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Soil Moisture Dataset of the Zhonggou River Basin in the Loess Plateau of Gansu Province

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Abstract: Zhonggou River basin was chosen as a typical small watershed of Longdong Loess hilly-gully region of the Loess Plateau of China. The *robinia pseudoacacia* planted in the 1970s and natural recovery grassland were selected as the research sites. Ten sample plots of forest land and three sample plots of grassland were set up according to the changes of vegetation type, forest age, and site characteristics. The soil moisture of all samples was measured by drying method and Time Domain Reflectometer (TDR). The maximum depth of soil moisture measurement pipe is 3 m, and the maximum depth of soil drill is 2 m. In 2018, the complete observation of all sample plots was achieved, and the measured data of soil mass moisture and volumetric moisture during the growing season were obtained. The dataset includes: (1) 13 geographical location and topographic data of the observed plots, as well as the forest age, density, DBH, and other main stand structure data; (2) Measured data of soil mass water content and volumetric water content from April to October, 2018. The dataset was archived in .xlsx, .shp, and .kmz data formats with data size of 252 KB in 9 data files (compressed to 238 KB in two data files). The research results related to the dataset were published in the *Journal of Arid Zone Research* (Vol. 36, No. 5, 2019).

Keywords: soil mass moisture; soil volumetric moisture; *robinia pseudoacacia*; the Loess Plateau; Journal of Arid Zone Research

1 Introduction

The climate is drought and the precipitation in the Loess Hilly Region of Gansu province are less and unevenly distributed, low forest vegetation coverage, deterioration of ecological environment and serious soil erosion in this area. The relationship between vegetation and water is the core issue of ecological restoration and vegetation construction in the Loess Plateau of Gansu province[1–3]. China has invested a series of key forestry ecological projects

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in this region, and a large area of ecological forests such as *Robinia pseudoacacia*, *Pinus tabulaeformis*, *Platycladus orientalis*, *Hippophae rhamnoides*, and *Caragana korshinskii* have been constructed. However, in the process of ecological restoration in early large-scale plantation, the characteristics of natural environment and spatial-temporal distribution of soil moisture were neglected. In order to meet the needs of strong evapotranspiration, the plants have rapidly expanded their roots and utilized deep soil water storage, resulting in soil degradation in plantation grassland[4]. At the same time, the tree species selection is not scientific, and the way of construction is not reasonable, resulting in a single tree species structure and high planting density, and the survival rate and preservation rate are low. Even if they survive, they grow very slowly and enter the degeneration stage earlier. As a result, a series of problems, such as poor stability of forestry ecosystem, stagnation of growth and regeneration of forest trees, low ecological effect, soil drying, and decline of groundwater level, have emerged one after another[5–7]. The only source of soil moisture is rainfall, but the soil water consumption is much larger than precipitation, leading to a long-term deficit of soil moisture[8]. Consequently, the expected effect of ecological engineering construction has not been achieved. Therefore, it is of great theoretical significance for guiding the restoration and sustainable development of plantation vegetation in this area to study the eco-hydrological process of typical plantation in this area and to grasp the distribution of soil moisture in this area.

2 Metadata of Dataset

The metadata of "*In situ* soil moisture dataset in the Zhonggou River basin of Loess Plateau (2018)"[9] are listed in Table 1, including the name, author, geographical region, time, dataset files, data publisher, data sharing policy, etc.

3 Survey of Research Area and Data Development Method

3.1 Survey of Research Areas

The study area is located in Jingchuan county, Gansu province (Figure 1). It is a typical loess hilly and gully area. Slope direction: sunny slope, semi sunny slope, shady slope and semi shady slope, of which semi sunny slope is the main one[11]. The climate in the study area is typical continental climate, with annual sunshine duration of 2,274 hours, annual average temperature of 10.7 °C, frost-free period of 174 days, annual average rainfall of 555 mm, annual evaporation of 1,181.6 mm, humidity of 0.81–1.04, and dryness of 0.95–1.28[12]. The soil is black loam soil, yellow loam soil and brown soil. The vegetation type belongs to the forest grassland transition zone. The existing forest land area of the county is 5,420 km^2, and the forest coverage rate is 47.33%. The artificial forest planted in Guanshan forest farm is 132.7 km^2, mainly *Robinia pseudoacacia*[7]. The experimental area of the project is located in Zhonggou River basin (35°20′N, 107°31′E) of Guanshan Forest Farm. The watershed covers an area of 2.09 km^2, with an elevation of 1,072–1,351 m. The vegetation type belongs to the transition zone between forest and grassland. *Robinia pseudoacacia* accounts for 92% of the total forest area. It can be roughly divided into four different forest ages: 20 years, 25 years, 30 years, and 35 years.

