of *Elaeagnus* species, pioneer multipurpose tree species, to various salinity. To exam physiological behavior, I investigated the photosynthetic performance of 1-year-old *Elaeagnus angustifolia* L saplings were exposed salt stress for one week (NaCl concentrations: 0, 200, 400, 600 mM). Net photosynthesis rate, stomatal conductance, and transpiration rate were markedly decreased at 200 mM NaCl concentration, and the chlorophyll contents and the maximum quantum yield of PSII in leaves also little decreased. However, all values were compromised at 600 mM NaCl. It can be considered that photosynthesis seems to be limited mainly by stomatal closure rather than malfunction of PSII under 200 mM NaCl concentration, but to be decreased severely in photosynthesis rate owing to possible malfunction of PSII under 600 mM NaCl concentration.

Finally, salt-induced changes in growth, photosynthesis, and osmolyte accumulation were analyze in *Elaeagnus oxycarpa* seedlings, these were affected different salinity (NaCl concentrations: 0, 50, 100, 200, or 300 mM) for 30 days. Plant growth and biomass decreased with an increase in salinity. However, seedlings were able to cope with up to 300 mM NaCl without any effect on survival. Gas exchange was unaffected at 50 mM NaCl. Maintenance of PSII function (*Fv/Fm*) at high salinity (200 mM) supported *E. oxycarpa* growth. Leaf and root Na^+ concentrations increased with increasing salinity, but most Na^+ was retained in the root system at low and moderate salinity (50 and 100 mM NaCl) while high concentrations of nutrients (e.g. K^+ and Ca^{2+}) were maintained in the leaves. Seedlings accumulated a set of important osmolytes in leaves under salinity stress: sucrose, β-alanine betaine, proline, and glycine increased markedly at 200 and 300 mM NaCl. Therefore, it could be conclude that salt tolerance in *E. oxycarpa* is based on maintenance of PSII function, ionic homeostasis, and osmolyte accumulation.

(2) Master's Theses

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Chromosome dynamics in the Triticeae x Pennisetum early hybrid embryos based on the phylogeny and chromosome structure of the Pennisetum species