Experimental Studies on the Effect to Rainfall Infiltration and Vegetation Growth by Use Bulk Subsoil Technology in Loess Plateau

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Abstract: Through plot testing, the effects to rainfall fluid and infiltration by using bulk subsoil techniques in the natural slop of loess plateau area were approached in the paper. The results indicated that bulk subsoil technique is great improve soil structure and increase soil infiltration, especially to promote caragana growth. The branches growth of Caragana in area that was subsoiled increased 50.15% compare to contrast region.
Keywords: bulk subsoil, rainfall infiltration, vegetation growth

1 Introduction

The affects to plant growth and soil and water properties for existing sole are the common knowledge. The hard and high density plowing zone are not only has a worse aeration condition in soil profile, but also inhibited plant rooting that cause lower crop production (Giraldez, etc., 1988, Zhang GX 1997, Liu XZ etc., 1999). The Calcium deposited zone formed in some area has same affection as plowing zone, which is the main reason that caused “the small old trees” in loess plateau. Bulk subsoil technique is only way to broke the zones.

Bulk subsoil is of special function to improve soil structure and soil physical properties. First because of not turn the soil, bulk subsoil could keep vegetation on soil surface, which are of great significant in the area of cause easily soil erosion. Second the plowing zone and calcium deposit zone are broken and create a new soil structure that is suitable to plant growth, and the abilities of soil water storage, flood drainage and salt leaching is great increased. The conditions of soil moisture, fertilizer, aeration and temperature are adjusted reasonable, the soil water and fertilizer use efficiency are increased, and soil and water erosion is relaxed also. Bulk subsoil will be a new tillage technique for soil and water conservation, soil reclamations, fertilizing soil and increasing crop production in arid and semi- arid area. After bulk subsoil, soil infiltration rate is increased 5—10 times (Liao,ZX, etc., 1995). At present, bulk subsoil technique was tested mostly in farmland (Gu JB etc., 1994, Liao ZX etc., 1995), and there is less report that bulk subsoil was used in some loess plateau areas where was trampled by people and animal again and again for pasture frequently as well as its affection to vegetative growth.

There are two technological ways to develop water harvesting. One is water fluid collection (Carter D.C and Miller S, 1991, Peng KS,2000). There is much kind of materials for build the land surface to collect fluid, but the cost of all the materials are high. And because usually need lot of money and labors to built water storage construction, it is a main limited factor to develop water harvesting technology in the under-developed economic area.

Another way is that increase soil water infiltration rate and store the rainfall on the spot for plant use in drought season through some technological methods（Giraldez J.V. etc., 1988, Gu,JB etc., 1994）. Based on the purpose and using theory analysis and field tests, the affections of vegetative and tiller to water infiltration, the applications of bulk subsoil technology in water harvesting, its disadvantages as well as easy to extension and acceptable technology were approached in the paper.

2 Materials and methods

The test was conducted in Liuhuiliang village, Qingshuihe Country where located in south of Huhhot City Capital of Inner Mongolia. The soil belongs to loess plateau area and irrigation only rely on precipitation. Rainfall is concentrated in July to September and the rainfall is usually heavy rain with short time. So most of rainfall forms surface fluid and cause soil and water erosion for special properties of loess soil. And vegetation and plant growth were inhibited.

About 50% of total land the slope gradient is less than 7°, about 21.4% is 7°—15°, 21% is 15°—25° and 7.8% is over 25°.

2.1 Treatments

Three treatments was designed that bare soil is with and without bulk subsoil, soil growth vegetation (Caragana) is with and without bulk subsoil. As below:

Treatment A: natural bare soil without disturbing
Treatment B: natural bare soil with bulk subsoil
Treatment C: Caragana land with bulk subsoil
Treatment D: Caragana land without disturbing

2.2 Test plots design

The plot test was adopted and plots were laid on the slope facing to the south where uphill is bare soil and down hill is caragana land. The bare soil plot size is 2m×8m and the Caragana land plot size is 4m×12m. Each plot was surrounded by low bank of earth to prevent out site water fluid in. A tank was arranged in slope foot of each plot to collect rain fluid. Bulk subsoil plough that was designed by CAU and produced by Beijing Agricultural machinery factory was driven by a caterpillar belt tractor with 75 horsepower. The width and depth of subsoil are 100 cm and 50 cm respectively. Diagrammatic sketch of plots arrangement show in Figure 1 and Figure 2.

