

Engineering problems of crop farming in Mongolia for climate change

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1. The climate conditions and current changes in the ecosystem of Mongolia

The climate of Mongolia is continental and with four seasons that characterized by long and cold winter and cool summer, small amount annual precipitation, big temperature fluctuation and relatively high number of sunny days. January is the coldest period with average temperature of -15°C to -40°C . July is the warmest month with average air temperature ranging from $+15^{\circ}\text{C}$ to 30°C .

The period when air temperature exceeds $+10^{\circ}\text{C}$ and the total heat accumulation during this period are important, because the total generated heat is necessary for vegetation growth. This period is about 90 days at attitudes of 2000 m sea level, 90-110 days in the forest step zone and 110-130 days in the desert steppe zone of Mongolia.

Precipitation varies both in time and space or area. The annual mean precipitation varies 200-300 mm in mountain regions, 150-200 mm in steppe area, 100-150 mm in the steppe desert areas and 50-100 mm in the Gobi desert area.

Recent years have seen a visible change in the ecosystem of Mongolia with increasing desertification, soil erosion, depletion of water resources and biodiversity which in their turn have been related to significant change in the climate worldwide. During last 64 the annual temperature in Mongolia has warmed by 1.8°C and by $1.3-1.8^{\circ}\text{C}$ in spring and autumn, by 0.5°C in summer and by 3.6°C in winter.

According to the forecast released by the state meteorological institute, it is estimated that the air temperature in a summer season will be increased by 3.53°C in the year of 2020, by 6.35°C in 2080 respectively in Mongolia. When it comes to an annual precipitation in summer time, it will be decreased by 5.2 mm in the year of 2020 and by 13.6 mm in 2080 year respectively.

The agriculture of Mongolia depends heavily on weather condition. Climate change is expected to have a large impact on crop production and can cause serious problems in the 21st century.

2. Agriculture development

Livestock husbandry sector produces approximately 80% of total agricultural products and more than 20% of total export. One third of the country's total human population are employed in livestock husbandry sector to secure incomes and provide directly or indirectly the remaining two third with food.

Enormous loss in agricultural sector caused by draught and severe weather disaster exerts adverse impact on living of rural population, followed by shortage of human food consumption, reduction of raw material supply and exportable products for national manufacturers and entrepreneurs and increase of poverty and unemployment in rural area.

Mongolian bread livestock is well adopted for severe continental climatic condition and peculiar with all around pasture grazing, but its yield and productivity is not sufficient. Although our nation gained enormous wealthy experiences of grazing livestock for centuries, worldwide ecological changes has been occurring in the present years, make more obvious

feeling that we are not able to work and live relying on old traditions and experiences. Therefore, in conjunction with climatic changes and modern animal husbandry development tendency it is time to develop intensified livestock in Mongolia.

Considering the above mentioned situations of Agriculture, the government of Mongolia released an official paper “**State policy on food supply and agriculture**” in 2003. The purpose of this policy is to provide convenient conditions for sustainable agriculture development in the near future and increase food supply the population of Mongolia.

Crop farming

Approximately, 82.5% of Mongolian territory used for agriculture and only 1% out of 1.7 mln hectares are applicable for crop production.

Recent years, over half of arable land has been abandoned and annually about 270-285 thousand hectares prepared as summer fallow and 227-240 thousand hectares are cultivated, supplying only 30% of domestic annual consumption of flour or wheat and 50% of potato and vegetables. There is number of factors affecting the considerable reduction of crop production and one of the major factors is the present climate changes and drought, which cause soil erosion and desertification process in arable area in Mongolia.

As shown in the next figure the sown area and crops harvested are decreased year by the year at present time.

