1. Article

1.1 Summaries of Doctor Theses

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Climatological Studies on Productivity of Livestock Farming and Agriculture in the Inner Mongolia Autonomous Region of China

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China manages to supports 22% of the world population (1.2 billion people) on 7% of the world arable land at present. Besides suitable lands for farm land reclamation have almost reached to the limit in the south-east China which is the advanced agricultural region where almost 90% of the population and arable lands are concentrated in. This small amount of arable land has been decreasing by recent economic growth. Thus, the development of livestock farming and agriculture in the north west China centering around the Inner Mongolia Autonomous Region (hereafte the Inner Mongolia) has greatly expected. Inner Mongolia belongs to arid and semi-arid regions where the land is fragile against human impact, and the possibilities of desertification are very high. Therefore, establishment of appropriate methods to estimate productivity of agriculture and livestock farming to implement sustainable development is required. This subject is not only the domestic problem of China but also global issue of food supply. Thus, in this studies, case studies of the Inner Mongolia in China has been conducted. It is intended to consider the background and transition of livestock farming and agriculture from both natural and social sciences, and examine the climatological evaluation of those productivity.

Firstly, the recent transitions of economic system, production management, and productivity of livestock farming and agriculture are analyzed. The results show that the livestock farming and agriculture are classified five stages; "*Former Society Stage*" before the formation of the Inner Mongolia (1947), "*Democratic Revolution Stage*" after the formation, "*Socialistic Transformation Stage*" from 1953, "*Peoples Communes Stage*" include the Great Proletarian Culture Revolution from 1958 and "*Economic System Reformation Stage*" from 1981. In each stage, activity of the society and incentive of the people in response to the economic policy influence the production of livestock farming and agriculture. It is indicated that the livestock farming should change the style from nomad to sedentary for prevention of desertification and sustainable development in the current of overpopulation and commercial economy. It is pointed out that agriculture should introduce multiple management including livestock farming and forestry. Land conservation by appropriate cultivation is important as well as improvement of productivity by introducing infrastructure and modern technology.

Secondly, climatic features of the Inner Mongolia are evaluated from various aspects and relationship between the climate and the land use has been discussed. Most part of the Inner Mongolia except the north-east is classified into continental arid climate zone because it is located in the inland of Asia continent and the influence of the Pacific monsoon is weak. Although it is very cold in winter, it is warm and rainy during spring and summer. This climatic feature, which is called "Rain-Heat in the Same Season", gives a big advantage for the livestock farming and agriculture. Possibility of drought, however, is high because the fluctuation of precipitation is large. Air temperature, duration of sunshine and pan evaporation increase and precipitation decrease westward. Radiation Dryness Index (RDI) increase westward from 1.6 to 30. Livestock farming is mainly distributed in the region where RDI is greater equal 4. Agriculture is located principally the region where RDI is 2-4. Dry farming is situated in the region where RDI is 2-3. Irrigation agriculture is independent of RDI, and located near the rivers. The region where RDI is less equal 2 is covered by forest.

Thirdly, climatological estimation of productivity of livestock farming and agriculture using Chikugo model is discussed. Chikugo model was originally designed to estimate Net Primary Productivity (NPP) of natural vegetation include roots. It is indicated that NPP has linear correlation with productivity of natural grass and crops of dry farm. Although there is no direct relations between NPP and crop productivity of irrigated farm, there is a linear relation between ratio of crop productivity to NPP and irrigation ratio.

In conclusion, it is described that NPP by Chikugo model is not only an index of productivity of natural

vegetation but also indexes of livestock farming and agriculture, and it will be very useful for sustainable development in the Inner Mongolia where the livestock farming and agriculture have been drastically changing by population pressure and commercial economy.

Mechanisms of interspecific differences of vegetative growth response to soil drying in the three gramineous crops

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Interspecific differences of vegetative growth response of three gramineous crops, pearl millet (Pennisetum typhoideum Rich.), barnyard millet (Echinochloa framentacea Link.) and maize (Zea mays L.) were studied under soil drying conditions as indicators of drought tolerance.

Four experiments, one in the field, one in pots and two in polyethylene glycol (PEG) solutions were conducted. In the field experiment, seeds of the three crops were sown in a sandy soil. Soil moisture stress was determined by stopping irrigation in some plots and continuing irrigation in the others. The second experiment was conducted in pots (Wagner 1/2000 a), to restrict root development and irrigation was applied when the weight of pots reached 3 or 10% w/w for wet and dry treatments, respectively. The objective being to identify whether root development or resistance to water flow through the plant (R) are determining factor for the differences of drought tolerance among the three crops. In the third experiment, crops were raised in a uniform root environment, with the water potential of solution at -0.93 MPa, using aqueous PEG solutions. Both root depth and distribution were eliminated, the objective being to identify whether root depth, root distribution or root length was the most important component of root development. In the forth experiment, effect of low water potential on root growth was studied by transplanting "leaf-cutting" plants to nutrient solutions with -0.02 and -0.54 MPa for control and stressed treatments, respectively.

Measurements to evaluated the relative performance of the three crops, regarding their drought tolerance, included the following: (a) Net assimilation rate (NAR) and leaf area ratio, as determining factors for relative growth rate (RGR) as an indicator of drought tolerance; (b) Photosynthetic rate (P) as the main determining factor for NAR; (c) CO2 fixation rate (Ci), stomatal conductance (gs), leaf water potential(Ψl) and leaf osmotic adjustment (OA), as determining factors for P, (d) Depth, distribution and length of roots and R as components of water uptake ability factors of keeping Ψl.