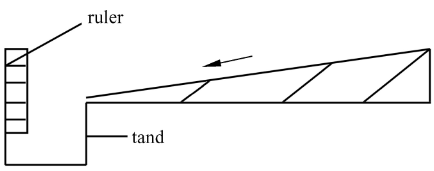

Fig.1 Diagrammatic sketch of plots arrangement in profile

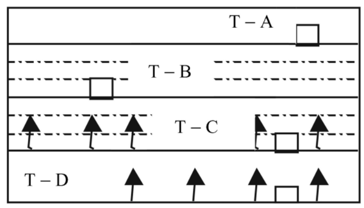

Fig.2 Diagrammatic sketch of plots arrangement in plane

2.3 Methods

Main soil physical parameters measured are soil bulk density, soil texture, soil water characteristic curve and soil diffusivity in each plot. A rain gauge was installed in the field to measure rainfall amount and rain time.

A ditch with slop of 1/100, covered by plastic film, was built in down fringe of each plot, and connect with a tank at end of the ditch for measuring amount of water fluid and soil erosion.

The typical Caragana was chosen according to their height, canopy size, growth age and growth environment. Branches growth rate of Caragana is a main factor to determine the affections under different treatment.

Initial soil moisture, three place chosen in top, middle and down of each plot with layers of 0cm—10cm, 10cm—20cm, 20cm—40cm, 40cm—60cm, was measured first when the experiment started and the measurement was continued once a week while no rainfall duration. Amount and time of rainfall water fluid and soil erosion formed were recorded during the raining. Soil moisture in profile was measured when rain stop 24h. Branches growth rate of Caragana was measured once of every two weeks until the growth stopped.

3 Results and analysis

There are only three rainfalls during the experimental stage. Except for a small rainfall all the plots didn't form water fluid, another two rainfalls were caused water fluid in two CK plots, but no water fluid in all plots with bulk subsoil treatment. Slope affection is significant to the plots without bulk subsoil treatment (include bare soil and Caragana land), its soil moisture in top side is lower than it in down side of plots. However soil moisture in the plots with bulk subsoil treatment is uniformity no matter in top or down side of the plot. That means bulk subsoil land could reduce the slope affection to cause soil and water erosion. Soil profile moisture measured after rainfall on August 9 shown as below:

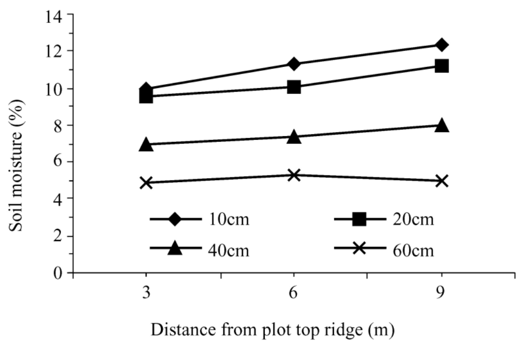

Fig. 3 Soil moisture distribution in plot A

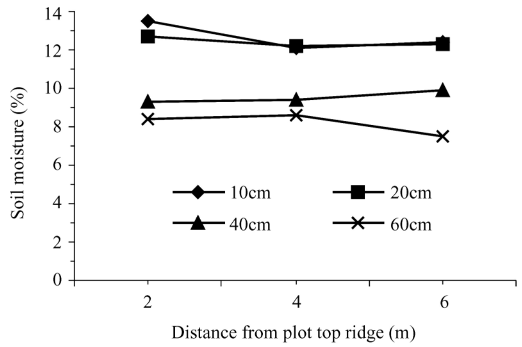

Fig. 4 Soil moisture distribution in plot B

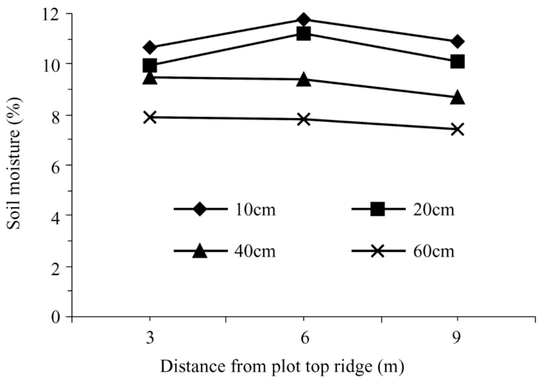

Fig. 5 Soil moisture distribution in plot C

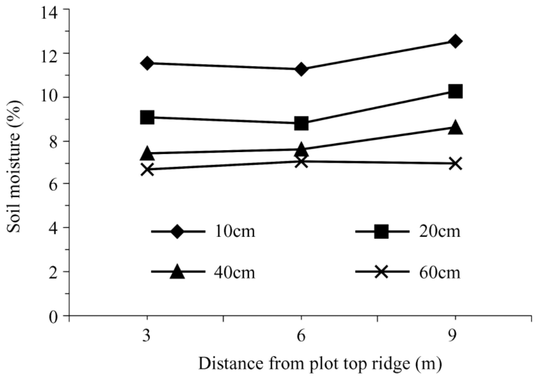

Fig. 6 Soil moisture distribution in plot D

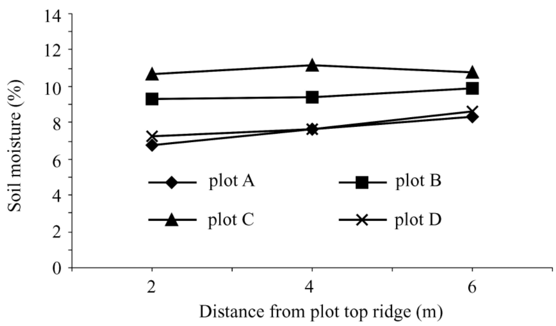

Fig. 7 Soil water capacity in the layer of 0cm—10cm

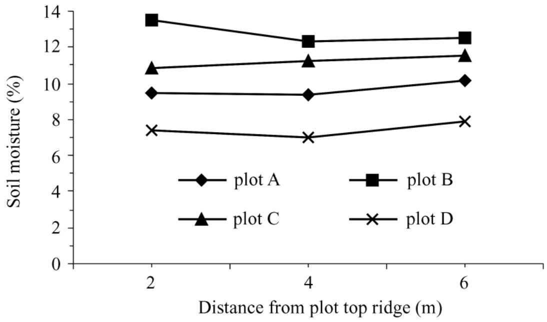

Fig. 8 Soil water capacity in the layer of 10cm—20cm

(1) As figures shown that soil water capacity in bulk subsoil plots are great increased compare with the plots without bulk subsoil. And the soil moisture in different layers (include in T-B and T-D) are all higher than that of CK.(T-A and T-C). Obviously, bulk subsoil technique had increased soil porocity and soil water capacity.

(2) Caragana in bulk subsoil plots were growth quickly than CK plots. The maximum growth length of branches in bulk subsoil plots was 62 cm and 55% higher than the length of CK plots which maximum growth length was 40 cm. The mean branch length of Caragana ware 41.2 cm and 24.9% higher than those of CK plots in which was 33.4 cm. Bulk subsoil treatment is evidently promoted Caragana growth for it improved soil water conditions.

(3) It was found that Caragana growth in down side of CK plots was longer than that of up side, however, this things didn’t happened in bulk subsoil plots. It means that caragana growth is effected by the position of geography in natural condition, and bulk subsoil treatment could improve the unfavorable plant growth condition which caused by geography. In practice, it had better to choose the suitable places to plant Caragana according to its growth requirement to geographical condition. And bulk subsoil technique is recommended to used in the Caragana land that will be promote vegetative growth and increase vegetative cover.

(4) A unusual phenomena happened in Caragana land without bulk subsoil treatment, its water infiltration was lower than that of bare soil without bulk subsoil treatment, tt is contrary to the common results. Grosh(1994) found that the best vegetative to improving soil and increasing water infiltration is the shrubbery, then is the wood and the third one are grass and crops. The reasons we observed that Caragana land is the main grazing ground to local people, Caragana is of the biological properties of successive mow and moderate mow or gnaw could promote its growth and increase branches, however, if over gnawing or lack of soil water supply the Caragana growth will be stopped or even become weakness, almost all the caragana land was overgrazing, the soil is harder for livestock’s trample frequently. Such trample caused that soil density was increased, soil porosity, soil aeration, water conductivity and infiltration were decreased, soil and water erosion was accelerated. In other words, caragana land is not only lost its functions to increase soil water capacity and water infiltration, improve soil structure, but also the caragana land growth environment went evil. So it is an important things that how to develop forest scientifically especial to the shrubbery land for livestock grazing. Soil density of bare soil and caragana land shows as below:

This pervasive regulation is mentioned us that while developing forestry and animal husbandry, the ecological capacity themselves should be considered at same time, otherwise the results would be just contrary. Therefore how to break the limited factors in caragana land is the first things that develop shrubbery land for livestock grazing in this kind of areas. The bulk subsoil technique we adapted in the experiment could break the soil surface hard shell of caragana land, and improve soil physical properties, increase soil water infiltration, so that basically forms a suitable soil water environment and directly promote caragana growth.