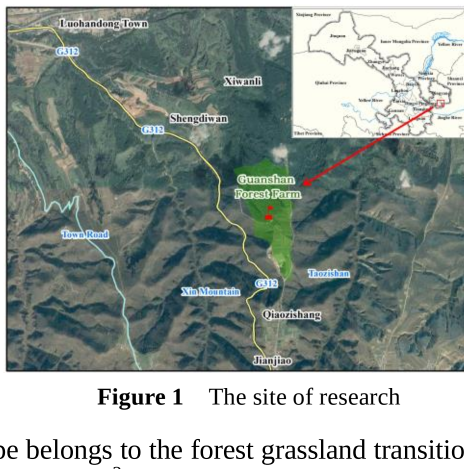

Figure 1 The site of research

Table 1 Metadata summary of "*In situ* soil moisture dataset in the Zhonggou River basin of Loess Plateau (2018)"

Items	Description
Dataset full name	*In situ* soil moisture dataset in the Zhonggou River basin of Loess Plateau (2018)
Dataset short name	SoilMoistureLoessPlateau
Authors	Di, L., Gansu Agricultural University, dili@gsau.edu.cn Li, X. Y., Lanzhou University, lixiaoying@Lzu.edu.cn Chen, Z. N., Gansu Institute of Forestry Science, chen.zhengni@gmail.com Zhang, J. AAA-5731-2019, Gansu Agricultural University, zhangjun@gsau.edu.cn Huang, H. X., Gansu Agricultural University, haixiahuang@ gsau.edu.cn Wang, A. M., Pingliang Institute of Soil and Water Conservation, 593928177@qq.com Fang, S. M., Gansu Agricultural University, fangsm@gsau.edu.cn Ru, H. L., Pingliang Institute of Soil and Water Conservation, 1175332809@qq.com Jing, G. Y., Gansu Agricultural University, 960249539@qq.com Zhang, X. M., Gansu Agricultural University, 2248530337@qq.com Fei, J. E., Gansu Agricultural University, 943416926@qq.com
Geographical region	Zhonggou River basin of Loess Plateau (35°20′N, 107°31′E)
Year	Apr.–Oct., 2018 Data format .xlsx, .shp, .kmz Data size 252 KB
Data files	(1) Information of sampling plots (2) Soil mass water content of 13 sampling plots during Apr.–Oct., 2018 (3) soil volumetric water content of 13 sampling plots during Apr.–Oct., 2018
Foundations	National Natural Science Foundation of China (41461112, 31660235)
Data publisher	Global Change Research Data Publishing & Repository，http://www.geodoi.ac.cn
Address	No. 11 A Datun Road, Chaoyang District, Beijing 100101, China
Data sharing policy	***Data*** from the Global Change Research Data Publishing & Repository includes metadata, datasets (data products), and publications (in this case, in the *Journal of Global Change Data* & *Discovery*). ***Data*** sharing policy includes: (1) ***Data*** are openly available and can be free downloaded via the Internet; (2) End users are encouraged to use ***Data*** subject to citation; (3) Users, who are by definition also value-added service providers, are welcome to redistribute ***Data*** subject to written permission from the GCdataPR Editorial Office and the issuance of a ***Data*** redistribution license, and; (4) If ***Data*** are used to compile new datasets, the 'ten percent principal' should be followed such that ***Data*** records utilized should not surpass 10% of the new dataset contents, while sources should be clearly noted in suitable places in the new dataset[10]
Communication and searchable system	DO I, DCI, CSCD, WDS/ISC, GEOSS, China GEOSS

The stand stereo structure is simple, besides *Robinia pseudoacacia*, there are arbors, such as *Populusspp*, *Platycladus orientalis*, *Pinus tabulaeformis*, *Paulowniaspp*, and *Salix matsudana etc*; Shrub includes *Amorpha fruticosa*, *Prunus davidiana*, *Hippophae rhamnoides*, *Caragana korshinskii*, *Artemisia gmelinii*, *Stipa breviflora*, *Lespedeza fioribunda*, *Syringa persica*, *Hippophae rhamnoides Linn*, *Xanthocera sorbifolia*, etc.; Understory herbs include *Stipa breviflora*, *Astragalus adsurgens*, *Pennisetum centrasiaticum*, *Bothriochloaischaemum*, *Setaria faberi*, *Chenopodium album L*, and so on[13–15].