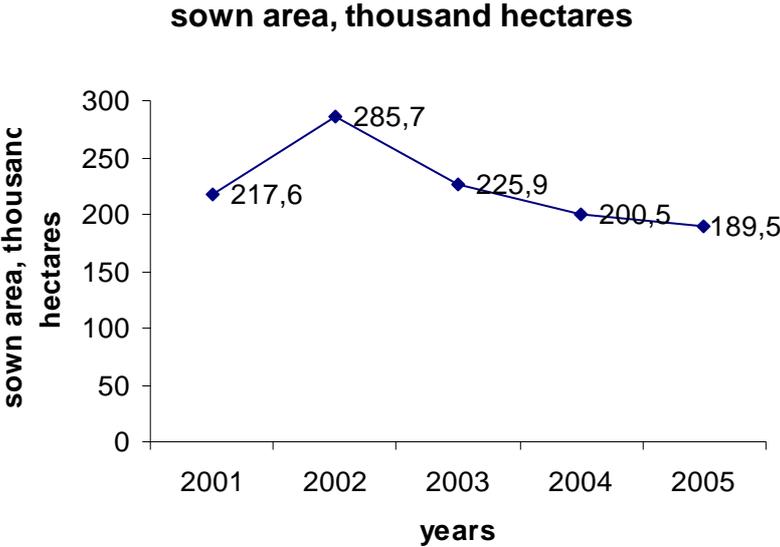


Figure 1. Sown area, thousand hectares

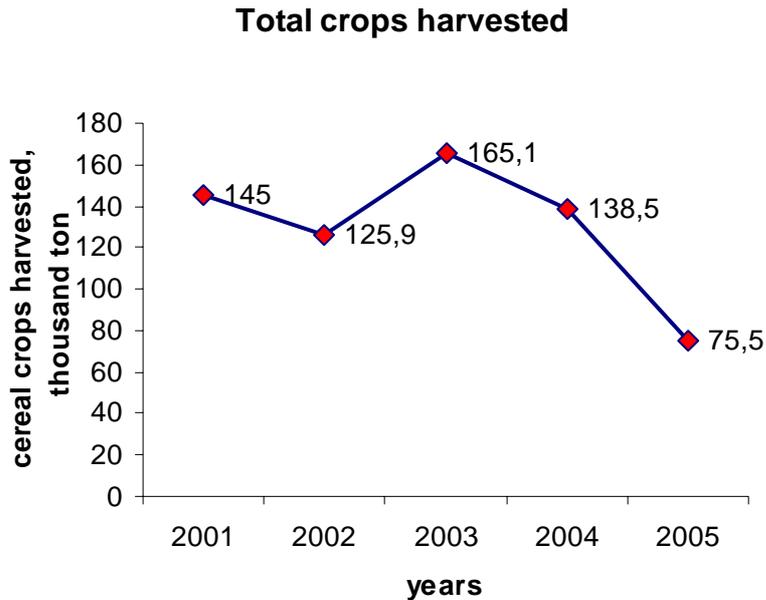


Figure 2. Total crops harvested in the years of 2001-2005, thousand tons

Difficulties and problems caused by the present climate changes in crop production sector

It is clear the following negative consequences have been arising as an effect of the climate changes in Mongolia in present days. Namely:

1. Due to unsuitability the germination and growing features of the most popular varieties planted in Mongolia to the climate changes, leads to lose plant yield completely.
2. As a direct effect of soil plowing and frequent mechanical soil cultivation and tillage operation conducted in the field, soil erosion is becoming a catastrophic scale.
3. Due to shortage of soil moisture, contents of soil decay decreased by 37-52% thus leads to loss soil fertility and weakening
4. There is a tendency of spreading plant diseases affected by world warmth effect in Mongolia in the last 5 years. Also number of harmful insects is increasing.

It considered that if climate is dry and suffer drought and soil fertility is weak, then recommended to use an ecologically oriented crop production technology which suites to the native terrain and land features and region climate peculiarity, acclimatized to the current climate changes.

Directions and measures to be implemented in crop farming system in Mongolia to overcome effects of climate changes. For instance:

1. As a consequence of world warmth effect winter season annual precipitation in Mongolia estimated to be increased by 15-20% in present time. Therefore, it is recommended to use shallow tillage for wintering and stripe planting technology to accumulate snow fall during winter time and to make straw cover to prevent soil moisture evaporation and to increase soil moisture absorption.
2. To pay more attention on conservation of soil fertility and other natural recourses. In the near future to use soil shallow tillage instead of plowing and, to refuse of application mechanical soil cultivation and to practice more and more conservation

technology and no tillage technology and to use of fertilizers and herbicides thus decrease effect of climate changes.

3. By practicing modern and advanced technologies of plant breeding and achievements of biotechnology have to spread or to popularize and plant the new varieties of the crops, which are resistant to drought, stable for climate changes. To promote flexible, ecological and sustainable agriculture which, meets the demands of agro ecological stability in the country.

The cultivation technology development in Mongolia

The technologies of soil conservation and soil fertility improvement and cultivation of the major crops has been developed and practiced in Mongolia last 15 years. These include:

1. Strip planting technology
2. Soil conservation technology through soil shallow tillage
3. Green manured fallow preparation technology
4. Yield protection technology
5. Fertilization system of agricultural crops
6. Wheat cultivation technology on chemical fallow
7. Technology for early yield maturity in cereals
8. Soil mulching technology by straw
9. New bacterial fertilizer production technology

As a consequence of the spread use of direct soil plowing technology in Mongolia, the soil moisture content has decreased significantly and soil erosion has become serious problem in crop production system. Although, since 1970's the shallow tillage technology applied in crop production, this technology does not give satisfactory results to prevent the soil erosion problems, therefore the current situation requires further implementation soil conservation and no tillage technology or chemical fallow preparation technology spreadly in crop production sector in Mongolia.