(5) Soil water content in bulk subsoil plots are higher than the plots without bulk subsoil treatment . Total amount of soil water content in soil profile of 60 cm, according to measuring on October 12, are 52.5mm, 63.5mm, 63.9 mm and 50.8 mm respectively from T-A to T-D. It is indicated that bulk subsoil

treatment could increase soil water capacity. This time caragana growth had stopped and water consumption was reduced. Soil water storage to caragana growth next year is very important. From turning green stage middle of April to flower stage weather is dry and few rain, so soil moisture condition determine directly to caragana development a year. In common year precipitation does not meet with caragana growth, so its growth only rely on soil available water content. It is very important that increases soil water content as it could in rain season and stores it up to next spring for caragana or other vegetation growth in loess plateau. And bulk subsoil technique is one of the best way to realize the aim.

(6) Bulk subsoil technique, depth of bulk subsoil is 50 cm, is able to improve soil structure to promote plant root growth. The maximum lateral root length of caragana could grow up to 6m—8m, bulk subsoil was usually conducted in plant rows like belts, so it is useful to lateral root development and increase its water uptake ability.

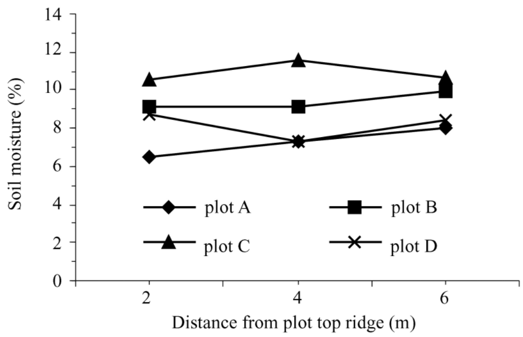

Fig. 9 Soil water capacity in the layer of 0cm—10cm

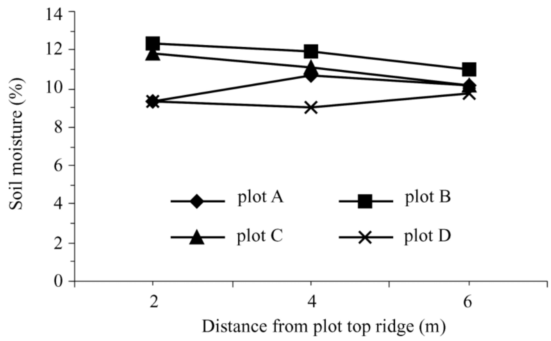

Fig. 10 Soil water capacity in the layer of 10cm—20cm

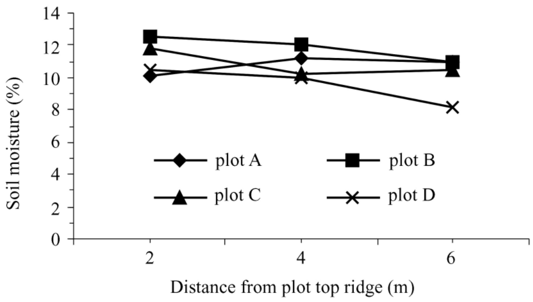

Fig. 11 Soil water capacity in the layer of 20cm—40cm

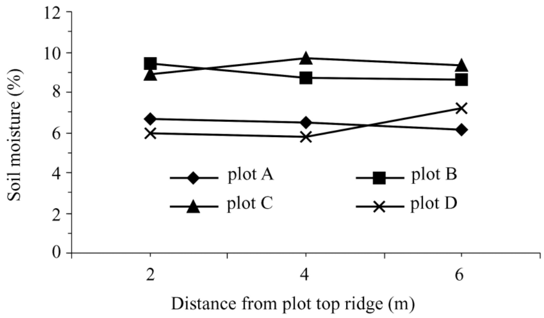

Fig. 12 Soil water capacity in the layer of 40cm—60cm

4 Conclusion

Bulk subsoil technique could increase soil water infiltration, soil water capacity and soil water content, that is significant to resist spring drought and to soil and water conversation in loess plateau area.

Bulk subsoil technique could improve soil water condition of forest land and promote caragana growth. It is an efficient technique to improve soil structure especial to the forestland both for livestock grazing and for soil and water conversation.

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