3.2 Raw Data Acquisition

3.2.1 Basic Information of Sample Plots

On the basis of comprehensive consideration of stand structure and site differentiation, 10 plots of *Robinia pseudoacacia* with different slope orientations, gradients, ages, and densities, and 3 plots of grassland slope were selected (Table 2). Figure 2 is the conventional plot of *Robinia pseudoacacia* forest and Figure 3 is the grassland slope plot).

3.2.2 Soil Moisture

The volumetric water content and the mass water content of soil were measured by TDR and drying method, respectively.

(1) Measurement of soil volumetric moisture [15–16]

Measuring soil volumetric water content according to the transmission time of electromagnetic wave emitted by the detector (Figure 4).

Table 2 Information of sample plots in the Zhonggou River basin in the Loess Plateau of Gansu province

Sample plot	Stand age (a)	Location	Landform	Aspect (°)	Altitude (m)	Slope (°)	Density (plants/hm^2)	Average DBH (cm)	Average height (m)	Average tree height under first branch (m)	Even crown diameter (m)	Canopy density
1	35	35°20′25″N 107°31′2″E	Ridge slope	233 ° semi-sunny slope	1,235	35 °	4,563	7.83	5.63	3.38	1.85×1.55	0.87
2	30	35°20′32″N 107°31′9″E	Table-land	339 ° semi-cloudy slope	1,251	15 °	2,196	13.22	11.9	7.1	7.8×4.3	0.82
3	25	35°20′41″N 107°31′11″E	Table-land	332 ° semi-cloudy slope	1,239	13 °	750	16.24	13.88	7.9	4.91×5.1	0.8
4	25	35°20′47″N 107°31′11″E	Table-land	9 ° shady slope	1,325	2 °	1,600	15.66	12.83	6.95	4.7×4.5	0.83
5	20	35°20′44″N 107°31′55″E	Ravine	218 ° semi-sunny slope	1,127	17 °	5,400	9.16	11.07	5.25	3.6×3.0	0.86
6	35	35°20′22″N 107°31′6″E	Ridge slope	227 ° semi-sunny slope	1,252	16 °	3,780	11.54	8.36	4.1	2.7×3.4	0.82
7	25	35°21′1″N 107°31′36″E	Table-land	341 ° shady slope	1,251	8 °	1,227	15.5	14.46	8.54	4.9×4.2	0.8
8	25	35°20′56″N 107°31′34″E	Table-land	216 ° sunny slope	1,255	2 °	1,625	16.94	13.24	7.14	4.7×4.6	0.79
9	25	35°20′51″N 107°31′33″E	Table-land	247 ° semi-sunny slope	1,243	18 °	1,000	14.2	11.96	5.56	4.9×4.8	0.82
10	35	35°20'10″N 107°31'7.5"E	Ridge slope	255 ° semi-sunny slope	1,283	29 °	3,550	6.15	7.6	4.3	3.2×2.5	0.88
11	Grass-land	35°20′42″N 107°31′8.5″E	Table-land	239 ° semi-sunny slope	1,228	22 °	–	–	–	–	–	–
12	Grass-land	35°20′44″N 107°31′2″E	Ridge slope	225 ° semi-sunny slope	1,201	35 °	–	–	–	–	–	–
13	Grass-land	35°20′43″N 107°31′53″E	Ravine	257 ° semi-sunny slope	1,137	10 °	–	–	–	–	–	–

Methods: TDR tubes were buried in 13 selected sample plots in the previous year. After calibration, soil moisture was measured between the trees germination in the middle and late April of the following year and the end of October, which was a complete growing season. In theory, TDR tubes were measured every 15 days, and the measurement was added after raining. The actual operation depends on the weather conditions and the time interval from the previous sampling. Sometimes individual sample plots were not measured because of the water inflow in the measuring tube, resulting in data missing.

The depth of measurement varies according to slope, aspect, age, and planting density. The specific settings are as follows: Three 3-m TDR tubes were buried in each sample plot of No.1, No.3, No.4, and No.5, respectively. Two 3-m TDR tubes were buried in No.2 sample plot. Two 2-m TDR tubes were buried in each runoff field of No.6 and No.11 sample plots. Three 2-m TDR tubes were buried in each sample plot of No.7, No.8, and No.9. TDR tubes of 3 m and 2 m were buried in each sample plot of No.10 and No.12 plots, respectively. Two 1.5-m TDR tubes were buried in sample No.13. Maximum test depth is 300 cm. The probe of TDR is put into the observation tube during measurement. Soil moisture was measured at 0–10, 10–20, 20–40, 40–60, 60–80 cm, respectively, and recorded every 20 cm downward. The measuring time basically kept synchronization with the earth drilling observation.