The results of the field experiment showed that soil drying decreased RGR which was depended on NAR. Regarding crops, pearl millet displayed the lowest reduction in RGR, NAR, P and gs as compared to the other two crops. The extension of roots of pearl millet deep into the soil profile might have enabled it to sustain a better water uptake and maintenance of a lower R resulting in a high leaf water status, which helped to keep a high P and consequently high RGR under soil drying conditions.

When root development of the crops was resricted, by planting them in pots, there was no significant interspecific difference in RGR among the three crops, suggesting that the interspecific differences of drought tolerance were associated with root growth. The results of the third experiment indicated that there were interspecific differences among the three crops, showing that pearl millet having the lowest reduction in RGR and this was closely related with the interspecific differences of leaf area-specific root length. In the forth experiment, RGR of the root.

Efficient Water Application of Supplemental Irrigation and Two-dimensional Capillary Supply of Drip Irrigation In Upland Field

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Japan, a humid country, experiences high rainfall regimes in a humid region usually irrigation is supplemental to rainfall and stored soil water in effective soil layer . The characteristic of su pplemental irrigation is to make the most of soil water from rainfall Also capillary supply of water is supplemental water from the lower layer to effective soil layer.

Drip irrigation is rapidly being developed in the arid regions of the world, with the advantage of saving irrigation water and reducing salt damage to crops. Recently, the standard design for drip irrigation schedules was completed in the U.S.A. and Israel leadi ng to a comprehensive compilation of the basic studies since. the 1970s. Also, a guideline for planning and design for land improvement was completed in Japan.

In this study, irrigation performances in a humid and arid region were investigated. Studies were conducted using frequent, low-intensity irrigation in the HOJO sand dune fields and the MU US SIIAMO Desert Research Center. A two dimensional capillary supply model for drip irrigation was proposed.

Water use in the HOJO sand dunes was monitorred by computing the standard and net water requirements. It was concluded from the results that standard water requirement increased with decreased effective rainfall due to increased greenhouse horticulture. Also the effect of frequent, low-intensity irrigation in HOJO sand dune fields was better than in the MU US SHAMO Desert Research Center.

The main purpose of this study was to develop a two dimensional capillary supply model in drip irrigation fields,using finite element numerical techniques to estimate the soil water distribution and capillary supply.

Capillary supply of water was not only from the lower layer of effective soil layer but also from the sides too. A two-dimensional capillary supply model with water uptake under irrigation and rainfall was proposed. The soil water flow was modelled experimentally, using a two-dimensional soil tank system consisting of a soil tank, a wind tunnel and a gamma ray attenuation apparatus.

Soil water distribution obtained for rainfall condition with root uptake, using the numerical model simulation compared well with measurements of experimental model. The ratios of side capillary supply to lower capillary supply obtained by numerical model were between 90～92%, suggesting that a substantial amount of capillary supply came from the sides.

For the irrigated condition with water uptake, numerical model prediction of soil water distribution, capillary supply and percolation loss from side zone and lower zone, agreed well with measurements of experimental model. Also, capillary supply increased with increased soil water storage.

Finally, the model was tested using existing sugar cane root distribution field data and it was concluded that soil water distribution was affected by size of the root zone. Side capillary supply showed the tendency to decrease more with increased size of root zone than in the case of lower capillary supply. Also, it was shown that percolation loss was used as capillary supply under both rainfall and irrigation conditions.

Characteristics of Plant Growth and Soil Water on Artificial Bed Soil in Sparce Vegetation Areas

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The use of artificial bed soil with continuous fibers for revegetation of areas of sparse vegetation was discussed. The development of an artificial bed soil is a basic requirement for revegetation. In this investigation, first for the purpose of applying the artificial bed soil with continuous fibers to sparse vegetation areas, its basic properties were examined. Secondly, based on these results, the characteristics of growth of green plants planted by seeding in the artificial bed soil with continuous fibers were studied on a steep slope and dune slope. The characteristics of soil water content were also studied.

It was observed that on steep slope the growth of arboreous plants were well, and their height reached 2m. Their growth was better at lower part than upper part of the slope depending on the condition. And it was realised that Yamahagi which is arboreous plant is better for drought conditions herbaceous plants. Because the root system of arboreous plants was distributed mainly in the artificial bed soil during initial growth stage, it was concluded that the artificial bed soil fulfilled its most important role during its initial stage of development.

It was observed that the moisture condition for plants on steep slope was better at the lower than upper part of the slope. In the experimental field on a sand slope, an experimental of soil water under nonrainfall condition was carried out and it was concluded that developing the artificial bed soil which saves high amounts of water is useful for growth of plants. Even though the artificial bed soil saves high amount of water on sand slope and reduces the percolation losses of irrigation water It Increases evaporation from the soil surface under high temperature and low humidity conditions. On the other hand It was observed that sand mulch over the artificial bed soil is useful for controlling evaporation from the soil surface. And simulation model for water movement in the artificial bed soil on a steep slope was developed of planning and management of vegetation. Numerical simulations with meteorological data were carried out Comparing numerical results with measured values from experimental field, it was realised that this simulation model could have wider application in the planning and management of revegetation slope