The research study results of the Plant Science and Agricultural Research Institute, Mongolia show that when applied chemical fallow for soil treatment, the content of soil moisture increased by 0.6-2.1 mm in depth of 0-30 mm and resulted in increasing the crop yield by 0.01-0.08 ton/ha compare to shallow tillage technology.

3. Technical and technological renovation of crop production

Mongolia entirely belongs to arid and semiarid region. Due to no attention paid to soil erosion the sustainability of agriculture is broken already, that about 46.5% of arable land is eroded for some extent and 12.9 % (72.4 thousand hectares) heavy from this.

Therefore one of the problems to provision of sustainable development of agriculture is adaptation conservation technology in the crop production. The main features of this system is reduction number of mechanical cultivation, preservation more of plant residue on the soil surface and rational application of chemicals for weed control.

Mongolia does not manufacture any agricultural tractors and machineries in big scale and therefore has to rely solely on imported tractors and equipments.

In order to disseminate and introduce the soil conservation technology in crop production we should solve the technical renovation issue in the following ways:

1. To import the agricultural machineries for conservation technology from the countries where this advanced technology practised for the years, such Canada and USA. In this stage we encounter some difficulties because of high cost of these machineries.

2. To import and utilize agricultural machineries adapted to the conservation technology, manufactured in Russia and former soviet union countries, which are some kind familiar to the Mongolian farmers in terms of its maintainance and service and used to in crop farming in Mongolia and cheaper than manufactured ones in the developed countries.
3. Modification the existing agricultural machineries with modern soil treatment tools adapted to the conservation technology such with weed control and spreading out the plant recidue on the field. At the present days we have been conducting some research studies on this issue and achieved good results in crop production.

Renovation and modification the existing machineries for conservation technology in Mongolia

Soil cultivation and seeding machinery should be multifunctional, highly capacity and be able to perform several operations in their one pass, that is, in order to avoid from repeated soil distributions. Moisture is our number one limitation factor to production. Therefore seed- to-soil contact is even more important when direct seeding and to create it require the press wheel behind the openers. In the condition of Mongolia offers two type openers of seeder as sweep and single disc. The sweep type openers have a long leading edge and that good cut roots weed.

According to technical requirements dealt with a seeder from Novosibirsk (Russia) as Obi-4 what combined cultivation, seeding in band and packing.

For chemical application of plants and for conservation tillage system such a boom and trailer type sprayer should be suitable, which has a pressure more than 3 bar in its system, a width of 15-18 m (50-60 ft), spray control in cab adjustable.

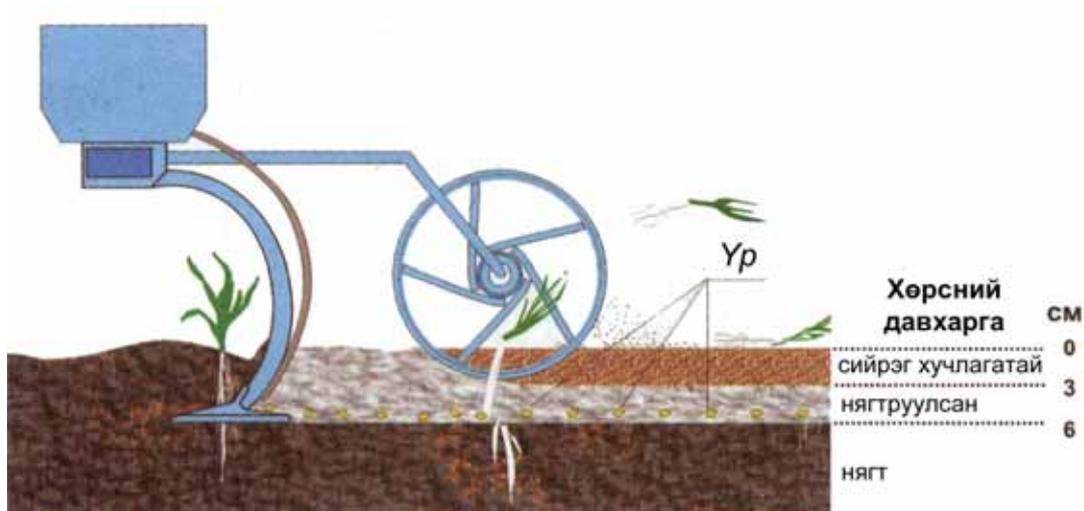
As show the results of our research study on modification a crop tillage seeder of SZS-2.1 imported from Russia for conservation technology by replacing the openers with weed control and packer, the yield harvested per hectar increased by 0.2-0.4 ton. Clear evidence of this work shown in the next picture.