Figure 2 No.3 test plot

Figure 3 No.12 grassy slope sample land

Figure 4 Soil water content measured by TDR

(2) Soil mass water content

Methods: From the middle of April when trees began to germinate to the end of October after defoliation, soil moisture was measured every 15 days (Figure 5) and the measurement was added after rainfall. In actual measurements, adjustments are made according to weather conditions (sampling time will be lengthened with continuous precipitation) and the time interval from the previous sampling. Soil samples were taken from top to bottom with drills at different depths. Sampling depths were 0–120 cm, stratified by 0–10, 10–20, 20–40, 40–60, 60–80, 80–100, and 100–120 cm, respectively. Soil mass water content was calculated as follows.

Figure 5 Soil sampling by soil auger

$$Q = \frac{W_2 - W_3}{W_3 - W_1} \tag{1}$$

where Q was soil mass water content (%), W_1 was weight of sampling box (g), W_2 was weight of wet soil and sampling box (g), W_3 was weight of dry soil and sampling box (g).

4 Data Results

During the growing season from May to October, the soil moisture of *Robinia pseudoacacia* plantations with different densities is showed as follows (Tables 3, 4): 1,600 trees/hm^2 (18.75%)>2,196 trees/hm^2 (15.93%)>750 trees/hm^2 (15.92%)>4,563 trees/hm^2 (11.87%). Soil moisture in different topographic locations: soil moisture was the best for the *Robinia pseudoacacia* forest in the tableland surface (upper), in the middle for the *Robinia pseudoacacia* forests in the tableland surface (lower) and the ditch, and the worst for the *Robinia pseudoacacia* forest in the beam. As far as slope aspect was concerned, soil moisture was the best in shady slope, followed by the semi-shady slope and sunny slope, and was the worst in semi-sunny slope. As far as the vertical variation of soil moisture was concerned, soil moisture was usually the largest in the surface layer, decreased with the deepening of the soil layer and then tended to be stable. For different topographic locations, the variation coefficient of soil moisture between different layers for *Robinia pseudoacacia* forest on the tableland (upper) was the smallest, with the soil moisture relatively stable, followed by *Robinia pseudoacacia* forests on the tableland surface (lower) and on the gully, and was the largest for the *Robinia pseudoacacia* forest on the beam, with a rapid variation layer reaching 90 cm. For the slope direction: the change of soil moisture in sunny slope and semi-sunny slope was more active than that in shady slope and semi-cloudy slope, in which the sunny slope was more stable than the semi-sunny slope and the shady slope was more stable than the semi-cloudy slope[17].

Table 3 Volumetric water content of soil in May 2018 (partly)

Depth (cm)	Sample sites				
	1	2	3	…….	13
0–20	8.80	15.18	8.47		10.57
20–40	6.02	12.87	11.39		12.56
…	…	…	…	…	…
180–200	…	…	…	…	13.10
280–300	10.49	10.45	10.75		

Table 4 Mass water content of soil in May 2018 (partly)

Plot No.	Sampling depth (cm)						
	0–10	10–20	20–40	40–60	60–80	80–100	100–120
1	18.52	9.99	8.53	8.66	9.13	10.13	9.53
2	24.15	19.12	14.44	12.71	14.48	14.99	15.66
3	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…
13	22.54	16.70	12.94	14.19	14.06	13.02	12.90

5 Discussion and Conclusion

The seasonal variation of soil moisture in *Robinia pseudoacacia* plantation during the annual growth season was studied. It was found that the seasonal variation of soil moisture in *Robinia pseudoacacia* plantation could be divided into consumption period (May–June), replenishment period (July), regression period (August–September) and stabilization period (October). Despite the increase of rainfall in June, soil moisture was still declining, which may be attributed to the increased demand for water at the early growth stage of *Robinia pseudoacacia* and the enhanced evaporation of forest land. In July, the soil moisture fluctuated greatly in different plots, mainly because the strong rainfall had a significant impact on the surface layer, which made the surface soil moisture increase sharply. However, with the evaporation after rain strengthening, the soil moisture would change greatly. As far as the vertical change of soil moisture was concerned, the soil water content showed a similar trend with the change of rainfall. The continuous observation for many years can be used as an important index data for the change of regional ecological environment. It can also be used as the basic input data for climate model, hydrological model, and vegetation growth analysis.

Author Contributions

Di, L. made the total design of the experiment and the dataset. Chen, Z. N. assisted in experimental design and field observation. Li, X. Y. was mainly responsible for data analysis. Wang A. M., Jing, G. Y., Zhang, X. M., *et al*. were responsible for data collection. Di, L., and Zhang, J. carried out data verification and wrote the data paper.

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