Picture 1.

a- crop sprouting after planting by tiller seeder SZS-2.1 imported from Russia

b- crop sprouting after planting by tiller seeder SZS-2.1 equipped by an opener with weed control



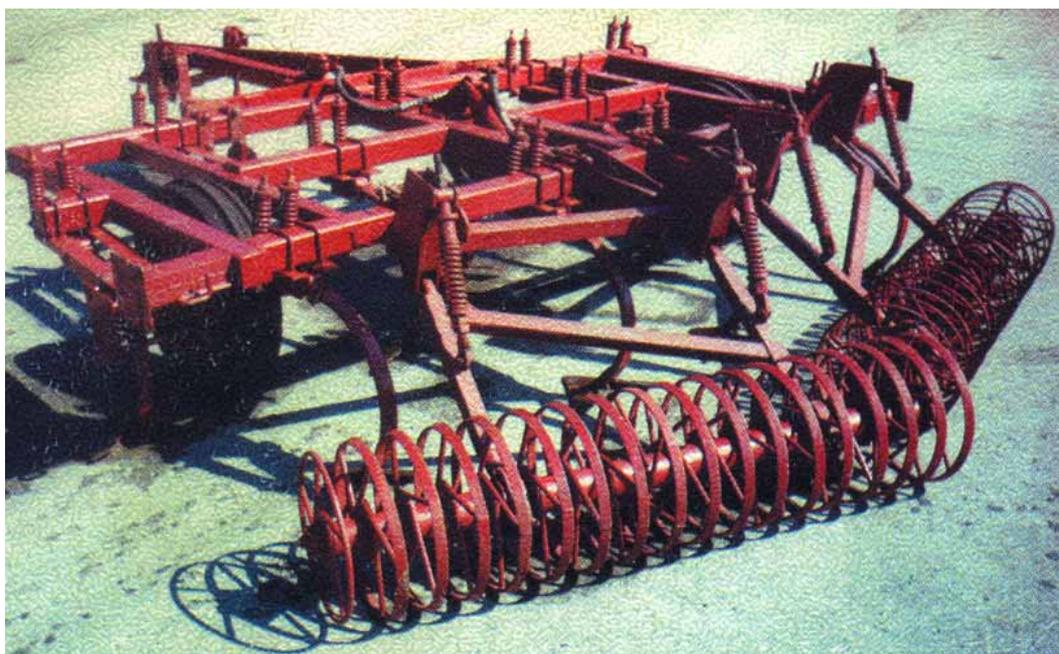
Picture 2. Technological scheme of operating the modernized seeder SZS-2.1

The positive results of replacing existing tillage seeder by the openers with sweep and equipping by coil packer are as follow:

1. Better weed cutting and destroy
2. Packing prevents soil moisture evaporation and soil erosion and make a cover on the field surface from the plant residue and weed, thus help faster and even germination.

It is recommended to use cultivator coil packers for soil tillage. These machineries have following advantages compare to old cultivator used to in Mongolia.

1. Good soil compaction to retain soil moisture and create the ideal environment for germination
2. Even covering the field surface by weed and plant residue removed from the soil to reduce moisture evaporation and soil erosion by wind.



Picture 3. Tiller-cultivator "Lider-4" for conservation technology imported from Russia



Picture 4. Operating principle of tiller-cultivator “Lider-4” for conservation technology



As for crop harvesting technology, farmers prepare to use harvester equipped with straw chopper and broadcaster of PC-2M, Russia, which gives satisfactory results for mulching the soil surface by straw cover of 4.-4.5 m width and 0.10-0.15 m depth. It creates good conditions and possibilities to apply no tillage technology in crop farming in the near future in Mongolia.



Picture 6. Chopping and spreading the straw on the soil surface during harvesting

Spreading straw residue on the soil surface is important for the protection of soil from wind erosion and helps to increase its fertility. Studies carried out at Plant Science and Agricultural Research Institute show that the fluctuation of soil temperature is reduced by 2.0-2.7 °C and its moisture can be increased by 20-25 mm after spreading straw and chaff on the field surface at rate of 3.0 tones per hectare.

Conclusions:

Existing system of crop farming technology take negative impact in the sustainable agriculture Mongolia, specially in the cereal production.

For the ecological and sustainable agriculture development in Mongolia is expedient throughout adaptation conservation technology ensure saving soil, fertility and moisture versus wind erosion and drought.

To develop conservation technology recommended use three forms to provision of machinery and equipment: import agricultural machineries for conservation technology from the countries where have been realizing this type of technology or import machinery what may be adapt for conservation technology and modification existing machinery for conservation technology.